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NETSSAF

- Network for the development of Sustainable approaches for large Scale Implementation of Sanitation in Africa-

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D04: Criteria for the evaluation and classification of conventional and innovative low cost sanitation technologies

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INTRODUCTION

Lack of access to improved sanitation and safe water is a global crisis, but nowhere in the world are the effects of inadequate sanitation more visible, more pervasive and more devastating than in sub-Saharan Africa. The provision of sanitation facilities in the region is important and urgent, requiring the use of emerging, existing, innovative, and low-cost technologies. It was recognition of the urgency and severity of the crisis that prompted the United Nations, at its Millennium Summit and at the 2002 World Summit for Sustainable Development, to declare the Millennium Development Goals (MDGs) for safe water and sanitation. The MDGs call on the global community to halve the proportion of people without access to safe drinking water and adequate sanitation by 2015.

It is feared that the MDGs will spur on the building of millions of conventional sanitation systems – deep pit latrines and flush toilets – in developing countries over the next couple of years. These systems promote a linear flow of materials and impact severely on the environment and resources, and are therefore not sustainable.

In view of the need to respond to this situation, a wide range of criteria is presented in the following report which will strengthen decision-making towards the selection of sustainable sanitation technologies at various levels, especially in peri-urban and rural settlements, as well as small and medium-sized towns in Africa.

For the past years different authors have formulated criteria and models for assessing sanitation systems (Louis & Ahmad, 2004; Louis & Bouabid, 2004; Braken *et al*, 2004, among other). But, the variation and range of the criteria highlight the challenge of identifying effective tools for evaluating the technologies. Therefore, deeper consideration for some of the criteria, along with new criteria and indicators, need to be incorporated into current models to holistically evaluate and classify conventional and innovative low cost sanitation systems.

The criteria presented here are the outcome of a series of consultations and meetings of a working group in NETSSAF and are drawn from the works of various authors, with a huge emphasis on the criteria developed by Bracken *et al*. The document is designed to serve as a working tool for work package 3 (Sanitation technologies assessment) and would constitute the first step towards the development of a systematic method which will enable households/authorities decide which sanitation option is most suitable given the profile of their communities. It has to be emphasised that the criteria given here is a non-context list of criteria. For any given situation locally relevant criteria would have to be identified from this general list. The merge of these non-context criteria with the framework conditions of typical settlements will be done in future activities of the consortium, once a scanning of the West African region has been performed (WP2) and a complete list of feasible sanitation systems for the given conditions is developed (WP3).

1. BACKGROUND INFORMATION

Description of the Work Package 1

The work package 1 will be the basis for the future evaluations to be performed throughout the region, since it will aim at the standardisation of the assessment criteria. The members of this work package will bring together existing evaluation criteria, producing at the end a guideline of evaluation applicable across the region. This will allow for a harmonisation and systematisation of the existing information, producing tools for obtaining reproducible results regardless of the country. In some cases, more indicators will be proposed, according to the decision of the specialists; but the principal aim is to bring together and take into account already existing guidelines, methodological framework, indicators and methods of assessment. Special attention will be given to the recommendations and results produced by the World Health Organisation, UNICEF, the World Bank Water and Sanitation Programme, World Development Programme, EcoSanRes of the Swedish Government and EAWAG-Switzerland, as well as inputs by members of the consortium who actively participate in other international organisations.

Methodology of development of the task

Essentially, this task has been realised through in-depth discussions, literature scans, local and international consultations and scenario building.

It was recognised that it is not possible to identify the full range of locally relevant criteria representing the different conditions in West Africa, for which results of the other work groups (task 1.1 “Multidisciplinary criteria for evaluation and classification of peri-urban and rural settlements with no access to improved sanitation” and WP2 “Regional evaluation and classification of typical settlements”) are needed in order to formulate the context relevant criteria, with the involvement of a wide range of stakeholders in the region. This will constitute part of the deliberations of the mid-term meeting scheduled for month 13th 2007 in Mali, in which the workshop of the task 4.1 “Assignment of appropriate low-cost technologies according to characteristics of typical settling” will take place.

The institutions involved in the identification process are:

- Technologie Transfer Zentrum Bremerhaven (TTZ), Germany
- BioAzul, Spain
- Hamburg University of Technology (TUHH), Germany
- International Ecological Engineering Society (IEES), Switzerland
- Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Switzerland
- EcoSan Club Austria (ESCA), Austria
- Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), Germany
- Swedish University of Agricultural Sciences (SLU), Sweden

2. OBJECTIVES

The overall objective of this task is to propose an integrated “evaluation criteria of sanitation systems” which could harmonise the assessment exercises to be carried out in the frame of NETSSAF Coordination Action, particularly in work packages 3 and 4. These criteria shall include technical, social, legal and institutional, financial and environmental aspects, giving as a result a multidisciplinary tool that allows a holistic evaluation (regarding sustainability) and systematisation of sanitation systems, given the profile of a community.

Furthermore, it is intended that these criteria should set the basis for the evaluation that will include framework conditions, and which will be designed to assist city planers and end users in West

Africa in the large-scale implementation of improved sanitation systems in rural and peri-urban areas.

The specific objectives of this task are to:

- identify criteria that enable critical evaluation of sanitation technologies
- promote the appropriate selection and use of sanitation systems,
- optimise the sanitation systems according to the results of the evaluation and
- foster innovative/holistic thinking in the area of sanitation.

3. DEFINITIONS

To facilitate the use of this document, some key terms need to be clarified.

ii) What is meant by the term “Sanitation system”?

Bracken et al. (2005) define a sanitation system as compromising the users of the system, the toilet infrastructure, the collection, transport, treatment, and management of end products (human excreta, solid waste, grey water, storm water and industrial wastewater).

i) A definition of the term “Sanitation”

Sanitation covers a broad range of aspects including all the elements identified in a sanitation system, in addition to hygiene education. The term can take different definitions depending on the circumstances. For the purposes of this report, we have chosen to use an adaptation of the definitions of sanitation and adequate sanitation provided by Kader Asmal et al.

The term sanitation refers to the principles and practices relating to the collection and management of refuse, human excreta and wastewater, as they impact upon communities, users, operators and the environment.

ii) What is meant by “Adequate sanitation”?

Adequate sanitation refers to the situation where there is provision and ongoing operation and maintenance of a system of removing and managing human faeces, solid waste and wastewater which is acceptable and affordable to the users (Kader Asmal et al, 1996).

iii) What is meant by “Sustainable Sanitation”?

Sustainable sanitation refers to sanitation systems that protect and promote human health, do not contribute to environmental degradation or depletion of the resource base, are technically and institutionally appropriate, economically viable and socially acceptable (Kader Asmal et al, 1996).

4. REVIEW OF EXISTING EVALUATION CRITERIA OF SANITATION TECHNOLOGIES

A short consideration of current approaches (criteria and models) for assessing sanitation systems will provide points of critique and consideration for identification of new criteria. For the past years different authors have identified criteria, formulated models and other schema for assessing sanitation systems. But, the variation and range of the criteria highlight the challenge of identifying effective tools for evaluating the systems.

Some models such as Patrick Bracken *et al*’s Identification of Criteria for the Sustainability of Sanitation Systems (2005) and Annelies Balkema *et al*’s Multi-Criteria Analysis for Sustainable wastewater Treatment (2001) focus solely on using sustainability-oriented criteria for comparing and selecting technologies. Though each of them acknowledges the need for context specific criteria (knock-out criteria), both fail to provide a framework for formulating the knock-out. Their criteria include economic, environmental, technology/functional, health and socio-cultural/institutional issues.

Katherine L. Clopeck et al's Implementation of Appropriate Household Water Purification System in Tourou, Cameroon (2006) add a new dimension to the criteria identification process by including "service" (water availability, range of precipitation) and "human resources" as separate criteria. Their eight criteria (so-called capacity factors) and the corresponding indicators provide a frame for evaluating sanitation systems. Panesar A. et al's Concepts for Ecologically Sustainable Sanitation in Formal and Continuing Education (2006) journeys a step further by formulating holistic criteria for comparative sustainability assessment of sanitation systems.

Other existing models place emphasis on the unique profile of host communities (characteristics, opportunities and challenges) rather than technologies. Garrick Louis' Community Assessment for Sustainable Sanitation Services in Low-Income Communities (2004) presents a model for assessing a community's capacity to manage and sustain sanitation systems.

The above models only present lists of criteria and indicators without proposing a methodology of evaluation. However, Hellström et al. (2000) improved on this approach by proposing a set of methods for the evaluation of selected priority criteria, including:

- Health and hygiene criterion: Microbial risk assessment, to evaluate Risk for infection
- Social and cultural criterion: Action research and assessment scales, to evaluate Acceptance
- Environmental criteria: Life-cycle assessment, computer-based modelling, material-flow analysis, and exergy analysis to evaluate eutrophication, spreading of toxic compounds to water and to arable soil, and use of natural resources.
- Economical criterion: Cost-benefit analysis, to evaluate total cost
- Functional and technical criterion: Functional risk analysis, to evaluate robustness.

Furthermore, the World Health Organisation (WHO) suggests in its Guidelines for the Reuse of wastewater, excreta and greywater, the application of the so-called DALYs (Disease adjusted life years) as measuring instrument for health risk, together with further risk management strategies (incl. hazard barriers and health protection measure).

Although these approaches provide seemingly reliable procedure to evaluate the indicators, they are too involving (needing a lot of time and resources), and often associated with too many assumptions. It is also well known that their application is limited to specific big scale projects or some research projects. In addition, these methodologies have been subjects of criticism, as some authors including Balkema et al. (2000) questioned the applicability of Life Cycle Assessment (LCA) when analysing the sustainability of a wastewater treatment by end users and planners. According to the author, this methodology includes some subjectivity, as there is no full consensus on the environmental impact categories.

All evaluation approaches mentioned above represent without doubt a significant step in the assessment and classification of sanitation systems, as they identify and address key sustainability criteria. However, they neither suggest a methodology for evaluating the technologies nor provide a framework for formulating locally relevant criteria. Therefore, an approach grounded in these, with deeper consideration for some of the criteria, along with new criteria and indicators need to be incorporated into current models to holistically evaluate and classify conventional and innovative low cost sanitation systems.

5. SYSTEM BOUNDARY DEFINITION

A clear system boundary definition is a prerequisite for the evaluation of sanitation systems and forms the basis for additional steps. According to Panesar et al. (2006) clear boundaries defining the limits of a sanitation system are of main importance to identify criteria that can be used to assess the sustainability of sanitary systems. The selection of the boundary is strongly dependent from the context. Bracken *et al*. writes that the system boundary "should be chosen in such a way as to ensure that there is no export in either space or time of problems that may be created by the system."

The following definition is based on:

- The "Open planning of sanitation system" approach by Kvarnström and Petersens, 2004. This approach describes a five step planning process, where Step 2 "Identification of boundary conditions" includes the definition of sanitation system boundaries through asking the following questions: Where does the system begin and end? Does the system include all wastewater fractions of the household? Will the wastewater fractions be managed in a separate or combined manner? Does the system start at the boundary of the garden or within the bathroom? Does the system include other houses? Does the system include treatment or only collection and discharge to a larger system?

- The "Household-centred environmental sanitation" approach (Eawag, 2005): The HCES approach is a ten step planning process, which is based on the concept of "zones". These zones are defined by political boundaries (for example city wards or towns) or reflect common interests (for example water sheds or river basins).

- The system boundary definition of Panesar et al. (2006), who writes that a sanitation system should comprise from the cradle to the final destination all parts of the sanitation system, including: the users and other stakeholders demands and needs, collection, transport, treatment, reuse or final disposal of human excreta and domestic wastewater, organic household wastes, with option to include as well industrial wastewater, storm water, solid waste, animal manure or other agricultural wastes. But these boundary conditions also include the social aspect of sanitation, the economic and logistical side, and the idea of resource management, as well as any indirect impacts, costs or benefits of the system.

These broad definitions explicitly emphasize that sanitation has to be recognised in a broader context. Thus for the purposes of the NETSSAF project the system boundary will comprise the sanitation and the reuse system including the mass-flow system, technical system and socio-economic system. The mass-flow system includes water, urine, brown water, grey water, solid waste (incl. Bio- and non biodegradable waste) and storm water. The referring technical system comprises the production, collection, transport, treatment, reuse/final destination mass flows and the construction and O&M of the mass-flow system. The socio-economic system includes users, operators and other stakeholders, but also legal, organisational and infrastructural as well as financial aspects.

