STAKEHOLDER-BASED LIFE CYCLE ASSESSMENT: APPLICATION IN MULTI-STAKEHOLDER DECISION-MAKING CONTEXTS FOR SUSTAINABLE DEVELOPMENT PLANNING AND IMPLEMENTATION

By

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To my Thaththa and Amma

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LIST OF ABBREVIATIONS

ACF	Apalachicola Chattahoochee Flint
ADB	Asian Development Bank
AHP	Analytical Hierarchy Process
AHP	Analytical Hierarchy Process
AIC	Appreciate Influence and Control
ANSI	American National Standards Institute
BUWAL	Swiss Agency for the Environment Forest and Landscape (Bundesamt für Umwelt, Wald und Landschaft)
CAA	Commonwealth Architects Association
CAA	Commonwealth Architects Association
CAP	Community Action Planning
CBO	Community-based Organization
CIA	Central Intelligence Agency
CLAP	Community Livelihood Development Planning
CML	University of Leiden Institute of Environmental Science (Universiteit Leiden Centrum voor Milieuwetenschappen)
CO_2	Carbon dioxide
CSEB	Compressed Stabilized Earth Blocks
DS	District Secretary
DSD	Divisional Secretary
EDP	Energy Depletion Potential
EDPI	Environmental Design of Industrial Products
EIA	Environmental Impact Assessment
EIO-LCA	Economic Input and Output Life Cycle Assessment
EPS	Environment Priority Strategies

ESU	ESU Services, Ltd. Switzerland
ETH	Swiss Federal Institute for Technology (Eidgenössische Technische Hochschule)
GDP	Gross Domestic Product
GN	Grama Niladari (Village Officer)
GNP	Gross National Product
GTZ	German Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit)
GWP	Global Warming Potential
HO	Housing Officer
HVAC	Heating Ventilating Air-conditioning
IDEMAT	Mechanical Physical Financial and Environmental Data of Delft University of Technology
IDP	Integrated Development Planning
IFSP	Integrated Food Security Program
INGO	International Non-profit Organization
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standards
IVAM	Interfaculty Environmental Science Department (Interfacultaire Vakgroep Milieukunde van de Universiteit van Amsterdam)
LA	Local Authority
LA21	Local Agenda 21
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LCCA	Life Cycle Cost Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment

LCT	Life Cycle Thinking
LCT/A	Life Cycle Thinking and Assessment
MAUT	Multi-Attribute Utility Theory
MGD	Millennium Development Goal
MIT	Massachusetts Institute of Technology
MPAHA	Ministry of Public Administration and Home Affairs
NAE	National Academy of Engineering
NAED	National Academy of Environmental Design
NAICS	North American industry Classification System
NAMEA	National Accounting Matrix with Environmental Accounts
NAS	National Academy of Environmental Science
NHDA	National Housing Authority
NIST	National Institute of Standards And Technology
NSSI	Natural and Social Science Interface
NWSDB	National Water Supply and Drainage Board
O&M	Operations and Management
OECD	Organization for Economic Cooperation And Development
PAP	Participatory Action Planning
PCA	Paired Comparison Analysis
PHI	Public Health Inspector
PSTI	Public Servants Training Institute
QAS	Quantitative Systems Analysis
RA	Risk Assessment
RADA	Reconstruction and Development Agency
RRA	Rapid Rural Assessment

SBLCA	Stakeholder-based Life Cycle Assessment
SETAC	Society of Environment Toxicology and Assessment
SIA	Social Impact Assessment
SLCA	Social Life Cycle Assessment
SLHF	Sri Lanka Heritage Foundation
SLSI	Sri Lanka Standard Institute
SMART	Simple Multi-Attribute Ranking Technique
SMART	Simple Multi-Attribute Ranking Technique
TAFREN	Taskforce for Rebuilding the Nation
THSP	Tsunami Housing Support Project
TO	Technical Officer
TRACI	Tool for Reduction and Assessment of Chemical and Other Environmental Impacts EIO-LCA millennium development goal
UDA	Urban Development Authority
UF	University of Florida
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNFAO	United Nations Food and Agriculture Organization
UPIT	University of Pittsburgh
US	United States
USA	United States of America
USDA	United States Department of Agriculture
USDOE-CDIAC	United States Department of Energy Carbon Dioxide Information Analysis Center
UTC	University of Cape Town

VDC	Village Development Committee
WB	World Banka
WHO	World Health Organization
WRI	World Resource Institute

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According to the targets set for sustainability, integrating the principles of sustainable development into country policies and programs is one of the main goals for development projects. A major challenge in the development field is cross-sectoral integrated planning and achieving multi-stakeholder consensus for collaborative joint projects, especially when sustainability is a goal. This increases the complexity of the multi-stakeholder interaction in decision making and requires enhanced mechanisms for stakeholder participation, coordination, and commitment beyond narrow self-interest. A critical aspect in the decision making process is to enable stakeholders to not only interpret and make decisions based on expert judgments, but also to appropriately involve the relevant parties in the research and decision making process. Therefore, scientific analyses in multi-stakeholder contexts have to be more transparent, participatory, and stakeholder-based in order to provide useful information to assist in responsible decision making.

This dissertation presents a stakeholder-based life cycle assessment (SBLCA) approach that can be used to support sustainable decision making in multi-stakeholder contexts. The framework is discussed and compared to other common methods used to support environmental

decision making in development projects. We argue that the fundamental concept of life cycle thinking can be effectively used to incorporate stakeholders in the research and decision making process, which can lead to more comprehensive, yet achievable assessments in collaboration with stakeholders. Life cycle thinking is not just a way to examine environmental impacts of activities, but also a way to comprehend and visualize a broader set of upstream and downstream consequences of decisions in development planning and implementation.

The applicability of the framework is demonstrated using simple examples extracted from a pilot case-study conducted in Sri Lanka for sustainable post-tsunami reconstruction at a village scale. How the method could be potentially used in other planning situations is also demonstrated using an exemplary case-study on integrated watershed management. The applicability of SBLCA in specific planning stages, how it promotes transdisciplinary learning and cross-sectoral stakeholder integration in phases of project cycles, and how local stakeholders can practice life cycle thinking in their development planning and implementation are discussed. A participatory rating and ranking method that can assist in organizing information from assessments and support consensus building among stakeholders is also introduced.

CHAPTER 1
INTRODUCTION

Aim and Objectives of Research

The aim of the research study is to investigate the applicability of life cycle thinking and assessment (LCT/A) in multi-stakeholder decision making contexts for sustainable cross-sectoral development planning and implementation, especially in developing country contexts. The specific objectives of the study include the following:

- identify key challenges in multi-stakeholder development contexts, and specific characteristics required by the assessment methods to effectively address the challenges;
- develop a stakeholder-based life cycle assessment (SBLCA) framework that facilitates cross-sectoral integration;
- identify useful economical, social, environmental indictors under data scarce situations to be used in the framework;
- identify planning stages where SBLCA can be applied;
- identify other complementary methods and tools that can be used along with SBLCA in development planning and implementation.

Introduction to Research

The Millennium Development Goals (MDGs) that were agreed upon at the United Nations Millennium Summit by nearly 190 countries established that the environment is a priority by making sustainability one of the primary development goals (UN Millennium Project, 2005). The MDGs emphasized that environmental sustainability should be integrated into efforts towards achieving goals such as eradicating extreme poverty, reducing child mortality, improving maternal health, and combating diseases like malaria. Therefore, according to the targets set for environmental sustainability, integrating the principles of sustainable development into country policies and programs is one of the main goals for development projects (UNEP, 2003). In addition, there is a clear need to reinforce the importance of environmental concerns in the entire disaster management cycle of prevention, preparedness, assessment, mitigation and response, and to integrate environmental concerns into planning and implementation for relief, rehabilitation, reconstruction and development (Berke et al., 1993; Berke and Campanella, 2006).

A major challenge in meeting sustainability goals is that in the development field, sectoral planning is still dominant over cross-sectoral planning (UNEP, 2003). Cross-sectoral project integration is necessary to achieve sustainable development goals and therefore, improving stakeholder participation, coordination, and commitment beyond their narrow self-interests is required. Robust, participatory environmental decision making is an essential component in this process (University of Cape Town, 2006). In contemporary sustainable planning and policy, the paradigm is that the community is at the center of the process and the stakeholders, including the community, are empowered to influence and share control over development initiatives, decisions, and the resources affecting them (Allen and Kilvington, 1999). In this context, science is challenged to work with the community and the respective stakeholders to enable them to identify and interpret broad environmental issues interlinked with economic and social aspects, and support decision making for long lasting development solutions within the community's capacities (Van Asselt and Rijkens-Klomp, 2002). This has led to efforts to make scientific analyses, e.g., environmental assessment methods in multi-stakeholder contexts, more transparent, participatory, and stakeholder based in order to provide useful information to assist environmentally responsible decision making.

Engaging stakeholders in responsible decision making is a key prerequisite for stakeholders to assume a greater role in the development process (Kasemir, 1999; Ravetz, 1999). A critical aspect in this process is to enable stakeholders to not only interpret and make decisions based on expert assessments, but also to appropriately involve the relevant parties in the assessment process. From recent work, it has been established that the essential requirements for responsible stakeholder involvement, i.e., stakeholders comprehend the problems and the alternative ways to address them, are: 1) conducting context-specific analyses including upstream and downstream effects of direct activities in order to establish broad levels of environmental quality and development, and 2) making information accessible such that the interpretation of the information by different stakeholders from different sectors and disciplines are understood to the greatest extent by all stakeholders (UNEP, 2003; University of Cape Town, 2006; Allen and Kilvington, 2002; Weik, et al., 2006).

Typical environmental assessment methods such as Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), Risk Assessment (RA), and Life Cycle Assessment (LCA) are generally carried out for one client or one interested party to assist decision-making for sustainable or greener practices. In community development, sustainable planning promotes integration of programs which requires the commitment of a number of stakeholders in different disciplines (Googins and Rochlin, 2002; Marsden and Bristow, 2000; Moss, 2004; ADB, 2005). For example, housing development and reconstruction in a disaster situation should be interlinked with relevant infrastructure, social service, and livelihood development to make the housing project sustainable in the long-run (Slocombe, 2003).

In multi-stakeholder contexts with different interests and priorities, the fundamental concept of life cycle assessment can be effectively used to incorporate stakeholders in the assessment and decision making process, which can lead to more comprehensive, yet simple assessments together with the stakeholders. Life cycle thinking is not just a way to examine environmental impacts of activities, but also a way to comprehend and visualize a broader set of upstream and downstream consequences of decisions in development planning and implementation. The ability to break down activities in life cycle stages with the flexibility to inventory economic, social, and environmental aspects can be very useful for stakeholders (Akai, 1999; UNEP-SETAC Life Cycle Initiative, 2006). A life cycle framework including the mapping of stakeholder involvement at each activity in upstream and downstream stages would give stakeholders a holistic view of issues that they otherwise may not have. It could identify their specific roles in relation to the roles of other stakeholders, the resources required from stakeholders for each activity, and the costs and benefits of decisions. This approach is particularly suited for programs and projects that go beyond sectoral limits, which is a timely need in the development field and can potentially enable sustainable development by providing a basis for consensus building in joint programs and projects (Innes, 1996).

Statement of Problem and Research Questions

The research objective within this study is to experiment how the fundamental concepts of life cycle thinking can be used in multi-stakeholder decision-making for sustainable development planning and implementation. Especially in developing countries where data and information are not readily available, and often, most decisions are driven by short-term economic aspects. The aspects of sustainability in the present context of development planning and implementation are examined. The application and modification necessary for life cycle thinking and assessment is investigated through action research. The main research questions and sub-questions that are intended to be addressed in the study are as follows:

1. How should an expert-based tool like LCA be used in a multi-stakeholder decision making process such that environmental criteria are incorporated together with the economic, social, and cultural aspects that are inherent in sustainable development?

- What are the key features of common methods of environmental decision making that can be applied in multi-stakeholder contexts?
- What are the ways in which they a) address different types of environmental impact and meet the requirements of different stakeholders, and b) enable access to information by different stakeholders thereby narrowing their respective interpretation of the information?

2. How can the fundamental concepts in LCA be used to narrow down the different views and interpretations of stakeholders from different disciplines and build consensus on issues related to sustainable development?

- What are the specific modifications and improvements to conventional LCA that are required for this application in decision making in multi-stakeholder contexts?
- What is the most appropriate form for the results generated?
- How is locally relevant data gathered and incorporated into an LCA-based tool?
- What decisions can be made even if the data is limited?

3. How can transdisciplinary knowledge be incorporated in a participatory multi-stakeholder decision making process using existing features as well as modifications to LCA?

- Where does an LCA-based tool fit into the decision process, specifically, which stage(s) and which stakeholders are involved?
- What is the nature of the expert-stakeholder interactions?
- What are the design and implementation aspects of the case studies?
- How can the economic and social impacts be quantified or qualified and incorporated together with the traditionally quantified environmental impacts in LCA?

Rationale of Study

Integrated development planning (IDP) is an approach to planning that involves all institutions[1] in finding the best solutions for development. Usually, the IDP process results in a comprehensive development plan for a given area. It aims to co-ordinate the work of local and

[1] *Institutions can mean citizens/community, government officials, local and international donors, etc., who should all be part of the participatory process.*

other government agencies, and donors in a coherent plan to improve the quality of life for the residents. It should take into account the existing conditions, the challenges, and the resources available for development. The plan should look at economic and social development for the area as a whole. It must set a framework for how land should be used, what and to what level infrastructure and services are needed, and how the environment should be protected (UN, 2002). For example, integrated settlement planning would include the following aspects:

- Identifying housing needs along with infrastructure, social services, livelihood and environment;
- Identifying all programs and projects in the areas noted above;
- Involving stakeholders including beneficiaries in the areas noted above;
- Committing resources for achieving development goals without compromising stakeholder capacities; coordinating actions across programs and projects.

Even though the need for integration and the basic approach can be easily understood, realizing integrated planning in the field has been a challenge. For example, generally in communities, development programs such as sanitation, livelihood improvement and micro-finance are conducted independently. Integrating these programs in a manner such that the livelihood improvement program trains local labor to be employed in the sanitation program, and the micro-finance program creates saving schemes among the village households to promote local contributions to sanitation related construction can be understood as mutually beneficial. However, the uncertainties from relying on inputs and outputs of the other programs are critical barriers to actually conducting them in an integrated manner. To overcome the uncertainties, the individual programs have to consider additional planning and implementation measures that incur extra costs.

The extra costs to overcome uncertainties are referred to as transaction costs. According to the new institutional economics, also known as institutional political economy, the collaborative development program activities can be identified as transactions in imperfect markets (University of Southern California 1999-2000). There are three underlying factors that cause transaction costs and hence, affect integrated planning: (a) bounded rationality, (b) asset specificity and (c) opportunistic behavior (Aoki 2008; Chen 2007; Deng 2007). These factors create uncertainties and transaction costs in engaging in integrated planning and implementation of projects. These factors and effects are illustrated by the following examples related to reconstruction:

Bounded rationality: Bounded rationality limits housing implementing stakeholders to develop an understanding only about housing. Affected by bounded rationality, housing stakeholders expect all other stakeholders to follow that same rationality. For example, housing funding agencies operating in owner-driven reconstruction expect the affected households to concentrate on completing the house, irrespective of the needs and capacities of different households, without much knowledge of the future consequences of only providing a housing unit.

Asset specificity: Asset specificity is the factor that makes the resources of implementing and other stakeholders tied to specific activities, without concern for the changing requirements and priorities on the ground; for example, housing donor agencies cannot allocate resources to develop community infrastructure in owner-driven housing as funding is tied to the house units and the objective is to build as many housing units as possible in the shortest period of time.

Opportunistic behavior: When stakeholders conduct themselves by only considering their own benefits and affecting the opportunities and benefits of others, it is termed as opportunistic behavior; for example, housing sector stakeholders are focused only on completing donor-driven housing projects without considering the needs and aspirations of the communities.

In this, both coordinating and implementing stakeholders may conduct themselves opportunistically as the communities are not present at these sites to communicate their needs in resettling.

The above factors affect integration in achieving common objectives for sustainability at three main areas:

- within divisions of stakeholder institutions;
- among the stakeholder institutions within a sector and among different sectors;
- implementing projects with multiple institutions.

Developing an understanding of the presence of these factors in multi-stakeholder political environments and the way in which they affect the programs within and among the stakeholder institutions becomes a key requirement before development and implementation of integrated programs and projects. Hence, to make integration possible, a decision support framework for stakeholders to move beyond bounded rationalities, work through asset specificities, and minimize opportunistic behavior by explicitly understanding resource requirements and corresponding benefits is needed (Wiek, et al., 2006).

Challenges in participatory planning approaches: In many planning approaches, the ability to apply a systems thinking approach while recognizing the power structures within the system is limited and allocating sufficient resources, e.g., time and money, towards understanding the current system including the subtle connectivities of stakeholders and issues is quite limited. For example, often one issue is a priority for one segment of the community, while another stakeholder group has never viewed the issue from their perspective and therefore the issue is not a priority; an example of bounded rationality. Another group may turn a blind eye, because the same situation may be providing a benefit rather than a disadvantage; an example of opportunistic behavior. This limited thinking and understanding always affects the entire life cycle of the project, including the planning process and the subsequent integration required for implementation, unless common understanding is created from the beginning of the planning process.

Similarly, in formulating solutions, the stakeholders are not successfully integrated into the planning process, and as a result, do not participate in assessing the improvements and evaluating which alternatives would best meet their goals. Stakeholders are rarely provided with a clear picture of all the activities behind the proposed improvements – both the nature of the activities and the short-term and long-term resource commitments that are required to implement them. For example, determining the appropriate level of improvement, including identifying the operation and maintenance (O&M) costs that would have to be provided by the community in the long term are often not identified, communicated, nor discussed at the planning stage. Therefore, improvements have often become failures.

Hence, the challenge in integrated planning approaches is to combine appropriate concepts, decision support frameworks, and useful information analysis tools with effective soft skills to ensure active participation, sharing knowledge, structured discussion, and a negotiating and consensus process, which is focused on sustainable and implementable solutions that fit local contexts, without forgetting the political nature of multi-stakeholder environments.

This dissertation outlines a life cycle assessment-based framework that can be used to support sustainable decision making in multi-stakeholder contexts. The framework is developed in a manner that it can be embedded into participatory integrated planning processes. Under the literature survey, key global sustainable development initiatives and need for participatory knowledge sharing approaches for planning and implementation of sustainable development projects are investigated. How systems thinking and transdisciplinary learning can positively contribute to design participatory approaches are further investigated. Three environmental assessment methods frequently used in project assessment, namely EIA, SIA, and RA, are reviewed. The strengths and weaknesses of these methods, including their adoption of participatory approaches, are evaluated relative to the needs in multi-stakeholder contexts. Traditional approaches for conducting LCA and their limitations are also reviewed. Criteria are used to evaluate the methods' applicability in a multi-stakeholder integrated development planning process, specifically for planning in a developing country context. Using the same criteria, a life cycle approach called Stakeholder-based Life Cycle Assessment (SBLCA) is presented in an example case of post-disaster reconstruction planning. Then, the application of the tool along with other supporting concepts and tools in a case-study conducted on village development planning in Sri Lanka is presented. Application of the method in other planning situations is demonstrated using an exemplary case-study on Apalachicola-Chattahoochee-Flint watershed management. Participatory ranking methods frequently used in development project assessments are reviewed and a simplified method that can be used in multi-stakeholder integrated development planning process is discussed, especially that can suit community level development planning situations by the local experts.

Summary

The aim and the objectives of the research are to investigate the applicability of LCT/A in multi-stakeholder decision making contexts for sustainable cross-sectoral development planning and implementation, especially in developing country contexts. The research questions are mainly targeted at how to modify the technicalities of LCA to be integrated into integrated development planning process, and promote transdisciplinary learning among the stakeholders. According to the rationale of study, the environmental assessment method should be sufficiently simple and transparent to minimize different interpretations of information by the stakeholders belonging to different sectors and disciplines to build consensus on collaborative action necessary for sustainable development. The fundamental concept of LCT/A can be effectively used to incorporate stakeholders in the assessment and decision making process, which can lead to more comprehensive yet simple assessments together with the stakeholders. It is not just a way to examine environmental impacts of activities, but also a way to comprehend and visualize a broader set of upstream and downstream consequences of decisions in development planning and implementation.

CHAPTER 2
LITERATURE REVIEW

Sustainable Development Paradigm

Sustainable development is related to a number of viewpoints, and hence, various definitions. However, all definitions of sustainable development require viewing the world as a system that contains finite amount of resources that connects space and time (International Institute for Sustainable Development, 2006). One of the key aspects of the definitions is to seek a balance between the basic needs of the people and the essential needs of the life supporting ecosystems. There are different viewpoints that development sounds the same as growth, and the term sustainable would hint no-growth. Addressing the above growth and no-growth concerns, distinctions are made between growth and development: while growth essentially suggests getting bigger, development can mean getting bigger and also, getting better (The Environmental Quality Board, 1998).

Some of the well-known articulations on sustainable development concepts are defined based on normative and positivist interpretations: normative meaning expressing a judgment about what ought to be, and positive meaning stating what is with no indication of approval or disapproval. The most widely used is the normative interpretation, which is expressed by the World Commission on Environment and Development (1987) as "the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs". This statement is appealing to those who focus on the regenerative capacity of the environment as well as the parties who focus on the potential for the technological progress to adapt to changing conditions (Meppem and Gille, 1997). Another important view was expressed in Costanza (1994), stating that "sustainability entails maintenance of 1) a sustainable scale of the economy relative to its ecological life support system, 2) a fair distribution of the resources and the opportunities between the future generations, as well as between the agents in the current generation, and 3) an efficient allocation of resources that adequately accounts for the natural capital". Another argument is expressed by Goodland et al. (1991), shifting the emphasis towards increased efficiency and productivity of natural and cultural resources, suggesting that growth is not essentially limited by the availability of resources, but on the sink functions such as absorption of wastes, for example greenhouse gases by the atmosphere, oceans, and the forests. Goodland et al. (1991) mentions that current development indicators such as gross national product (GNP) do not make allowance for cultural diversity, social cohesion, or improvements in environmental quality, and therefore, broader measures or indices are required to support a broader goal.

The positivist interpretation of sustainable development involves significant scientific findings on the degradation of the natural environment. The World Resource Institute (1994), Energy Information Administration (1993), and Wilson (1992) are among those important scientific publications in the recent past. This scientific evidence has contributed to gaining greater international political attention on the increasing environmental concerns related to development (Meppem and Gille, 1997). The United Nations Conference on Environment and Sustainability held in 1992 convening global political leadership in response to the above need is one of the significant milestones in initiating action for sustainable development. However, Ludwig et al. (1993) expresses that initiating necessary action and measures to promote sustainable development is affected by the scientific consensus on the implications of human activity on natural ecosystems. Hutchocroft (1996) claims that scientific positivism cannot adequately address the political cultural issues concerned when planning and designing action for sustainable development. Analyzing the above viewpoints and philosophical aspects of complex-problem solving in the real world, Meppem and Gille (1997) draws attention to prospects for inductive learning alternatives that are interactive, generate information, enable agents to learn and adapt as they go along, and encourage innovation and institutional change towards negotiating and achieving what is sustainable in a given system.

Considering the above arguments, a sustainable community is broadly defined as a community that uses its resources to meet current needs while ensuring that adequate resources will be available for future generations. The communities do this by limiting waste, preventing pollution, maximizing conservation, promoting efficiency and developing local resources to generate a healthy local economy. In the broadest sense, a sustainable community resembles a living system in which all resources, human, natural, and economic, are interdependent and draw strength from each other (International Sustainable Development, 2006).

Sustainable Development Programs

Agenda 21

Agenda 21 is a program initiated by the United Nations on sustainable development. In Rio de Janeiro in 1992, at the United Nations Conference on Environment and Development, also known as the Earth Summit, most of the world's nations committed themselves to the pursuit of economic development in ways that would protect the Earth's environment and non-renewable resources and adopted Agenda 21 as a global plan to fulfill this commitment. The program was agreed to by 179 countries (UN, 2004).

The full content of the Agenda was declared at the Earth Summit. The implementation of Agenda 21 was intended to involve action at international, national, regional and local levels. Some national and state governments have legislated or advised that local authorities take steps to implement the plan locally, as recommended in Chapter 28 of the document. Such programs are often known as 'Local Agenda 21' or 'LA21' (UN, 2004). According to Chapter 28, "each local authority should enter into a dialogue with its citizens, local organizations, and private enterprises and adopt a local Agenda 21. Through consultation and consensus-building, local authorities would learn from citizens and from local, civic, community, business and industrial organizations and acquire the information needed for formulating the best strategies".

The four main chapters of Agenda 21 include the following (UN, 2004):

- Section I: Social and Economic Dimensions - including combating poverty, changing consumption patterns, population and demographic dynamics, promoting health, promoting sustainable settlement patterns and integrating environment and development into decision-making.
- Section II: Conservation and Management of Resources for Development - including atmospheric protection, combating deforestation, protecting fragile environments, conservation of biological diversity (biodiversity), and control of pollution.
- Section III: Strengthening the Role of Major Groups - including the roles of children and youth, women, non-profit organizations (NGOs), local authorities, business and workers.
- Section IV: Means of Implementation - including science, technology transfer, education, international institutions and mechanisms and financial mechanisms.

Chapters 7, 8, 35, 36, 37 and 38 of the Agenda 21 particularly highlight the importance of integrated planning at local levels while simultaneously enhancing scientific understanding and capacities for informed and collaborative decision-making and implementation (UN, 2004). It also emphasizes the need for improved participatory assessment methods and scientific knowledge sharing among the local communities, governmental and non-governmental organizations, and technical and academic institutions.

Millennium Development Goals

United Nations Development Program (UNDP)'s Millennium Development Goals (MDGs) are eight development goals focused on reducing poverty, hunger, disease, lack of adequate shelter, while promoting gender equality, health, education and environmental sustainability (UN Millennium Project, 2005). MGDs are formulated according to the targets and action agreed at the United Nations Millennium Summit held in year 2000 by nearly 190 countries. The eight primary goals are broken into twenty one quantifiable targets which are to be achieved by the year 2015. One of the significant aspects to observe in establishing these goals and targets is the explicit emphasis on environmental sustainability (MDG 7) and its direct interlinks in measuring economic development and social well-being (Figure 2-1). This was a major step towards promoting goal-oriented environmentally sound sustainable development in the member countries. The MDG 7 targets include the following:

- Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources
- Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss
- Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation
- By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers

According to the above targets, it could be noticed that sustainable urban settlement planning integrating the necessary urban services and economic opportunities with efficient use of environmental resources is a priority among the global development challenges. The Commonwealth Architects Association (CAA) document on infrastructure and MDGs, outlines a triple bottom-line framework for designing for sustainable settlements extracting relevant objectives set by the Agenda 21 (CAA, 2005) and it is illustrated in Figure 2-2. While the Millennium Development Project develops concrete action plans at the global level to achieve the time bound development targets, the individual countries are expected to draw country and local level policies, programs and projects to accomplish the global level action plans in Agenda 21.