Fig 1 shows the interaction between the different system components, which are strongly related to each other:

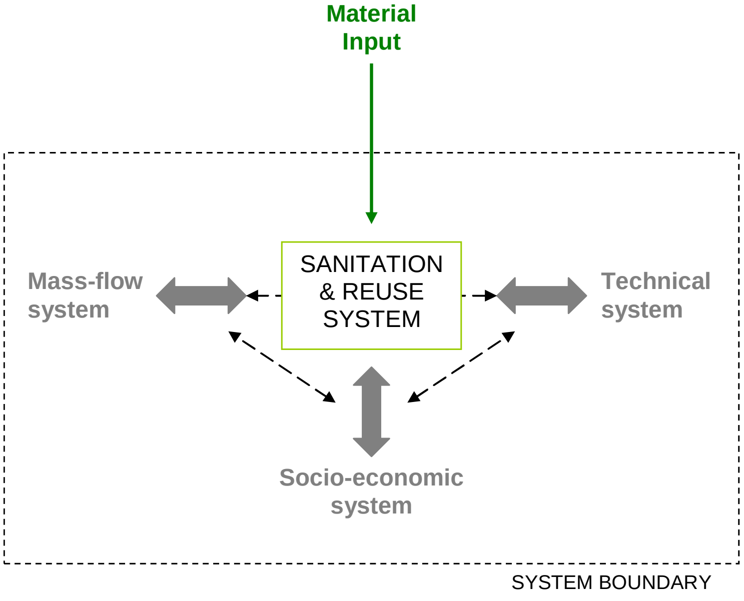

Fig 1.- *The system boundary*

6. CRITERIA FOR THE ASSESSMENT OF SANITATION TECHNOLOGIES

The following table contains a set of identified criteria sorted according to different aspects considered critical when using a holistic approach to assess sanitation systems. These include (1) health criterion, (2) environmental and resource criteria, (3) technical and operational criteria, (4) financial and economical criteria, (5) social, cultural and gender criteria. The objective is to include a comprehensive list of evaluation criteria to provide the decision makers with a complete overview of the existing aspects of sanitation systems.

The starting point for the development of the criteria was the list proposed by Bracken et al. (2004), in which five criteria were proposed as an expansion of the conventional triple bottom line usually accepted as the three pillars of sustainability –economy, society and the environment (Panesar et al., 2006).

For the purposes of this document, each criterion is accompanied by simple and easily interpretable indicator. The indicators will allow the planers and end-users to describe the technical, social, financial requirements as well as the impacts and the benefits obtained by the application of a sanitation system.

When dealing with a measurable aspect, for instance energy required, a measurement will be chosen with an appropriate unit. In this case, the planers will be able to evaluate different sanitation systems by comparing the value of the measurements. For instance, land required by system A is equal to 1,0 m^2/pe, which is less than the land required by system B (1,2 m^2/pe). To ensure that all relevant aspects of a sanitation system are covered, qualitative evaluation has been suggested as methodology to evaluate those indicators, which cannot be expressed quantitatively.

The final choice of sanitation system to be implemented will be the decision of the users and planners who will select from the given set of criteria, those parameters relevant to their community's profile. Furthermore, it is open for the decision makers to select a rating system that better suits their local framework.

Table 1*.-Criteria for the assessment of sanitation systems*

Health issues	
The risk of exposure to pathogens and non-pathogenic substances, that could infect members of communities, is classified in different groups according to the mode of contact. The degree of sanitation achieved by the sanitation technology is also considered in this section, assumed as an additional factor in health issues. This group of criteria also includes the health benefits; including hygiene, nutrition and improvement of livelihood achieved by the application of a certain sanitation technology. For details refer to section A.1.	
Criteria	**Indicator for characterisation**
Exposure to pathogens and risk of infection related to all system elements including collection, transportation, treatment, reuse and final destination of products / wastes.	
• For communities of users and consumers	Qualitative evaluation
• For operators of the sanitation system	Qualitative evaluation
Health benefits due to food production, nutrition status, livelihood	Qualitative description
Impact to the Environment/Nature	
This set of criteria involves the required natural resources for construction and running of the sanitation system, as well as the potential emissions to the environment (water, air and soil) that could result from the use of such systems. It also includes the potential gained benefits from reusing material, contributing to the cycle of nutrients and water. For more details on impact to the environmental, refer to section A.2.	
Criteria	**Indicator for characterisation**
Use of natural resources – Construction:	
• Land	m^2/pe
• Energy	MJ/pe

• Construction materials	type and quantity
Use of natural resources- Operation and Maintenance (O&M):	
• Land	m^2/pe/yr
• Construction materials	type and quantity
• Energy from renewable resources	MJ/pe/yr
• Energy from non-renewable resources	MJ/pe/yr
• Total use on non-renewable resources	Non-renewable resource units
• Fresh water	m^3/pe/yr
• Precipitation agents or other chemicals	Type and quantity/pe/yr
Emissions to the environment:	
- Discharge to surface water	
• BOD	g of BOD/pe/yr
• COD	g of COD/pe/yr
• Nutrients	g of N/pe/yr
	g of P/pe/yr
• Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, natural and synthetic hormones	mg of Cd/pe/yr
	mg of Cu /pe/yr
	mg of Ni /pe/yr
	mg of Pb /pe/yr
	mg of Zn /pe/yr
	mg of Hg /pe/yr
	mg of Cr /pe/yr
	mg/pe/yr of persistent organic compound
	mg/pe/yr pharmaceutical residues
	mg/pe/yr hormonal substances
• Salts	g/pe/yr of NaCl
- Discharge to groundwater	
• BOD	g of BOD/pe/yr
• COD	g of COD/pe/yr
• Nutrients	g of N/pe/yr
	g of P/pe/yr

• Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, natural and synthetic hormones	mg of Cd/pe/yr
	mg of Cu /pe/yr
	mg of Ni /pe/yr
	mg of Pb /pe/yr
	mg of Zn /pe/yr
	mg of Hg /pe/yr
	mg of Cr /pe/yr
	mg/pe/yr of persistent organic compound
	mg/pe/yr pharmaceutical residues
	mg/pe/yr hormonal substances
• Salts	g/pe/yr of NaCl
- Emissions to the air	
• Emissions of climatic relevant gases (e.g. CO_2, CH_4, GHGs, etc)	kg of CO_2 equivalent/pe/yr
• Emissions of acidifying gases (e.g. NH_3, SO_2 etc)	kg mole of H^+ equivalent/pe/yr
Resources recovered	
• Mass	g/pe/yr of weight for each recovered product
• Nutrients	g/pe/yr of N
	g/pe/yr of P
	g/kg of S
	g/pe/yr of K
• Energy	MJ/pe/yr
• Organic material	g of total organic matter/pe/yr
• Quality of recycled products (released to soil): heavy metals, persistent organic compounds, pharmaceutical residues hormones, etc.	mg/pe/yr of persistent organic compound
	mg/pe/yr pharmaceutical
	mg/pe/yr hormonal substances
	mg of Cd/pe/yr
	mg of Cu /pe/yr
	mg of Ni /pe/yr
	mg of Pb /pe/yr
	mg of Zn /pe/yr

	mg of Hg /pe/yr
	mg of Cr /pe/yr
• Area of common staple crop that can be fertilised	m^2/pe
• Water	m^3/pe/yr
• Area of common staple crop that can be irrigated	m^2/pe
Accumulation of environmental burden in landfill	
• Nutrients	g/pe/yr of N
	g/pe/yr of P
• Organic material	g/pe/yr
• Estimated cumulative production of green house gases (CH_4, N_2O etc.)	kg of CO_2 equivalent/pe/yr
• Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	mg/pe/yr of respective substance
• Water (increases risk of leachate formation)	m^3/pe/yr
• Volume on landfill	m^3/pe/yr
Technical characteristics of the sanitation system and its operation	
This set of criteria includes the technical characteristics of a sanitation system regarding the functionality and the ease with which the system can be constructed, operated and monitored by the own members of a community. Furthermore, it evaluates the robustness of the systems and the adaptability of its technical elements to the existing infrastructure. For details refer to section A.3.	
Criteria	**Indicator**
Construction	
• System robustness	Qualitative description
• Robustness against drought, flooding, earthquake etc.	Qualitative description
• Possibility to use local competence for construction	Qualitative description
• Durability / lifetime	Yrs
• Compatibility with existing system	Qualitative description
• Flexibility / adaptability (to urban development, population growth etc)	Qualitative description
• Complexity of construction	Qualitative description
• Need of large scale infrastructure	Qualitative description
O&M	
• System robustness: risk of failure, effect of failure	Qualitative description
• Robustness to use of system: shock loads, effects of abuse of system	Qualitative description
• Availability of spare parts, parts for maintenance, etc.	Qualitative description
• Possibility to use local competence for O&M	Qualitative description
• Ease of system monitoring	Qualitative description
• Need of large scale infrastructure for operation	Qualitative description
• Complexity of O&M	Qualitative description
Economical and Financial Issues	

The economical and financial issues are related to the capacity of the communities to pay for the sanitation service, including both the construction of the facilities and maintenance of the system. This set of criteria also includes the economic benefits that could be obtained through the application of a sanitation system, including employment creation and enterprise possibility. For details refer to section A.4.

Criteria	Indicator
Construction	
• Input of own resources and labour in construction	Hours and quantities/pe
• Initial costs/ construction costs, total and annual costs	Costs/pe and cost/pe/yr
Operation and Maintenance	
• Annual costs for operation and maintenance	Cost/pe/yr
• Input of own resources and labour in operation and maintenance	Hours and quantities/pe/yr
Local economy	
• Employment creation	Number
• Business and income generation, enterprise possibility	Qualitative or quantitative
• Benefits from reuse	Generated income/pe/yr or increased production in kind/pe/yr
• Environmental and health costs	Cost/pe/yr or qualitative

Social, cultural and gender aspects

The social, cultural aspects and gender aspects refer to “soft criteria”, which are of utmost importance but difficult to evaluate. The criteria in this category shall evaluate the acceptance and appropriateness of the system, legal and institutional requirements, convenience, system perception and gender issues. For details refer to section A.5.

Criteria		Indicator
• Acceptance by the users/social acceptability		Qualitative evaluation
• Willingness to contribute through work and or money for sanitation services (% of available income)		Qualitative evaluation
• Convenience	- comfort	Qualitative evaluation
	- personal security	Qualitative evaluation
	- privacy/dignity	Qualitative evaluation
	- smell	Qualitative evaluation
	- noise	Qualitative evaluation
	- attractiveness/ status	Qualitative evaluation
	- adaptability to needs of different age and handicapped, gender and income groups	Qualitative evaluation
	- location and availability	Qualitative evaluation
• Current and foreseen legal acceptability and institutional compatibility		Qualitative evaluation
• Appropriateness to current local cultural context (acceptable to use and maintain)		Qualitative evaluation
• System perception (complexity, compatibility, observability – including aspects of reuse)		Qualitative evaluation
• Ability to address awareness and information needs		Qualitative evaluation
• Positive/negative impact to women, children and elderly.		Qualitative evaluation

7. METHODOLOGY OF APPLICATION OF THE PROPOSED CRITERIA

7.1 The Household-centred environmental sanitation approach

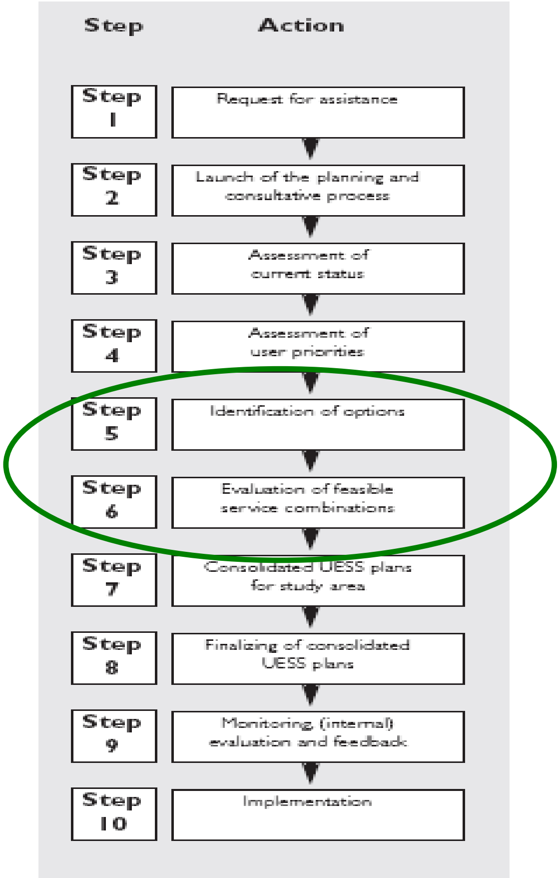

Fig 2: *The 10 step process of the HCES approach (Eawag, 2005)*

The evaluation of sanitation systems shall not be seen as an isolated tool, it is more part of a participatory planning and decision making process. Several relevant planning approaches were developed and/or adapted during the last years, like the "Household-centred environmental sanitation (HCES) approach" (Eawag, 2005), the "Open planning of sanitation systems approach" (EcoSanRes, 2004) and the "Ecosan project steps" (GTZ, 2003).