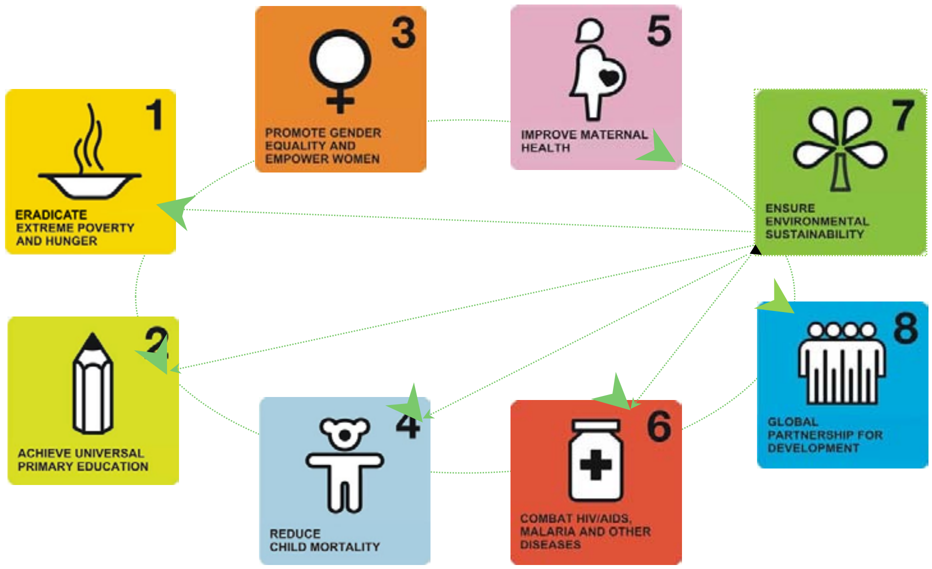

Figure 2-1. Environmental Sustainability as a key goal under the MDGs with direct interlinks to achieving other development goals and targets

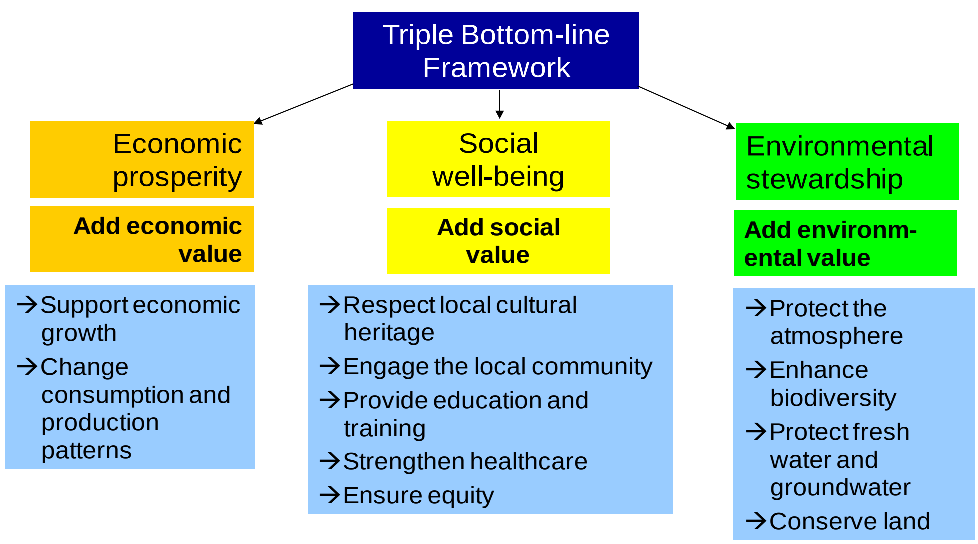

Figure 2-2. The triple bottom-line framework for designing and constructing for sustainability

Sustainable Settlement Development

Agenda 21 is recognized as one of the first policy documents to address changing consumption and production patterns (Chapter 4) and to make reference to the role of the building sector in achieving sustainable development imperatives (Chapter 7). It recognizes the causal relationship between resource use and benefits generated, and articulates the need for new concepts of sustainable economic growth and prosperity. Chapter 7 of Agenda 21 is dedicated to promoting sustainable human settlement development. According to Chapter 7 Section 4, human settlement objectives are outlined as: "Improve the social, economic and environmental quality of human settlements and the living and working environments of all people, in particular the urban and rural poor. Improvement should be based on technical cooperation activities, partnerships among the public, private and community sectors and participation in the decision-making process by community groups and special interest groups such as women, indigenous people, the elderly and the disabled. The approaches should form the core principles of settlement strategies, taking fully into account their social and cultural capabilities".

The program areas included in Chapter 7 Section 4 include:

- Providing adequate shelter for all.
- Improving human settlement management.
- Promoting sustainable land-use planning and management.
- Promoting the integrated provision of environmental infrastructure such as water, sanitation, drainage, and solid-waste management.
- Promoting sustainable energy and transport systems in human settlements.
- Promoting human settlement planning and management in disaster-prone areas.
- Promoting sustainable construction industry activities.
- Promoting human resource development and capacity-building for human settlement development.

Some key points regarding necessary action for promoting the integrated provision of environmental infrastructure, commonly termed as urban environmental services as given in Section 4.D in Chapter 7 is as follows:

- An integrated approach is necessary to the provision of environmentally sound infrastructure in human settlements. It is an investment in sustainable development that can improve the quality of life, increase productivity, reduce diseases and improve health.

- Developing countries should be assisted at the national and local levels in adopting an integrated approach to the provision of urban services, and external funding agencies should ensure that this approach is applied in particular to environmental infrastructure improvement in informal settlements based on regulations and standards that take into account the living conditions and resources of the communities to be served.

- Policies need to aim at recovering the actual cost of infrastructure services, while at the same time recognizing the need to find suitable approaches to extend basic services to all households.

- In promoting the integrated provision of environmental infrastructure, research should be conducted in the area of integrated policies of environmental infrastructure programs and projects based on cost-benefit analysis and overall environmental impact, and identify methods of assessing "effective demand", utilizing environment and development data as criteria for selecting technology.

- Awareness should be raised on approaches and benefits of the provision of environmental infrastructure facilities, especially among local community

- A cadre of professionals should be trained with adequate skills in integrated infrastructural service planning and maintenance of resource-efficient, environmentally sound and socially acceptable systems.

- Institutional capacities of local authorities and administrators should be strengthened for the integrated provision of adequate infrastructure services in partnership with local communities and the private sector.

From the key points mentioned above, it is conceivable that for sustainable settlement development, local level integrated planning with the respective stakeholders in the center is a must. Scientific research within integrated planning should assess and create awareness on economic, social and environmental costs, benefits, and impacts.

Integrated Development Planning and Steps Toward Implementation

In accomplishing global, national, and local level sustainable development targets, integrated planning at relevant strategic scales becomes an important aspect. Integrated development planning is expected to bring together economic, social, and environmental aspects of development issues and solutions and the actors across sectors responsible to a common planning forum (Geyer, 2006). The term integrated means a) to combine parts as a whole, b) to consider all aspects of issues, c) to look into all the circumstance that may affect a project or a plan in a holistic manner, and d) to coordinate stakeholders from all respective sectors. The term development in local contexts means a process that improves the quality of life of the community and enhances opportunities and choices for growth. Planning helps a local community to envision the direction of growth and balance of the new development with the societal and ecological capacities and constraints (Cape Town Gatewat, 2007; Geyer, 2006). Hence, integrated planning essentially needs to utilize participatory approaches, where the communities and the stakeholders become key players in decision making and take ownership of their decisions. The integrated planning processes typically take the stakeholders through a sequence of planning steps to insure that the development interventions are financially viable, realistically achievable and sustainable in the long-run. The steps essentially include the following (Cape Town Gateway, 2007; Weik, 2006):

- Understanding sustainable development concepts, principles and goals: this step is for the stakeholders to identify aspects of sustainability, concepts and principles related to their local context and to be prepared to assess the current state of issues and needs in a community or a region in forming a shared vision.
- Assessing the current state: this step is for the stakeholders to identify and analyze the current issue and interconnectivities in a community system, the distance to targets, and possible causes and effects of implementational gaps.
- Prioritizing issues: this is to prioritize issues or needs for the communities or the regions, as all issues could not be addressed at once due to various reasons such as resource constraints,

institutional incapacities, lack of technical knowhow, and political barriers. The prioritizing of issues or needs is usually done based on logical criteria with a thorough understanding of the current status of issues and needs.

- Formulating options: this step is to identify and build on plausible options and scenarios to address the prioritized issues, so that stakeholders would be able to envision their future options and effects of choices.

- Assessing options: this step is for the stakeholders to interactively negotiate and agree on which options are viable, sustainable, and beneficial under the local opportunities and constraints.

- Strategizing options: this is to identify specific tasks, responsibilities, resource contributions and timelines for implementation.

- Evaluation and monitoring: this step is integrated with all of the above steps and beyond to track whether the action is moving according to the plan, and if not to take corrective action as necessary to achieve the intended goals.

Integrated planning is incremental and cyclic, i.e., the above steps need to be repeated and readdressed as the communities progress with their development and as action changes current conditions. The current conditions need to be revisited to address further issues and challenges. Within the above steps in a planning process, various assessment methods, frameworks, and tools are applied to support informed decisions and consensus building towards sustainable action.

However, as discussed in Chapter 1, realizing integrated planning is found to be a challenging task in the field. Sectoral planning is still dominant over cross-sectoral planning. This is due to the uncertainties and resulting transactions costs related to one program relying on another to conduct cross-sectoral integrated programs (University of California, 1999-2000; UNEP, 2003). There is limited understanding about the factors that affect integrated planning, namely bounded rationalities, asset specificities and opportunistic behaviors, which are described in detail in the previous chapter, and hence, limited decision support frameworks for stakeholders to move beyond bounded rationalities, work through asset specificities, and minimize opportunistic behavior by explicitly understanding resource requirements and corresponding benefits (Wiek, et al., 2006).

Systems Thinking in Multi-Stakeholder Planning

A system is generally defined as a collection of parts, or sub-systems which are integrated to accomplish an overall goal or a defined objective (Boyed, 1998). If one part of the system is changed, the nature of the overall system is often changed. Systems thinking is recognized as an effective approach to assess and visualize the links, interdependencies, and interactions of a given system. It is also a way of viewing systems from a broad perspective that includes seeing overall structures, patterns and cycles in a system, rather than seeing only specific events in the system (Pegasus Communications, 2004). This broader view is intended to help identify the underlying causes of issues in a system and understand which elements to focus on in order to identify and implement solutions effectively. Based on this approach, a variety of principles and tools for the purpose of analyzing and changing systems have evolved. In development planning contexts, systems thinking tools serve as a participatory learning tool where key driving forces, interconnectivities and level of interdependencies of a current issue or future transition can be identified and visualized (Meppem and Gille, 1997; Scholz and Tietje, 2002; Wiek, 2006b; Lang, 2006). They can also explore economic, social, and environmental dimensions interrelated in a system. However, systems thinking covers a snap shot of dynamics of a current system or a future transformed system. It may not investigate the upstream and downstream elements which may fall outside a system (for example, external sand mining for housing construction within a village system), but yet need to be considered. Furthermore, in multi-stakeholder development contexts, where the decisions are often negotiated weighing costs and benefits, the system thinking based tools do not usually provide a framework for eliciting those cost and benefit indicators and structuring interlinked upstream and downstream elements for negotiating and strategizing implementable solutions. The current methods could still be very useful depending on the planning stage and context.

Transdisciplinarity and Transdisciplinary Learning

In the integrated development planning paradigm, engaging relevant stakeholders including the communities belonging to multiple disciplines and sectors is an essential element. The knowledge and experience brought in to the planning process by the stakeholders are diverse, and often, the ways of framing and understanding development related issues depends on their knowledge, expertise and experience. In such a planning exercise, getting the stakeholders to common ground by exchanging and building up on each other's knowledge and expertise becomes a valuable first step towards responsible decision making towards collaborative action. The process of exchanging, generating, and unifying knowledge among experts, practitioners and stakeholders in a given context is broadly termed as transdisciplinary learning (Klein, 2001). However, the term "transdisciplinarity", where the transdisciplinary learning concept has evolved, have different, yet related definitions. The present day researchers have developed various strategies to adapt the aspects of transdisciplinarity for learning and planning for addressing and solving complex real world problems (Müller et al., 2005; Sholz et al., 2006; Luks and Siebenhünerb, 2007; Walter et al., 2007).

Under the topic of the future of transdisciplinarity, Lawrence and Després (2004), attempts to discuss "what is transdisciplinarity" by drawing together the contributions from some key theorists who have contributed to its emergence as a new way of looking at the relationship between knowledge, science and society. The argument for the need for transdisciplinary approaches that go beyond inter- or multi-disciplinary research is expressed, highlighting the fact that natural sciences such as physics, architecture, engineering, economics, sociology, biology, or law, individually or in combination, is non-comprehensive and insufficient in dealing with the increasingly diverse societal conditions and challenges in human-made environments (Lawrence and Després). In fact, human societies today need to deal with diverse sets of interrelated problems that are not confined within conventional disciplinary boundaries or sectoral professional practice (Sholz et al., 2001, Klein, 2004; Pinson, 2004). Hence, transdisciplinarity is expected to expand the horizons beyond the academic disciplines, or the sectors of the society by involving the scientists, professionals, policy decision-makers, interest groups and communities who have a stake in taking action for solving real world multi-dimensional problems. The key common messages extracted from Lawrence and Després (2004) and Klein (2004), in transdisciplinarity and approaches adapted by various theorists can be summarized as follows:

- It deals with research problems and organizations that are defined from complex and heterogeneous domains
- Knowledge production is hybrid in nature (non-linear and reflexive) transcending any academic disciplinary structure and sectoral professional practice
- It accepts local contexts, uncertainty, and context specific negotiation of knowledge
- Transdisciplinary knowledge is the result of inter-subjectivity
- It includes practical reasoning of the individuals
- Transdisciplinary research is often action oriented, frequently deal with real-world topics, and generates knowledge that not only address societal problems but also contributes to their solution
- One of its aims should be understanding the actual world and bridging the gap between the research world and societal practices
- Transdisciplinary research should not be limited to applied knowledge, but should be open to integrate theoretical developments

In practicing transdisciplinarity, according to Lawrence and Després (2004), the obstacles that need to be dismantled due to the limitations of expert-based disciplinary thinking are summarized as follows:

- Ontological frameworks that do not embrace the complexity of the natural and human-made environment;
- Epistemological positions that value rational, utilitarian approaches to interpret the layout, use and management of human and natural ecosystems;
- Specialization, segmentation and bureaucratization of knowledge and expertise;
- Lack of transfer and communication between professionals, politicians, interest groups and communities.

Bruder (1994) describes the requirements within transdisciplinary approaches. One of the key requirements is that team members share roles and cross disciplinary boundaries systematically. The primary purpose of this requirement is to pool and integrate the expertise of the team members, so that more efficient and comprehensive assessment can be evolved in the process. The form of communication in these teams involves continuous give-and-take among all the members on a regular and planned basis. Teaching, learning, and working together to accomplish a common set of goals and targets are an essential part of the process. Transdisciplinary researchers are also required to understand the nature of the disciplines and their underlying assumptions in order to integrate, translate, and implement research transcending, yet respecting, established traditions. Specific training is required by the researchers to collaborate effectively with the multidisciplinary and cross-sectoral partners.

Meppem and Gill (1997) bring out the need to identify sustainable development as a learning process. The learning process is expected to be facilitated by a debate among the actors with vested interests, ideologies and perceptions, as opposed to a top-down, expert-driven and certainly less learning-oriented decision-making process, which tends to ignore intangible and non-quantifiable, yet important societal aspects. Their observations also bring out the key imperatives in participatory processes and direct contributions from transdisciplinary learning integrated with participatory planning processes. As issues in sustainable development encompass disciplines and sectors, developing solutions should be envisaged to go beyond disciplines. In such planning processes, sustainable and effective solutions evolve with knowledge integration and continuous learning among the responsible actors. Learning promotes reasons for action. Also, learning helps to understand different viewpoints and dimensions on the same issues, which may otherwise fail to be recognized by the respective parties. Hence, it can be concluded that transdisciplinary learning can potentially become an integrated element in participatory planning approaches that enhance broader objectives of consensus building for action and deliberations towards sustainable development.

However, in light of assessing transdisciplinary learning as an inclusive element in sustainable development research, Klein et al. (2001) points out certain flaws or limitations related to the knowledge generated in such processes. One of the points is that an integral knowledge produced in a transdisciplinary process does not conform to the ideal of scientific knowledge as universal, explanatory, and proven. Hence, the quality and the robustness of the new knowledge produced could be questioned in relation to the strict norms in the distinct disciplines. Participation fallacy, which is defined as having biases that affect the facilitation of a mutual learning process, is considered as another flaw. Whether the facilitators are ready for a mutual learning process with sufficient flexibility and fairness to the new knowledge, and how comfortable they would be with the knowledge generated that goes beyond a single discipline and may not be as robust as discipline specific analyses in natural sciences, could also affect the results of a transdisciplinary process. Another key point that can be brought into focus is that transdisciplinary research does not necessarily adopt one method. There are several different methodologies adopted for information generation, knowledge integration, and consensus building for behavioral and institutional changes for useful action towards sustainability by the relevant actors in the relevant disciplines and sectors. Whether these methodologies, which may be chosen depending on the context, necessarily achieve the final goal of the process, and who would decide on what methods are most suited, and how it could it be justified, are aspects still not explicitly and broadly discussed in transdisciplinary research practice. However the counter argument is that the attempt to facilitate subjective practices does not require hard and fast definitions. While these definitions may be useful for disciplinary application, making them a starting point in debate acts as a barrier to evolving civil society to address sustainable development (Memmpem and Gill, 1998). The outcome of this process in a nutshell is expected to be that people understand each other well enough that common goals are possible. It is described as “a vision of democracy that involves those who wish to be involved and that recognizes that the highest expression of human rationality is not nuclear physics or econometric models, but ordinary people speaking and reasoning together on issues of common concern” (Yankelovich, 1991).

Environmental Assessment Methods in Multi-Stakeholder Planning

Several different methods and tools for integrating sustainability aspects within a participatory approach have been developed based on impact assessment techniques such as EIA, SIA, and RA. While these tools vary in name and terminology, e.g., strategic environmental assessment, strategic impact analysis, participatory social impact assessment, participatory risk assessment, and integrated assessment, they each attempt to ensure that sustainability aspects are considered within the entire planning, programming and policy-making cycle (UNEP, 2003). In this context, “integrated” means the economic, social, and environmental aspects considered together. Even though the concepts, methodology, and application in practice vary, there is an overlap among the assessment methods in how sustainability aspects are integrated. As discussed above, in addition to integrating sustainability aspects, making methods useful for multi-stakeholder collaboration and cross-sectoral integration in joint projects is a crucial aspect in sustainability planning. Hence, it is useful to analyze the strengths and weaknesses of the above methods to examine how suitable they may be as a methodology or framework for multi-stakeholder co-operation in developing joint projects and programs, especially where merging various interpretations and reconciling different sectoral objectives and priorities of stakeholders is important.

EIA, SIA, and RA were evaluated using criteria developed from a review of the literature on integrated assessments (WB, 1991; UNEP, 2003; Becker, 2004; Grosskurth and Rotmans, 2005; Lee, 2005). The evaluation criteria are structured into two sections. Concerning methodological flexibility, the following criteria are applied: 1) the method can adapt to data scarce situations (vs. full data sets); 2) the method considers a holistic view of the issues, including upstream and downstream consequences (vs. analysis limited to one or two obvious phases); 3) the method can deal with cross-sectoral issues (vs. a single-sector focus) and highlight cross-sectoral inter-linkages; 4) the method allows for assessing all dimensions of sustainability (vs. one dimension of sustainability); 5) the method has the ability to assess alternative scenarios (vs. status quo assessment); and 6) the method accommodates strategy building (vs. being limited to assessment only). Concerning stakeholder participation the following criteria is applied: 7) the method allows for stakeholder interaction at all stages of the process; 8) the method promotes consensus building for joint projects; 9) stakeholders have transparent access to information so that they can examine the assumptions made and projected outcomes of decisions; and 10) the communication of results and impacts to the stakeholders is clear and easy (Table. 2-1).

Environmental Impact Assessment (EIA)

EIA is accepted as a method that can contribute to a richer conceptual understanding of sustainable development. Usually, local legislation and laws are consulted to determine whether an EIA is required to evaluate the impacts of the project. However, many stakeholders believe EIA performs unsatisfactorily in practice (Benson, 2003; Sheate, 2003). The major criticisms of EIA are a limited consideration of alternatives, scientifically inadequate impact predictions, and the difficulties associated with involving stakeholders in a meaningful and productive manner as the analysis products do not lead to coherent interpretations (Shepard and Bowler , 1997; Wood, 2003). Stakeholder engagement plays an important role in promoting learning among stakeholder groups. However, EIAs often appear to be overwhelmingly 'technical', the procedures are not transparent, and consequently it does not support building a consensus around the outcomes of the analysis (Cashmore et al., 2004; Owens, 2004; Novek, 1995). Furthermore, EIA studies also entail difficult questions regarding system boundaries, i.e., integrating upstream and downstream activities when the study is limited to the local area. The ability to incorporate scenario and strategy development in addition to assessment is difficult and not intuitive. Many EIA applications are single-project-based, involving only direct stakeholders. Indirect stakeholders and inter-linkages of activities are harder to represent. Hence, EIA is considered to be a good way to assess a selected project, but not as well suited to reducing uncertainty and transaction costs and achieving the commitment of multiple stakeholders in joint projects for sustainable development.

Social Impact Assessment (SIA)

Social Impact Assessment is usually carried out under traditional EIA legislation in order to assess the related social implications of a project. One of the main objectives of an SIA is analyzing how a project may affect people, and how a social change could be better managed

(UNEP, 2003). In some instances, SIA is carried out with a stand-alone method integrating economic and ecological aspects in the societal point of view (Akpofure and Ojile, 2003; UNDP China, 2002). SIA typically includes a questionnaire-based survey and structured interviews. The questionnaire-based survey is administered to the population that is directly impacted by the proposed project and the direct stakeholders in the project. The questionnaire-based survey may have a large number of modules including leadership surveys (for government and local bodies), small group surveys (for groups of stakeholders), household surveys (both urban and rural), and occupation-based surveys. Structured interviews of the population and the governing bodies are used to evaluate the social impacts that are anticipated by the stakeholders and those directly affected by the project (Landcare Research, 2003). Methodology in SIA is stakeholder-based, and in the UN definition, primarily limited to identifying potential issues in a project. However, other researchers have defined SIA as having an initial phase that includes problem analysis and project design, and a main phase that includes scenario and strategy development, assessment of impacts, ranking of strategies, and evaluation (Akpofure and Ojile, 2003). Similar to EIA, it is used for sectoral project-based analysis, and does not necessarily reduce uncertainty and transaction costs, nor does it facilitate achieving the commitment of multiple stakeholders for joint project development.

Risk Assessment (RA)

Risk assessment is a principal step in a risk management process. RA typically involves measuring two quantities of risk: the magnitude of the potential loss and the probability of occurrence (Smith et al., 2000). In the estimation of risk, the two main steps are: 1) Hazard identification, which aims to determine the probability that an individual receiving a specific dose of the contaminant (chemical, radiation, noise, etc.) will develop an adverse effect; and 2) Exposure quantification, which aims to determine the amount of a contaminant (dose) that individuals in a population may receive. The results of the two steps above are combined to produce an estimated risk. Because of the different susceptibilities and exposures, this risk is expected to vary within a population. The methodology is tedious and context specific, yet in development projects, RA is used in a participatory manner involving the stakeholders. This is mainly in hazard identification rather than exposure identification, which is a highly technical and quantitative estimation process involving experts (Fisher 1991; Smith et al., 2001). RA is also a widely used tool among healthcare and policy agents in identifying potential risks in a community in a process that combines community and stakeholder judgment. It has limited usefulness in multi-stakeholder contexts for enhancing knowledge and fostering stakeholder commitment (Fisher, 1991; Andrews, 1999). At the end of the assessment, there is public involvement for feedback and comment, but since the analysis process is not very transparent, this step cannot easily merge different interpretations by stakeholders in different disciplines. RA typically has a narrow study focus, and does not facilitate incorporating upstream and downstream stakeholder inter-linkages. In addition, RA does not usually accommodate economic, social and cultural aspects, i.e., community needs and aspirations, in the analysis. RA methodology, therefore, is not a stand-alone tool that could provide a holistic perspective of development issues, and incorporate necessary aspects of sustainability for consensus building in cross-sectoral decision making and strategy development.

Summary of Comparison of Environmental Assessment Methods

The evaluation of these three methods indicates that multiple separate assessments, which would typically be project based, would be required for an integrated sustainability assessment. Using multiple methods has led to increased complexity and dissimilar interpretations by the various stakeholders. Inherent limitations in the methodologies, especially for providing a holistic view of the issues and problems, motivated the current research and the development of a technique which can accommodate transparent simplistic analysis, integrate sustainability aspects, stakeholder knowledge, and stakeholder participation throughout the planning process, and communicate results through easily understood indicators (Table 2-1).

Table 2-1. Comparison of assessment methods in multi-stakeholder contexts

	Criteria	Method		
		EIA	SIA	RA
1.	Adapt to data scarce situations	Yes	Yes	To a limited extent
2.	Consider holistic view of issues	No	No	No
3.	Deal with cross-sectoral issues and highlight inter-linkages	To a limited extent	To a limited extent	No
4.	Assess all dimensions of sustainability	Yes	Yes	To a limited extent
5.	Assess alternative scenarios	To a moderate extent	Yes	To a limited extent
6.	Accommodate strategy building	No	Yes	No
7.	Stakeholder involvement in all stages	No	Yes	No
8.	Promote consensus building	To a moderate extent	To a moderate extent	To a limited extent
9.	Transparent assessment and results	To a limited extent	To a moderate extent	To a limited extent
10.	Clear and easy communication of results	To a limited extent	To a moderate extent	To a limited extent

Life Cycle thinking and Life Cycle Assessment

Background

Life cycle thinking (LCT) is a concept that people use unwittingly in their daily lives (Boustead, 1996). A real life example is the decision to purchase an expensive, yet a durable and fuel efficient vehicle versus a cheaper alternative; the cost of operation, maintenance, and the secondary market price of the vehicle are intuitively factored into the decision making apart from the initial cost of the vehicle that reflects the production cost. In a similar sense, the earlier application of the LCT concept has focused on the economic performance of products over their life cycle phases such as production, use and maintenance, and end-of-life options. The need to use LCT to assess environmental performance has evolved in the 1960's with modeling world resource systems and pollution levels at a broader scale (Boustead, 1996). At the time, those analyses were termed as energy and resource analysis. Over the years, similar kind of analyses were referred to as eco-balance, eco-profile, and cradle-to-grave analysis, which essentially attempted to measure the energy and materials depletions, and resulting pollution levels (emissions) in a defined system (Boustead, 1996; Udo de Haes, 2007).

In broader terms, LCT is referred to as a qualitative framework to assess and understand systems. Often, in an industrial context, LCT brings out the important questions such as "What are the systemic impacts of an industrial action or process? If certain actions are taken, what are the resulting consequences throughout the supply chain and beyond to natural systems?", considering the fact that natural and man-made systems are inseparable. LCT does not produce easy answers, but it does provide a framework to recognize and understand complex systems and their interrelationships (Leflar, 2008). On the other hand, LCA is referred to as rather a quantitative tool used to develop partial answers to the questions posed by LCT.

Process-Based Life Cycle Assessment

The term "life cycle assessment" and the first approach to conduct LCA was officially agreed at the first Society for Toxicology and Chemistry (SETAC) conference involving 54 of the practitioners in the field held in Vermont, USA in 1990. The first approach of conducting LCA was termed as process-based LCA referring to itemizing the inputs (materials and energy resources) and the outputs (emissions and wastes to the environment) along the phases of producing a product or a service. The important challenge addressed in this workshop was how to link the measurable or estimated input and output processes of industrial systems to the resulting environmental impacts which is widely unknown (SETAC, 1991). The first technical framework for conducting Process-based LCA was developed at the above conference. It included three distinct phases to address the above challenge. The illustration of the first SETAC LCA framework, also known as the SETAC triangle is given in Fig. 2-3-A. The description of the three phases is as follows:

- The inventory phase: provide a detailed description of the inputs of energy and raw materials into the system and the outputs of solids, liquids and gaseous wastes from the system.
- The interpretation phase: provide inventory results that are linked to identifiable environmental problems.
- The improvement phase: provide the system modifications in some way in an attempt to reduce the environmental impacts.

In 1992, at the Leiden workshop, this triangle was modified as shown in Fig. 2-3-B introducing the goal definition, scoping and impact assessment explicitly into the framework.

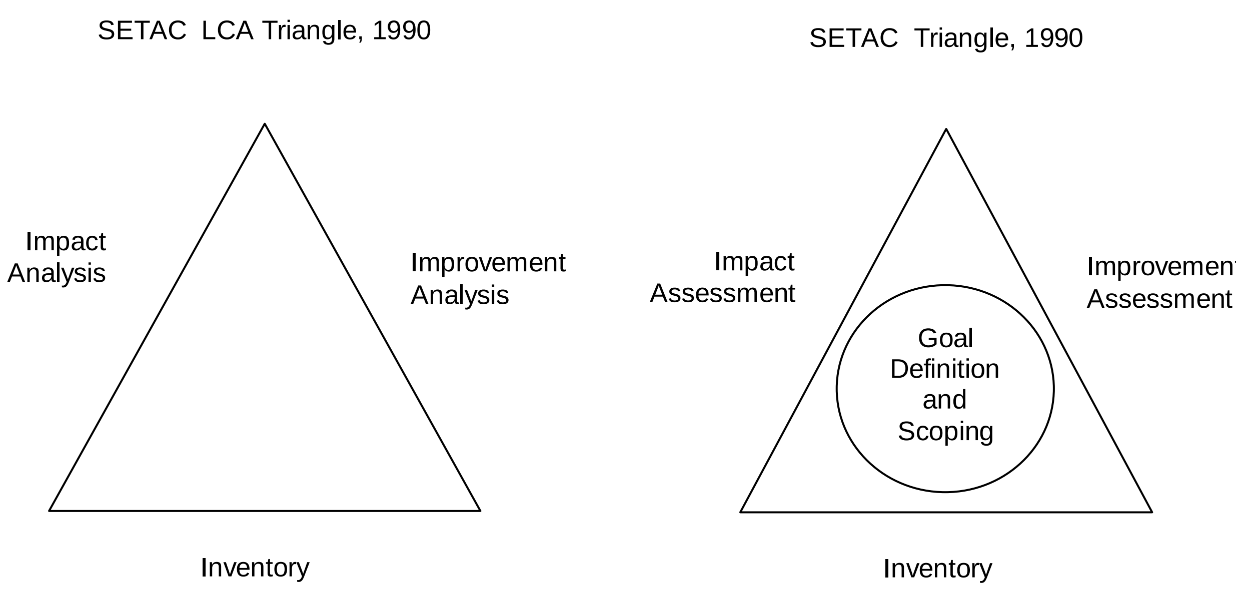

Figure 2-3. SETAC frameworks for Life Cycle Assessment (SETAC, 1991). A) 1990 First version. B) 1992 Modified version.

Standards for Life Cycle Assessment

In 1997, with the inputs from SETAC World Congress in Vancouver, 1995, the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) introduced the national and international standards for LCA with the ISO 14040 environmental management series. In ISO terms, LCA is a “compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle” (ANSI / ISO 1997). A network of national standards institutes from 146 countries developed a standard set of guidelines (ISO14040) for conducting LCA studies. It includes 1) goal and scope definition, 2) life cycle inventory (LCI), 3) life cycle impact assessment (LCIA), and 4) interpretation phases. The four phases of the ISO 14040 framework are illustrated and defined in Figure 2-4.

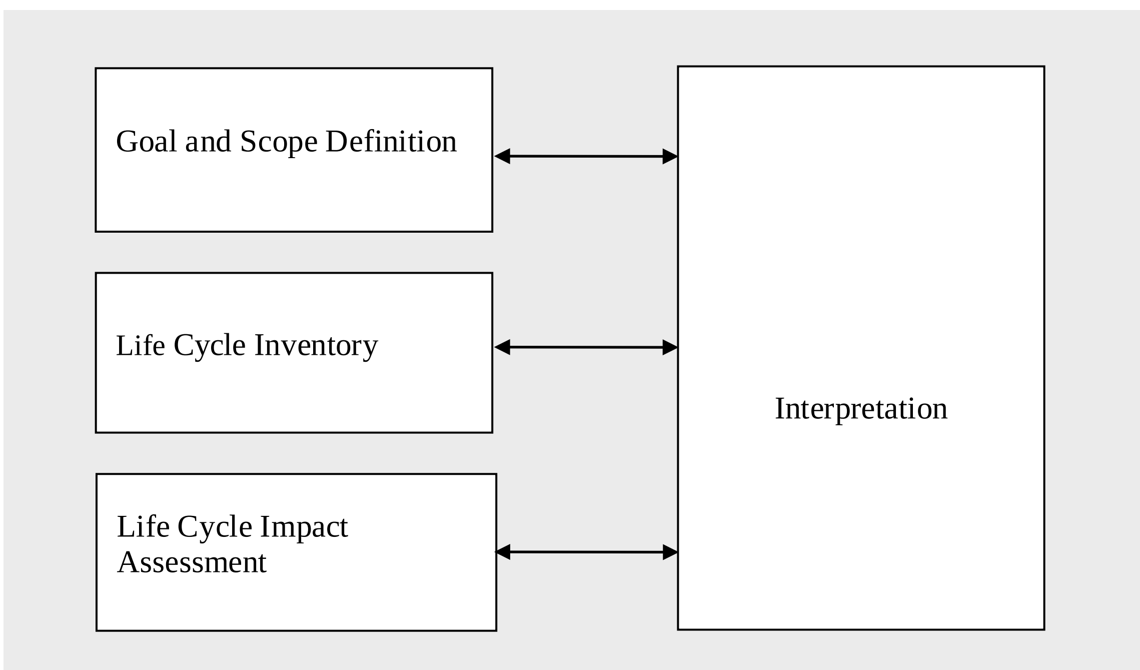

Figure 2-4. ISO 14040 framework for Life Cycle Assessment

The descriptions of the above conventional phases of the assessment are as follows:

- Goal and Scope definition: specifying the reason for conducting the study, intended use of study results, intended audience, boundaries for analysis, data requirement, functional unit on which material and energy consumption data are allocated, and study limitations.

- Life Cycle Inventory (LCI): collecting, validating and aggregating input and output data to quantify material use, energy use, environmental discharges, and waste associated with each life cycle stage.

- Life Cycle Impact Assessment (LCIA): using impact categories, category indicators, characterization models, equivalency factors, and weighting values to translate an inventory into potential impact on human health and the environment.

- Interpretation: assessing whether results are in agreement with defined goals and scope, providing an unbiased summary of the results, defining significant impacts, and recommending methods for reducing material use and environmental burdens.

Inventory Databases and Impact Methods

In typical LCA assessments for energy and material analysis, the boundaries include the typical life cycle phases such as 1) material extraction, 2) manufacturing, 3) transport, 4) use and maintenance, and 5) end-of-life disposal as depicted in Figure 2-3. Defining the boundaries in terms of which unit processes to be included and which emissions to be measured is a subjective task depending on the nature of the problem to be assessed. The emission inventories for unit processes are developed by a number of research groups worldwide. Some of the commonly used inventory databases are summarized in Table 2-2. These databases are developed using direct industry data or published research data particular to a geographic region. The inventory categories and how the emissions are measured or modeled can be different from one database to the other, i.e., emission factors for similar unit process in different LCI databases could be substantially different. A collection of databases are available in software developed to build LCA process modules, and estimate respective emissions and resource depletions choosing appropriate databases, or inserting own databases from scratch (Pre Constantans, 1996-2009). The ecoinvent data v.2 of the Swiss Center for Life Cycle Inventories has compiled the available LCI databases from different parts of the world. It accommodates about 4,000 datasets for unit processes often used in LCA case-studies harmonizing the terminologies, number of LCI categories, and energy and material allocation criteria (Swiss Center for Life Cycle Inventories, 1998-2009).

Table 2-2. Product-based LCI databases and descriptions

LCI databases	Description
ecoinvent v2	Contains harmonized international and industrial life cycle data for nearly 4000 industrial processes. Developed by the Swiss Centre for Life Cycle Inventories.
ETH-ESU 1996	Includes 1200 unit processes and 1200 system processes related to transport, processing, and waste treatment. Developed by ETH-ESU, Switzerland.
BUWAL 250	Includes packaging materials, including data on packaging materials (plastic, carton, paper, glass, tin plated steel, and aluminum), energy, transport and waste treatment. Developed by the Swiss Ministry of the Environment.
IDEMAT 2001	Includes processed related to engineering materials, energy, transport. Developed by Delft Technical University, The Netherlands.
IVAM	Includes data on materials, transport, energy and waste treatments, and focuses primarily on Dutch data. Developed by IVAM Environmental Research, Amsterdam, The Netherlands.
Franklin US LCI	Includes North American inventory data for energy, transport, steel, plastics, processing. Developed by Franklin Associates, USA.

Some LCA studies are terminated at the inventory stage. Typically, the inventories are converted to environmental impacts or damages using several different methods usually based on numerous chemical fate and transport modeling methods. The fate and transport models are global or regional with different approximations on spatial, temporal and other model parameters. The impact modeling is conducted at mid-point or end-point (damage level). Figure 2-5 illustrates an example list of mid-point impact and end-point categories given in Impact 2002+ (Jolliet et al., 2003).

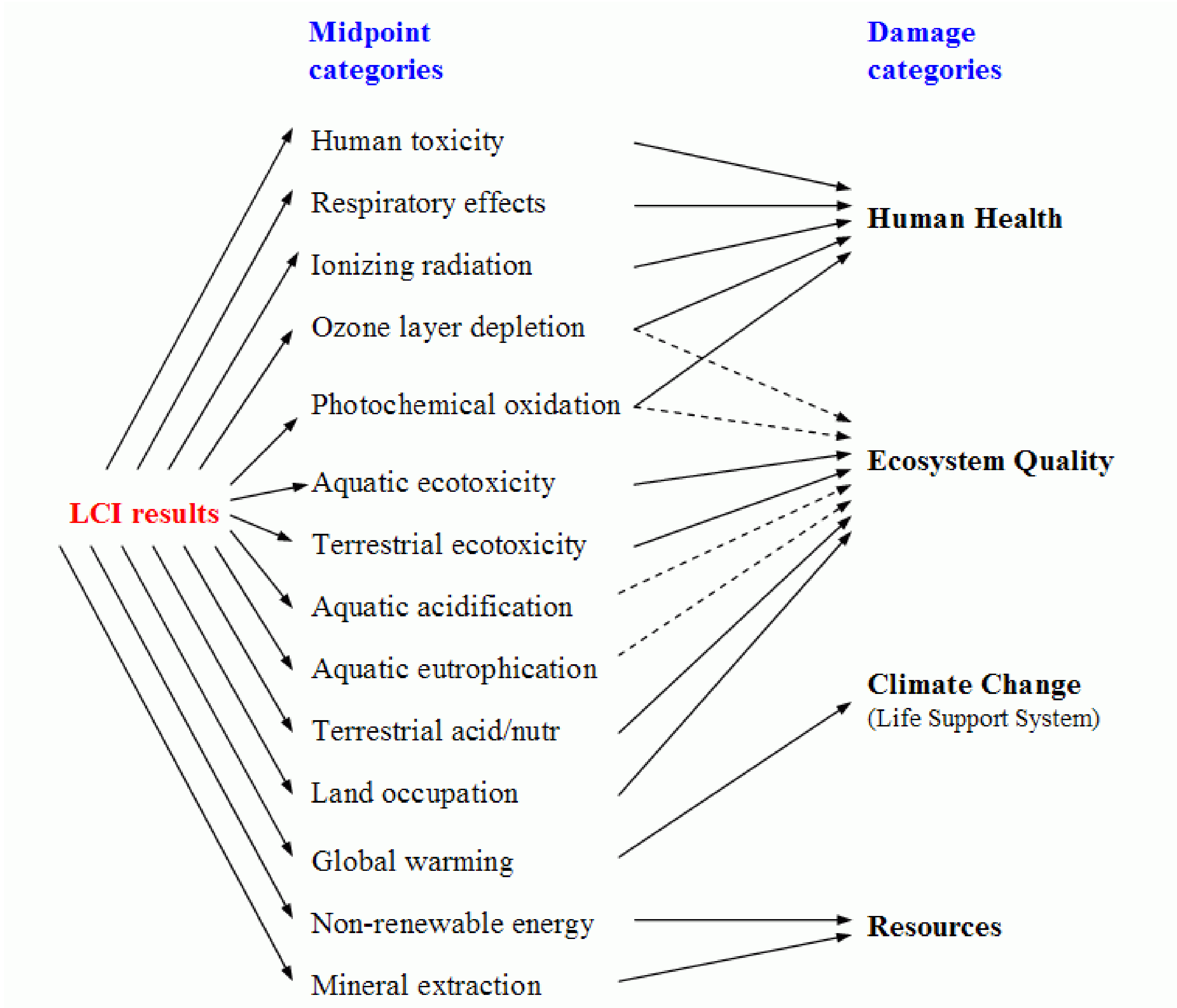

Figure 2-5. An example list of mid-point and end-point (damage) LCIA categories

Mid-point impact modeling essentially attempts to classify the hundreds of inventory categories into a few environmental issues of interest; global warming potential (GWP), acidification, aquatic toxicity, and ozone depletion potential are a few examples of mid-point LCIA (Figure 2-3). Mid-point LCIA characterization factors are developed to meet scientifically and internationally acceptable standards when possible. Some mid-point classifications such as aquatic toxicity remain too complex to be modeled due to considerable parameter uncertainties and sensitivities (Bare, 2000; Bare, 2006).

End-point impact modeling, also referred to as damage modeling, further classifies the mid-point impacts into a fewer damage categories such as human health, ecosystem health, damage to resources, and climate change (Figure 2-5). These were suggested as more relevant to and easy to interpret by the decision makers. However, for the scientific modeling for end-point impact factors, the assumptions and scientific data requirements are significant. Essential risk factors for all inventory categories are not available, and hence, not all the inventory categories are included in the end-point damage categories. The uncertainty in the end-point impacts is far greater relative to the mid-point impacts (Bare, 2006).

Commonly used LCIA methodologies are given in Table 2-3. One of the critical flaws in the past has been, when different LCIA methods are applied to the same inventory, the resulting impacts have led to different conclusions. The resulting choices can be significantly different according to the preferences. In the latest ecoinvent data v2.0, most of the current LCIA methods are compiled resolving such discrepancies to some extent. The impact categories are sometimes normalized and, or, weighted in order to assign a single score to the option or options in the evaluation. The normalization values vary in different impact methodologies. The weight combinations for impact categories vary depending on the subjective preferences and viewpoints of the stakeholders.

Economic-Input-Output Life Cycle Assessment

Economic-Input-Output life cycle assessment (EIO-LCA) is another approach for conducting LCA. The method development was initiated in the 1970’s by the economist Wassily Leontief based on his earlier economic input-output theory developed in the 1930’s. EIO-LCA

Table 2-3. Commonly used LCIA methodologies and their descriptions

LCIA Method	Description
Eco-indicator 95, Eco-indicator 99	Elaborates an endpoint approach for damage modeling. Developed by Pre Consultants, The Netherlands.
CML 1992, CML 2 2000	Elaborates a problem-oriented midpoint approach. Developed by Centre for Environmental Studies (CML), University of Leiden, The Netherlands.
EDP	Presents the creation of Environmental Product Declarations (EDP) following the recommendations of the Swedish Environmental Management Council. Developed by International EDP Consortium.
EDIP 1997 and 2003	EDIP'97 Presents a midpoint approach while EDIP'2003 extends to spatially differentiated characterization modeling closer to a damage-oriented approach. Developed by Institute for Product Development, Technical University of Denmark.
EPS 1996 and 2000	Adopts a damage modeling approach with characterization factors defined by location, size and temporal occurrence. Developed by the Centre for Environmental Assessment of Products and Material Systems.
IMPACT 2002+	Links all types of LCI results via 14 midpoint categories to 4 damage categories. Developed by University of Michigan.
IPCC 2001	Presents damage factors for emissions that contribute to climate change. Developed by International Panel on Climate Change of the World Meteorological Organization and by the United Nations Environment Program.
TRACI	Adopts a midpoint approach, defining characterization factors specific to the US. Developed by the US Environmental Protection Agency.

method estimates the energy and material consumption and resulting environmental emissions in the economic sectors considering the entire economy as the boundary. In the mid 1990's, with the technology to solve large-scale matrices which represent nearly 500 sectors of the US economy, the researchers at the Green Design Institute of the Carnegie Mellon University operationalized Leontief's method for wider use by the LCA community (CMU Green Design Institute, 2009). EIO-LCA methodology is developed as a user-friendly on-line web application.

The underlying basic assumption in using economic-input-output matrix which reflects the economic value of the sectors of the economy to compute the amount of environmental discharges in the economic sectors is that economic value of a sector and the resulting environmental emissions are linearly related. For example, $1 worth of product from a sector generates a certain amount of CO_2 emissions, $10 worth of product from the same sector would generate 10 times the CO_2 emissions compared to the previous case.

An economic sector represents a collection of industry types. Both economic and environmental data that are categorized by industry sectors using the North American Industry Classification System (NAICS) or other generic categories (e.g., the USDA categorizes farms by crop type). The industry sector data usually does not directly map onto the matrix of economic sectors. The data is disaggregated and allocated to the appropriate economic sectors using weighted averages, information from data sources or other publications (Hendrickson and Horvath, 1998). EIO-LCA models do not segregate the major imports and exports related transactions and resulting emissions into the input-output matrix as the underlying theory is developed for a confined single economy.

EIO-LCA essentially generates an inventory of emissions corresponding to the economic activities, i.e., change in demand in the sectors. When developing an LCA model, all the material and resource demands should be identified and related to an appropriate sector, and a monetary value for demands should be assigned. This monetary value has to be expressed in the currency used in the economy discounted using appropriate economic index to the most recent or relevant economic year of the available EIO-LCA model. The demand should be expressed as producer prices or consumer prices as appropriate. When the demand is inserted to a relevant sector of the EIO-LCA model, the results represent the increased economic and environmental output by all relevant sectors of the economy. These outputs for the most part are related to the production phase; the use phase and end-of-life phases are not directly included in the results. However, additional analyses using the EIO-LCA method can capture these life cycle stages (CMU Green Design Initiative, 2009).

The EIO-LCA models stop mainly at the LCI stage, with the exception of greenhouse gas emissions taken to the midpoint impact stage and presented as GWP. The inventory categories are limited to economic activity, conventional air pollutants, greenhouse gas emissions, energy, toxic releases, and employment. The inventory results of environmental emissions or resource consumption associated with the life cycle of an industry sector are not transformed to estimate the actual environmental or human health impacts from these emissions or consumptions.

Currently EIO-LCA models have been developed for the Netherlands, Denmark, and Japanese economies (Table 2-4).

Table 2-4. EIO-LCA databases and their descriptions

EIO-LCA databases	Description
US Input Output database	Utilizes Input-output table of 481 sectors of the US economy for 1998. Developed by Carnegie Mellon University, USA.
Danish Input Output database	Utilizes the Danish statistical data (NAMEA) for 1999. Developed by Danish Environmental Protection Agency.
Dutch Input Output database	Utilizes Input-Output table of 105 economic sectors compiling data from 1973 to 1990 with foreign input output tables for the OECD and non OECD regions. Developed by 2.-0 LCA Consultants, Denmark.
Japanese Input Output database	Utilizes the Input-Output table of 400 industrial sectors in Japan. Developed by the Environmental Technology Laboratory of the Corporate Research & Development centre of Toshiba Corporation, Japan.
Canadian Input Output database	Utilizes input-output table of 105 sectors of the Canadian economy for 2002. Developed by University of Toronto and Statistics Canada.
German Input Output database	Utilizes input-output table of 58 sectors of the German economy for 1995. Developed by German Design Institute.
Chinese Input Output database	Utilizes input-output tables of 122 sectors of the Chinese economy for 2002. Developed by National Statistics Bureau of China.

Hybrid Life Cycle Assessment

Hybrid LCA is a methodology that combines the Process-based LCA and EIO-LCA where one methodology alone may not be adequate to reasonably model the life cycle consumptions, emissions, and impacts, or combination of methods could improve the relevance and interpretation of the results to a greater extent. For example, if a LCA is conducted to improve the environmental performance of a product line within a facility, a process-based LCA would be more useful. However, if broader decisions are need to be taken considering the entire supply chain of a product, then incorporating the EIO-LCA information would be meaningful to get an idea about consumptions and emissions to the other sectors.

In conducting process-based LCA, the processes should be well defined to match the unit processes available in databases or other sources to generate the appropriate inventories. But in instances where the information on the specific processes is constrained or unavailable, it would be useful to generate generic inventories. However, when aggregating the inventories developed using the two approaches, care must be taken to do so meaningfully; for example, isolating the respective industry from the rest of the sector, extracting emissions from the sectors that match with the defined boundary of analysis, and so forth.

Limitations of Life Cycle Assessment Approaches

The two main LCA approaches as described above are the process-based LCA and EIO-LCA. Both approaches have advantages as well as limitations in real life applications. The major concern regarding process-based LCA is the tediousness in working through the hierarchy of processes included in a model boundary. The LCI results generated using available LCI databases may be approximations considering the spatial, temporal, and technological variations. When the boundary for analysis is larger, process-based LCA is criticized as time consuming, expensive, and the results are not transparent and harder to interpret. LCIA impacts involve large amount of uncertainties and the damage factors may not necessarily reflect real impact levels, and therefore decisions could not be based on single damage scores.

The key limitations of EIO-LCA are the aggregation of industries into economic sectors, which means that the results produced are generic to a sector. The uncertainty involved in the results is considerable due to the fundamental approximation of economic activity and environmental discharges as linearly related. Specific improvements to a product or service could not be directly judged, and further process-based modeling would be necessary to compliment EIO-LCA. When imports and exports are predominant in a supply chain, the results may not adequately reflect the increased consumption and emissions from additional transportation and other logistics.

Reviewing the methodological aspects and limitations, it could be understood that LCA studies adopting either approach could only develop partial answers to the issues in concern. LCA provides only an approximation to the possible environmental impacts. Thus, LCA should be viewed as a guiding framework for understanding the likely areas of impact (Leflar, 2008).

Life Cycle Cost Assessment and Social Life Cycle Assessment

Responding to the debate on sustainable development, environment assessments methods in current practice are required to be able to capture and integrate the aspects of sustainability, i.e., economic, social, and environmental impacts. Life cycle cost assessment (LCCA) methodologies, also referred to as life cycle cost analysis or life cycle accounting have been in the industrial use in the past (Akai, 1999), but the methodologies for assessing social aspects along the life cycle phases are still new to the field (Jørgensen et al., 2008).

Life Cycle Cost Assessment (LCCA)

Early applications of LCCA have been widely used in building construction and facility management sector. In 1995, the National Institute of Standards and Technology (NIST)

Handbook 135, 1995 edition, has defined the building life cycle cost (LCC) as "the total discounted dollar cost of owning, operating, and disposing of a building or a building system over a period of time". The life cycle cost categories in the building sector could include the following (SAEED, 1999):

- Initial investments costs or capital costs: costs incurred prior to the occupation of the facility, for example, costs involving land acquisition, site preparation, project management, design and contracting, indirect administration, and construction;

- Operations costs: monthly or annual costs involving the operation of the facility, for example, monthly or annual bills for of electricity and natural gas for heating, cooling, and ventilation, water for drinking, toilet flushing and landscaping, wastewater and solid waste disposal, and debt or lease payments;

- Maintenance and repair costs: maintenance costs are scheduled costs associated with the upkeep of the facility, for example, repainting walls, doors and windows, and inspection of heating ventilating air-conditioning (HVAC) systems, plumbing systems, and other; repair costs are unanticipated expenditures that are required to prolong the life of a building system without having to replace the system, for example, repair of a broken door.

- Replacement costs: costs generated by replacement of a building system or component that has reached the end of its useful life, for example, replacing interior and exterior equipments, light fixtures, roof systems, and other;

- Residual or scrap value: is the net worth of the building system at the end of the LCCA study span. The residual value of a building is important when evaluating which items can be reused, recycled, or resold.

Similarly, LCCA is used to evaluate the economic performances of other commercial products or services in a typical life cycle phase outlined above. Typical LCCA inventory indicators would be similar to the types of cost categories as expressed above. Often, LCCAs are conducted up to the inventory stage. In current LCA studies, it could be observed that LCCA is conducted alongside life cycle environmental assessment to get a picture of the costs involved in improving environmental performance of products and services. For example, the Governor's Green Building Initiative of California has developed user-friendly on-line LCCA spreadsheets that can be used by the public for assessing life cycle cost savings from efficient energy and material consumption in green buildings (Green California, 2008).

Social Life Cycle Assessment (SLCA)

There has been an increasing interest for incorporating social aspects into the environmental LCA of products and systems in recent years. The experience is growing, and multiple approaches have been initiated to include social impacts ranging from direct impacts on workers to broader societal considerations and consequences (Jørgensen et al., 2008). Different areas of current day SLCA studies include investment (Methot 2005), design (Schmidt et al., 2004, Gauthier 2005), industrial management (Cañeque 2002, Schmidt et al., 2004, Dreyer et al., 2006, Nazarkina and Le Bocq 2006), consumers (Spillemaeckers et al. 2004) and public decision making (Hunkeler, 2006). A number of potential methodologies for conducting SLCA have been expressed in Barthel et al., 2005; Flysjö, 2006; Manhart and Grießhammer, 2006; Norris, 2006; and Weidema, 2006.

There are different view points on how to conduct SLCA. The methodological framework of SLCA as proposed by the UNEP-SETAC Life Cycle Initiative Cross-cutting Taskforce 3 on Integration of Social Aspects in LCA, suggests adopting the conventional LCA framework as specified by ISO 14040, namely: Goal definition; scope definition; inventory analysis; and impact assessment (Grießhammer et al., 2006). Dreyer et al. (2006) and Spillemaeckers et al. (2004) argue that it may not be a valid approach due to the fact that social impacts, in most situations, do not have direct links to the processes of a product or a service; rather how the process is conducted or implemented may indicate a link to the respective social impacts.

The UNEP-SETAC feasibility study on integrating social aspects to LCA brings out important considerations that go beyond the scope of traditional LCA. Some of the key points are as follows (Grießhammer et al., 2006):

- Compared to environmental and economic aspects, social aspects present special problems because they can be highly diverse and are valued very differently by different interest groups and in different countries and regions.

- Compared with the traditional environmental LCA the integration of social aspects demands a higher priority on “a process and the integration of stakeholder”.

- Integration of stakeholders bases the indicators and judgments on a broader discussion and helps to collect data.

- Social aspects such as time requirements, convenience, and prestige should be captured as key aspects of the product utility and defining the functional equivalence in comparing alternatives.

- Social impacts or benefits on the consumers should be described as part of the product utility. Social impacts on the society correspond with common or internationally accepted values and should be described as other social impacts along the life cycle.

- Traditional LCAs use mainly inventory indicators and midpoint indicators, but also endpoint indicators. But in SLCA, as much as possible, midpoint indicators should be used, as they are closer to the activities and understanding of the decision makers. For example, in SLCA of brick production, job creation in the local market could be a mid-point social indicator; resulting in poverty reduction, and the end goal of improved family health could be considered as an end-point social indicator.

- In developing SLCA indicators, combination of quantitative, semi-quantitative, qualitative, or descriptive indicators should be allowed as quantitative data and indicators alone are insufficient to cover all aspects of social impacts. The aim should be to produce accurate and relevant indicators as much as possible.

- For social indicator classification, the stakeholder approach is preferred over the classification with traditional damage impact categories (Human health, Ecosystem health, and Damage to resources). In the stakeholder approach, the stakeholder categories where the impacts should be classified includes: workforce (workers or employees), local community, consumers, and society (national and/or global).

- Establishing a comprehensive inventory of SLCA and guidelines to develop them would take 10 to 15 years of research work.

Figure 2-6 extracted from Jørgensen et al. (2008) summarizes the SLCA indicator categories used by different SLCA approaches by different researchers, and whether the indicators are quantitative. In the current SLCA studies, midpoint indicators are preferred over endpoint indicators. There are still debates on whether the SLCA indicators should be site-

A. Impact categories and indicators at midpoint level

Impact categories	Barthel et al.	Cañeque	Dreyer et al.[1]	Flysjö[2]	Gauthier	Hunkeler	Manhart & Grießhammer	Méthot[3]	Nazarkina & Le Bocq[4]	Schmidt et al.	Spillemaeckers[5]	Included in approaches
	Number of indicators, quantitative/descriptive (q/d):											
Human rights												
Non-discrimination, including indicators on diversity, such as composition of employees on all levels according to gender, age group, disabled, part-time workers and other measures of diversity	2,q	10,q	1,q	3,q	1,d		1,d	?,q	4,q	5,q	2,q	10
Freedom of association and collective bargaining	2,q		1,q	1,d			1,d	?,q	1,q	1,q	8,q	8
Child labour, including hazardous child labour	2,q		1,q	1,d			1,d		1,q	1,q	3,q	7
Forced and compulsory labour	1,q		1,q	1,d			1,d		1,q	1,q	3,q	7
Labour practices and decent work conditions												
Wages, including equal remuneration on diverse groups, regular payment, length and seasonality of work and minimum wages	1,q	3,q		6,q 1,d			2,d	?,q	4,q	1,q	5,q	8
Benefits, including family support for basic commodities and workforce facilities				1,d		1,q	1,d		6,q	4,q		5
Physical working conditions, including rates of injury and fatalities, nuisances, basal facilities and distance to workplace	2,q	2,q	1,q	2,q 3,d	1,d		1,d	?,q	4,q	6,q	9,q	10
Psychological and organisational working conditions, such as maximum work hours, harassments, vertical, two-way communication channels, health and safety committee, job satisfaction, and worker contracts				1,d	1,d		2,d		10,q	1,q	8,q	6
Training and education of employees		2,q		2,d	1,d		1,d	?,q	6,q	1,q	2,q	8
Society												
Corruption, including incidents/press reports concerning fraud, corruption and illegal price-fixing, and violation of property rights.					1,d		2,d		2,q	1,q		4
Development support and positive actions towards society, including job creation, support of local suppliers, general support of developing countries, investments in research and development, infrastructure, and local community education programmes	6,q			1,q			12,d	?,q	12,q	8,q	5,q	7
Local community acceptance, such as complaints from society, and presence of communication channels					1,d			?,q	4,q	1,q	5,q	5
Ensuring of commitment to sustainability issues from and towards business partners							2,d				6,q	2
Product responsibility												
Integration of costumer health and safety concerns in product, such as content of contaminants/nutrients, other threats/benefits to human health (including special groups) due to product use, and complaint handling system				2,q	1,d					5,d	1,q	4
Information about product to users, such as labelling, information about ingredients, origin, use, potential dangers, and side effects.										1,q 2,d	2,q	2
Marketing communications, such as ethical guidelines for advertisements										1,d		1

B. Impact categories and indicators at endpoint level

Impact categories	Number of indicators, quantitative/descriptive (q/d)	
	Norris	Weidema[6]
Mortality	1,q	?
Morbidity	1,q	?
Autonomy		15?,q
Safety, security and tranquillity		6?,q
Unequal opportunities		?
Participation and influence		?