The open planning approach as well as the Ecosan project steps are both based on the HCES approach (Fig 2), thus for the purpose of the NETSSAF project it was decided to integrate the evaluation of sanitation systems into the HCES approach.

The "Household-centred environmental sanitation" model is strongly based on the Bellagio principles. Within the HCES the principle of subsidiarity shall be emphasised. Accordingly any activity of any unit of the society shall be subsidiary in itself, drawing functions only to a higher level when the capacities of the lower level are insufficient (and can not reasonably be improved, supported, etc.) to fulfil these functions.

The HCES uses consequently the concept of zones, avoiding that problems are "exported" downstream by solving the problems as close to the source by establishing a series of zones. Problems are only exported from one zone to the next larger zone if they cannot be solved in the first zone.

In particular Step 5, Identification of options and Step 6, Evaluation of feasible service combinations, of the HCES approach are in accordance with WP 1, 2 and 3 of the NETSSAF project. Step 5 includes the elaboration and description of adequate sanitation solutions, considering a wide rang of conventional as well as innovative sanitation technologies and concepts. Step 6 involves the participatory evaluation of the options identified in step 5, with respect to technical, economic, social, institutional, public health and other relevant aspects.

7.2 Evaluation of sanitation systems

As a following step in the NETSSAF project, in work package 3, the existing sanitation systems will be schematised and classified as conventional and innovative sanitation systems, for the future evaluation of its suitability for the large scale implementation in rural and peri-urban areas of West Africa.

In order to characterize a sanitation system, a clear description of the technologies involved together with a definition of the sequence or scheme will be necessary. Following, the set of criteria described in chapter 6 will form the basis for system evaluation.

Based on information available in literature as well as data from field studies of members of NETSSAF, a value will be given to each indicator related to a qualitative assessment. In this sense, data such as land required, employment creation, cost, etc, will be given.

In the case of criteria associated to qualitative assessment, it will depend on the planners and stakeholders to decide a range for the evaluation, based for instance, on framework conditions. However, in the Appendix section, there is a proposed methodology of evaluation for each case, which could serve as a guide for the actual planners.

8. RELATIONSHIP BETWEEN THE IDENTIFIED CRITERIA FOR EVALUATION OF SANITATION SYSTEMS AND THE CRITERIA FOR CLASSIFICATION OF THE SETTLEMENTS.

When evaluating a sanitation system, one has to take into consideration the characteristics of the settlement. This is crucial to determine whether a certain kind of sanitation system is feasible in the first place, and whether it will be sustainable in the long term. Therefore, the settlements as defined in *"D03: Criteria of evaluation of rural and peri-urban settlements in West Africa*" (refer to tables 2 and 3), will be used to evaluate the most relevant criteria for each of the six rural and peri-urban settlement types.

It is clear that a thorough evaluation of all assessment criteria for sanitation technologies remains to be done for each specific project that is going to be launched. Additionally, there are certain peculiarities that differ from village to village; such as soil/ground water characteristics, existing infrastructure in water and energy, institutional settings and characteristics in the particular location, or the fact whether a public toilet or individual systems are built. Still, the following to sub-chapters (8.1 and 8.2) shall give an overview of the most important or crucial assessment criteria for typical rural or peri-urban areas in West Africa.

Each of the tables that will be presented as follow gives a short overview of the most important assessment criteria for the respective settlement types. This has been conceived by combining the settlement tables from D03 (tables 3 and 6), with the assessment criteria listed above in this document (table 1). The assessment criteria were rated accordingly from "highly relevant" (bold) to "low relevance".

8.1 Important Assessment Criteria for Sanitation Systems in Rural Settlement Types

The table below shows the characteristics of rural settlement types as described in *D03: Criteria of evaluation of rural and peri-urban settlements in West Africa.* Following is the combination of the types of rural settlement types with the assessment criteria for sanitation technologies/systems described further above in this document.

Table 2- *Rural Settlement Types*

Criterion	**Characteristics of settlement types**					
	One	**Two**	**Three**	**Four**	**Five**	**Six**
Environment	**Dry**	Dry	Dry	Dry	**Humid**	Humid
Settlement Pattern	**Dispersed**	Dispersed	**Nucleated**	Nucleated	Nucleated	Nucleated
Population Density	**Low**	Low	**High**	High	High	High
Religion	**Christian**	**Muslim**	**Christian**	**Muslim**	**Christian**	**Muslim**
Wealth Status	**Poor**	Poor	Poor	Poor	Poor	Poor
Agriculture	**Compound farming**	Compound farming	**Bush farming**	Bush farming	**Distant farming**	Distant farming

Table 3 - *Assessment criteria for rural settlements type one and two*

Rural Settlement Type One and Two (dry environment, dispersed settlement pattern, low population density, Christians (type one) or Muslims (type two), poor wealth status, compound farming[1])		
Health issues	*Exposure to pathogens:*	**Highly relevant**: Health issues should always be considered a relevant assessment criterion for sanitation systems. The risk for disease transmission is generally limited to one family compound, as it is a dispersed settlement type, where not centralized sanitation facilities can be built. The practice of compound agriculture requires the input of fertilizer (see footnote). If faeces and urine are used for food production for humans, close to the living areas, it *is absolutely crucial* that the sanitized excreta are absolutely hygienic. Perception of physical cleanliness is especially important in *Muslim communities*, which tent to view everything related to human excreta as impure.
	Health benefits:	**Highly relevant**: Health status due to food production and nutritional status could be greatly increased if faeces and urine are recycled as fertilizer.
Impact to Environment/ Nature	*Use of natural resources:*	Land: Resources depend on the size of the compound and the ownership criteria of the land outside the compound. Energy: Relevant: There will be most likely no permanent energy supply (electricity), which means that a system should work without input of electrical energy. Construction Materials: **Highly relevant**. Only local resources available. Due to poor wealth status, only limited amount of money available for construction. Use of fresh water: **Highly relevant**. Any system that uses large amounts of freshwater will fail.
	Emissions to the environment:	Discharge to surface water: Low relevance. Depending on existence of surface water. However, as it is unlikely that water will be used for a sanitation system in this settlement type, the discharge to surface water is unlikely. Discharge to ground water: Relevant. As this settlement type is located in a dry climate, most drinking water will come from groundwater. It is crucial that this groundwater stays clean. Emissions to the air: Low relevance, as this is a low density, dispersed settlement type and the amount of recyclates and therefore also the discharge to the air is generally low.
	Resources recovered:	**Highly relevant**, as fertilizing resources are badly needed in compound farming.
	Accumulation of environmental burden in landfill	-- Not relevant (Landfills unlikely in individual use)
Technical Characteristics	*Construction*	**Highly relevant:** As in this settlement, family-operated individual solutions will be the most frequent options, the systems have to be robust, and easy to build, so that local competence can be used (poor wealth status).
	O & M	**Highly relevant:** Most systems will be operated by the families themselves – no technical support is usually available. Therefore, they must be easy to maintain, robust to shock loads and spare parts must be locally available. If a system is designed for *Muslim communities*, it

[1] Compound farming: Compound fields are located around the houses. Nutrients are recycled in form household wastes and ashes. Thus nutrients are extracted from the larger bush fields and applied on the smaller compound field, in the form of wastes.

		is very important that there is no direct contact with faeces, and that the steps undertaken to sanitize the excreta are perceived to be sufficient.
Economical and financial issues	*Construction*	Relevant: Construction costs must be very low in terms of what has to be bought from outside – input of own resources and labour depends on the willingness of the end users.
	O & M[2]	Relevant: Cost must be low, input of own resources and labour depends on the willingness of the end users.
	Local economy	Ambivalent. Could be important if individual sanitation systems can be built locally by a service provider at a low cost. However, if the economic situation does not allow for anything else than the own construction of sanitation systems, this criterion is not very relevant. Local economy is rather unlikely to be important in terms of operation, due to dispersed settlement type.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse of faeces is generally higher in Christian communities than in (e.g.) Muslim communities – which means that awareness raising and information is extremely crucial.
	Willingness to contribute:	**Highly relevant:** Due to the poor wealth status, willingness to contribute through work is probably crucial (affordability). Moreover, if the recycled excreta are used in compound farming, the proper use and application in individual action is essential for the success of the project.
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Low relevance, as in dispersed settlements with a low population density, legal requirements are usually not very high. However, in *Muslim communities*, it is highly relevant that the required religious norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Christian communities generally tend to be more open towards recycling and reuse systems than Muslim communities.
	System perception:	**Highly relevant:** As the users will also be the operators of the system, it is highly relevant that the system is perceived as easy to maintain and safe (i.e. can be operated without help). Especially for Muslims, it is important that the system is perceived to sufficiently sanitize the excreta so that they are no longer regarded as excreta, and thus no longer impure.
	Ability to address awareness needs	Low relevance: Due to dispersed settlement types, not very important.
	+/- impact on women, children and elderly	Relevant: It is important that the systems is accepted and has a positive impact on *women* especially, as they will most likely be responsible for the maintenance of the family owned system. If there is no positive impact, incentives for proper maintenance will be low. *Elderly:* Positive impact relevant, as they are often those that make the decisions. *Children*: Positive impact important, as they will be future decision makers.

[2] Operation and Maintenance

Table 4 - *Assessment criteria for rural settlements type three and four*

Rural Settlement Type Three and Four **(dry environment, nucleated settlement pattern, high population density, Christians (type three) or Muslims (type four), poor wealth status, bush farming[3])**		
Health issues	*Exposure to pathogens:*	Relevant: Health issues should always be considered a highly relevant assessment criterion for sanitation systems. Risk for disease transmission is higher due to high population density and nucleated settlement pattern. If faeces and urine are used for food production for humans, close to the living areas, it *is absolutely crucial* that the sanitized excreta are 100% hygienic. Perception of physical cleanliness is especially important in *Muslim communities*, which tent to view everything related to human excreta as impure.
	Health benefits:	Medium relevance: Health status due to food production and nutritional status could be increased if faeces and urine are recycled as fertilizer. However, options have to be found how fertilizers can be brought to the fields – otherwise they have to be used in household gardens, if available.
Impact to Environment/ Nature	*Use of natural resources:*	Land: **Highly relevant**: Large amounts of land will most likely only be available outside of the village; inside it will be very limited. Energy: Relevant: It is likely that there are no permanent power lines. It is likely that the system will have to survive power failures and blackouts and should therefore most likely be independent of foreign power sources. Construction Materials: Relevant. Due to poor wealth status, only limited amount of money available for construction. Use of fresh water: **Highly relevant**. Any system that uses large amounts of freshwater will fail.
	Emissions to the environment:	Discharge to surface water: **Highly relevant if** water is used for the sanitation system (treatment and discharge!) Discharge to ground water: **Highly relevant**. As this settlement type is located in a dry climate, most drinking water will come from groundwater. It is crucial that this groundwater stays clean. Emissions to the air: Relevant: Depends on the size and type of the chosen sanitation system. However, as a public system is likely (poor wealth status, high population density), emissions to the air must be considered important if there is a common treatment plant (i.e. biogas plant).
	Resources recovered:	**Ambivalent:** Relevance depends on whether the recovered resources can be used locally as fertilizers. If they cannot, i.e. if the fields are located to far away, this criterion has only a low relevance, as resources can then only be used in a limited way (i.e. household gardens with a limited size only).
	Accumulation of environmental burden in landfill	-- Low relevance (Landfills unlikely in this type of settlement)

[3] Bush fields are usually located away from the homesteads. The distance from the compound to the bush farm can vary – from one to several kilometres. The distance from the compound to the field has a strong influence on the farming activities. If the field is far away, soil tillage, the application of fertilizer, manure or pesticides become more tedious or it is not practicable because all the inputs have to be carried on the head or transported by bicycle to the field.