The numbers, d, and q in Table 1 and 2 refer to the number of indicators included on the given impact category, and whether the indicators are descriptive (qualitative) or quantitative

[1] Dreyer et al. (2006) include both some universal indicators and some site-specific indicators that are defined locally. Only the former, which all address human rights of the workers are included in the table. Several of these, however, do also address impact categories included under the 'labour practices and decent work conditions' category.

[2] Flysjö (2006) includes some economic indicators not included in the table. These are: Production costs, values added and government subsidies.

[3] The SLCA-FIDD tool (Méthot 2005) is based on a questionnaire comprising more than 200 questions. The questionnaire is confidential and it is therefore difficult to state the exact number of indicators for each impact category included.

[4] The list of indicators is a summary based on many of the other SLCA approaches.

[5] Spillemaeckers et al. (2004) also include several indicators concerning environmental, overall management issues, such as compliance with legislation, that are not included in the table.

[6] Only examples of indicators are given in Weidema, 2006, hence the question marks.

Figure 2-6. Midpoint and endpoint SLCA impact categories compiled by Jørgensen et al., 2008.

specific and less comprehensive (Norris, 2006). Hunkeler, 2006 argues that generic data for SLCA should be national or sector specific, instead of striving towards regionally or globally applicable data as in the traditional LCA.

Discussion: LCA in Sustainable Development Planning

LCA so far has not been identified as a tool used for assessing impacts and integrating economic, social, and environmental aspects within participatory development planning approaches. Although the life cycle thinking and assessment concept has immense relevance in assessing the upstream and downstream of development issues and interventions in a systematic manner, the conventional approaches of conducting LCA may not necessarily contribute to meeting the challenges of multi-stakeholder decision making environments.

From the literature review on various LCA methods, it can be observed that the application of LCA remains a tedious technical tool confined to assessing economic, social, and environmental performance of industrial or commercial products and services. There are increasing concerns regarding the transparency of the analyses, the communication of results, and the robustness of the conclusions. The concerns are escalated when multiple stakeholders have a role to play not only in making decisions, but also in committing resources. Often, LCA studies are conducted for a single client, centered on the client’s needs and objectives. In current practice, analyses are typically conducted by experts, and stakeholders are primarily involved in interpreting and communicating the results and conclusions. This may be useful in industrial single-client based applications, but in the development field, where multi-stakeholder interactions are complex and political, more than communicating robust LCA results, a process of mutual learning and assessment together with the stakeholders has a greater importance in meeting the challenges of multi-stakeholder decision making environments. An important aspect in reaching consensus for collective action in multi-sector, multi-discipline development contexts is to build shared stakeholder perceptions and understanding of the state of the system and the potential solutions.

In typical development planning processes, the important decisions are resource-driven and time-bound, which in most instances, have contributed to failing to meet sustainable targets. According to literature on transdisciplinarity, it was evident that transdisciplinary learning could be an integral part of integrated development planning processes. Scientific knowledge is required to be integrated with non-scientific knowledge that may not necessarily be quantifiable, yet be important in collective decision-making for pragmatic action. Thus, if LCA is to be meaningfully used in integrated development planning where multiple stakeholders from different sectors and disciplines have vested interests and different knowledge capacities, it is necessary to modify LCA and integrate it into a transdisciplinary learning process, so that the data and information are gathered, processed, and discussed in a transparent and interactive manner.

Hence, that interactive element has to be integrated into the LCA assessment process to engage the stakeholders from different sectors and disciplines in structured dialog for narrowing down bounded rationalities and different interpretations of information. It is hypothesized that each step of conducting LCA should be interactive to the level possible. Similar to the discussions of SLCA, much is needed to produce traditional indicators that can provide robust information to the stakeholders. Site-specific indicators which are not universally accepted should also be investigated and generated in a quantitative, qualitative or descriptive manner enhancing greater relevance of information to the stakeholders, especially when consensus on the actual implementation of sustainable interventions is a priority.

The more the stakeholders comprehend the data, the process, and the meaning of the results, and could envision the economic, social and environmental costs, benefits, and risks, the more consensus building on collective action becomes an achievable goal. The next Chapter discusses the features and modifications of life cycle assessment from this perspective, and discusses the development of an LCA-based tool for informed participatory decision making while promoting cross-sectoral integration for multi-stakeholder development programs and projects.

Rating and Ranking Methods in Multi-Stakeholder Contexts

In participatory planning processes, prioritizing issues to be addressed, evaluating and comparing alternative solutions, and selecting the most sustainable solutions to implement within a certain criteria and constraints are essential milestones. There are various methods used in current participatory planning processes to finalize the conclusions on the above. Some of the key methods include Rating, Ranking, Paired Comparison Analysis (PCA), Analytical Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), and Simple Multi-Attribute Ranking Technique (SMART). These methods are briefly analyzed to check their suitability for multi-stakeholder planning contexts where stakeholders are in the center of applying these methods. The methods are looked at as a support tool that can be used to structure the information derived from participatory assessment methods and assist further negotiations in situations where prioritizing or selecting among the alternatives which do not show a clear dominance over the other.

Rating or Scores

Rating or scoring is one of the simplest and easiest forms of appraisal of the value of an alternative or a choice. It indicates a standing or a position regarding an alternative or choice on a quantitative or a qualitative scale (Coe, 2002). An example of a qualitative scale can be a score of poor, fair, very good, or, excellent. An example of a quantitative scale can be a score of 0% to 100% or 1 to 5. These scores are described as ordered categorical. With respect to the latter quantitative example, an observation scoring 3 is considered as higher than an observation scoring 2, but it cannot project that it is better by the same amount that an observation scoring 5 is better than an observation scoring 4 (Coe, 2002). In a participatory development planning process, this method is often used in assessing stakeholder judgment and preferences as the method is sufficiently simple to be communicated to the stakeholders, and to be meaningfully used by the stakeholders. However, when there are multiple criteria to be considered in evaluating multiple alternatives, the scoring or rating alone may not be adequate to handle the complexity.

Ranking

Ranking is also a simple method to highlight the preference among the alternatives or choices. In many participatory evaluations on preference, the data are collected by guiding the stakeholders to rank alternatives (Coe, 2000; Coe, 2002). The alternatives are placed in order of preference, but with no attempt to describe how much one alternative differs from the other. For example, alternative A is ranked above alternative B, and alternative C is ranked above B, yet none of the alternatives may be considered as sufficient. The data would look the same in the case where a stakeholder placed the alternatives in the same order (Coe, 2002). Similar to ranking, when multiple criteria are to be considered in evaluating multiple alternatives, the ranking process alone is inadequate to handle the complexity.

Paired Comparison Analysis (PCA)

PCA also known as Paired Choice Analysis helps to work out the importance of a number of alternatives relative to each other. The method is known to work where there are conflicting demands on resources and also when comparing completely different alternatives. When there are several criteria to assess the performance of the alternatives, paired comparison can be conducted for each criterion, the alternative that performs the best against the specific criteria can be selected. If there is a clear dominance by one or two alternatives against all criteria, then the use of the method would be successful. Otherwise, the method would still leave the selection open ended. The paired choice matrix is a visual method that can promote group discussions and participation. The method is considered as not too complex for the participatory planning processes (Mind-Tools, 1995-2009).

Analytical Hierarchy Process (AHP)

AHP is a multi criteria decision making method. The method is particularly used for complex decisions involving decision elements that are difficult to quantify. The method assumes that in situations where the problem at hand is complex, the natural human reaction is to cluster the decision elements according to the common characteristics (Saaty, 1980). The first step of the process is to decompose the decision goal into its constituent parts, progressing from the general to the specific. The hierarchical structure comprises a goal, criteria and alternative levels. Each set of alternatives can be further divided into an appropriate level of detail. The more criteria included, the less important each individual criterion may become. By making pair-wise comparisons at each level of the hierarchy, participants can develop relative weights called priorities to differentiate the importance of the criteria. The a relative scoring-scale recommended by Saaty (1994) is 1 through 9, with 1 meaning no difference in importance of one criterion in relation to the other, and 9 meaning one criterion is extremely more important than the other, with increasing degrees of importance in between. The essence of the AHP calculations involves solving an eigenvalue problem involving the reciprocal matrix of comparisons. The relative weights are then synthesized through the model, yielding a composite score for each alternative at every level of the hierarchy, as well as an overall score for the alternatives (Grandzol, 2005). When problems become complex with more criteria and alternatives, it is hard to justify and sufficiently explain the reasons why one alternative is better, or more preferable than another. In a participatory development planning situation, the mathematical requirements and the communication of the method would not be easy.

Multi-Attribute Utility Theory (MAUT)

The conceptual basis of this method is that the decision makers act to maximize a utility or a value function that depends on specific criteria or attributes; typically an expected value of a utility function (Dyer, 1992; Wallenius, et al., 2008). There are two categories of MAUT problems: multiple criteria discrete alternative problems and multiple criteria optimization problems. The multiple criteria discrete alternative problems usually consists of modestly sized collection of alternatives, and the optimization problems consists of a very large or an infinitely many alternatives defined by a system of equations. The multiple criteria optimization problems are likely to require relatively more computational resources than discrete problems and are designed to handle scientifically complex problems. The multiple criteria discrete problems capture the decision maker’s utility mathematically to estimate the alternatives’ expected utility (Wallenius, et al., 2008). The discrete methods are intended to create an interactive thinking environment as part of the process. The discrete MAUT problems typically have to follow the following steps: a) identify what is important (hierarchy), b) identify the relative importance (weights) among criteria or attributes, c) identify the utility functions of criteria, and d) identify how well each alternative does on each criterion (utility scores or rating). In a participatory planning context with sets of quantitative as well as qualitative criteria with scientifically undefined system equations, the discrete alternative method would be more relevant. In a developing country local scale planning contexts, identifying non-linear utility functions, communicating, and applying the method would still be tedious.

Simple Multi-Attribute Rating Technique (SMART)

The concept behind the method is the same as MAUT, and can be referred to as the simplest form of the MAUT based methods. Once the important criteria are identified, they are ranked and rated (weighted). The relative weights for the attributes need to be agreed upon in a group of decision makers. The performance of the alternatives needs to be rated (discrete utility values) against the individual criteria or the attributes. The performance of the alternatives against criteria is simple and is the weighted algebraic mean of the utility values. The method is simple and additive as it does not define utility functions that reflect the range of utility values from worst utility value level to best among the alternatives (Fülöp, 2005): in complex decision making contexts, this is considered as a shortcoming. Edwards (1977) proposes a simple method to assess weights for each of the criteria to reflect its relative importance to the decision. First, the criteria are ranked in order of importance and 10 points are assigned to the least important criterion. Then, the next-least-important criterion is chosen, more points are assigned to it, and so on, to reflect their relative importance. The final weights are obtained by normalizing the sum of the points to one (Fülöp, 2005). Edwards and Barron (1994) points out that the comparison of the importance of attributes is meaningless when it does not reflect the range of the utility values of the alternatives as well. However, in a scientifically less complex, multi-stakeholder development planning context, this method can serve as an easily implementable method.

Summary of Methods

The evaluation of the above methods indicates that rating, ranking, and simple multi attribute theory are relatively simple methods that can be implemented in a participatory development planning process, where stakeholder capacities of interpreting and being able to involve in the method applications vary to considerable extents. AHP and MAUT are mathematically sound methods, yet the complexity of the analysis may not be transparent, or it could not be easily communicated in some planning contexts. PCA is a relatively easier method to communicate and apply, yet the method easily becomes tedious when the number of variables in the analysis increases. Rating and ranking for that matter may not be useful to reflect a clear view point, but may be useful to build up further discussion among the stakeholders that may improve the negotiation and consensus process. Section 3 outlines a modified rating and ranking based method similar to SMART which can be used for prioritizing development issues and selecting among alternative solutions by the stakeholders in a participatory manner.

Table 2-5. Comparison of rating and ranking methods in multi-stakeholder contexts

Criteria	Method					
	Rating	Ranking	PCA	AHP	MAUT	SMART
How easy it is to communicate the methodology	Easy	Easy	Relatively easy	Not easy	Not easy	Relatively easy
How easy it is for the stakeholders to participate	Easy	Easy	Easy	Not easy	Not easy	Easy
How easy it is to conduct the analysis	Easy	Easy	Not easy	Not easy	Not easy	Easy
How transparent is the analysis	Trans-parent	Trans-parent	Trans-parent	Not Trans-parent	Not Trans-parent	Trans-parent
How easy it is for the stakeholders to interpret results	Easy	Easy	Relatively easy	Not easy	Not easy	Easy
How useful it is when the alternatives to evaluate are many	Some-what useful	Some-what useful	Not useful	Not useful	Not useful	Useful
How relevant it is when the criteria to be considered are many	Some-what useful	Some-what useful	Not useful	Not useful	Not useful	Useful
How useful it is when the stakeholder groups are bigger	Useful	Useful	Some-what useful	Some-what useful	Some-what useful	Useful

Summary

The discussions on sustainable development express that it should be an adaptive learning process involving the respective stakeholders understanding their systems for suitable action in better managing quality of life while preserving resources for the future. Global sustainable development programs such as Agenda 21 and MDGs acknowledge the importance of environmentally responsible decision making and outline strategies and targets to enhance economic, social, and environmental well-being of all people. While there should be global and national level strategies, bottom-up community level development planning and implementation is identified as a key approach to achieving sustainability. Sustainable settlement development is a key target in Millennium Development Goal 7, Ensuring Environmental Sustainability. Agenda 21 recognizes it as a multi-faceted and multi-dimensional problem that needs integration of multiple sectors such as urban infrastructure and services, social services, and economic opportunities, and improvement of technological knowhow and human and institutional capacities.

Integrated development planning at local level involving community and other responsible stakeholders is a vital response to the call by the global sustainable programs. Integration of sectors and programs for collaborative action is found to be a challenging process. Decision frameworks that could minimize factors that affect integration acknowledging the political nature of the multi-stakeholder development environment are limited.

Systems thinking helps to broadly identify causes of issues in a system. Based on systems thinking, a variety of principles and tools for the purpose of analyzing and changing systems has evolved. In development planning contexts, systems thinking tools are useful to identify and visualize key driving forces, interconnectivities and level of interdependencies of current issues or future transitions, but the use is limited.

Transdisciplinarity has many definitions, yet transdisciplinary learning broadly is a process of exchanging, generating, and unifying scientific and non-scientific knowledge among experts, practitioners and stakeholders in solving real world complex problems. Transdisciplinary learning could be a useful element in integrated development planning.

Typical assessment methods used in development planning include EIA, SIA and RA. Evaluation of these methods indicates that the methods are typically conducted project based, and stakeholder involvement in assessment process is limited. Methods have inherent limitations in providing holistic view of the issues, accommodating transparent simplistic analysis and integrating stakeholder knowledge, and facilitating stakeholder discussion and negotiation throughout the planning process.

LCA is still not identified as an assessment method in development planning. LCT is a qualitative framework, while life cycle assessment is a qualitative method that addresses environmental, economic, and social impacts linked to resource consumption. Traditional LCA is an expert-based technical tool. The underlying concept of upstream and downstream analysis has greater relevance applied to development planning, but modifications are necessary to meet the needs and challenges in multi-stakeholder contexts.

There are several rating and ranking methods available to assist prioritizing and selecting options, namely, PCA, AHP, MAUT, and SMART. Some of them are too complex to be used in multi-stakeholder development planning contexts. The concepts could be simplified and used in a manner that matches the planning context and promotes further negotiation and agreeing on options after comprehensive assessments.

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CHAPTER 3
METHODOLOGY AND PROCEDURES

Concepts

The purpose of introducing life cycle thinking and assessment into integrated development planning is to holistically assess development issues and build solutions in a participatory manner minimizing the factors that affect integrated planning. Facilitating integration of sectors for successful and sustainable action is a key priority. The stakeholders' and the experts' knowledge has to be integrated in generating information that are relevant to the respective stakeholders to negotiate and agree on implementable strategies. Information generation and communication has to be a transdisciplinary learning process not limited to communicating expert-based results. Stakeholder-based life cycle assessment (SBLCA) is developed as a decision support framework where multiple stakeholders could actively participate in identifying their system, goals, priorities, and responsibilities, and negotiate resource commitments that lead to achieving these goals. The main concepts used in developing the method to suit the development planning context include life cycle thinking and assessment, levels of service, and unbundling levels of service into activities and resources.

Life Cycle Thinking and Assessment

As broadly covered in the Chapter 2, literature review, typically, LCT/A is used for generating holistic information about a product or service in order to assess its environmental performance. A series of International Organization for Standardization (ISO) guidelines (ISO14040 – 44) specify the steps in conducting LCA: 1) defining the goal and scope for analysis; 2) deriving the life cycle inventory which includes material use, energy use, and environmental discharges; 3) life cycle impact assessment which translates an inventory into potential impact on human health and the environment; and 4) interpretation, which assesses whether results are in agreement with the defined goals and scope (ISO, 1998). Life cycle costing can be conducted along with LCA, and is frequently used in industrial applications (Akai, 1999). Incorporating social impact assessment is a recent development in LCA, and ISO 14044 describes approaches for including social aspects in LCA (Cooper, 2003; Grießhammer et al., 2006; Weidema, 2006). In a multi-stakeholder development context, life cycle thinking can be applied to find solutions to a number of issues with a holistic approach. Often, it is observed that fixing one problem results in affecting, or, triggering another problem. In certain cases, solutions applied to problems miss the mark because the real issue is somewhere upstream and not necessarily observable from a narrow frame of reference. Life cycle thinking is a way to map the upstream and downstream of issues and solutions to insure that the improvements are applied at the right points to lead to implementable sustainable solutions.

Levels of Service

In development contexts, a level could be affiliated with various subjects. In the scope of this research, we focus on what we call a “level of service” (City of Cape Town, 2001; GTZ-IFSP, 2003). Services in area development can include essential individual and community services such as water supply, wastewater and storm water handling, solid waste management, and communication. It is an obvious fact that individuals or community segments receive different “levels of services”. For example, individual taps vs. a common well or unpaved road vs. a paved road, due to limited resources and capacities. For the same reason, the existing and planned levels of service need to be examined when improvements are planned. The general term ‘resource’ could mean resources such as financial resources, institutional resources, physical resources, human resources and natural resources. The level of service can be viewed from both the perspective of the service receiver and from the perspective of the service provider. A level can be good when it meets a stipulated standard, regulation, or a recommendation developed through a satisfactory stakeholder participation process resulting in benefits for all stakeholders. A level can be problematic when not all stakeholders adequately participate in the process towards meeting the stipulated standard or regulation, or have not participated in developing a recommendation, often resulting in stakeholders' believing that they are worse off. In order to achieve a certain level of service in a community planning activity, it is necessary to understand, communicate, and visualize the roles of the stakeholders and the stakeholder activities and resources required over time. The above components are implicitly "bundled" in a level of service (Figure 3-1).

Unbundling Levels of Service

The service level then needs to be "unbundled" to visualize its key interlinked components. Unbundling disaggregates a level of service into its contributing components. Determining a level of service and unbundling it is analogous to the goal, scope, and process inventory mapping used for life cycle thinking and assessments. Apart from the key components, users can add relevant and useful components depending on the context of the problem. The basic key components include activities, stakeholder participation, corresponding costs and benefits, resources, and cost recovery systems. Depending on the level of current or targeted development, the interlinked components such as activities, corresponding costs, resources, stakeholder participation and benefits related to maintaining a given level may vary (Figure 3-1).

Incorporating level of service and unbundling concepts into the LCA process helps to bring in the participatory element that is much required by the assessment methods in development planning. It helps the stakeholders to become involved in structured dialog by interactively identifying the levels of service and unbundling its interlinked components thereby integrating their knowledge and experience with inputs from experts' knowledge bases.

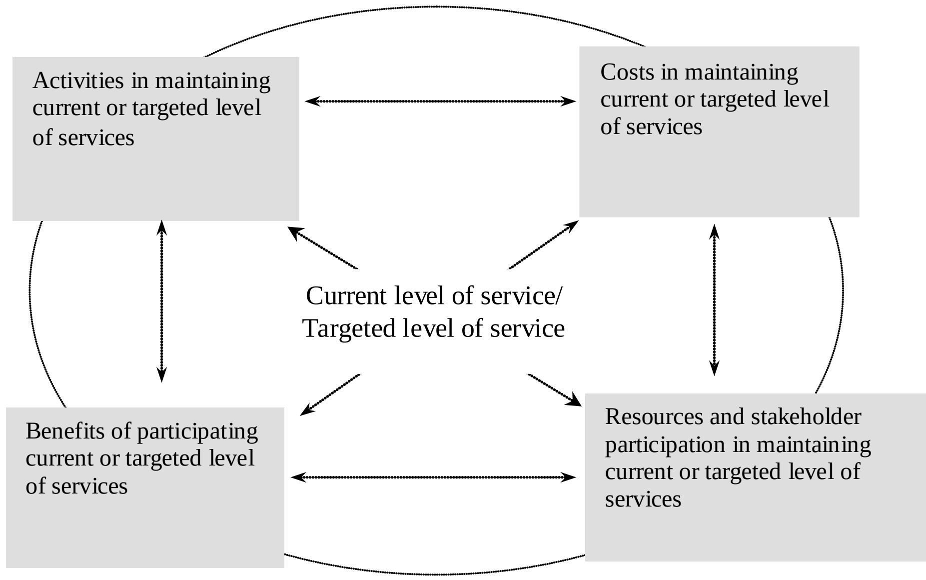


Figure 3-1. Interlinked elements for maintaining current or targeted level of services

Methodological Framework: Modifications and Features

The above three concepts are combined in the SBLCA framework. The modified LCA framework chains the upstream and downstream activities while mapping out the stakeholders involved, the resource needs, and the costs and benefits including the economic, social, and environmental indicators associated with each activity. In terms of application within a cross-sectoral integrated planning process, the concept of life cycle thinking and assessment is modified to analyze who is better-off and worse-off, directly or indirectly, in all life cycle activity stages in order for the targeted level of development to be sustained. This is critical because, eventually, stakeholder commitment depends upon foreseeing those aspects which are related to their current and required future activities. For example, if the development issue in an area is wastewater, upstream and downstream activity phases such as water supply (treatment and distribution capacities), water use patterns (per capita demands depending on the level of water supply), wastewater generation, disposal and treatment means, and maintenance arrangements (operation and maintenance costs and cost recovery) need to be analyzed in order to assure the solutions are long-lasting and sustainable (Figure 3-2).

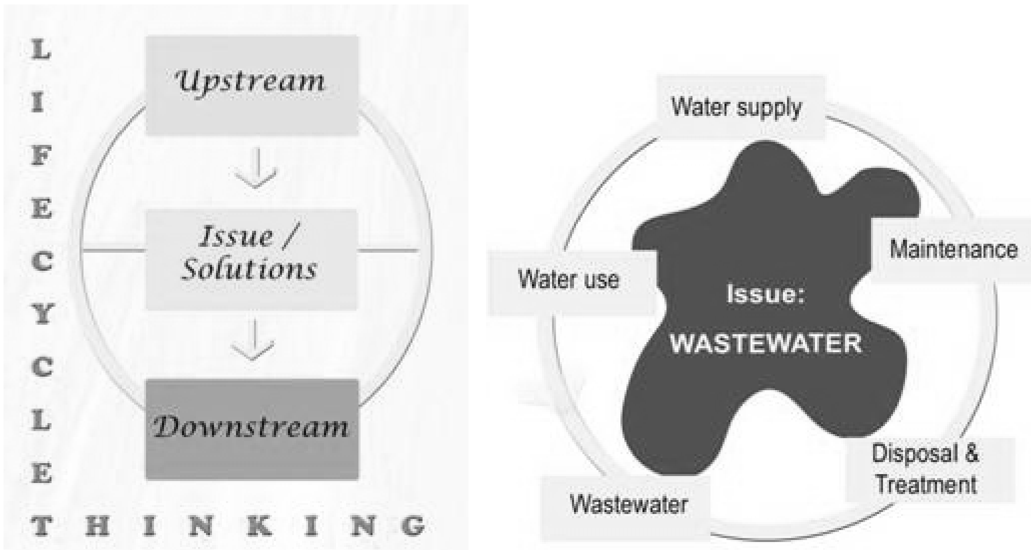
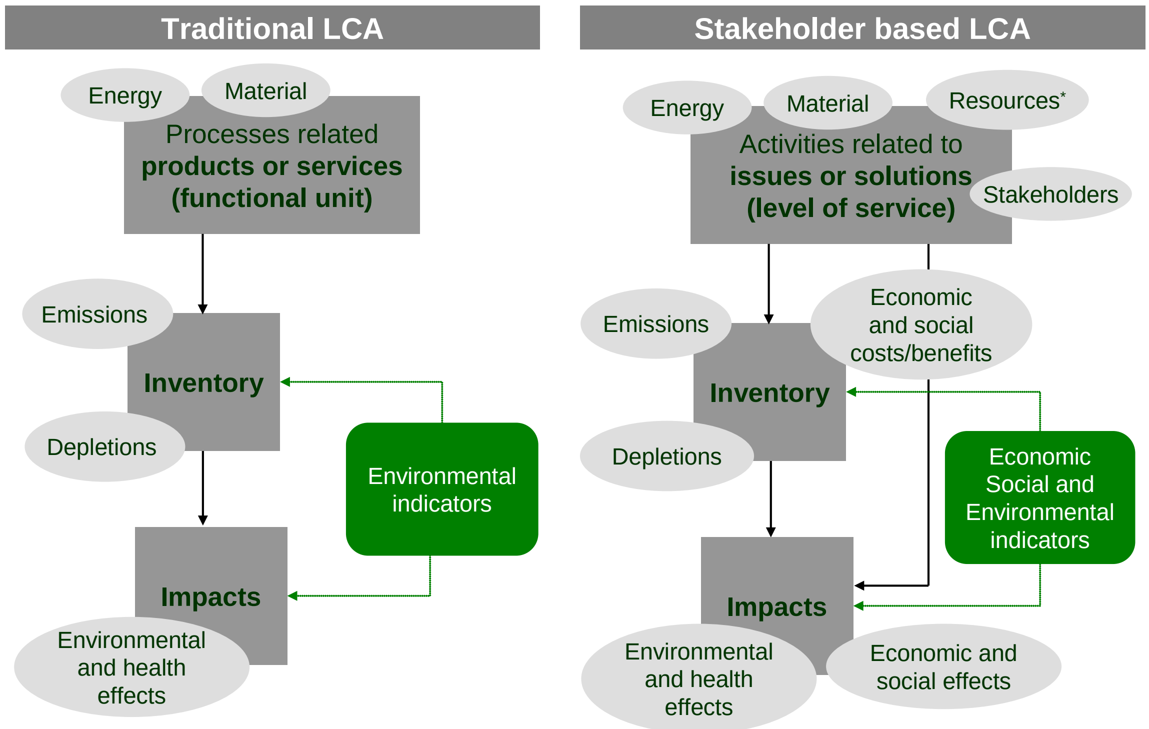


Figure 3-2. The life cycle thinking approach, e.g., chaining upstream and downstream of water issue

The traditional LCA practices for assessing an industrial product or a service is discussed in Chapter 2. The principle modifications to typical LCA practice is discussed in detail under 1) Goal and Scope Analysis and 2) Inventory and Impact Analysis. The modifications are summarized in Figure 3-3 and they are discussed in detail in the following sub-sections.