Technical Characteristics	*Construction*	**Highly relevant**: The high population density and poor wealth status make a public toilet a feasible solution. Thus, it has to be built designed in a very robust way, if possible with the help of local competence. Moreover, a system for this settlement type should be easily adaptable to urban development or population growth, and should not need a large scale infrastructure (cost!).
	O & M	**Highly relevant:** System should be easy to maintain, robust to shock loads and spare parts must be locally available, as highly technical systems require the availability of a skilled staff (cost!). It should be possible to use local competence for the O & M of the system. If a system is designed for *Muslim communities*, it is very important that there is no direct contact with faeces, and that the steps undertaken to sanitize the excreta are perceived to be sufficient.
Economical and financial issues	*Construction*	Relevant: Construction costs must be very low in terms of what has to be bought from outside – input of own resources and labour depends on the willingness of the end users.
	O & M	Relevant: Cost must be low, input of own resources and labour depends on the willingness of the end users.
	Local economy	**Highly relevant**: Sanitation systems could be built, implemented and maintained locally by a service provider at a low cost.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse of faeces is generally higher in Christian communities than in (e.g.) Muslim communities – which means that awareness raising and information is extremely crucial.
	Willingness to contribute:	**Highly relevant:** Due to the poor wealth status, willingness to contribute through work, in construction and O&M is probably crucial (affordability).
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Relevant: The sanitation system has to be in accordance with existing rules and regulations. However, in *Muslim communities*, it is **highly relevant** that the required religious norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Christian communities generally tend to be more open towards recycling and reuse systems than Muslim communities.
	System perception:	**Highly relevant:** As the users will also be the operators of the system, it is highly relevant that the system is perceived as easy to maintain and safe (i.e. can be operated without help). Especially for Muslims, it is important that the system is perceived to sufficiently sanitize the excreta so that they are no longer regarded as excreta, and thus no longer impure.
	Ability to address awareness needs	**Highly relevant**: New types of toilet can have an exemplary character for other potential users in the village.
	+/- impact on women, children and elderly	Relevant: Positive impact on *elderly* important, as they are often those who make the decision and can best influence others. *Women*: mostly responsible for O&M of household based systems – thus important that it has a positive impact on them, as they will not support the system otherwise. *Children*: Positive impact important, as they will be future decision makers.

Table 5 - *Assessment criteria for rural settlements type five and six*

Rural Settlement Type Five and Six **(humid environment, nucleated settlement pattern, high population density, Christians (type five) or Muslims (type six), poor wealth status, distant farming[4])**		
Health issues	*Exposure to pathogens:*	Relevant: Health issues should always be considered a highly relevant assessment criterion for sanitation systems. Risk for disease transmission is higher due to high population density and nucleated settlement pattern. If faeces and urine are used for food production for humans, close to the living areas, it *is absolutely crucial* that the sanitized excreta are 100% hygienic. Perception of physical cleanliness is especially important in *Muslim communities*, which tent to view everything related to human excreta as impure.
	Health benefits:	Medium relevance: Health status due to food production and nutritional status could be increased if faeces and urine are recycled as fertilizer. However, options have to be found how fertilizers can be brought to the fields – otherwise they have to be used in household gardens, if available.
Impact to Environment/ Nature	*Use of natural resources:*	Land: **Highly relevant**: Large amounts of land will most likely only be available outside of the village; inside it will be very limited. Energy: Relevant: It is likely that there are no permanent power lines. It is likely that the system will have to survive power failures and blackouts and should therefore most likely be independent of foreign power sources. Construction Materials: Relevant. Due to poor wealth status, only limited amount of money available for construction. Use of fresh water: Medium relevance: Freshwater should be available in a humid climate. However, it must be checked carefully whether water potentially used for sanitation systems is not taken away from other, more important uses. Additionally, it is very important, that, *if* water is used, there is no pollution to other water sources.
	Emissions to the environment:	Discharge to surface water: **Highly relevant if** water is used for the sanitation system (treatment and discharge!) Discharge to ground water: **Highly relevant.** Seepage is more likely to occur in humid climates especially during rainy seasons – therefore containers for excreta must be leak-proof. Extremely important if groundwater is at the same time used as a drinking water source. Emissions to the air: Relevant: Depends on the size and type of the chosen sanitation system. However, as a public system is likely (poor wealth status, high population density), discharge needs to the air needs to be considered (especially if there is a common treatment system, as e.g. a biogas plant).
	Resources recovered:	Low relevance: Relevance depends on whether the recovered resources can be used locally as fertilizers. As this is not very likely in distant farming, only limited reuse in household gardens (limited size) is possible
	Accumulation of environmental burden in landfill	Medium relevance: If landfills are constructed (in case there is really NO way how to reuse the recyclates). Landfills in humid climates carry a high risk of leaching which has to be considered.

[4] Distant farming includes fields that are usually located quite far away from homes. In some cases, the location of the fields can vary throughout the course of the year, depending on weather, climate and water availability.

Technical Characteristics	*Construction*	**Highly relevant**: The high population density and poor wealth status make a public toilet a feasible solution. Thus, it has to be built designed in a very robust way, if possible with the help of local competence. Moreover, a system for this settlement type should be easily adaptable to urban development or population growth, and should not need a large scale infrastructure (cost!). In a humid climate, potential flooding or torrential rains must also be considered in the construction
	O & M	**Highly relevant:** System should be easy to maintain, robust to shock loads and spare parts must be locally available, as highly technical systems require the availability of a skilled staff (cost!). It should be possible to use local competence for the O & M of the system. It is important that the system can also be operated and maintained easily during potential rain seasons If a system is designed for *Muslim communities*, it is very important that there is no direct contact with faeces, and that the steps undertaken to sanitize the excreta are perceived to be sufficient.
Economical and financial issues	*Construction*	Relevant: Construction costs must be very low in terms of what has to be bought from outside – input of own resources and labour depends on the willingness of the end users.
	O & M	Relevant: Cost must be low, input of own resources and labour depends on the willingness of the end users.
	Local economy	**Highly relevant**: Sanitation systems could be built, implemented and maintained locally by a service provider at a low cost.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse of faeces is generally higher in Christian communities than in (e.g.) Muslim communities – which means that awareness raising and information is extremely crucial.
	Willingness to contribute:	**Highly relevant:** Due to the poor wealth status, willingness to contribute through work in the construction, O & M is probably crucial.
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Relevant: The sanitation system has to be in accordance with existing rules and regulations. However, in *Muslim communities*, it is **highly relevant** that the required religious norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Christian communities generally tend to be more open towards recycling and reuse systems than Muslim communities.
	System perception:	**Highly relevant:** As the users will also be the operators of the system, it is highly relevant that the system is perceived as easy to maintain and safe (i.e. can be operated without help). Maintainability must also be guaranteed in humid seasons. Especially for Muslims, it is important that the system is perceived to sufficiently sanitize the excreta so that they are no longer regarded as excreta, and thus no longer impure.
	Ability to address awareness needs	**Highly relevant**: New types of toilet can have an exemplary character for other potential users in the village.
	+/- impact on women, children and elderly	Relevant: Positive impact on *elderly* important, as they are often those who make the decision and can best influence others. *Women*: mostly responsible for O&M of household based systems – thus important that it has a positive impact on them, as they will not support the system otherwise. *Children*: Positive impact important, as they will be future decision makers.

8.2 Important Assessment Criteria for Sanitation Systems in Peri-Urban Settlement Types

The table below shows the characteristics of peri-urban settlement types as described in *D03: Criteria of evaluation of rural and peri-urban settlements in West Africa.* Following is the combination of the types of peri-urban settlement types with the assessment criteria for sanitation technologies/systems described further above in this document.

Table 6: *Peri-urban Settlement Types*

Criterion	**Characteristics of settlement types**					
	One	**Two**	**Three**	**Four**	**Five**	**Six**
Environment	**Dry**	Dry	**Humid**	Humid	**Dry**	**Humid**
Settlement Pattern	**Nucleated**	Nucleated	Nucleated	Nucleated	Nucleated	Nucleated
Population Density	**High**	High	High	High	High	High
Religion	**Muslim**	**Christian**	**Muslim**	Christian	Muslim/Christian	Muslim/Christian
Wealth Status	**Poor**	Poor	Poor	Poor	**Rich**	Rich
Agriculture	**Market gardening**	Market gardening	Market gardening	Market gardening	**Backyard gardening**	Backyard gardening

Table 7 - *Assessment criteria for peri-urban settlements type one and two*

Peri-Urban Settlement Type One and Two **(dry environment, nucleated settlement pattern, high population density, Christians (type one) or Muslims (type two), poor wealth status, market gardening[5])**		
Health issues	*Exposure to pathogens:*	**Highly relevant:** Health issues should always be considered a highly relevant assessment criterion for sanitation systems. Risk for disease transmission high due to high population density and nucleated settlement pattern. Both faeces and urine will be used for food production for humans, close to the living areas. It is thus *absolutely crucial* that the sanitized excreta are 100% hygienic. *Muslim communities* tent to view everything related to human excreta as impure. Here, it is highly important that steps taken to sanitize the excreta render a product that can be regarded as valuable by Muslims as well as Christians.
	Health benefits:	**Highly relevant:** Health status due to food production and nutritional status can be increased greatly if faeces and urine are recycled properly as fertilizer. Food benefits do not only result from the consumption of the own produce (which tends to be fresher and usually contains more nutrients than market produce, as there are no losses due to storage), but also from the fact that families yield a higher income and can buy more or better food.
Impact to Environment/ Nature	*Use of natural resources:*	Land: **Highly relevant**: Large amounts of land will most likely only be available outside of the village; inside it will be very limited. Intelligent solutions for in-compound gardening (pots, wall- and roof-planting) have to be found. Energy: Relevant: Though electricity will probably be available in peri-urban areas, t is likely that the system will have to survive power failures and blackouts and should therefore most likely be independent

[5] Food is both grown inside of the compounds (urban farming) for own purposes and for generating additional income by selling it on the market.

		of foreign power sources. Construction Materials: Relevant. Due to poor wealth status, there is only a limited amount of money available for construction. Use of fresh water: **Highly relevant:** As this project is located in a dry climate, freshwater use for sanitation should be kept to an absolute minimum, otherwise the project will fail.
	Emissions to the environment:	Discharge to surface water: Depending on the existence of surface waters. Relevant only if water is used for the sanitation system (treatment and discharge!) – however, we are in a dry climate, a flush system seems very unlikely. Discharge to ground water: **Highly relevant**. As this settlement type is located in a dry climate, most drinking water will come from groundwater. It is crucial that this groundwater stays clean. Emissions to the air: Relevant: Depends on the size and type of the chosen sanitation system. However, as a public system is likely (poor wealth status, high population density), discharge to the air needs to be considered; especially if there is a common treatment plant (i.e. biogas plant).
	Resources recovered:	**Highly Relevant**: The yield of a good, high-quality, sanitized fertilizer is crucial for this kind of project, as the sanitized excreta are used for food production for human consumption. It could also be that compost is sold to other users, and the quality and amount of the recovered resources is thus crucial.
	Accumulation of environmental burden in landfill	Low relevance: As the sanitized excreta will be used in urban agriculture, a landfill is not likely.
Technical Characteristics	*Construction*	**Highly relevant**: For this type of settlement (high density, peri-urban, poor), it is highly relevant to build a simple and robust toilet that can be built with the help of local competence and does not require fancy parts. Moreover, a system for this settlement type should be easily adaptable to urban development or population growth (if public), and should not need a large scale infrastructure (cost!).
	O & M	**Highly relevant:** System should be easy to maintain, robust to shock loads and spare parts must be locally available, as highly technical systems require the availability of a skilled staff (cost!). It should be possible to use local competence for the O & M of the system. If a system is designed for *Muslim communities*, it is very important that there is no direct contact with faeces, and that the steps undertaken to sanitize the excreta are perceived to be sufficient.
Economical and financial issues	*Construction*	Relevant: Construction costs must be very low in terms of what has to be bought from outside – input of own resources and labour depends on the willingness of the end users.
	O & M	Relevant: Cost must be low, input of own resources and labour depends on the willingness of the end users.
	Local economy	**Highly relevant**: Sanitation systems could be built, implemented and maintained locally by a service provider at a low cost. The creation of jobs/income in the subsequent fields of composting, gardening and selling of produce must also be considered very important.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse of faeces is generally higher in Christian communities than in (e.g.) Muslim communities – which means that awareness raising and information is extremely crucial.
	Willingness to	**Highly relevant:** Due to the poor wealth status, willingness to

	contribute:	contribute through work is probably crucial (affordability). Moreover, if the recycled excreta are used in urban farming, the proper use and application in individual action is crucial.
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Relevant: The sanitation system has to be in accordance with existing rules and regulations. However, in *Muslim communities*, it is **highly relevant** that the required religious norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Christian communities generally tend to be more open towards recycling and reuse systems than Muslim communities. Especially if it is planned to reuse the sanitised excreta in urban farming, awareness raising is highly relevant among Muslim communities.
	System perception:	**Highly relevant:** If the users will also be the operators of the system, it is highly relevant that the system is perceived as easy to maintain and safe (i.e. can be operated without help). Especially for Muslims, it is important that the system is perceived to sufficiently sanitize the excreta so that they are no longer regarded as excreta, and thus no longer impure.
	Ability to address awareness needs	**Highly relevant**: New types of toilet can have an exemplary character for other potential users in town.
	+/- impact on women, children and elderly	Relevant: Positive impact on *elderly* important, as they are often those who make the decision and can best influence others. *Women*: mostly responsible for O&M of household based systems – thus important that it has a positive impact on them, as they will not support the system otherwise. *Children*: Positive impact important, as they will be future decision makers.

Table 8 - *Assessment criteria for peri-urban settlements type three and four*

Peri-Urban Settlement Type Three and Four **(Humid environment, nucleated settlement pattern, high population density, Christians (type three) or Muslims (type four), poor wealth status, market gardening[6])**		
Health issues	*Exposure to pathogens:*	**Highly relevant:** Health issues should always be considered a highly relevant assessment criterion for sanitation systems. Risk for disease transmission high due to high population density and nucleated settlement pattern. Both faeces and urine will be used for food production for humans, close to the living areas. It is thus *absolutely crucial* that the sanitized excreta are 100% hygienic. *Muslim communities* tent to view everything related to human excreta as impure. Here, it is highly important that steps taken to sanitize the excreta render a product that can be regarded as valuable by Muslims as well as Christians.

[6] Food is both grown inside of the compounds (urban farming) for own purposes and for generating additional income by selling it on the market.

	Health benefits:	**Highly relevant:** Health status due to food production and nutritional status can be increased greatly if faeces and urine are recycled properly as fertilizer. Food benefits do not only result from the consumption of the own produce (which tends to be fresher and usually contains more nutrients than market produce, as there are no losses due to storage), but also from the fact that families yield a higher income and can buy more or better food.
Impact to Environment/ Nature	*Use of natural resources:*	Land: **Highly relevant**: Large amounts of land will most likely only be available outside of the village; inside it will be very limited. Intelligent solutions for in-compound gardening (pots, wall- and roof-planting) have to be found. Energy: Relevant: Though electricity will probably be available in peri-urban areas, t is likely that the system will have to survive power failures and blackouts and should therefore most likely be independent of foreign power sources. Construction Materials: Relevant. Due to poor wealth status, there is only a limited amount of money available for construction. Use of fresh water: Medium relevance: Freshwater should be available in a humid climate. However, it must be checked carefully whether water potentially used for sanitation systems is not taken away from other, more important uses. Additionally, it is very important, that, *if* water is used, there is no pollution to other water sources.
	Emissions to the environment:	Discharge to surface water: **Highly relevant if** water is used for the sanitation system (treatment and discharge!) Discharge to ground water: **Highly relevant.** Seepage is more likely to occur in humid climates, especially during the rainy season – therefore containers for excreta must be leak-proof. Extremely important if groundwater is at the same time used as a drinking water source. Emissions to the air: Relevant: Depends on the size and type of the chosen sanitation system. However, as a public system is likely (poor wealth status, high population density), discharge to the air needs to be considered; especially if there is a common treatment plant (i.e. biogas plant).
	Resources recovered:	**Highly Relevant**: The yield of a good, high-quality, sanitized fertilizer is crucial for this kind of project, as the sanitized excreta are used for food production for human consumption. It could also be that compost is sold to other users, and the quality and amount of the recovered resources is thus crucial.
	Accumulation of environmental burden in landfill	Low relevance: As the sanitized excreta will be used in urban agriculture, a landfill is not likely.
Technical Characteristics	*Construction*	**Highly relevant**: For this type of settlement (high density, peri-urban, poor), it is highly relevant to build a simple and robust toilet that can be built with the help of local competence and does not require fancy parts. Moreover, a system for this settlement type should be easily adaptable to urban development or population growth (if public), and should not need a large scale infrastructure (cost!). In a humid climate, potential flooding or torrential rains must also be considered in the construction planning.
	O & M	**Highly relevant:** System should be easy to maintain, robust to shock loads and spare parts must be locally available, as highly technical systems require the availability of a skilled staff (cost!). It should be possible to use local competence for the O & M of the system. It is important that the system can also be operated and maintained easily during potential rain seasons. If a system is designed for *Muslim*

		communities, it is very important that there is no direct contact with faeces, and that the steps undertaken to sanitize the excreta are perceived to be sufficient.
Economical and financial issues	*Construction*	Relevant: Construction costs must be very low in terms of what has to be bought from outside – input of own resources and labour depends on the willingness of the end users.
	O & M	Relevant: Cost must be low, input of own resources and labour depends on the willingness of the end users.
	Local economy	**Highly relevant**: Sanitation systems could be built, implemented and maintained locally by a service provider at a low cost. The creation of jobs/income in the subsequent fields of composting, gardening and selling of produce must also be considered very important.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse of faeces is generally higher in Christian communities than in (e.g.) Muslim communities – which means that awareness raising and information, especially among Muslims, is extremely crucial.
	Willingness to contribute:	**Highly relevant:** Due to the poor wealth status, willingness to contribute through work is probably crucial (affordability). Moreover, if the recycled excreta are used in urban farming, the proper use and application in individual action is essential for the success of the project.
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Relevant: The sanitation system has to be in accordance with existing rules and regulations. In *Muslim communities*, it is **highly relevant** that the required norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Christian communities generally tend to be more open towards recycling and reuse systems than Muslim communities. Especially if it is planned to reuse the sanitised excreta in urban farming, awareness raising is highly relevant among Muslim communities.
	System perception:	**Highly relevant:** If the users will also be the operators of the system, it is highly relevant that the system is perceived as easy to maintain and safe (i.e. can be operated without help). Maintainability must also be guaranteed in humid seasons. Especially for *Muslims*, it is important that the system is perceived to sufficiently sanitize the excreta so that they are no longer regarded as excreta, and thus no longer impure.
	Ability to address awareness needs	**Highly relevant**: New types of toilet can have an exemplary character for other potential users in town.
	+/- impact on women, children and elderly	Relevant: Positive impact on *elderly* important, as they are often those who make the decision and can best influence others. *Women*: mostly responsible for O&M of household based systems – thus important that it has a positive impact on them, as they will not support the system otherwise. *Children*: Positive impact important, as they will be future decision makers.

Table 9 - *Assessment criteria for peri-urban settlements type five and six*

Peri-Urban Settlement Type Five and Six **(dry environment (type five), humid environment (type six), nucleated settlement pattern, high population density, Christians (type three) or Muslims (type four), rich wealth status, backyard gardening[7])**		
Health issues	*Exposure to pathogens:*	**Highly relevant:** Health issues should always be considered a highly relevant assessment criterion for sanitation systems. Risk for disease transmission high due to high population density and nucleated settlement pattern. If faeces and urine will be used for food production for humans, close to the living areas. It is thus *absolutely crucial* that the sanitized excreta are 100% hygienic. *Muslim communities* tent to view everything related to human excreta as impure. Here, it is highly important that steps taken to sanitize the excreta render a product that can be regarded as valuable by Muslims as well as Christians.
	Health benefits:	Medium relevance: As this project type is located in a rich neighbourhood, food security will not be greatly influenced through production of additional produce. Health benefits may include safer drinking water.
Impact to Environment/ Nature	*Use of natural resources:*	Land: Medium relevance: In rich environments, it is most likely that indoor toilets will be built, which does not greatly affect land use. Land use for treatment could be scarce, due to high population density and nucleated settlement pattern. Energy: Medium relevance: Electricity will most likely be available and could be used in the system. However, if it is used, a backup system is necessary to overcome possible power failures. Construction Materials: Medium relevance. As this project is located in a rich neighbourhood, construction materials should not be a problem. However, it is still important to consider that spare parts should be available. Use of fresh water: Relevant in *dry climates*: Though freshwater will most likely always be available in rich communities, it is crucial that this water is not taken away from other potential users. Medium relevance in *humid climates*: Freshwater should be available in a humid climate. However, it must be checked carefully whether water potentially used for sanitation systems is not taken away from other, more important uses. Additionally, it is very important, that, *if* water is used, there is no pollution to other water sources.
	Emissions to the environment:	Discharge to surface water: **Highly relevant both in *humid and dry climates* if** water is used for the sanitation system (treatment and discharge!) Discharge to ground water: **Highly relevant.** Seepage is more likely to occur in *humid climates*, especially during rainy seasons – therefore containers for excreta must be leak-proof. However, seepage must also be considered in *dry climates*. Extremely important if groundwater is at the same time used as a drinking water source. Emissions to the air: Medium relevance: Depends on the size and type of the chosen sanitation system. Here, mostly individual sanitation systems will be applied (rich wealth status) - emissions to the air must be considered important if there is a common treatment plant (i.e. biogas plant).

[7] Food is both grown inside of the compounds (urban farming) for own purposes and for generating additional income by selling it on the market.

	Resources recovered:	Medium relevance: As recovered resources will only be used for backyard gardening (if at all), the quality and amount of the recovered resources is only secondary in this type of project.
	Accumulation of environmental burden in landfill	Medium relevance: Depends whether there is a landfill, or whether recovered resources are used in own backyards or sold for urban agriculture.
Technical Characteristics	*Construction*	Medium relevance: As this project is located in a rich environment, construction features are secondary. The system should of course be robust and have a long lifetime, but in case of problems, service providers and professional maintainers can easily be hired.
	O & M	Medium relevance: O & M can be carried out by professional service providers (rich wealth status). Robustness of the system is more important in terms of treatment (i.e. biogas plant), than the individual toilets, as they will be used by a limited number of people only (family size). Spare parts can be imported.
Economy and finances	*Construction*	Low relevance: Construction costs are most likely not a crucial issue (rich wealth status). Prestige could be more important than costs.
	O & M	Low relevance: O &M costs are most likely not a crucial issue (rich wealth status). Prestige could be more important than costs.
	Local economy	Medium relevance: Construction, operation and maintenance could be done locally if sufficiently skilled and competent workers are available (possibly more technical system). Jobs could also be created in the subsequent treatment of the excreta or reuse in local urban agriculture.
Social, Cultural and Gender Aspects:	*Acceptance:*	**Highly relevant:** Any system that is not accepted will fail. Acceptance for reuse is maybe not crucial in this kind of project (backyard gardening, if at all). Reuse will more likely be done by others.
	Willingness to contribute:	Low relevance: Construction, O & M can all be done by professional service providers. The willingness to contribute is thus not very important.
	Convenience:	Relevant: Mostly depending on individual family preferences – can hardly be generalized for village types and needs to be assessed thoroughly for every project, i.e. with the help of family types.
	Legal acceptability:	Relevant: The sanitation system has to be in accordance with existing rules and regulations. In *Muslim communities*, it is **highly relevant** that the required norms and regulations are met.
	Appropriate-ness to current local cultural context	Relevant: Cultural context is highly influential on acceptance. However, the perception of appropriateness can be influenced by awareness raising and provision of information. Reuse is not a critical issue here, as it will most likely not always be done by the users of the systems themselves.
	System perception:	Medium relevance: The system must be perceived as important and sensible; otherwise people will chose another system. In *humid climates*, maintainability must also be guaranteed in humid seasons.
	Ability to address awareness needs	**Medium relevance**: New types of toilet can have an exemplary character for other potential users in town.
	+/- impact on women, children and elderly	Medium relevance: Impact will not differ substantially with different kinds of users.

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APPENDIX

A.1 Health risk associated with sanitation systems

Pathogenic Risk associated to human excreta

In most developing countries the principal risks to human health associated with the consumption of polluted water are microbiological in nature, in particular due to excreta-related diseases, spread through faeces which contain high concentration of pathogens –bacteria, viruses, protozoa and helminths (worms) causing gastro-intestinal (GI) infections in man (Strauss *et al*., 2003). As indicated in Chapter 18 of "Agenda 21" of UNCED, "An estimated 80% of all diseases and over one-third of death in developing countries are caused by the consumption of contaminated water and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases" (Wichmann and Bartsch, 2000).

One of the main goals of sustainable sanitation systems, when reuse is intended, is to capture nutrients present in the human excreta and recycle them back to agriculture, the heath risk related to excreted pathogens must be minimised in order to avoid the enhancement of disease transmission and an increase number of infections in human population that potentially can occur through urine and/or faeces.