Goal and Scope Analysis

The goal of the analysis is analogous to determining the performance of a current or a future level of service, and the scope is similar to deciding on which relevant activity phases are included for a given level of service. The activity phases are not necessarily limited to the typical life cycle phases. As in the case of any typical LCA, upstream and downstream processes could be extensive depending on the goal and scope of the study, which makes scoping and defining a boundary for analysis necessary. The same logic applies in the context of upstream and downstream activities.



** Resources include financial, institutional, physical, human and natural resource demands.*

Figure 3-3. Schematic view of conventional and stakeholder-based life cycle assessment illustrating their similarities and differences

When looking at upstream and downstream activities, stakeholders have to decide how far upstream and downstream would make sense in their analysis, and select activities that should be logically included (Figure 3-4). The analysis boundary defines the specific activities and sub-activities included. In this context, the functional unit in LCA is analogous to a specific level of service. For easier analysis and presentation purposes, activities can be chained in sequence, and examined for their sub-components with economic, social, and environmental aspects as relevant (Figure 3-4). Activity chaining is not limited to a linear sequence. The analysis can be carried out at a generic level or detailed level depending on the planning situation and scope, as each activity can always be further divided into sub-activities for closer analysis.

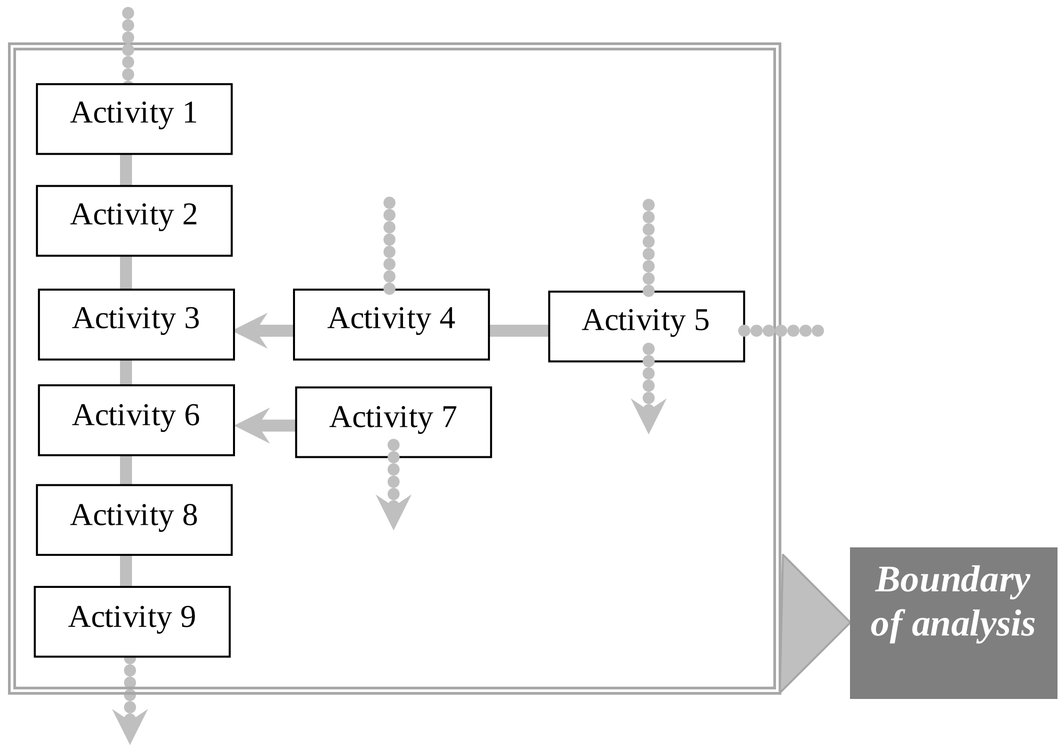


Figure 3-4. Upstream-downstream activity chaining and boundary of analysis

Inventory and Impact Analysis

Each activity in a development issue resembles a process in a typical LCA, where environmental emissions and raw material depletion are inventoried and later converted to communicable impact indicators. Similarly, inputs for inventory analysis in SBLCA can include stakeholders and resources, e.g., physical, human, financial, and institutional, and are not limited to energy and material. Simplified qualitative and quantitative indicators for stakeholder involvement, resource needs, and social, economic, and environmental costs and benefits can be inventoried for all upstream and downstream activities within the scope of the study as shown in Fig.4, instead of only environmental discharges and raw material depletion. The impact indicators may not necessarily be derived strictly from inventory data as in traditional life cycle impact assessment (LCIA), but may be associated with a stakeholder independent of any single activity. An indicator's value may not be linearly related to activity intensity as is typical in LCIA. As in LCIA, simplified qualitative and quantitative indicators can be mid-point such as wastewater load to surface water bodies, or end-point such as the number of people potentially affected by disease. This makes the assessment flexible, transparent and still useful in data scarce situations. The indicators used depend on the planning context, the accuracy required or expected, and data availability. The indicators are disaggregated at each activity level rather than aggregated for the whole issue or solution as is typical in LCA. This allows the different responsible or potentially responsible stakeholders to clearly visualize and understand the information directly and indirectly relevant for them.

With the above detailed analysis, stakeholders are exposed to additional knowledge, which can be used to foster collaboration to achieve joint targets in area development. The knowledge can enhance sustainable implementation, as this SBLCA framework explicitly structures the elements necessary for feasible and sustainable solutions, where stakeholders can actively contribute to the analysis, discussion, and negotiation, and therefore also agree to participate and collaborate. The framework assists stakeholders in identifying the cause of the issue, along with its elements, or, in the case of potential solutions, their roles, other stakeholders' roles, and the costs and benefits to themselves and to the region as a whole.

In summary, the main steps of the framework include 1) identify the levels of service, which can be current levels or target levels, 2) identify upstream and downstream activities in the scope of the analysis, and 3) unbundle each main activity within the scope of the study and include simplified economic, social, and environmental indicators to communicate the necessary information relevant to each upstream and downstream activity required for sustainable implementation (Figure 3-5).

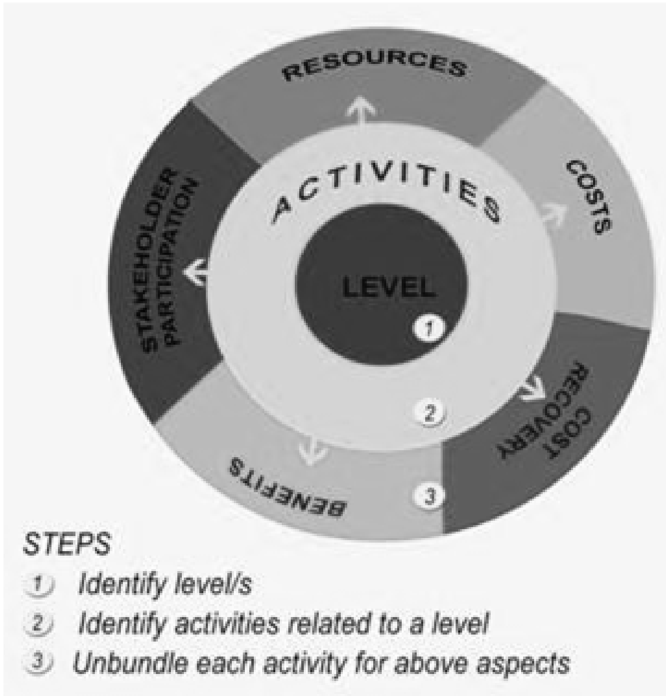
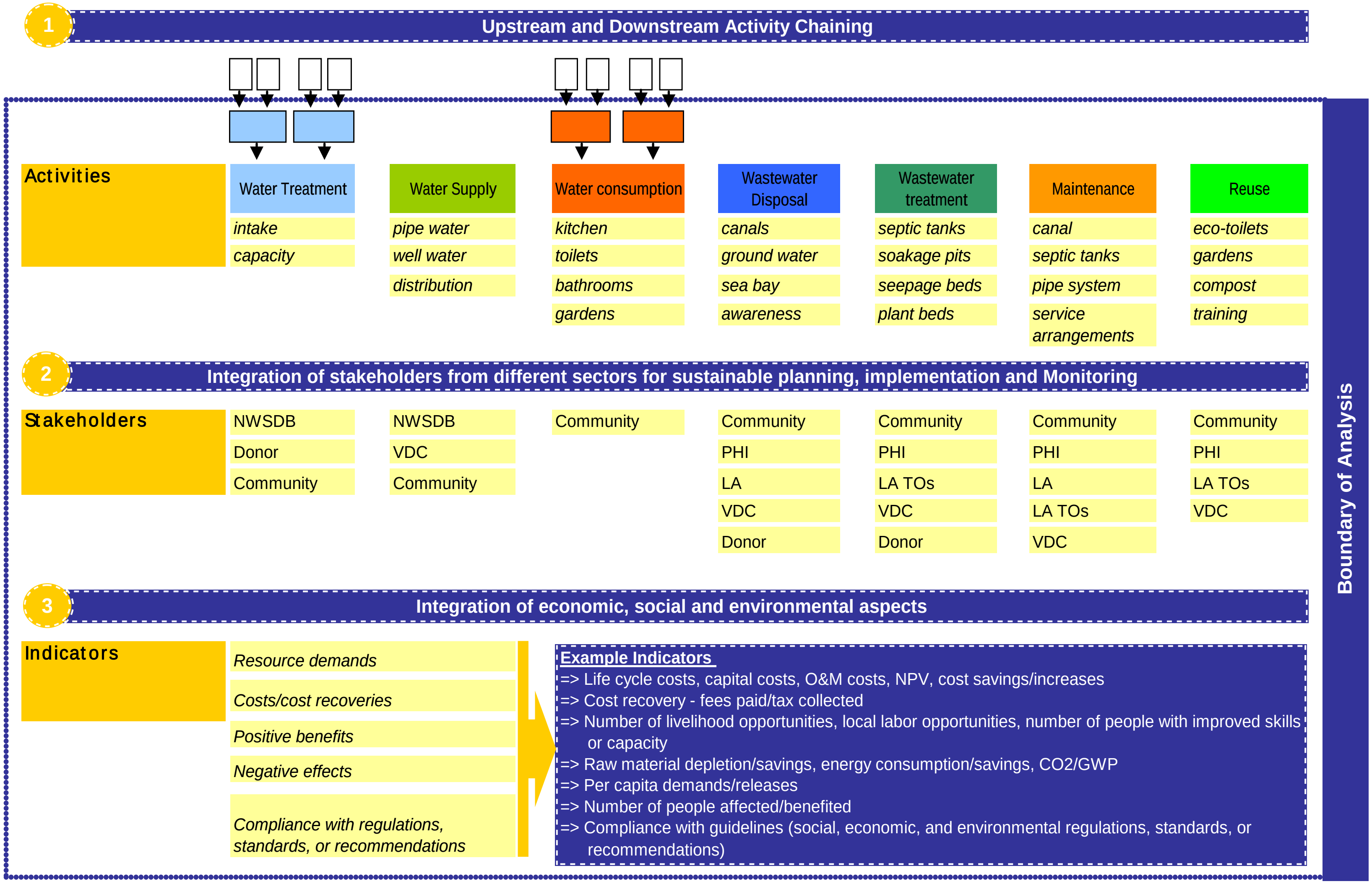


Figure 3-5. Unbundling a level of service

A generic schematic view of an application of SBLCA in a wastewater issue interconnected with upstream water supply, water use, and downstream wastewater treatment is illustrated in Figure 3-6. Point 1 in Figure 3-6 shows the chained upstream and downstream activity phases and the relevant sub-activity concerns; point 2 highlights the integration of stakeholders, and point 3 shows the integrated economic, social, and environmental indicators.

SBLCA Framework in Integrated Planning Approach

`Typical development planning approaches include phases such as 1) assessing the current state of the system, 2) prioritizing issues, 3) formulating and assessing options for solutions, 4) strategizing and implementing solutions, and 5) evaluation and monitoring (Wiek et al., 2006b). The LCT based decision framework is expected to be effectively used in any participatory planning approach when (Figure 3-7):



LA: Local Authority; NWSDB: National Water Supply and Drainage Board; PHI: Public Health Inspector; TOs: Technical Officers; VDC: Village Development Committee.

Figure 3-6. Lifecycle thinking with levels of service and unbundling activities applied to integrated assessment of water supply, water use, and water disposal in a tsunami-affected village in Sri Lanka.

- assessing the current system and issues and prioritizing them
    - holistic vision including interconnectivities of a system
- formulating, assessing, and strategizing solutions
    - assessing the suitability, viability and sustainability of solutions
    - negotiating and agreeing on resource commitments

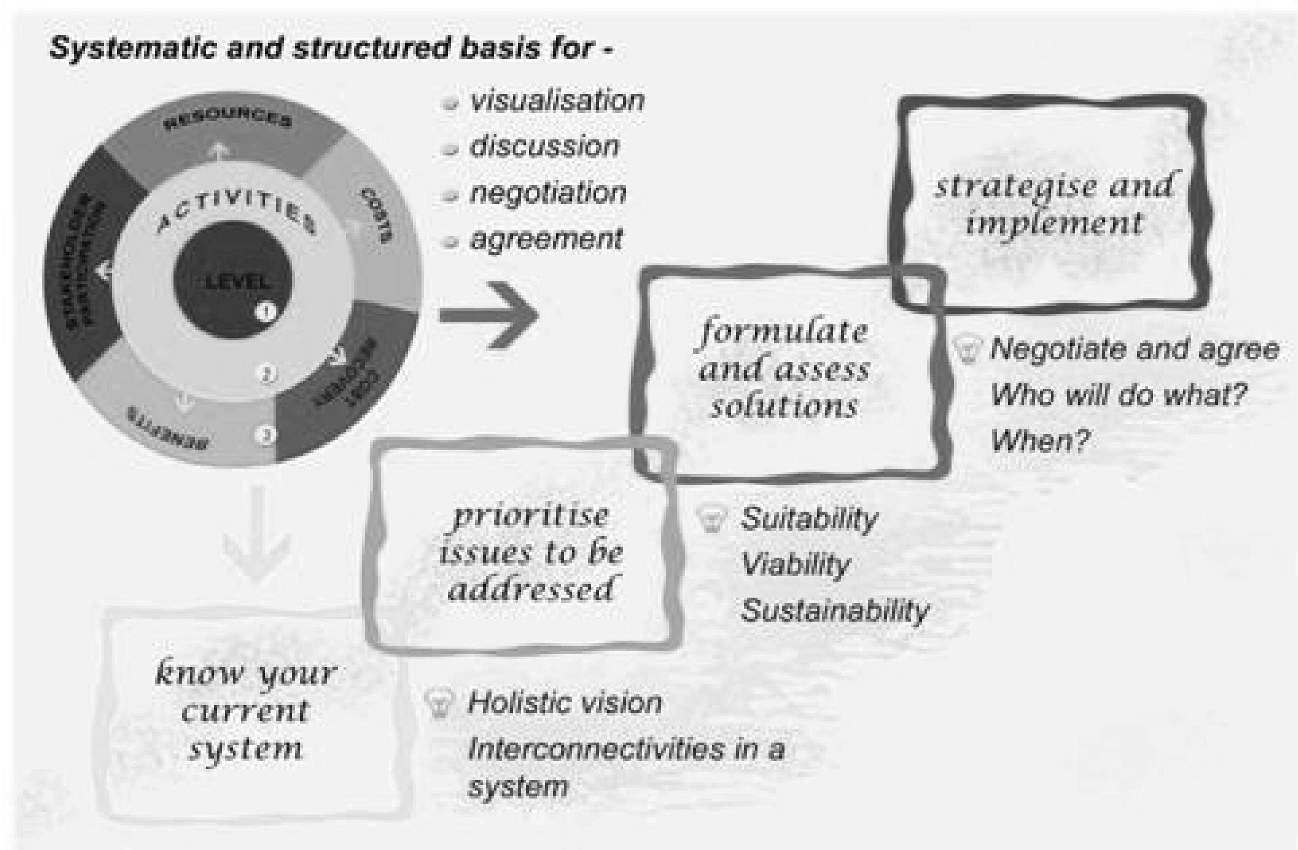


Figure 3-7. Where the decision framework can fit in a planning approach (basic steps and outcomes)

In these typical planning stages, the application of the framework can be explained in detail as follows:

1) In assessing the current state of the system and prioritizing issues: SBLCA is applied to analyze current development issues in detail, i.e., identifying the relevant upstream and

downstream activities, the interconnectivities of issues, the economic, social, and environmental aspects, the stakeholders from different sectors and disciplines, and the current and target levels of service. Available national or local standards, regulations, or recommendations can be used to set the targets and determine the distance from the current state. This knowledge is expected to assist stakeholders in both building consensus on prioritizing issues while recognizing stakeholder interconnectivities and in defining common goals and joint projects. Consensus in each planning step is expected to encourage long-term stakeholder commitment and cooperation towards developing joint programs and projects which would fit well with needs, available resources, and technologies.

2) In formulating, assessing, and strategizing options for solutions: Options for solutions can be developed on the basis of understanding and assessing the current state and an agreed level of service. In formulating options for solutions, the framework is applied in a similar manner, incorporating relevant and necessary upstream and downstream activities and the inherent components for maintaining an improved level. The outcome of this step is a spectrum of consensual, feasible, sustainable future options for improvements. Due to various constraints, the level of improvement that is feasible in a given context needs to be assessed, negotiated, and agreed to by the respective stakeholders. This is an important step where the stakeholders decide which options are viable for implementation in terms of local conditions, available technologies, resources, and stakeholder commitment.

A life cycle perspective plays an important role in emphasizing interconnectivities of upstream and downstream activities, associated costs and benefits, and the stakeholder involvement in building sustainable strategies. This enhanced knowledge puts stakeholders in a better position to comprehend the importance and necessity of certain activities, the resources required, individual as well as collective roles of stakeholders, and resulting individual and collective benefits in committing to a sustainable development process. The holistic view of the strategies contributes to minimizing the uncertainties and transaction costs associated with collaborating in joint projects, and promoting consensus among multiple stakeholders in relevant sectors.

3) In monitoring and evaluation: In a planning process, participatory monitoring and evaluation is an important element in ensuring that the intended activities are implemented as planned. The process of participatory monitoring is identified as a circular loop of action-learning-action comparing the on-going activities to the planned activities in a collective setting. If the implementation of activities is not going according to plan, steps can be taken to correct problems, concerns, and issues at an early stage. This can be done by adjusting the way activities are being implemented or, if necessary, by changing the action plan to adapt to the justified needs of participants. To assist this continuous feedback, a SBLCA framework could be useful to investigate which upstream and downstream activities are moving as planned and which are not. If alternative activities are required, then the new upstream and downstream requirements or outcomes can be investigated.

The application of the methodology is explained using some examples from the case-study given in the Chapter 4.

Indicator Development

In traditional LCA, energy and material consumption, inventory categories such as CO_2 emissions, mid-point impacts such as global warming potential, and end-point impacts such as human health are generally termed as indicators. Similarly, in LCA, resource inputs, stakeholder inputs, and resulting outcomes such as costs, benefits, and impacts are referred to as indicators.

The costs, benefits, and impacts could be in the form of economic, social, and environmental considerations specific to the planning context.

As described under Inventory and Impact Analysis, the SBLCA indicators could be universally accepted typical inventory categories or mid-point and end-point impacts, adjusted to represent the local conditions. Local on-site data, local scientific research data, publicly available data, and verified information from stakeholders could be useful sources to develop conventional LCA indicators. Conversely, SBLCA indicators could be unconventional indicators such as unquantifiable yet relevant economic, social, and environmental considerations which are critical to assess in multi-stakeholder development planning processes. In most situations, unconventional indicators which are simple and transparent, play a major role in developing shared stakeholder perceptions, compared to the conventional indicators.

Since the indicators depend on the development problem or solution under assessment, the descriptions of indicator development is included in the Case-study section of the Chapter 4. A sample set of economic, social, and environmental indicators particular to assessing the wastewater issue in a community in a development country context are summarized in Figure 3-6. The criteria outlined in the Sustainable Development Framework (CAA, 2005) for the construction sector provides good insights on development related economic, social and environmental indicators. The set of indicators are summarized in Appendix A.

Rating and Ranking Method

As reviewed in the Chapter 2, rating and ranking are the basic concepts behind the decision tools such as AHP, MAUT and SMART. Depending on the planning context, the nature of the problem under evaluation, and the capacities of the stakeholders, a rating and ranking based method needs to be chosen, or modified for meaningful application.

The purpose of working out a simplified rating and ranking method in development planning is to assist the stakeholders to further negotiate on priorities and options. When the system is holistically analyzed with sufficient information on upstream and downstream considerations, requirements, and causes and effects, the stakeholders would be in a better position to score and rate what suits their communities the best with reduced bounded rationalities, asset specificities and opportunistic behaviors.

The simple method outlined here is to be used in the option analysis phase. When an option is analyzed using the SBLCA framework, a number of indicators would highlight the performance of the options. Indicators would be quantitative and qualitative belonging to economic, social and environmental categories.

- Each indicator represents a criteria (A_i); let i represents the number of criteria.
- Each development alternative represents an option (O_k); let k represents the number of options.
- Every criterion is rated from a 0 – 10 scale: 0 – not at all an important criteria; 10 – very important criteria (subjective to vary on stakeholder interests, for example, a priority to the local authority may not be a priority of the community, hence, an opportunity to negotiate).
- The rating has to be assigned comparing the criteria pair-wise as much as possible, so that the rating reflecting the preference or the importance.
- The weight for a criterion (w_i) is the rating received for a criterion divided by the total value of the ratings received by all the criteria.
- According the weights received, the criteria are ranked to evaluate whether the weights are agreeable.
- Against every criterion (A_i), the options (O_k) are given a score (S_{ik}) comparing the relative performance within that criterion on a 0 to 10 scale. This is a linear expression of utility according to the qualitative or quantitative information in an indicator; the best indicator value could be assigned a score of 10 and relative scores assigned to the others.
- The total score of an option (Z_k) against all criteria is given by the sum of weighted score, which is expressed by:

$$Z_k = \sum_{\substack{i=1 \\ k=1}}^{n,m} w_i S_{ik}$$

- Weighted score could be represented as a percentage of the total weighted score (Z) of all the options (R_k%):

$$R_k = \sum_{k=1}^{m} Z_k / Z$$

- According to the total weighted scores or percentages, the options could be ranked.

The total score of an option only reflects the performance of the option according to the preference or importance of the criteria to the stakeholders. With this method, a large number of criteria could be included in the analysis. In a group, the different interest groups, for example, community and the local authority officers could perform the method separately, and compare the order of performance of the options. The different weights on criteria could help to further the discussions on why certain criteria are important to different groups and come up with a negotiated weight. This would be a generic way to get an idea about the better performing options. However, the best option does not necessarily mean it is the strategically viable option. Hence, in the light of approximately knowing what options perform better, the stakeholders could discuss and negotiate on what is feasible and not feasible, and beneficial or not beneficial in terms of committing their resources, and select the option that suits them accordingly.

The method is illustrated in Figure 3-8 and the application of the method is elaborated in Chapter 4 using some examples from the case-study.

Criteria	Rating for criteria	Weight for criteria	Options (O_i)							Options (O_i)							
			O_1	O_2	O_3	...	O_k	...	O_m	O_1	O_2	O_3	...	O_k	...	O_m	
(A_i)	(r_i)	$w_i = r_i/R$	*Options scores* (S_{ik})							*Weighted options scores* (w_i*S_{ik})							
A_1	r_1		S_{11}	S_{12}	S_{13}		S_{1k}		S_{1m}	w_1*S_{11}	w_1*S_{12}	w_1*S_{13}		w_1*S_{1k}		w_1*S_{1m}	
A_2	r_2		S_{21}	S_{22}	S_{23}					w_2*S_{21}	w_2*S_{22}	w_2*S_{23}					
A_3	r_3		S_{23}	S_{24}	S_{25}					w_3*S_{31}	w_3*S_{32}	w_3*S_{33}					
:																	
A_i	r_i		S_{i1}	S_{i2}	S_{i3}		S_{ik}		S_{im}	w_i*S_{i1}	w_i*S_{i2}	w_i*S_{i3}		w_i*S_{ik}		w_i*S_{im}	
:																	
A_n	r_n		S_{n1}	S_{n2}	S_{n3}		S_{nk}		S_{nm}	w_n*S_{n1}	w_n*S_{n2}	w_n*S_{n3}		w_n*S_{nk}		w_n*S_{nm}	
	$R=\Sigma r_i$	$\Sigma w_i=1.0$								$Z_1=\Sigma w_i*S_{i1}$	$Z_2=\Sigma w_i*S_{i2}$	$Z_3=\Sigma w_i*S_{i3}$		$Z_k=\Sigma w_i*S_{ik}$		$Z_m=\Sigma w_i*S_{im}$	$Z=\Sigma Z_k$
% Score of options										$R_1=\Sigma Z_1*/Z$	$R_2=\Sigma Z_2*/Z$	$R_3=\Sigma Z_3*/Z$		$R_k=\Sigma Z_k*/Z$		$R_m=\Sigma Z_m*/Z$	$\Sigma R_m=1.0$

Figure 3-8. Illustration of the rating and ranking-based decision tool for summarizing option performances

Summary

Stakeholder-based life cycle assessment (SBLCA) is developed as a decision support framework where multiple stakeholders could actively participate in identifying their system, goals, priorities, and responsibilities, and negotiate resource commitments that lead to achieving these goals.

The principal objective for a transdisciplinary SBLCA framework in multi-stakeholder conditions is to develop information such that it can be interpreted irrespective of a stakeholders' knowledge base and rationalities of their given sector, field, or discipline. It is hypothesized that, when the information is clear, holistic and transparent, the decision making and negotiation for action is enhanced. Hence, the SBLCA framework is more stakeholder-oriented than traditional LCA. For example, the goals, scope, and boundary of the analysis are identified in concert with the stakeholders. Indicators were developed to include all three aspects of sustainability in a quantitative or qualitative manner depending on data availability and the accuracy required or anticipated in the assessment.

In analyzing development issues and potential solutions, the functional unit has to be broader and relevant to the development context. Therefore, a set of upstream and downstream activities is identified with respect to a level of service, which can be analogous to a functional unit in a typical LCA.

In the development and reconstruction context, a service can be identified as a basic urban and community service, such as water supply, wastewater and solid waste management, and road maintenance. Depending on the a) availability of resources, b) stakeholder participation in required activities, and c) relevant costs and benefits of the activities, a sustainable level of service for a community can vary. Hence, in redevelopment and reconstruction, it is important to investigate the upstream and downstream activities of current and target levels of service when sustainable solutions are sought. In the assessment, the primary activity phases are not necessarily limited to the typical life cycle phases.

Identifying all relevant activities in the life cycle mapped together with their respective stakeholders is expected to provide useful insight in terms of identifying individual and collective resource inputs for sustaining a level of service in a community. The indicators are developed with stakeholders for each activity phase, and are not limited to environmental costs and benefits, but also capture social and economic costs and benefits. Indicators assess the direct and indirect outcomes of activities and are valuable for stakeholders' evaluation and commitment. The framework includes three main steps: 1) identify current or improved levels of service, 2) chain the upstream and downstream activities relevant to providing the current or optional levels of service, and 3) assess components of current or proposed activities in terms of stakeholder participation, resources, cost, cost recovery, and benefits using relevant economic, social, and environmental indicators.

A rating and ranking method is developed similar to simplified multi attribute theory to assist in organizing and evaluating the information from the detailed assessment. The weights for the indicator categories provide further opportunities to negotiate what is important for different stakeholders. Relative scores are assigned to the options based on the quantitative qualitative information. A large number of indicators irrespective of their classification into economic, social and environmental can be included in the evaluation. The best option has the highest sum of weighted scores. However, the best option may not necessarily be the strategically viable option. Hence, in the light of approximately knowing what options perform better, the stakeholders could discuss and negotiate what is feasible and not feasible, and beneficial or not beneficial in terms of committing their resources, and select the option that suits them accordingly.

CHAPTER 4
CASE STUDY AND METHOD APPLICATION

Background of Case study

The basis for this research study was laid in November 2005 with a fact finding mission to Sri Lanka on formulating general guidelines for sustainable post-tsunami reconstruction initiated by the Tsunami Housing Support (THSP) Project of German Technical Cooperation (GTZ) in Sri Lanka. Researchers from Massachusetts Institute of Technology (MIT), Massachusetts; Swiss Federal Institute of Technology (ETH), Zurich; University of Pittsburgh (UPIT), Pittsburgh; and professionals from Sri Lanka Heritage Foundation (SLHF) and THSP were invited to team up in order to conduct a thorough investigation on on-going post tsunami reconstruction, specific challenges in the field, and draw general guidelines for sustainable housing reconstruction in the country. THSP is a Sri Lankan – German Development Cooperation Project in partnership with the Sri Lankan Ministry of Housing and Common Amenities and financed by the German Federal Ministry for Economic Cooperation and Development. THSP's primary objective is to promote participatory approaches and sustainability in reconstruction through capacity building in responsible government institutions. Appendix B summarizes THSP's activities.