Non-pathogenic health risks associated to human excreta

Another potential risk associated with the reuse of excreta is the presence of chemical compounds contained in medicines consumed by humans. There are opposing opinions regarding the extent of the danger posed by these substances when applied in the agricultural land. The most unenthusiastic consideration is made by Strauss (2000) who expresses that it is still unknown whether they are attenuated or accumulated in soil, and stresses the possibility of their introduction in the food chain through crops uptake. According to Strauss *et al*. (2003), the wide and indiscriminate use of antibiotics in urban societies of developing countries, and therefore their manifestation in urban waste streams may turn out to constitute a greater threat to health that those from excreted pathogens. They also mention another relevant chemical contaminants: hormone active substances (HAS) and heavy metals. HAS, also termed "endocrine disrupting chemicals" (EDC), are excreted due to the consumption of rest of pesticides and contraceptive medicines. The major concern related to heavy metals is their conservative nature, which allows them to accumulate in the environment, particularly so in waste-amended soils.

Jönsson *et al*. (2004), in a more optimistic approach, maintain that the contents of heavy metals and other contaminating substances such as pesticide residues are generally very low in human excreta, and therefore the risk posed by these chemicals is negligible compared with chemical fertilizers (e.g. cadmium) and farmyard manure (e.g. chromium and lead) (Table 2.6). Since urine contains only substances that have entered the metabolisms, the levels of heavy metals are very low, unlike faeces that consist mainly of non-metabolised material, carrying unaffected heavy metals through the intestine. Jönsson *et al.* (2004) state that the hormones produced by the human bodies and the pharmaceuticals present in urine pose only a low risk on the quantity and quality of crops. They suggest that the vegetation and soil microbes have been adapted during the course of evolution to be able to degrade the hormones excreted by mammals in terrestrial environments. Regarding pharmaceutical substance, they claim that most of these substances are derived from nature and therefore it is possible to degrade them with long retention times in the topsoil through microbiological activity. They also point out that in many countries the human consumption of pharmaceuticals is small compared to that by domestic animals, which are feed with antibiotic substances added as growth promoters. According to them, it is in any case better to recycle human excreta to arable land than to flush them into wastewater plants, in view of the fact that the retention time in such installations is too short for many pharmaceutical substances to degrade, leading to the discharge on recipient waters and the exposure of aquatic systems to mammal hormones in unusual large quantities.

Improvement of livelihood

The number of people living with less than $1 a day in Sub-Saharan Africa reaches today 313 million, representing 46.4% of the total population in 2001 in this area. Sub-Saharan African people are suffering from hunger and the proportion of malnourished people has remained in the range of

33-35% since 1970. However, the absolute number of malnourished people in Africa has increased substantially with population growth, from around 88 million in 1970 to an estimate of over 200 million in 1999-2001. In order to fight poverty and hunger there is a need to manage problems arising from the deterioration of the soil (Rosegrant, 2005). Furthermore, it has been recognised that the famine crisis of many African nations is based on the low accessibility to fertilizer and insufficient irrigation, making their food production inefficient and unreliable. However, worldwide prevails the misconception of the human excreta as waste with no useful purpose, idea that has led to the development of this kind of “flush and forget” sanitation solutions.

Human excreta represent though a potential source of nutrients for crops, which could be used as fertilizer in a short and large scale. Farmers around the world yearly requiring 135 Mio tons of mineral fertilizer for their agricultural activities, could make use of human excrete, which is currently being dumped through conventional sanitation in the form of 50 Mio tons of fertilizer equivalents with a market value of around 15 Billion US dollar (data from Werner, 2004).

After collected and pre-treated, hygienically stable human faeces could be treated aerobically with organic refuse, obtaining at the end a compost that can be regarded as an excellent K, S and P fertilizer, with a great organic matter stability, which improves the water holding and the buffering capacity of the soil (Jönsson *et al.,* 2004). On the other hand, 75-90% of the Nitrogen present in the human urine is excreted as urea, which is quickly degraded to ammonium in the presence of urease. Ammonium is directly plant-available and an excellent N fertilizer, which is verified by the fact that urea and ammonium are two of the most used N fertilizers in the world. The P and K in the urine is almost entirely (95-100%) inorganic and is excreted in the form of ions, which are directly plant-available and thus it is no surprise that their plant availability has been found to be at least as good as that of chemical (Jönsson *et al.,* 2004). The relationship between nitrogen, phosphorus, potassium and sulphur is well balanced and, with appropriate doses, broadly corresponds to the needs of cereal crops (Johansson *et al.,* 1997).

<u>Proposed methodology for “qualitative evaluation”</u>

Borrowing from the implementation framework of Katherine L. Clopeck *et al.* (2006), each factor or criterion is associated with one or more indicators, and for each indicator there is a scale of 1 to 5 (or simply put, five levels). Each level has a value or description associated with a very low/limited, low, moderate, high and very high score, to facilitate the assessor’s judgement.

Following, a proposed description for the rating 1-5 for the indicators of health issues is given:

- Exposure to pathogens and risk of infection related to all system elements including collection, transportation, treatment, reuse and final destination of products / wastes.

    - For communities of users and consumers

1: Very High (direct exposure to unsanitised waste)

2: High (possible contact even if safety barriers are taken).

3: Moderate (possible contact if no safety barriers are taken).

4: Low (possible contact under critical circumstances, e.g. natural disasters of great scale)

5: Very Low (no direct exposure to pathogens)

    - For operators of the sanitation system

1: Very High (direct contact with completely unsanitised waste streams. E.g. shovelling, piling)

2: High (direct contact with partially sanitised waste stream. E.g. composted/desiccated faeces)).

3: Moderate (indirect contact with waste streams by using machines).

4: Low (contact with sanitised wastes)

5: Very low (no direct contact with waste streams. E.g. complete automatic system)

- Health benefits due to food production, nutrition status, livelihood

1: Very Low (no reuse).

2: Low (some reuse of the nutrients and/or safe water, mainly low efficiency and for general vegetation of low value).

3: Moderate (some reuse of the nutrients and/or safe water, for food crops and other valuable vegetation) .

4: High (reuse of a large part of the nutrients leading to improvement of the nutrition and/or general living conditions).

5: Very High (integrated and optimal recovery of nutrients and energy in a sustainable and safe way and for edible and other high value crops, leading to an increase of the nutrition status due to better crops and/or better economy).

A.2 Environmental Impact of sanitation systems

In regions where a large proportion of the population is not served with adequate sanitation systems, sewage flows directly into groundwater reservoirs, lakes, streams, and rivers and eventually reaches coastal and marine ecosystems causing environmental problems. Unfortunately, this is often the case throughout Africa where the treatment of wastewater can be as little as 2 % in some countries, where the dumping of untreated sewage, has strongly contributed to the contamination of surface water and is threatening coastal and marine ecosystems (UN, 2001).

The inappropriate discharge of untreated sewage causes important environmental problems. As representative examples, the emissions of organic water pollutants in West Africa is over 120 ton BOD per day (only considering the data available for Burkina Faso, Cote d'Ivoire, Gambia, Ghana, Nigeria, Senegal and Sierra Leone which constitutes 80% of West Africa's population) (Worldbank, 2005), and the pollution from phosphates and sulphate rich materials, like human excreta, leads to nutrient enrichment or eutrophication of water bodies which can result in the blooming of aquatic weeds particularly water hyacinth (UN, 2001).

Therefore, the lacks of sanitation management systems pose a fundamental threat to the environment. On the other hand, the conventional sanitation approach (a linear one based on end-of-pipe solutions) has proved to deliver as well significant impacts to the environment, such as intensive energy consumption, loss of valuable nutrients and accumulation of environmental burden in landfills, among others.

If it is planned to implement a sustainable sanitation system – thus meaning a system with no long-term negative environmental effects, that provides with the needed services and protects the human health and the environment at the expense of minimum natural resources- a sustainable perspective should be also adopted from the very beginning. This includes efficient and cost effective focuses with regard to the use of natural resources- specially those that will become scarce in the future such as water, P- and should also consider ecological sanitation alternatives in order to optimise the recovery of valuable substances from the sewage- such as nutrients to be used in agriculture.

The evaluation of different sanitation systems from an environmental point of view requires an integrated approach that should take into consideration a multitude of variables that may have impact on natural environment, along with health issues,

As a previous step, it is important to define the system boundaries for a correct evaluation. In the NETSSAF project the system boundary will comprise the sanitation and the reuse system including: urine, faeces/brown water, grey water, solid waste (incl. Bio- and non biodegradable waste) and rainwater/storm water.

Proposed methodology

The proposed methodology for the evaluation of a particular sanitation scenario from the environmental point of view will be based upon the well-known Multi-Criteria Analysis (MCA). MCA is a decision-making tool developed for complex problems. In a situation where multiple criteria are involved confusion can arise if a logical, well-structured decision-making process is not followed.

Another difficulty in decision-making is that reaching a general consensus in a multidisciplinary team can be very difficult to achieve. By using MCA the members don't have to agree on the relative importance of the Criteria or the rankings of the alternatives. Each member enters his or her own judgements, and makes a distinct, identifiable contribution to a jointly reached conclusion. The use of this methodology in the assessment of different sanitation scenarios has been supported by several authors e.g. Hellström *et al*. (2000) and Balkema *et al*. (2001)

For the implementation of the MCA method for the environmental impact, a series of evaluation criteria and their associated indicators has been developed, as pointed out in section 6, table 1. The implementation of MCA requires that to each criterion and indicator a scale is given. For each indicator a rating of 1 - 5 has been chosen.

The following scale is proposed for the set related to environmental impact criteria under the categories *Use of natural resources – Construction and Operation and Maintenance; Emissions to the environment,* and *Accumulation of environmental burden in landfill*.

1: Very High (Very high environmental impact)

2: High (High environmental impact)

3: Moderate (Moderate environmental impact)

4: Low (Low environmental impact)

5: Very Low (No/ limited environmental impact)

In the case of *Resources recovered*, the scale is as follows:

1: Very Low (Very low resources recovery potential)

2: Low (Low resources recovery potential)

3: Moderate (Moderate resources recovery potential)

4: High (High resources recovery potential)

5: Very High (Very High resources recovery potential)

Following a description of the environmental criteria and the associated indicators is given.

1 Use of natural resources – Construction and O&M

1.1 Construction

- **Land**: land in m^2/per person equivalent needed for the complete system incl. service area, treatment area and related infrastructure.

- **Energy**: energy needed per person equivalent (MJ/pe/year) for the complete construction and installation process.

- **Construction materials**: type and quantity of materials use for the construction of the complete system incl. service area, treatment area and related infrastructure.

The possibility of using local available construction materials (based on principle "ecological footprint" incl. production, transport, handling and recycling/reuse of materials), for the construction will reduce the transport needs and the environmental impact of the system. It may also open market opportunities for local construction companies.

1.2 O&M

- **Land**: land in m^2/per person equivalent occupied by the complete system incl. service area, treatment area and related infrastructure.

- **Construction materials**: type and quantity of materials use for the O&M of the complete system incl. service area, treatment area and related infrastructure.

The land occupied by the system once it is running should be the same as the one calculate in the construction phase, as the construction materials. It can be that once the system is running, after some time new infrastructures are required. It can be the case in those areas in which the population grows or the sanitation system is serving more population than expected in the designed and construction phase.

- **<u>Energy from renewable resources and energy from non-renewable resources:</u>** energy needed per person equivalent and year (MJ/pe/year) for the complete operation process including treatment and reuse of residues (e.g. pumping, aeration, sludge dehydration and transport, etc.)

Energy consumption during the operation of a particular sanitation system is also a key aspect concerning its environmental sustainability, apart from playing a relevant role in its economic efficiency. The required energy has been divided into energy coming from renewable (hydroelectric, solar, wind, etc.) and non-renewable (coal, natural gas, oil and uranium) resources, as they obviously imply a different degree of sustainability. In some cases the distribution among both types of energy will depend solely on the energetic mix of a particular country or region; in others, the specific sanitation system under study will also have an influence on which types of energy are consumed.