Overview of Post-Tsunami Reconstruction

Sri Lanka was hit by a tsunami in December 2004, resulting in the loss of 35,000 people, and over 100,000 housing units with approximately one million people displaced. Figure 4-1 shows some summary statistics of the devastation published by the Census Department of Sri Lanka (Sri Lanka Virtual Library Index, 2005). In a disaster, developing countries work closely with international multilateral stakeholders to respond to the situation. The governments often do not have sufficient budget allocations for disaster management, and many of the resources flow from international organizations to the developing countries. The Sri Lankan government had not faced a disaster of this magnitude in the past, and did not have adequate policies and government structures set up to face the challenges which were exacerbated by the need to collaborate with donors in the disaster response.

Human		
➢ Number of people killed		35,322
➢ Number of people injured		21,441
➢ Number of Internally Displaced People (IDPs)		516,150
Economic		
➢ Value of lost assets		US $900 million
➢ Number of lost livelihoods		150,000
➢ Number of houses damaged		89,000
➢ Proportion of fishing fleet destroyed		75%
➢ Extent of salinated agricultural land		23,449 acres
➢ Damage to tourism infrastructure	- Large hotels	53 out of 242
	- Small hotels	248
	- Related small enterprises	210
Social		
➢ Widowed, orphaned and affected elderly and disabled		40,000
➢ Health facilities damaged by the tsunami		97
➢ Education facilities damaged		
	- Schools	182
	- Universities	4
	- Vocational Training Centre	15
➢ Schools used as camps for IDPs		446
➢ School children affected		200,000

Tsunami affected regions in Sri Lanka

Figure 4-1: Summary statistics on damages due to Tsunami in Sri Lanka (Source: Department of Census and Statistics, Sri Lanka)

Subsequently, the Sri Lankan government appointed a special agency named Task Force for Rebuilding the Nation (TAFREN) to steer and coordinate the programs for rescue operations and emergency activities until the post disaster recovery phase was complete. The country progressed through the recovery stage by mid-2005 with local and international assistance, and subsequently focused on reconstruction and development (Reconstruction and Development Agency, 2005).

In 2006 TAFREN was replaced by the Reconstruction and Development Agency (RADA). The responsibilities of RADA included implementation of all short, medium and long term projects by coordinating, facilitating and finalizing the plans for reconstruction. The post disaster reconstruction was conducted under 4 main programs: 1) Housing, under the theme Bringing People Back Home; 2) Livelihoods, under the theme Bringing People Back to Work; 3) Social services, focusing on rebuilding educational and health facilities in the affected locations; and 4) Infrastructure, providing roads, bridges, railways, water supply and sanitation, power and energy, postal services, and telecommunications. The operating structures of these programs include 1) national, 2) district, 3) divisional secretariat, and 4) village levels. The main stakeholders include 1) affected communities; 2) divisional and district level governmental institutions and elected local authorities; 3) sectoral governmental agencies, 3) national scale governmental institutions such as ministries and RADA; 4) multilateral, bilateral and International Non-profit Organizations (INGO) including donors and implementing agencies; and 5) local interest groups (Reconstruction and Development Agency, 2006).

TAFREN was faced with difficulty in getting the institutions to think beyond giving affected people a housing unit or temporary means of commerce to ensuring sustainability in reconstruction and development activities. The major issues with post-tsunami reconstruction at the time was that the rapid construction of housing units with no or minimum consideration of integrating a) essential infrastructure such as access roads, 2) urban environmental services such as water supply and sanitation, 3) social services such as schools and community centers, and 4) livelihood opportunities for people who have lost their regular means of earning a living. The national and international donors and governmental and non-governmental institutions that belong to different sectors representing the above were working independently with meeting time-bound sectoral objectives without much attention focused on assessing and integrating community needs, preferences, local capacities and conditions, and short- and long-term operational and management arrangements (Wiek et al., 2006).

Being a developing country, one of the additional problems faced by the government and TAFREN was how to channel the resources into an integrated planning system given that the international donors and governmental institutions have individual sectoral objectives and priorities. These issues coupled with beneficiaries rejecting the new housing and returning back to their original places of residence, led TAFREN to request support from THSP to investigate the challenges and support TAFREN in implementing the on-going post-tsunami reconstruction in an effective and sustainable manner. THSP generated general guidelines for sustainable housing reconstruction in collaboration with a team of experts (Wiek et al., 2006)

In the general guidelines, a bottom-up integrated planning approach was introduced. The main goal was to integrate the four reconstruction programs, i.e., housing, infrastructure, social services and livelihood development, which were operating without coordination of their activities, resulting in unsuccessful housing settlements. For example, housing units were built without considering basic sanitation, transportation infrastructure, social-wellbeing, and livelihood opportunities. The guidelines emphasized involving all stakeholders in reconstruction, village planning, and implementation at local levels. An example of integrating programs and projects at local community levels involving stakeholders across sectors in a post-disaster redevelopment context is illustrated in Figure 4-2.

The guidelines document also outlined sustainability concepts and methodologies where sustainable planning and implementation could be achieved. The methodologies included the development of a life cycle thinking-based framework which allows multiple stakeholders from

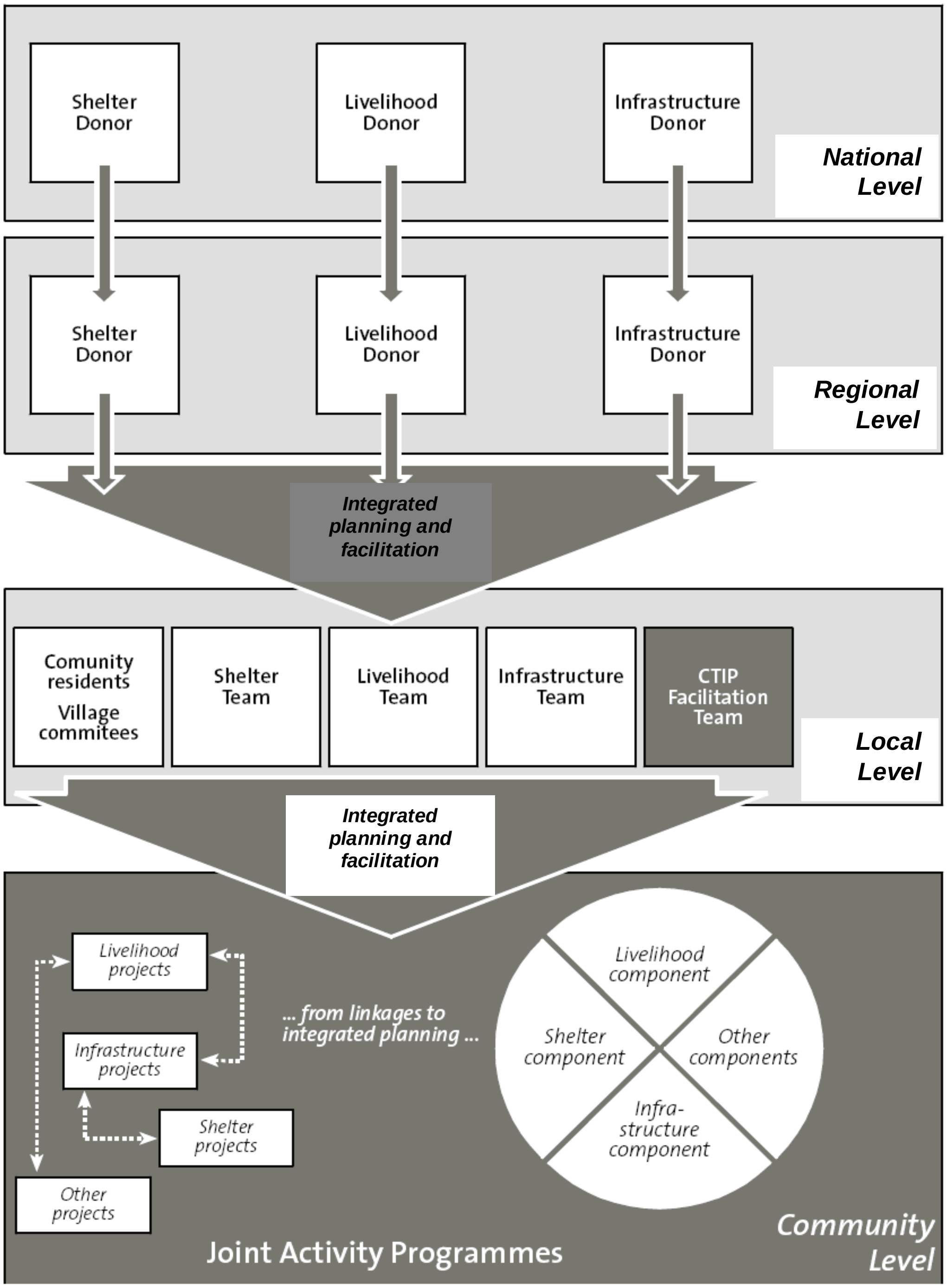


Figure 4-2: Example integrated planning scenario for developing joint programs and projects in post disaster redevelopment

different sectors and disciplines to develop a comprehensive view of issues and development decisions.

The second phase was to conduct a pilot study of the guidelines by implementing them in a tsunami affected village in Sri Lanka. The pilot field study examined the applicability of the guidelines and identified lessons learned. The study was used to develop the THSP participatory sustainable reconstruction implementation strategy for other tsunami affected villages. Some lessons learned were also communicated to relevant government ministries for use in other villages.

A general overview of the social, economical, and environmental profile indicators of the country is given in Appendix C.

Scope of Pilot Field Study

The pilot study started during the summer of 2006 in collaboration with RADA, THSP and SLHF in Unawatuna village in the south part of Sri Lanka (Figure 4-3). It is a coastal village with approximately 400 families. During this visit, all stakeholders including interested community members, community-based organization (CBO) representatives, local officials, and district officers were invited to introduce the need and objectives of the pilot program for the village. In this introductory meeting, basic sustainability concepts and the planning approach for village development were introduced. Village field visits with the village officer and interviews with the other stakeholders were conducted to get an understanding of the village as a whole, and reconstruction and development issues.

Actual implementation of the planning approach started in January 2007. By this time, with the election of the new government, RADA was dissolved and tsunami reconstruction responsibilities were transferred to institutions within the government administration. The President formed a new Ministry called the Ministry of Nation Development and Estate

Infrastructure Development (MNBEID), and under that, several grass-roots nationwide programs for development were introduced. Among them was the “Village Development” program where community participation was a must (MNBEID, 2006). (However, a proper strategy for implementing village development had not been identified.

Figure 4-3: The case-study location in Sri Lanka

THSP, given that capacity development of government stakeholders in participatory reconstruction planning and implementation is one of their prime objectives, took this opportunity to build a strategy to assist the village development program initiated by the government. THSP partnered with the Ministry of Public Administration and Home Affairs (MPAHA) to implement this task.

When developing the strategy for a nationwide program, one of the constraints that needed to be addressed was the lack of financial resources for experts to manage community-based integrated planning in every tsunami affected village in Sri Lanka. As a way forward, THSP together with the implementing counterparts decided to invest in local human capital (the grass-roots level field officers who work closely with the community as well as the higher level governmental officials) to build their capacities to become experts and handle their own village planning and implementation process. In parallel, top level responsible officials were prepared to support the village development process. The modules for training included the following:

- Teamwork and Leadership
- Communication Skills, including basic office management, filing systems and introduction to Internet and e-mail
- Positive Thinking and Competency Development
- Participatory Integrated Project Planning Implementation and Monitoring

For this nation-wide task within government structures, THSP introduced a new capacity enhancement program for the field officers in consultation with the Public Servant Training Institute (PSTI) of MPAHA, other national, district, and divisional level stakeholders and experts from relevant fields. It was expected to train 3,800 of the grass-roots level field officers working in 1,100 village officer divisions. The field officers included Village Officers, Samurdhi Development Officers (Micro-finance Officer), Agrarian Research and Development Officers, Local Authority field officers, Housing Officers, Community Development Officers and other field officers active within the community.

To encourage field officials to actively participate in the process, THSP together with the MPAHA, introduced a nationwide Rewards Program. Field officer teams applying sustainability concepts and tools in their village development planning and implementation were expected to be rewarded. A database was developed to measure the extent of participatory sustainable approaches that were applied in the village development planning process, and officers were expected to be rewarded as well as have their good practices widely publicized. In this context, the pilot field study became very useful in identifying and investigating the following:

- material to be included in the training manuals for local field officers
- potential for knowledge sharing
- potential for and to what extent village field officers can implement the planning process and implementation and
- what additional requirements are needed for successful planning and implementation
- a workable strategy which could be replicable in other villages
- lessons learned for future improvement of the process.

The full scope of work within this program is outlined in Figure 4-4.

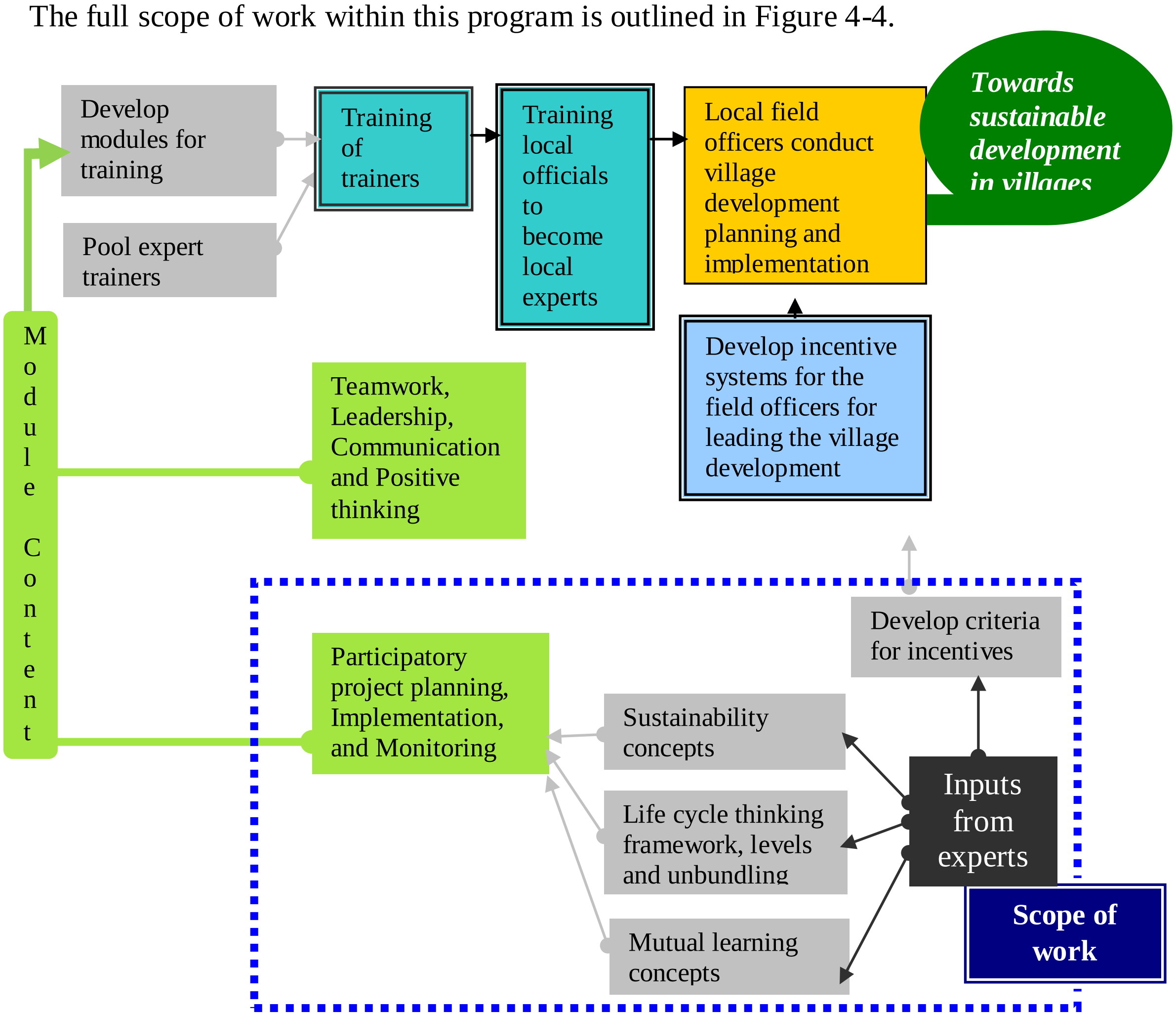


Figure 4-4. Strategy developed for capacity development for local officials and scope of the research assignment

Case-Study Framework

The planning approach introduced at the beginning of the study is shown in Figure 4-5. These steps were identified as generic steps of development planning processes such as Community Development Planning (CAP), Community Livelihood Development Planning (CLAP), Participatory Action Planning (PAP), and Rapid Rural Appraisal (RRA), which are practiced by development organizations in Sri Lanka. The proposed planning approach was modified together with the stakeholders to satisfy practical needs on site. The modified planning structure is given in Figure 4-6. The SBLCA tool was applied in the steps that are shown in Figure 4-6. They include:

- understanding current status of issues
- prioritizing issues to be addressed
- formulating options for solutions
- assessing options for solutions
- strategizing for implementation

The SBLCA framework was introduced as a decision support framework that could be used within any of the above development planning techniques. It was embedded into the generic planning steps coupled with planning tools, for clearer visualization of upstream and downstream activities together with necessary information to structure and support decision making at each step by stakeholders belonging to different sectors.

The necessity of the LCT/A based tool surfaced because many planning approaches do not consider the upstream and downstream of activities, which is necessary for sustainable implementation. Planning approaches lack a decision support framework for structured negotiation and consensus building that connects all related issues, activities, and respective stakeholders. The hypothesis was that, when information is clear and holistic, and developed with stakeholder participation, stakeholder collaboration towards achieving joint targets in sustainable village reconstruction would be enhanced.

In Unwatuna pilot field study, the SBLCA framework was successfully applied through the development and assessment of the future options stage. Strategy building for actual implementation was postponed due the ethnic conflict situation in the country where most international donors had ceased funding for new development activities. However, the tool gained acceptability and could be chosen by field officer teams to apply in their planning work.

Within the planning approach, sustainability concepts, other participatory decision support frameworks such as System Analysis tools were tested. Information gathered using field visits, semi-structured interviews and available literature, were presented at community workshops using many visualization tools such as flow diagrams, spiderwebs, and graphs. The field officers were pre-trained to conduct and facilitate the process. The background details of designing the Unawatuna pilot case-study and the lessons learned that were reported to fine tune the field officer training program conducted by GTZ with MPAHA are given in Appendix D.

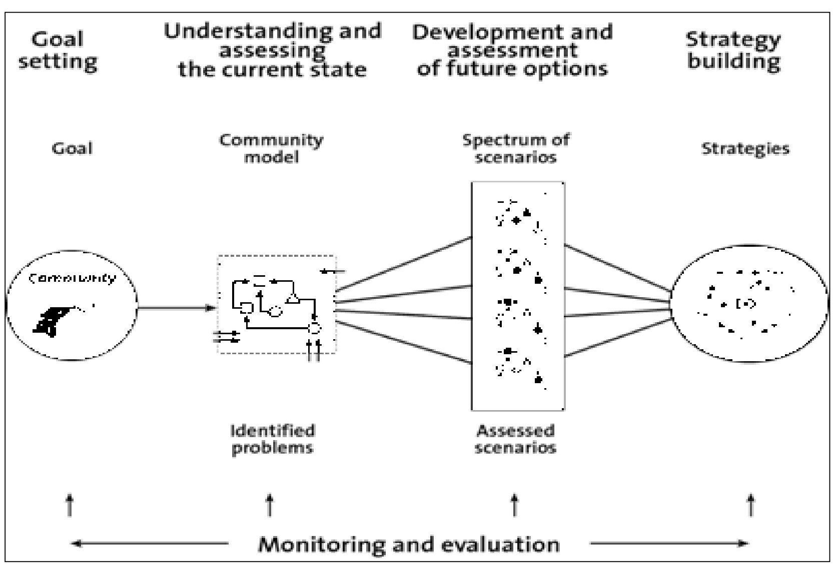


Figure 4-5. The planning process suggested in General Guidelines for post-tsunami reconstruction in Sri Lanka

Figure 4-6. Planning steps adopted at the Unawatuna case-study

Application of SBLCA Methodology

Case-Study Examples in Assessing the Current State

Within the first planning step, assessing the current state, 14 development issues were identified by the village development committee. The issues include the following:

- Access roads
- Potable water supply
- Wastewater disposal
- Stormwater drainage
- Solid waste management
- Non-functional toilets
- Unskilled labor
- Limited livelihood opportunities
- Haphazard and unauthorized construction
- Noise pollution

The above issues were found to be among the major issues in the village. The list of issues identified by the stakeholders is given in Appendix D.

The SBLCA framework was applied to analyze these issues in order to comprehensively understand the causes, effects, interconnectivities, and distance to target in meeting stipulated standards related to the issues. Along with this mutual learning about the current status, priority issues were identified through structured dialog. The criteria for prioritizing issues were the level of interconnectivity of issues, the urgency of an issue, and the potential for an issue to be implemented given local capacities.

The following examples extracted from the case-study elaborate the application the methodological framework of SBLCA in assessing the current water supply (Example 1) and wastewater issues (Example 2) in the village. The examples also elaborate how the interconnectivity of issues and solutions can be identified, and how the stakeholders in different disciplines would be exposed to clear and holistic information in order to make informed decisions. The application of the framework was developed such that the local experts, i.e., trained government field officers were able to use it in village development meetings and workshops together with the community and local government officials. Hence, the indicators developed required to be sufficiently simple and transparent.

Example 1 – analyzing the current state of the portable water supply issue

- Step 1: Identify current levels of water supply services – the level of service varies within the community. In this example , the levels include the following: (cf. Appendix E for detailed analysis on water supply):
    - some residents are supplied with well water
    - some residents are supplied with a common tap
    - the remainder are supplied with an individual National Water Supply and Drainage Boards (NWSDB)'s piped water connection.
- Step 2: Chain the upstream and downstream activities relevant to providing the above current levels of service.
- Step 3: Unbundle and assess components of current activities in terms of stakeholder participation, resources, costs, cost recovery, and benefits using relevant economical, social, environmental indicators.

A graphical representation of the framework applied to assessing these current levels of service for potable water supply is given in Figure 4-7 to Figure 4-12. Figures 4-7, 4-9, and 4-11 show the primary activities and related stakeholder mapping for the three current water supply levels. Figures 4-8, 4-10, and 4-12 show the economic, social, and environmental indicators related to the primary activities of the current water supply levels.

The quantitative and qualitative indicators which were used to analyze the potable water supply options are summarized in Table 4-1. The descriptions of indicator development are summarized in Table 4-8.

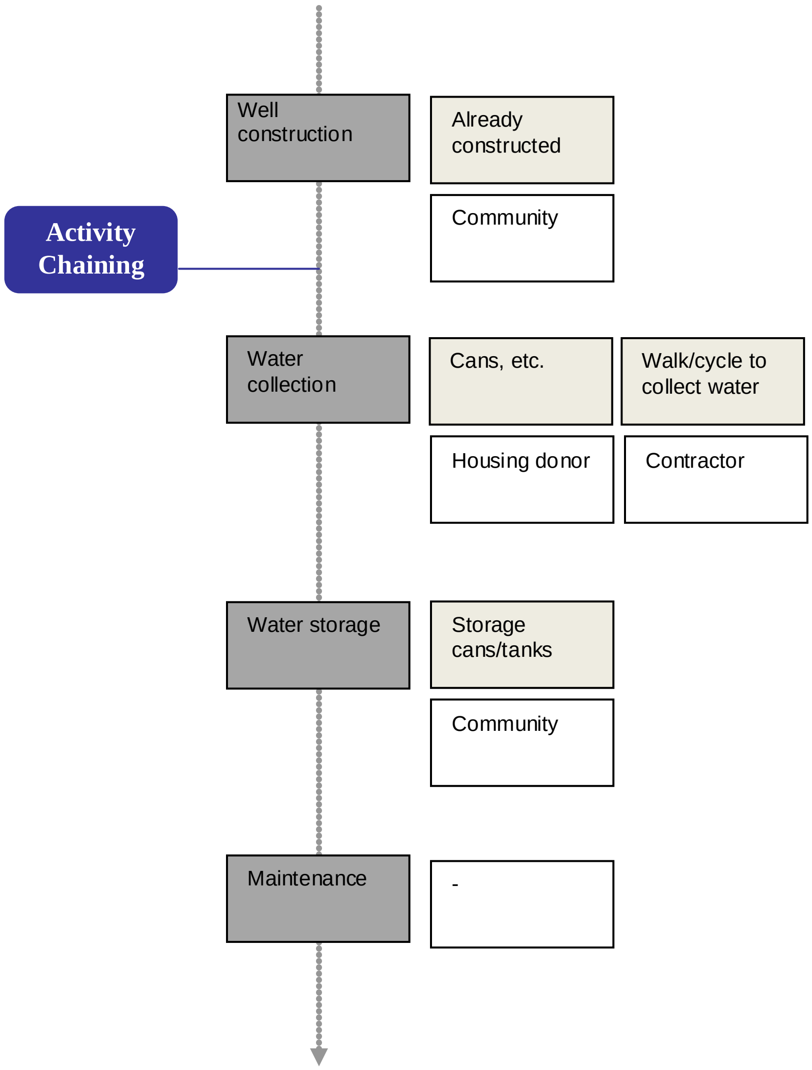


Figure 4-7. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement regarding the provision of water through a common well

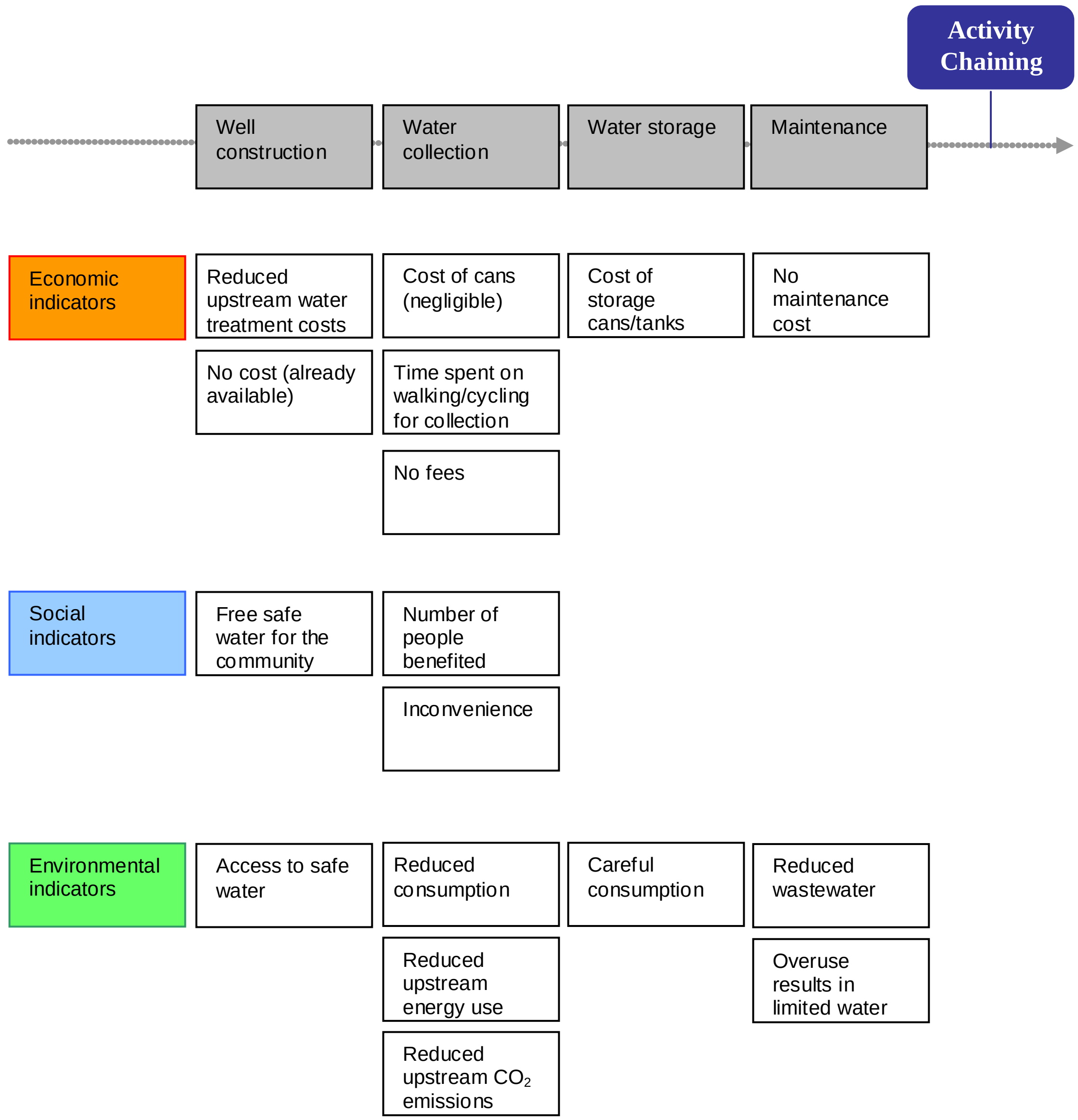


Figure 4-8. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding the provision of water through a common well

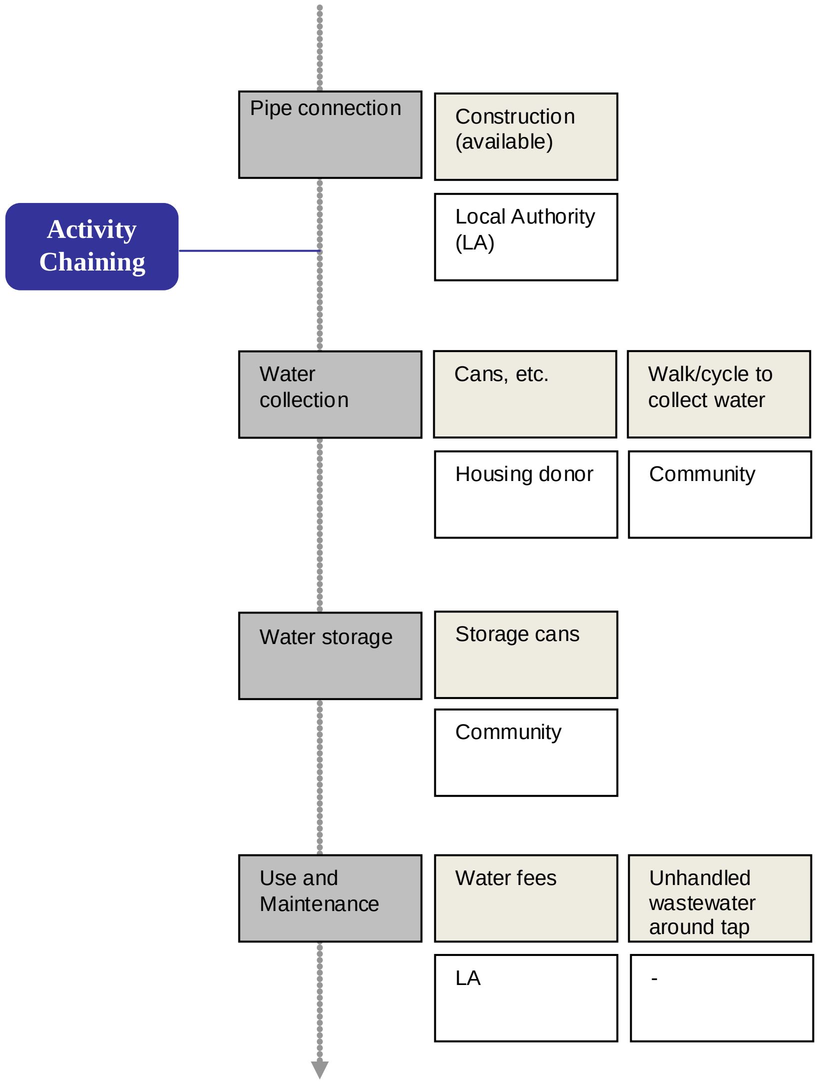


Figure 4-9. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement regarding the provision of water through a common tap.