- **<u>Total use of non-renewable resources:</u>** this parameter, expressed in "non-renewable resource units", 10^{-16}/pe/yr (see Fava et al., 1993 and Jönsson et al., 2004) reflects the fact that the operation of certain sanitation systems rely on the supply of energy from non-renewable resources, and that their functioning leads to the loss of nutrients (which are in turn released into the environment thus leading to eutrophication). In order to retain and improve productivity, these nutrients must be supplied back to agricultural fields by adding chemical fertilisers. However, use of chemical fertilisers is not sustainable, since their production relies on non-renewable resources such as mineral deposits and additional fossil energy. Moreover, some sanitation scenarios lead to further chemicals' consumption (e.g. some methods for the recovery of P require the use of S-containing sulphuric acid). Thus, under the concept of non-renewable resources plant nutrients N,P,K and S and non-renewable energy used both for fertilisers production and for plant operation and maintenance is included. With the aim of considering all these factors together, the concept of "non-renewable resource units" is used. This concept relies on the following equation proposed by Fava et al. (1993):

$$w = \frac{1}{RU}$$

Where w is the non-renewable resource index, R is the size of the reserve and U is the static reserve life, i.e. the size of the reserve divided by present consumption rate. By calculating the w index for each non-renewable resource (see table 10 below), and by using them together with life cycle inventory data on the production and use of different fertiliser products, it is possible to calculate the total non-renewable resources used by a specific Sanitation system or scenario, and to express it in the above-mentioned "non-renewable resource units".

Table 10- *Size of reserve, static reserve life and non-renewable resource index (w) for phosphorus (P), potassium (K), sulphur (S), natural gas, oil, coal and uranium (from Jönsson et al., 2004)*

	P[a]	**K**[a]	**S**[a]	**Gas**[b]	**Oil**[b]	**Coal**[b]	**Uranium**[a]
Size of reserve (R), 10^{12} kg	1.51	6.99	1.40	135 oile[c]	142	485 oile[c]	0.0027[c,d]
Consumption (C), 10^{9} kg/year	14.1	18.8	51.5	2181	3590	2137	0.032
Static reserve life (U), years	107	373	27	61	40	227	84
Index (w), 10^{-16} /kg, year	61.8	3.84	263	1.21	1.76	0.091	44092

a) Crowson (1996).

b) BP (www.bp.com).

c) Oile stands for oil equivalent.

d) Extraction losses, 5%, have been accounted for.

- **<u>Fresh water</u>**: the fresh water needed per person/year for operation of the system and related services (hand washing) plus transport, treatment and storage of residues.

As in the case of energy, the fresh water consumption for O&M should be one of the parameters to take into account when selecting a sanitation system. It is of high importance of those areas where there is problem with water scarcity.

The system to be selected should consume fresh water only in the case this is totally necessary. The use of treated water, in all the cases that will not lead in a public health problem, should be considered and will be an advantage of the system that allows it versus others, e.g. trucks could be washed with treated water if workers take the protection measures indicated.

- **Precipitation agents or other chemicals**: type and quantity of agents/chemicals used per person/year for operation of the system and related services (hand washing plus transport, treatment and storage of residues).

Some sanitation systems require the use of chemical at different steps of the process. For example, Phosphorus removal requires the use of chemicals such as ferrous or aluminium salts. Polyelectrolytes are also used for dehydrating the generated sludge. The sustainable sanitation approach demands the reduction or suppression on the consumption of these substances.

2 Emissions to the environment: Discharge to water bodies- surface and ground water

A sanitation system should be able to treat the sewage in a way that the discharges of the final effluent do not cause environmental problems. Maximum levels of potential pollutant should be defined in national legislations, if still they do not exist.

At European level, the Council Directive 2000/60/EC of 23 October 2000 establishes the framework for Community action in the field of water policy. This Directive sets an indicative list of the main pollutants (Annex VIII) for which water quality is measured, among which persistent hydrocarbons and persistent and bioaccumulable toxic substances; metals and their compounds; biocides and plant protection products; substances, which contribute to eutrophication (in particular, nitrates and phosphates); substances, which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.), can be found.

European legislation provides for measures against chemical pollution of surface water and ground water. There is currently a transitional period until the year 2013 from the "old" framework of Directive 76/464/EEC (which sets the list of dangerous substances) to the new Water Framework Directive. The EC adopted a proposal for a new Directive to protect groundwater from pollution on 19th September 2003 (COM(2003)550).

- **BOD / COD:** in g/pe/yr in the wastewater discharge or % of BOD/COD load removal.

The Biochemical Oxygen Demand (BOD) is defined by the European Environmental Agency (EEA) as the demand for oxygen resulting from organisms in water that consume oxidisable organic matter. This indicator illustrates the current situation and trends regarding BOD and concentrations of ammonium (NH4) in water.

The Chemical Oxygen Demand (COD) is defined by the European Environmental Agency (EEA) as the quantity of oxygen used in biological and non-biological oxidation of materials in water; it is normally used as a measure of water quality.

Both parameters reflect the demand for oxygen of the discharged effluent, and therefore to which degree it can hinder aquatic life through oxygen removal.

The Council Directive of 21 May 1991 concerning urban wastewater treatment governs at European level the collection, treatment and discharge of urban wastewater as well as aspects of treatment and discharge of biodegradable wastewater from certain industrial sectors. The Directive adopts the emission limit value approach and as such focuses on the end product of a certain process, which in this case is the quantity of pollutants present in wastewater that are allowed to be discharged to the receiving waters.

According to this Directive (91/271/EEC), the requirements for discharges from urban waste water treatment plants with regard to BOD and COD are presented in table11.

Table 11- *Requirements for discharges from urban waste water treatment plants as stated in the Directive 91/271/EEC.*

Parameters	Concentration	Minimum percentage of reduction (1)
Biochemical oxygen demand (BOD_5 at 20 ℃) without nitrification (2)	25 mg/l O_2	70-90 40 under Article 4 (2)(3)
Chemical oxygen demand (COD)	125 mg/l O_2	75

(1) Reduction in relation to the load of the influent

(2) The parameter can be replaced by another parameter: total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD5 and the substitute parameter.

(3) *Urban waste water discharges to waters situated in high mountain regions (over 1 500 m above sea level) where it is difficult to apply an effective biological treatment due to low temperatures may be subjected to treatment less stringent than that prescribed in paragraph 1, provided that detailed studies indicate that such discharges do not adversely affect the environment.*

Following European standards, the averages values of BOD and COD contribution to wastewaters by each person are:

- BDO_5: 60 mg/person/day- 21,9 g/pe/yr
- DQO: 85 mg/person/day- 31,02 g/pe/yr

As an example, for a population of 1000 persons the theoretical contribution to wastewater with regard to BOD and COD will be: 21,90 kg of BOD/year and 31,02 kg of COD/year.

- **Nutrients**: in g/pe/yr of N and P in the wastewater which is discharged to water bodies or the % of incoming nutrient load reduction.

According to the Commission Directive 98/15/EC, 'eutrophication' means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.

The Commission Directive 98/15/EC of 27 February 1998 amends the Council Directive 91/271/EEC with respect to the requirements establishing the limits for discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication. One or both parameters may be applied depending on the local situation.

Table 12-: Requirements for discharges from urban waste water treatment plants as stated in the Directive 98/15/EC.

Parameters	Concentration	Minimum percentage of reduction (1)
Total phosphorus	2 mg/l (10 100-100 000 p.e.) 1 mg/l (more than 100 000 p.e.)	80
Total nitrogen(2)	15 mg/l (10 000-100 000 p.e.) (3) 10 mg/l (more than 100 000 p.e.) (3)	70-80

(1) Reduction in relation to the load of the influent.

(2) Total nitrogen means the sum of total Kjeldahl nitrogen (organic and ammoniacal nitrogen), nitrate-nitrogen and nitrite-nitrogen.

(3) *These values for concentration are annual means as referred to in Annex I, paragraph D.4(c). However, the requirements for nitrogen may be checked using daily averages when it is proved, in accordance with Annex I, paragraph D.1, that the same level of protection is obtained. In this case, the daily average must not exceed 20 mg/l of total nitrogen for all the samples when the temperature from the effluent in the biological reactor is superior or equal to 12℃. Th e conditions concerning temperature could be replaced by a limitation on the time of operation to take account of regional climatic conditions.*

Following European standards, the averages values of Nitrogen (Kjeldahl) and Phosphorus contribution to wastewaters by each person are:

- N: 15 mg/person/day – 5,47 g/pe/yr
- P: 4 mg/person/day- 1,46 g/pe/yr

As an example, for a population of 1000 persons the theoretical contribution to wastewater with regard to N and P will be: 5,47 kg of N/year and 1,46 kg of P/year.

- **Hazardous substances**: in mg/pe/yrof heavy metals, persistent organic compounds, pharmaceutical residues in the wastewater and sludge discharge to water bodies.

The Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community covered discharges to inland surface waters, territorial waters, inland coastal waters and ground water. In 1980 the protection of groundwater was taken out of 76/464/EEC regulated under the separate Council Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances.

In the Annexes of the Decision 2455/2001/EC, amending the Directive 2000/60/EC, and of the Directive 80/68/EEC, the lists of substances which could have a harmful effect on surface and groundwater are included.

Heavy metals are normally present in relatively low concentrations in urban waters, usually less than a few mg/l, and the use of this wastewater (treated or not) may no cause any negative effect, even if applied for long periods. But attention should be paid to them when industrial wastewater is discharged to the urban sanitation system. When wastewater with high concentrations of heavy metals is used for irrigation, the metals may accumulate in the soil and crops, and create definite health problems in crop consumers.

A great variety of toxic organic compounds can be found in wastewaters, especially if there are industrial discharges. Among these compounds there are industrial compounds (PCBs, phthalates, etc), pesticides (lindane, endosulphan, DDT, etc.), petroleum components, disinfection by-products, pharmaceutical residues and hormones. These substances

Different pharmaceutical residues can be found in low concentrations in wastewaters. This could lead to human problems through drinking water if they contaminate surface or ground water. The reason is that some of them retain their activity, and may survive to secondary and even tertiary treatment.

Human and animal hormones may also be present in the wastewater and sludge, but no negative effects on human have been demonstrated since the concentrations are extremely low.

- **Salts:** in g/pe/yr of NaCl (% of incoming salt load removal) in the wastewater.

The levels of sodium in the wastewater should be decreased by the wastewater treatment since high levels of sodium in irrigation water (effluent) could well lead to accumulation in plants and direct toxicity resulting in a reduced crop yield.

3 Emissions to the air

- **Emissions of climate relevant gases** (e.g. CO_2, CH_4, etc) kg of CO_2 equivalent/pe/yr. It is defined as the total of all climate relevant gases which are relieved during process and treatment-mass balance with incoming load and discharge to water bodies.

- **Emission of acidifying gases** (e.g. NH_3, N_2O, etc.) in kg mole of H^+ equivalent/pe/yr. It is defined as the total acidifiying gases which are relieved during process and treatment- mass balance with incoming load and discharge to water bodies. As and example of some step with caused environmental damage are the production, storage and spreading of fertilizers (rich in Nitrogen).

4 Resources recovered: It has to be understood as the non-renewable resources saved by the use of the recovered materials from the system that replaces products, which would have been produced using non-renewable resources.

- **Mass**: the total amount of materials that are recovered in g/pe/yr of wet weight for each recovered product. It is important especially for organisation of the logistics and calculation of transport costs.

- **Nutrients:** g/pe/yr of Nitrogen, Phosphorus, Potassium and Sulphur. Taking into account that producing all these nutrients involves the consumption of non-renewable resources, their recovery is highly interesting from the sustainable sanitation point of view: recovering nutrients means that the corresponding chemical fertilisers necessary for maintaining agricultural productivity can be saved, and thus mineral deposits and fossil energy. All these nutrients are essential for plant development and therefore agricultural production:

  - Nitrogen (N) is the most limiting nutrient for plant growth, since it is an essential part of proteins and aminoacids. The N supplied by chemical fertilisers is fixed from the atmosphere, a renewable supply. However, this process uses much energy, mainly oil and natural gas (Davis and Haglund, 1999), non-renewable energy resources.

  - Phosphorous (P) plays an essential role in the energy turnover of the cell and is part of the DNA core and is thus essential to all living cells. Chemical P fertilisers are produced from rock phosphate by grinding, upgrading and, by the use of sulphuric acid, transformation to phosphoric acid, an intermediate fertiliser product. P is the eleventh most common element in the Earth s crust (NE, 1991).

  - Potassium (K) is the nutrient taken up by most crops in the second largest amounts. K is essential for all organisms and is mainly found as ions in the cell liquid. Chemical K fertilisers are mainly produced from KCl found in sedimentary deposits, usually also containing NaCl and MgSO4. The refining process mainly consists of grinding the ore to a fine slurry and then partitioning these compounds. K is the seventh most common element in the Earth s crust (NE, 1993).

  - Sulphur (S) forms part of some amino acids and some vitamins and is essential to all organisms. The chemical fertiliser industry is the largest user of S in the world and uses it both for production of plant nutrient S and for production of phosphoric acid. S is produced from limestone, ores, natural gas and crude oil high in S. Sulphur is the sixteenth most common element in the Earth s crust (NE, 1995).