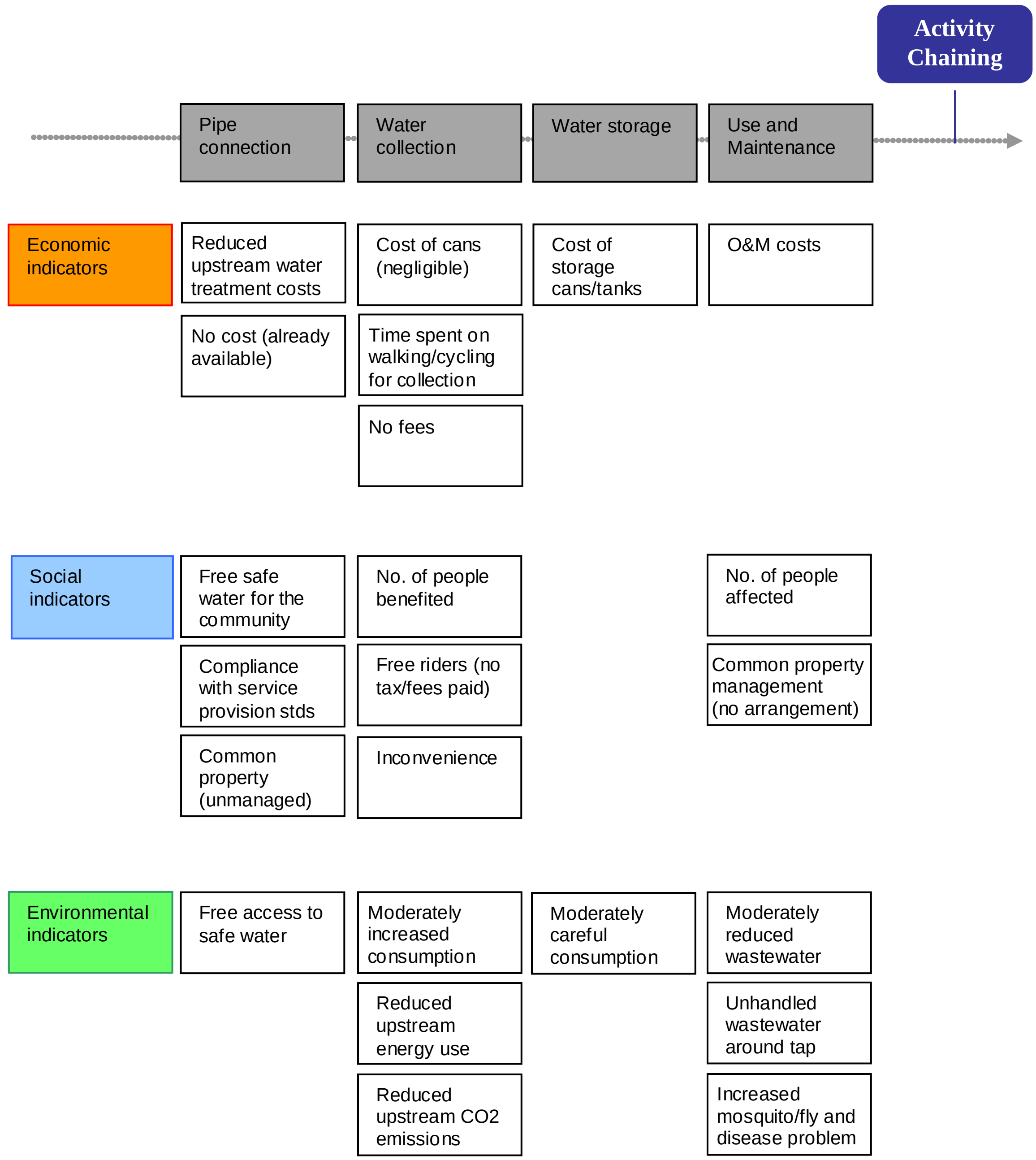


Figure 4-10. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding the provision of water through a common tap.

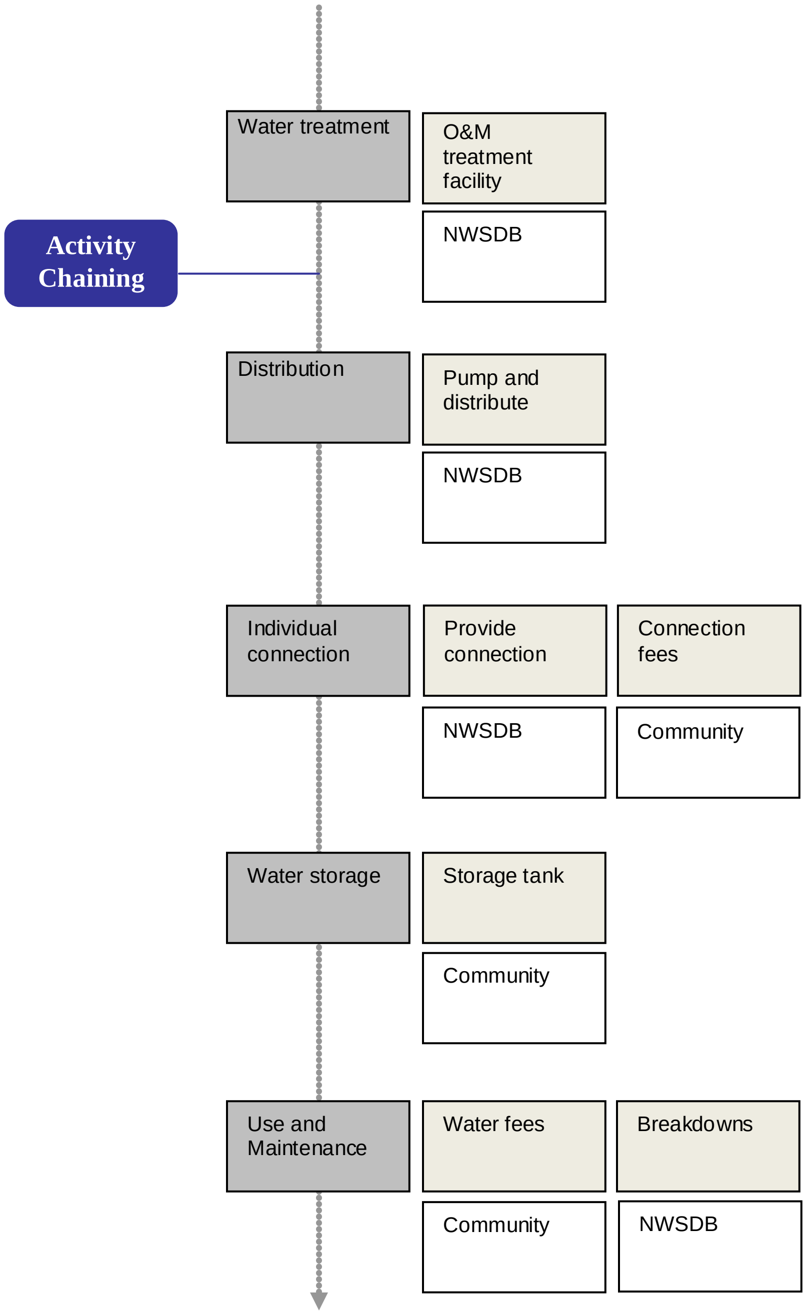


Figure 4-11. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement regarding the provision of water through an individual piped connection.

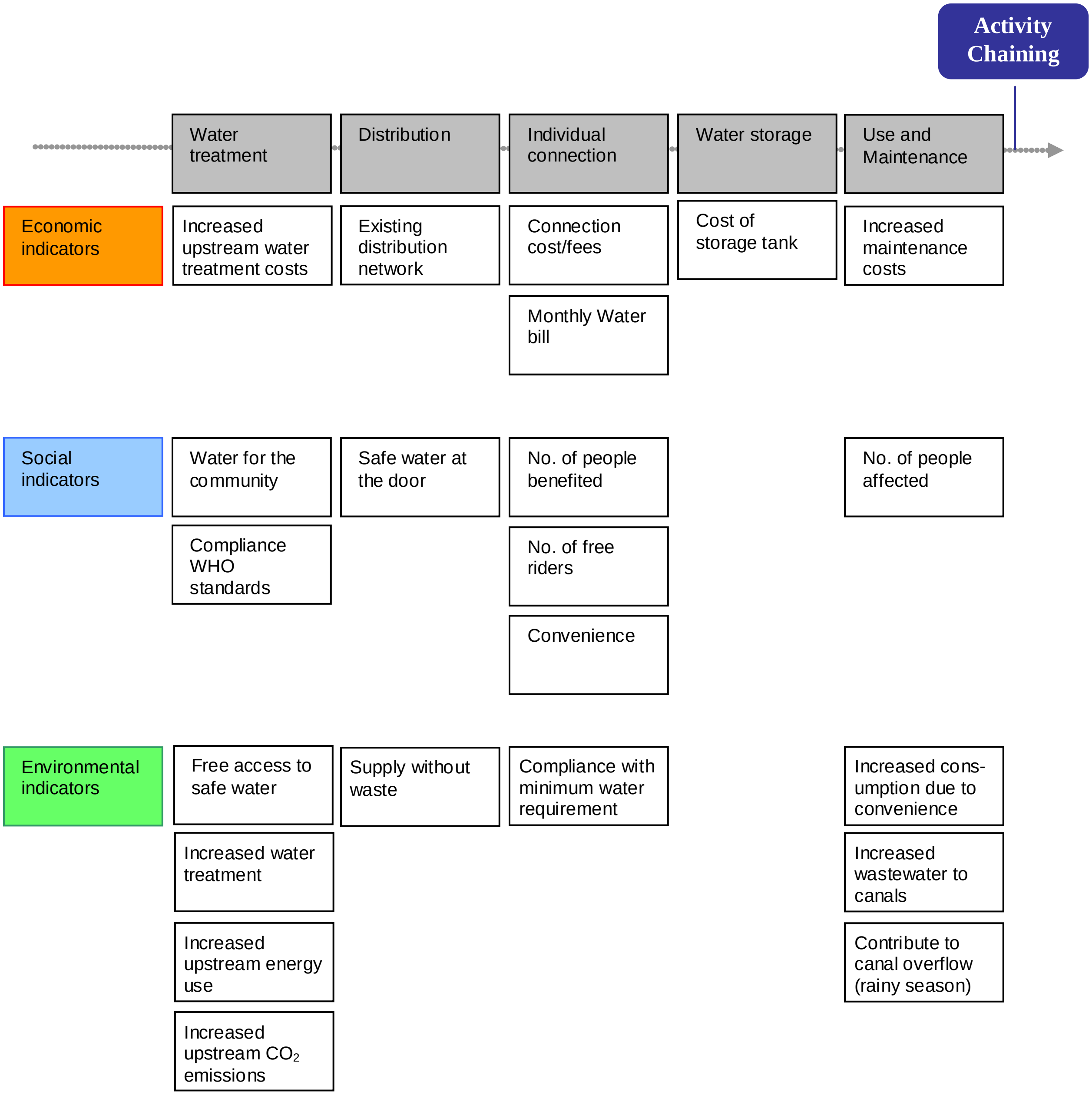


Figure 4-12. Unbundling of the activities and the respective economic, social, and environmental indicators regarding the provision of water through an individual piped connection.

Table 4-1. Evaluation of the quantitative, semi-quantitative and qualitative indicators for activities related to the three pre-existing levels of service for water infrastructure in a tsunami-affected village in Sri Lanka.

Indicator	Common well	Common piped-water connection	Individual piped-water connection
Economic			
Upstream water treatment costs	No cost	Reduced	Increased
Treatment/distribution maintenance costs	No cost	Reduced	Increased (Rs.13 per m^3 of treated water, Rs.7 per m^3 of distribution)
Distribution costs	No cost	Reduced	Increased
Collection time	30 – 90 min per day	30 – 90 min per day	-
Storage costs	Storage cans (Rs.1,000)	Storage cans (Rs.1,000)	Cost of tank (Rs. 20,000 for 20 m^3 plastic tank)
Connection fees	-	Paid by local authority	Paid by community (Rs.15,000 per connection)
Cost to end users	Free	Free	Not free
Water bill	-	Paid by local authority (Rs.15 per m^3)	Paid by community (Avg. monthly bill Rs.350 per household)
Social			
Safe water for community	Safe water	Safe water; complied with WHO standards	Safe water; complied with WHO standards
Convenience	Inconvenient	Inconvenient	Convenient
Free riders	-	Free riders	No free riders
Number of people benefited	Proportion from the village well receiving water	Proportion from the village receiving common tap water	Proportion from the village receiving individual tap water
Common property management	No arrangement	No arrangement	Individual property
Environmental			
Per capita water consumption	Reduced (20 liters per day)	Moderately reduced (30 liters per day)	Increased (50 liters per day)
Compliance with minimum water standard	Not complied	No complied	Complied
Amount of upstream water treatment required	-	20-30 liter per person per day	50 liters per person per day (10 m^3 increase per year per house connection)

Table 4-1. Continued

Indicator	Common well	Common piped-water connection	Individual piped-water connection
Wastewater generation	Reduced	Moderately reduced	Increased
Number of people affected with wastewater and diseases	-	Households living close to common tap and community as a whole	Households living along canal and community as a whole
Upstream energy use	-	0.2 kWh (Rs.3.50) per m^3 of water treated	0.2 kWh (Rs.3.50) per m^3 of water treated
Upstream CO_2 releases		0.14 g CO_2 per m^3 of water treated	0.14 g CO_2 per m^3 of water treated

Example 2 – analyzing the current state of the wastewater issue

- Step 1: Identify current levels of wastewater: the levels of service varies in the community (cf. Appendix F for details)
    - Grey water is either 1) discharged to the surface of the household's own plot of land, 2) discharged to a nearby canal, or 3) piped to a treatment plant.
    - Black water is either 1) discharged to the nearby canal, 2) discharged to a two chambered septic tank on the household's own plot of land, or 3) piped to a treatment plant.
- Step 2: Chain the upstream and downstream activities relevant to providing the above current levels of service;
- Step 3: Unbundle and assess components of the current activities in terms of stakeholder participation, resources, costs, cost recovery, and benefits using relevant economic, social, environmental indicators.

A graphical representation of the framework applied to assessing the current levels of service for wastewater discharge or treatment is given in Figure 4-13 to Figure 4-20. Figures 4-13, 4-15, 4-17 and 4-19 show the primary activities and related stakeholder mapping for the current levels mentioned above. Figures 4-14, 4-16, 4-18 and 4-20 show the economic, social, and environmental indicators related to the primary activities of the three current levels mentioned above.

The quantitative and qualitative indicators which were used to analyze the wastewater issue are summarized in Table 4-2 (Appendix F).

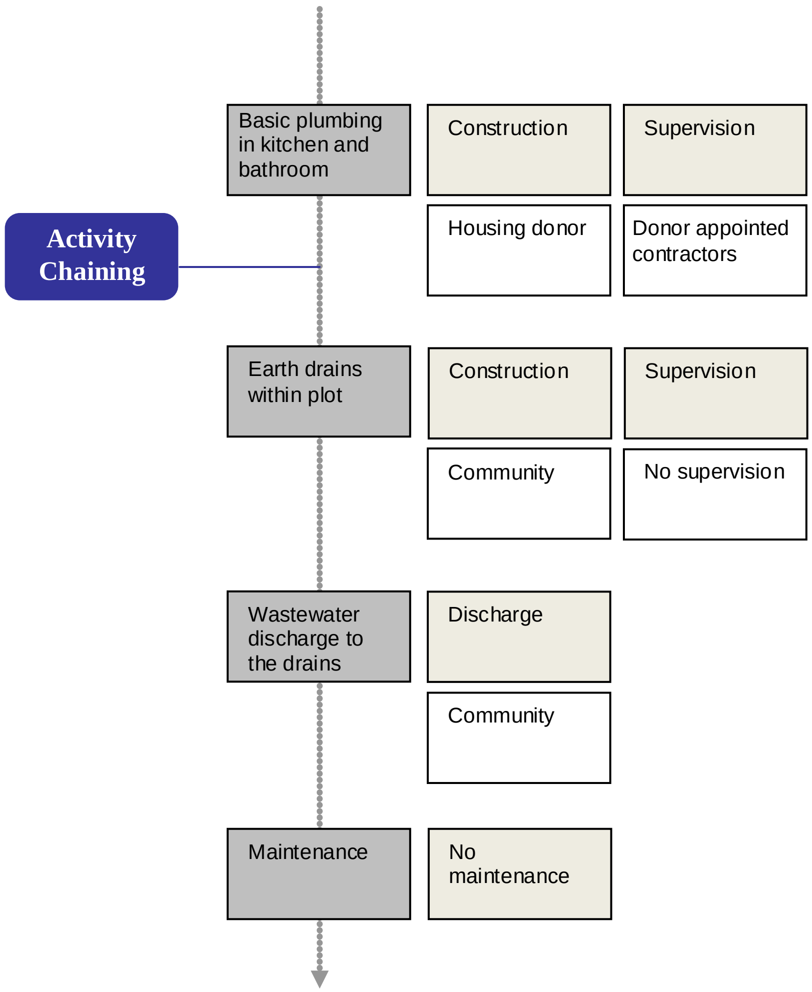


Figure 4-13. Unbundling the activities and the respective stakeholder involvement with grey water discharged to the household's own plot of land.

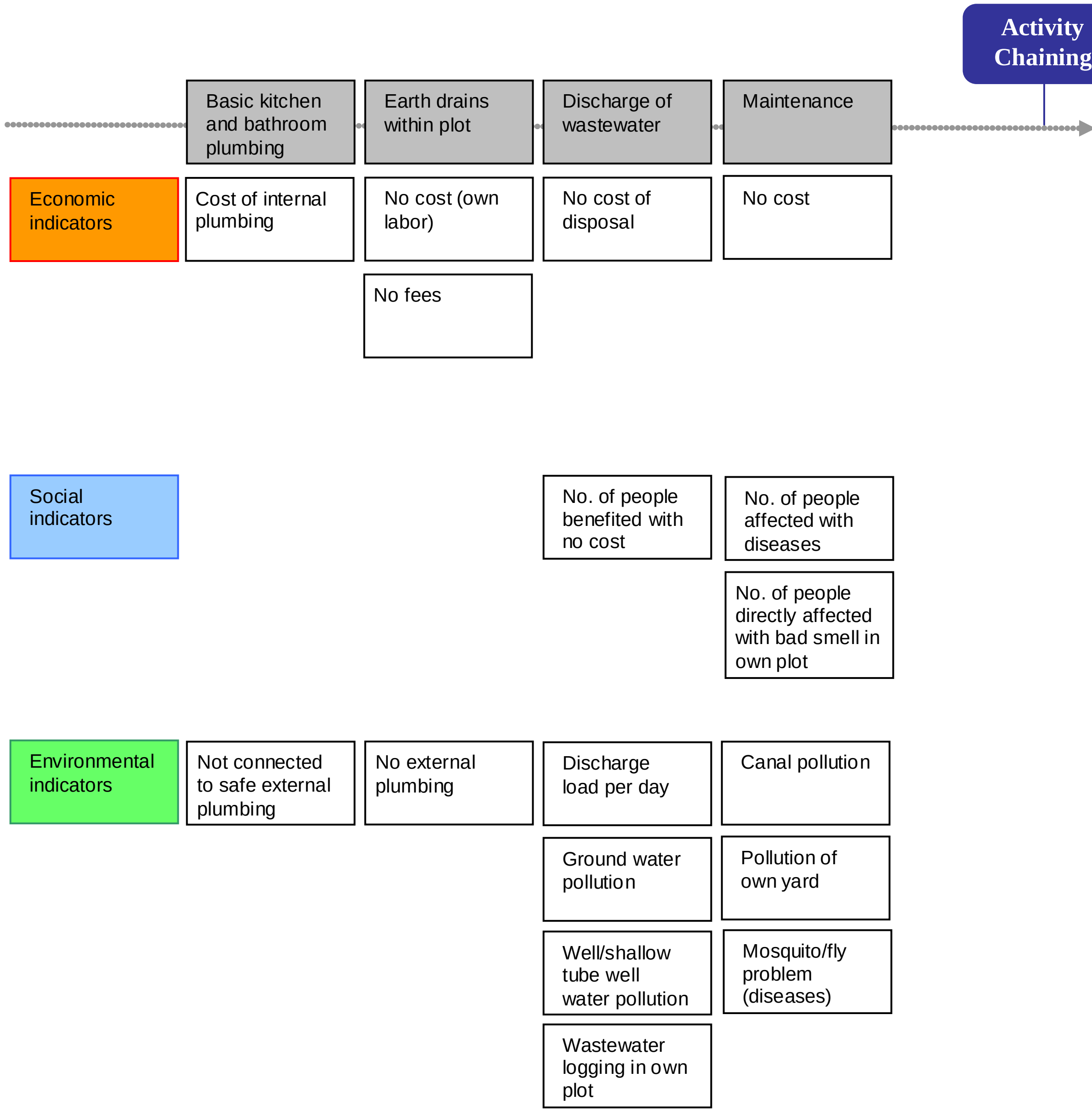


Figure 4-14. Unbundling the activities and the respective economic, social, and environmental indicators regarding grey water discharge within a household's own plot of land.

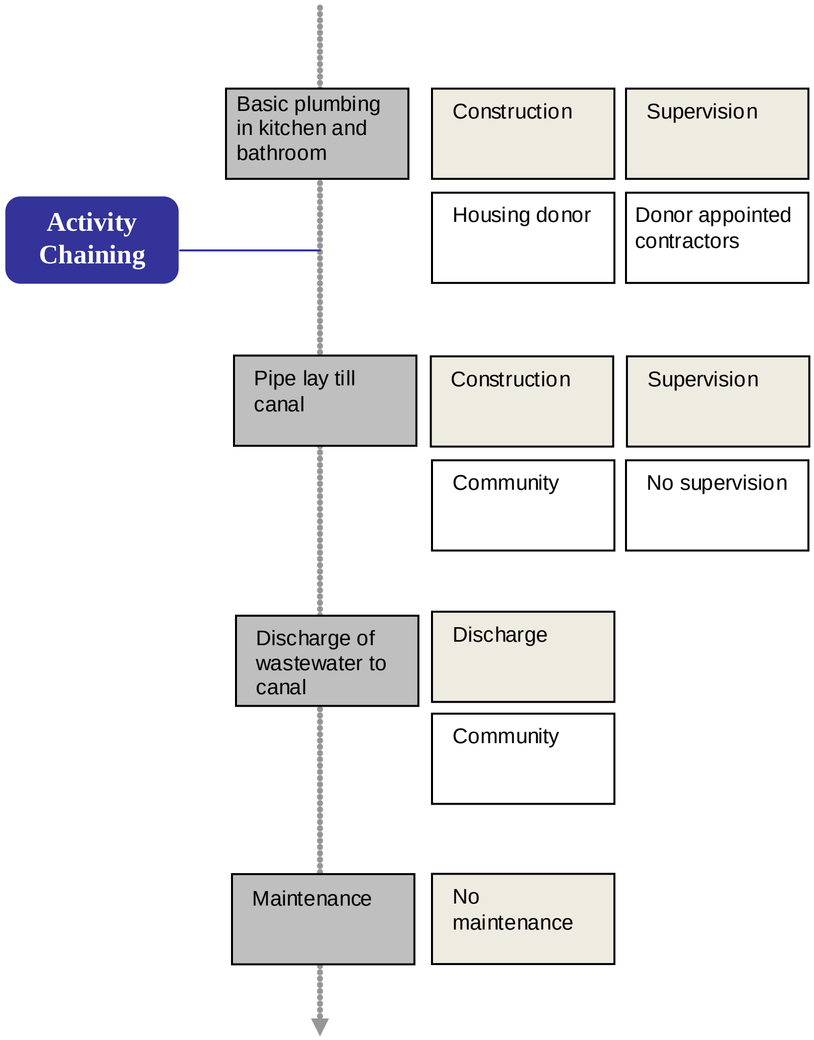


Figure 4-15. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement for grey and black water discharged to surface drainage canal

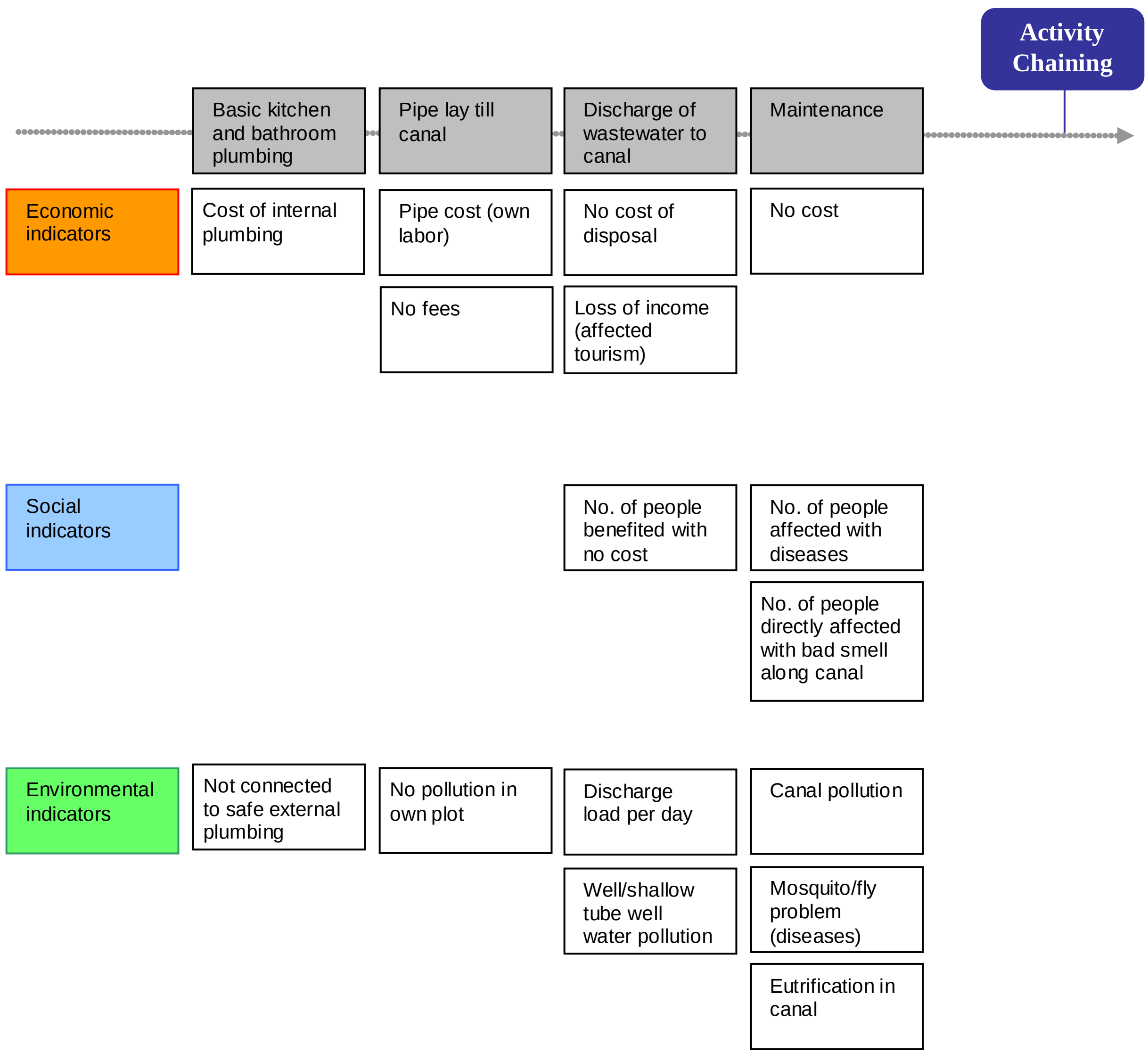


Figure 4-16. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding discharging grey and black water to a surface drainage canal.