The table 13 below provides information on the recoverable amounts of essential plant nutrients to be found in urine and faeces:

Table 13*- Average daily production and nutrient content of urine and faeces*

	Urine	Faeces
Per person	1,2 litres	150 grams (wet wt)
Nitrogen (g/person per day)	11	2
Phosphorus (g/person per day)	1	0.6
Potassium (g/person per day)	2.5	0.6

(Source: Del Porto *et al*., 1999)

- **Energy:** in MJ/pe/yr. the energy recovered by a certain sanitation scenario, due to fact that in some cases there is a possibility to use the biomass generated in the sanitation system as raw material for the production of energy (e.g. sludge digestion to produce biogas). Energy recovery positively affects sustainability by decreasing the consumption of non-renewable resources, and reduces running costs.

- **Organic material**: g of total organic matter/pe/yr. It is defined as the organic matter content in the wastewater used for irrigation.

Using wastewater for irrigation, not only adds nutrients to the soil as already seen, it also enriches the humic content of the soil. The organic material added increases soil moisture, retains metals and enhances microbial activity. This capacity of improving soil properties gives to the use of wastewater for irrigation additional advantages over synthetic fertilisers.

Most organic compounds in sewage (of human, animal and plant origin) are rapidly decomposed in the soil. Under aerobic conditions the breakdown is faster than under anaerobic conditions.

Wastewaters for irrigation with 110-400 mg BDO/l do have some beneficial effects on soil (improves microbial activity and soil fertility, diminishes salinity effects, retain and binds heavy metals) and crops (increase productivity). Continuous irrigation and high organic matter contents may cause problems such as pores clogging and important nitrogen losses by denitrification if combined with nitrogen.

- **Quality of recycled products released to soil** (mg/unit)**:** it refers to different compounds and substances such as heavy metals, persistent organic compounds, pharmaceutical residues, hormones, etc. that reach the soil through the use in agriculture of wastewater and sewage sludge generated in the sanitation system.

As already mentioned, the contents of heavy metals and other contaminating substances in urban wastewater and sludge are commonly very low. If we look at the fractions of the wastewater and sludge generated in the sanitation system, it is known that the content of heavy metals in faeces and kitchen waste is higher than in urine. In the following table (table 14), concentrations of heavy metals in the urine, faeces, urine+ faeces, and in source separated kitchen waste, compared with farmyard manure on organic cattle farms in Sweden is presented as reference.

Table14- *Concentrations of heavy metals in the urine, faeces, urine+ faeces, and in source separated kitchen waste, compared with farmyard manure on organic cattle farms in Sweden (in µg/kg wet weight)*

	Cu	Zn	Cr	Ni	Pb	Cd
Urine	67	30	7	5	1	0
Faeces	6667	65000	122	450	122	62
Urine + faeces	716	6420	18	49	13	7
Kitchen waste	6837	8717	1706	1025	3425	34
Cattle organic farmyard manure	5220	26640	684	630	184	23

(Source: Jönsson, H. *et al.,* 2004)

At European level, the Council Directive 86/278/EEC on the protection of the environment and in particular of the soil when sewage sludge is used in agriculture regulates the use of residual sewage sludge in agriculture. The approach adopted in this Directive is based on maximum limit values. The Directive imposes maximum limit values for concentration of heavy metals in soil and sludge to be applied to soil. It also specifies the conditions to be fulfilled while applying sludge, such as minimum time intervals for the sludge to be applied to individual types of soils based upon the nutrient needs of the plants, obligations to analyse the sludge and the soil, and sampling methods. The following tables (table 15 and 16) show the limit values for heavy-metal concentrations in sludge for use in agriculture and for amounts of them which may be added annually to agricultural land, based on a 10-year average (kg/ha/yr).

Table 15- *Limit values for heavy metal concentrations in sludge for use in agriculture (mg/kg of dry matter)*

Parameters	Limit values
Cadmium	20 to 40
Copper	1 000 to 1 750
Nickel	300 to 400
Lead	750 to 1 200
Zinc	2 500 to 4 000
Mercury	16 to 25
Chromium (1)	—

(1) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

***Table16**- Limit values for amounts of heavy metals which may be added annually to agricultural land , based on a 10-year average (kg/ha/yr)*

Parameters	Limit values(1)
Cadmium	0,15
Copper	12
Nickel	3
Lead	15
Zinc	30
Mercury	0,1
Chromium (2)	—

(1) Member States may permit these limit values to be exceeded inthe case of the use of sludge on land which at the time of notification of this Directive is dedicated to the disposal of sludge but on which commercial food crops are being grown exclusively for animal consumption. Member States must inform the Commission of the number and type of sites concerned. They must also ensure that there is no resulting hazard to human health or the environment.

(2) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive

- **Area of common staple crop that can be fertilised:** Based on the recovered nutrients and their contents in the recycled products, it is possible to calculate the area (m^2/pe) of a common staple crop which could be fertilised. Common staple crops in West African countries are mostly cereals (millet, sorghum, rice and maize), with manioc, coconuts, sweet potato and yams being important locally.
- **Water:** some sanitation systems allow water (m^3/pe/yr) recovery. This water can be then used for non-potable uses (toilet flush, irrigation, etc.), which clearly increases sustainability especially in places where fresh water supply has become inadequate to meet water needs. In general, it can be said that water is clearly a resource and when possible it should not be regarded as waste.
- **Area of common staple crop that can be irrigated:** Recovered water can be used for the irrigation of crops. The area (m^2/pe) of a common staple crop which could be irrigated with the recovered amount of water from a specific sanitation scenario can be calculated and is considered an indicator of sustainability from the sustainable sanitation approach point of view.

5 Accumulation of environmental burden in landfill

- **Nutrients :** g/pe/yr of N and g/pe/yr of P accumulate in landfills.
- **Organic material:** g/pe/yr of organic matter accumulates in landfills.
- **Estimated cumulative production of green house gases** (CH_4, N_2O etc.) kg of CO_2 equivalent/pe/yr.
- **Hazardous substances**: heavy metals, persistent organic compounds, pharmaceutical residues, hormones mg/pe/yr of respective substance accumulate in landfills.
- **Water** (increases risk of leachate formation) m^3/pe/yr
- **Volume on landfill** m^3/pe/yr

A.3 Indicators on economy and finance

Optimising the cost of financial costs of a sanitation system needs to take into account (1) capital costs (2) operation and maintenance (3) affordability (4) local development.

Capital costs include the initial and construction costs. From both the household and a community's point of view the affordability of a sanitation system is an important factor. A percentage of the average person's income in a community could be a figure that can be used as a measure of what a community can afford. What the percentage figure should be is determined by the importance given by community members to having the sanitation system in their community (UNEP, 2000). Generally, the lower the costs involved the more attractive the technology.

For household sanitation systems to be sustainable, the family should be willing and able to pay for the operation and maintenance costs of the system. At the community level, the willingness and capacity of users to pay for its use may lead to recovery of the capital costs.

The potential of the technology to further economic, social and educational development in a community is also an important consideration. The use of local materials and labour stimulates the local economy. Community productivity will increase as the health of the people improves due to access to adequate sanitation.

A.4 Indicators of Technology (incl. O&M)

The technology criteria include factors related to the functionality of a sanitation system, both during its construction and operation, and the possibility to be adapted to the local requirements and conditions.

One of the most important factors relates to its robustness, meaning the risk of failure, effect of failure, structural stability, robustness against extreme conditions, shock loads, abuse of system. Furthermore, aspects such as durability, flexibility and compatibility with existing systems will ensure the adaptation of long-lasting solutions.

It has been recognised that the involvement of the communities in all phases of the sanitation process promotes the sense of ownership. Therefore, aspects such as the possibility of construct it and operate it by using local men power also determines the sustainability of a sanitation system. The monitoring and operation of the system should be done by the same members of the community by using available materials and simple systems.

According to Bracket *et al.* , the technical functioning of the system is seen as the most flexible group of criteria, since they can to a large extent be relatively easily adapted to the needs and requirements.

<u>Proposed methodology for "qualitative evaluation"</u>

Borrowing from the implementation framework of Katherine L. Clopeck *et al.* (2006), each factor or criterion is associated with one or more indicators, and for each indicator there is a scale of 1 to 5 (or simply put, five levels). Each level has a value or description associated with a very low/limited, low, moderate, high and very high score, to facilitate the assessor's judgement.

The following scale is proposed for the set related to *Construction* and *Operation & Maintenance* listed below:

1: Very Low

2: Low

3: Moderate

4: High

5: Very High

<u>Construction</u>:

- System robustness
- Robustness against drought, flooding, earthquake etc.
- Compatibility with existing system
- Flexibility / adaptability (to urban development, population growth etc)
- Possibility to use local competence for construction

Operation and maintenance:

- System robustness: risk of failure, effect of failure
- Robustness of use of system: shock loads, effects of abuse of system
- Availability of spare parts, parts for maintenance, etc.
- Possibility to use local competence for O&M
- Ease of system monitoring

The description of each scale depends on the framework conditions, and it is up to the planners and decision maker to propose a comparison scale.

The following two criteria, complexity and need of large scale infrastructure, will also be given a scale, but with 1 as "very high" and 5 as "very low". In this case, the following descriptions of the rank are suggested, in order to support the judgment of the planners.

- Complexity of construction / operation and management

1: Very High (Very high level of skills required)

2: High (High level of skills required)

3: Moderate Low level of technical knowledge)

4: Low (Moderate level)

5: Very Low (No/ limited technical knowledge)

- Need of large scale infrastructure

1: Very High (Very large scale infrastructure needed)

2: High (Large scale infrastructure needed)

3: Moderate (Some need of infrastructure at block or township level needed.)

4: Low (Everything can be managed on household or block level)

5: Very Low (No large scale infrastructure needed- everything can be managed on household level)

A.5 Social and cultural aspects (incl. gender issues)

A sanitation system serves various goals. Bracken *et al*. (2004) writes that the prime of sanitation might be to protect human health and the environment, but sustainability in sanitation cannot be based only on these objectives. Drangert (2004) elaborates that households when contemplate a shift, other possible factors may be of concern, e.g. modernization arguments, less smell, improved security. However, social aspects are generally more dynamic, some are more variable than others depending on the time scale applied and the local situation.

- Acceptance by the users/social acceptability: Norms and attitudes on sanitation practices differ vastly and even more the attitudes on reuse (if practised). Acceptability depends on a range of factors like the status of the system, the design of the toilet, the practicability of the reuse system etc.
- Willingness to contribute through work and or money for sanitation services: Well working sanitation systems need various services which are strongly dependent on the level of the system or like the HCES approach[8] differentiates on the zone of the system. These services or part of these services can either be done by the users/households themselves or by the next zone: the neighbourhood, the town or the district. Thus its of main importance to take the willingness of contribution (in terms of work of money) into consideration.

[8] Eawag (2005). Household-Centred Environmental Sanitation. Implementing the Bellagio Principles in Urban Environmental Sanitation. Provisional Guideline for Decision-Makers. Eawag, Duebendorf.

- Convenience (comfort, personal security, privacy/dignity, smell, noise, attractiveness, adaptability to needs of different age and handicapped, gender and income groups): That's the question of "How user friendly is the option?"
- Current and foreseen legal acceptability and institutional compatibility: A critical element for supporting a sanitation system is an enabling environment. Many existing standards are based on those developed in industrialised countries. Due to totally different conditions they are often not appropriate or cannot be applied because they are too expensive (Eawag, 2005:17). However, they have to be recognised during the evaluation process.
- Appropriateness to current local cultural context (acceptable to use and maintain): The cultural attitudes toward human excreta management may differ vastly in different areas. Many people identify with these perceptions.
- System perception (complexity, compatibility, absorbability – including aspects of reuse): Perceptions of sanitation systems are influenced among others by local customs and cultural believes. These perceptions may influence the stakeholders opinion in a positive or negative way. Robinson (2005:88) describes an example in Kenya, where only the elders are using a skyloo, because it's a privilege to use it.
- Ability to address awareness and information needs: Various stakeholders need to understand the implication of the options, thus its important to raise their awareness and to provide them with the appropriate information that addresses their needs.
- Positiv/negative impact to women (eg work load, toilet sharing, privacy, security): It is well accepted that women and men usually make different, and sometimes unequal, contributions to sanitation and water management at household and community level. Women are the ones, which are mainly in charge for hygiene and sanitation related duties and responsibilities. The implementation of sustainable sanitation should be promoted more widely, especially taking into account women interests. If a toilet is for example indoor, this contributes to the security and the privacy of the users, particularly women and children using the toilet at night.