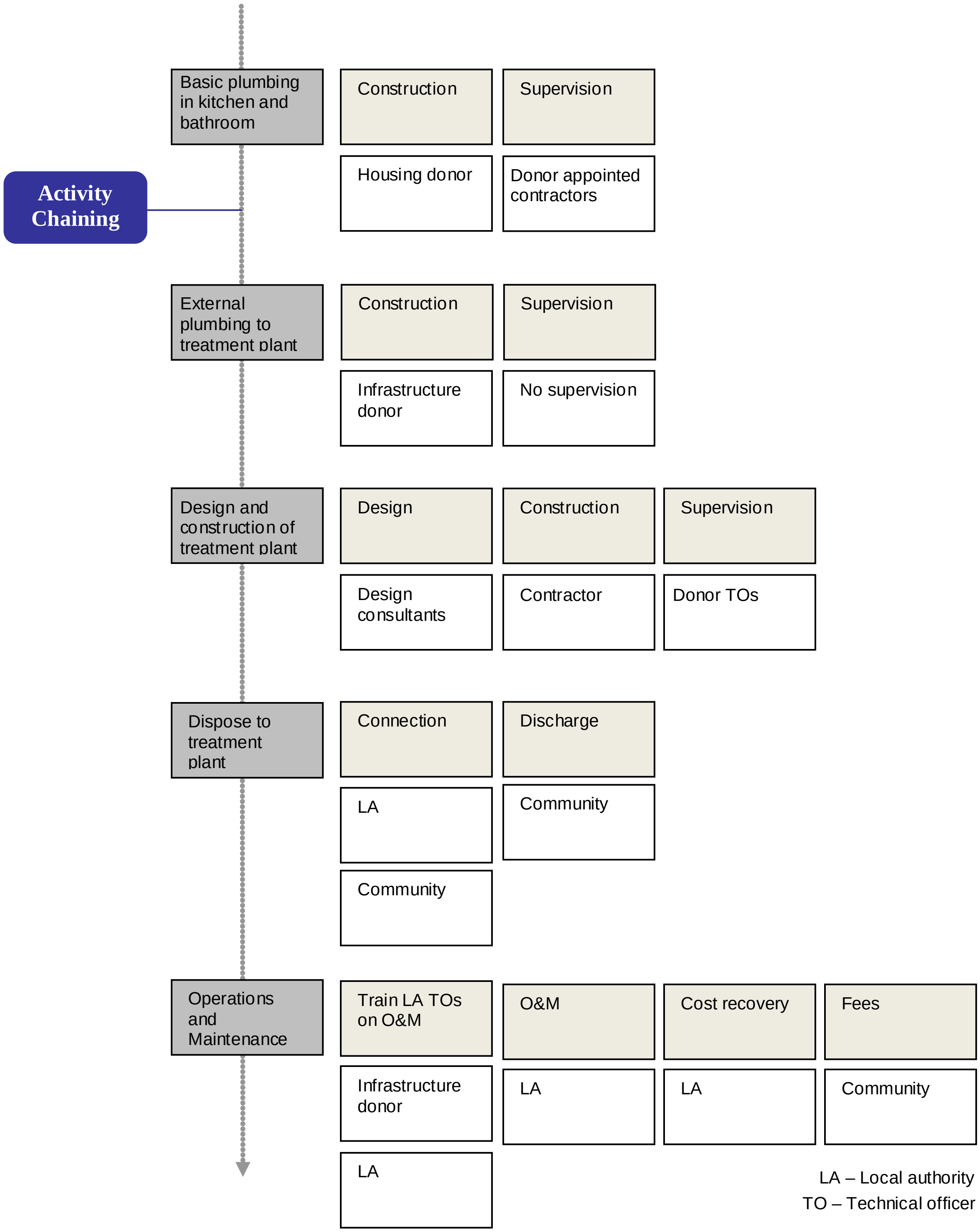


Figure 4-17. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement with grey and black water discharged to central wastewater treatment plant.

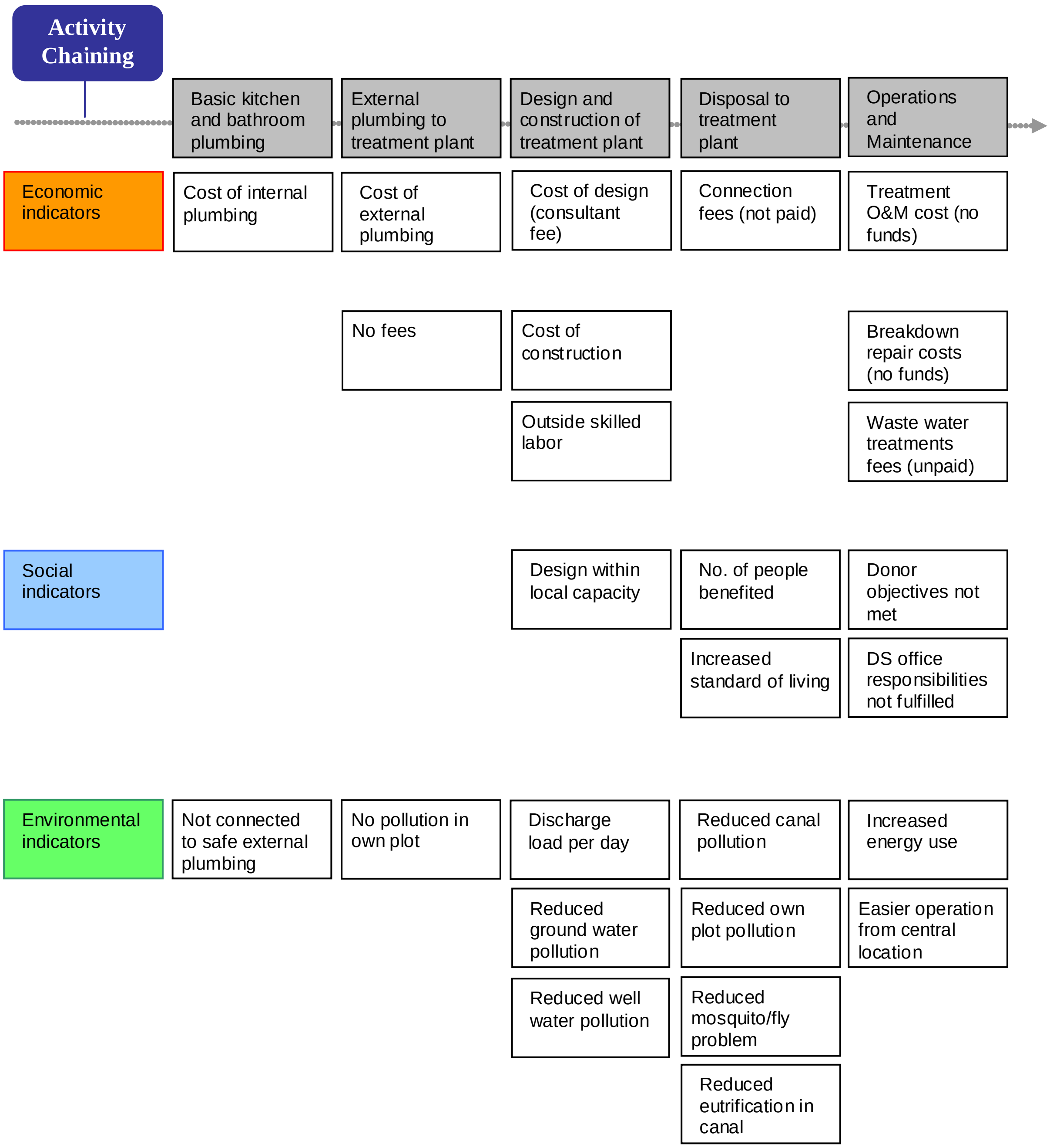


Figure 4-18. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding discharging grey and black water to a central wastewater treatment plant.

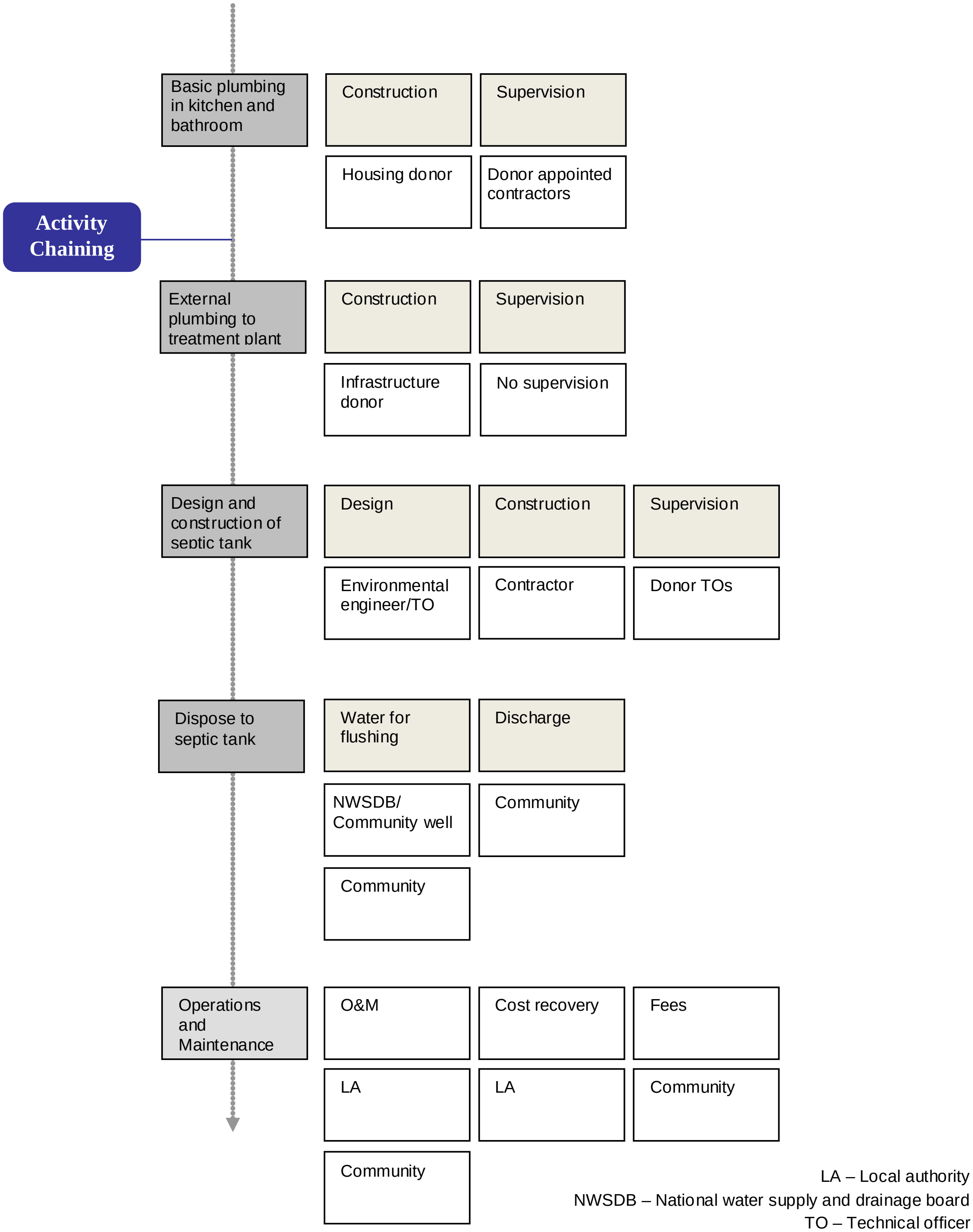


Figure 4-19. Activity chaining and unbundling the activities mapping the respective stakeholder involvement for grey and black water discharged to two chambered septic tank.

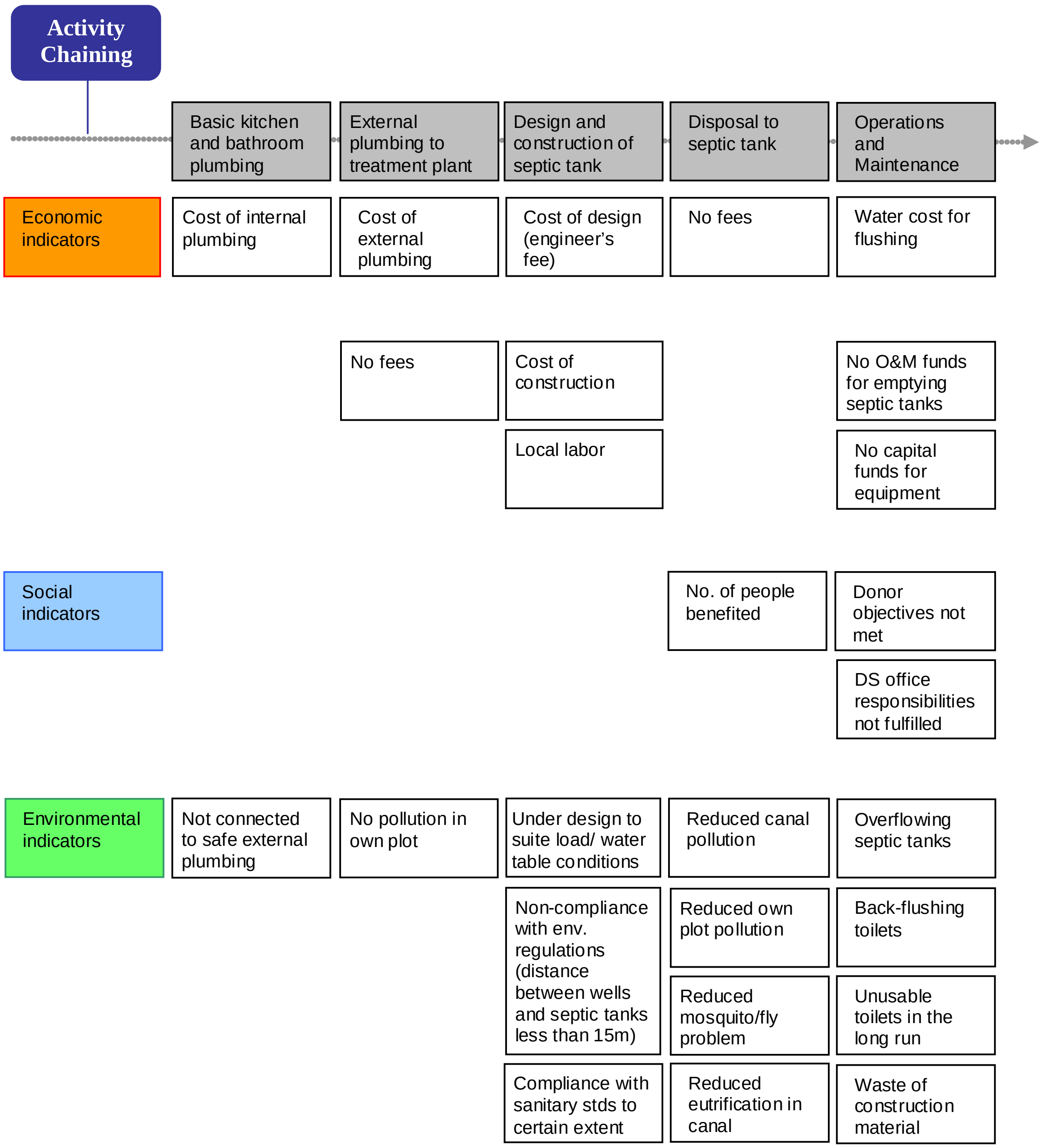


Figure 4-20. Unbundling the activities and the respective economic, social, and environmental indicators regarding discharging grey and black water to a two-chambered septic tank.

Table 4-2. Evaluation of the quantitative, semi-quantitative and qualitative indicators for activities related to the three pre-existing levels of service for wastewater infrastructure in a tsunami-affected village in Sri Lanka.

Indicator	Discharged within own plot of land	Discharged to surface water canals	Discharged to a two-chambered septic tank	Discharged to a central treatment plant
Economic				
Cost of internal plumbing	Rs.8,000 (Donor)	Rs.8,000 (Donor)	Rs.8,000 (Donor)	Rs.8,000 (Donor)
Cost of external plumbing	Minimal to beneficiary	Minimal to beneficiary	Rs.2,500 (Donor)	Rs.2,500 (Donor)
Cost of design	No cost	No cost	-	Rs.10,000 (Donor)
Cost of treatment unit construction	-	-	Rs.12,500 (Donor)	Rs.400,000 (Donor)
O&M Costs	No cost	No cost	Rs.153 per month (Water cost to households) + Rs.2,000 per 2years (Sludge removal by LA)	Rs. 800,000 (Unaffordable to LA)
Connection fees	-	-	-	Rs.10,000 per connection (Unaffordable to by households)
Monthly fees	No fees	No fees	No monthly fees; Rs.2,000 per 2years (Sludge removal By LA)	Rs.2,000 per month (Unaffordable to households)
Damage to tourism	Moderate	High	Moderate	No
Social				
Safe wastewater disposal in the community	Unsafe	Unsafe	Somewhat safe	Safe disposal complied with WHO standards

Table 4-2. Continued

Indicator	Discharged within own plot of land	Discharged to surface water canals	Discharged to a two-chambered septic tank	Discharged to a central treatment plant
Number of people benefited	Households discharging with no cost; LA not having to provide service	Households along the canal discharging with no cost; LA not having to provide service	Beneficiary households	Households benefiting from safe disposal
Number of people affected	Households that discharge and neighbors	Households along the canal and the village with floods	Households using well water	-
DS office objectives fulfilled	Not fulfilled	Not fulfilled		Fulfilled (if cost recovery is possible)
Donor objectives fulfilled				
Standard of living	No arrangement	No arrangement		Increased (if plant could be operated)
Environmental				
Grey water discharged	130 liters per day per household	36,000 liters per day to canal	130 liters per day per household	- (expected 5,200 liters per day)
Black water discharged	40 liters per day per household	5,000 liters per day to canal	40 liters per day per household	- (expected 1,600 liters per day)
Canal pollution	-	Increased eutrification	Reduced	Reduced
Diseases with mosquito and fly problem	Increased	Increased	Reduced	-
Groundwater pollution	Increased	Increased	Increased (high water table)	-
Well/shallow tube well water pollution	Increased (when distance <50m)	Increased (when distance <50m)	Increased (when distance <50m	-
Wastewater logging and pollution in own plot	Increased	-	-	-

Table 4-2. Continued

Indicator	Discharged within own plot of land	Discharged to surface water canals	Discharged to a two-chambered septic tank	Discharged to a central treatment plant
Compliance with environmental standards	Not complied	Not complied	Not complied (distance to water bodies <50m)	Complied with environmental standards
Compliance with sanitary standards	Not complied	Not complied	Somewhat complied	Complied with sanitary standards
Surface drainage	Moderately increased	Increased	Moderately increased	-

As illustrated above, the village team assessed the current levels of all major issues such as poor access roads, surface drainage, and haphazard construction in the community using the SBLCA framework. With the above approach applied to examine the current status of water supply and wastewater in detail, the following aspects were clearly visualized by the stakeholders:

- The direct interconnectivities of the portable water supply, wastewater, and drainage issues. Improving water supply without finding solutions for the wastewater issue would aggravate the wastewater and stormwater drainage problem.
- Proper design considerations at the initiation of programs plays a major role in avoiding harmful effects such as back flow of toilets, inoperable wastewater treatment plants, and non-functioning septic tanks due to high water tables.
- Providing two chambered septic tanks in high water table conditions would still contaminate the groundwater and can result in well water contamination increasing thepotential for diseases. Also, if sludge is discharged on open land, or to an improper landfill site, ground water and nearby surface water pollution is unavoidable. This is a common issue in almost all municipalities in Sri Lanka.
- Clear understanding of the essential upstream and downstream costs of activities that need to be the responsibility of the stakeholders such as the community, local authorities, technical officers, and donors together with the related positive and negative benefits to individual stakeholders and to the village as a whole.

The process of stakeholders explicitly contributing to the development of structured knowledge for the analysis creates consensus and helps to a great extent in reducing the bounded rationalities and opportunistic behaviors of the stakeholders. The process leads them to reach consensus on prioritizing the issues to be addressed in the village with an appropriate level of focus on the interconnected issues. This structured transdisciplinary learning in multi-stakeholder political environments prepares for the next stage of planning where the options for solutions need to be developed as cross-sectoral joint projects rather than single-sector, single-dimensional projects.

Case-Study Examples in Option Analysis and Strategizing for Implementation

In the option analysis phase, SBLCA was applied to formulate, assess and strategize optional solutions for the prioritized issues. Some of the issues identified for immediate action were potable water supply, toilet and wastewater disposal, and stormwater drainage issues, which had direct links to one another. The following examples elaborate the use of SBLCA in formulating, assessing, and strategizing options for improving water supply (Example 3) and wastewater issues (Example 4) explored under the current status analysis explained in the previous section.

Example 3 – option analysis for portable water supply

- Step 1: Identify options for improved levels of service:
  - Option 1: An individual piped water connection for everyone provides the highest level of service; every household and business in the community prefers to have individual piped-water connections.
  - Option 2: Provision of an individual piped-water connection for all individuals who do not have their own well as one solution.
- Step 2: Chain the upstream and downstream activities relevant to providing and maintaining the above optional levels of service.
- Step 3: Unbundle and assess components of proposed activities in terms of stakeholder participation, resources, costs, cost recovery, and benefits using relevant economical, social, environmental indicators.

A graphical representation of the framework applied to a piped-water supply for households without a well is presented in Figures 4-21 and 4-22. Figure 4-21 shows the primary activities and related stakeholder mapping for providing piped-water to households. Figure 4-22 shows the economic, social, and environmental indicators related to the primary piped-water activities.

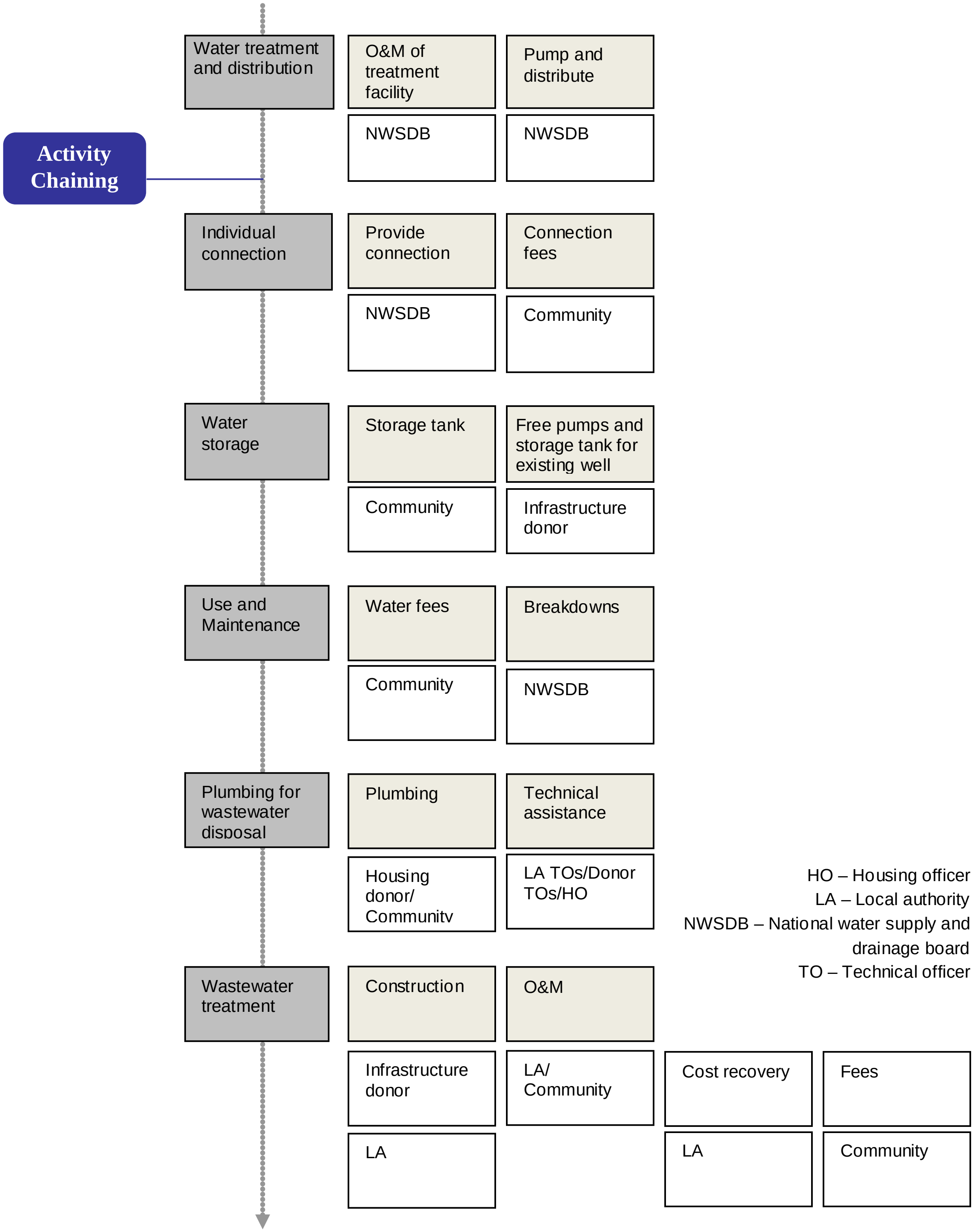


Figure 4-21. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement regarding the provision of water through individual piped water connections for all households without an existing well

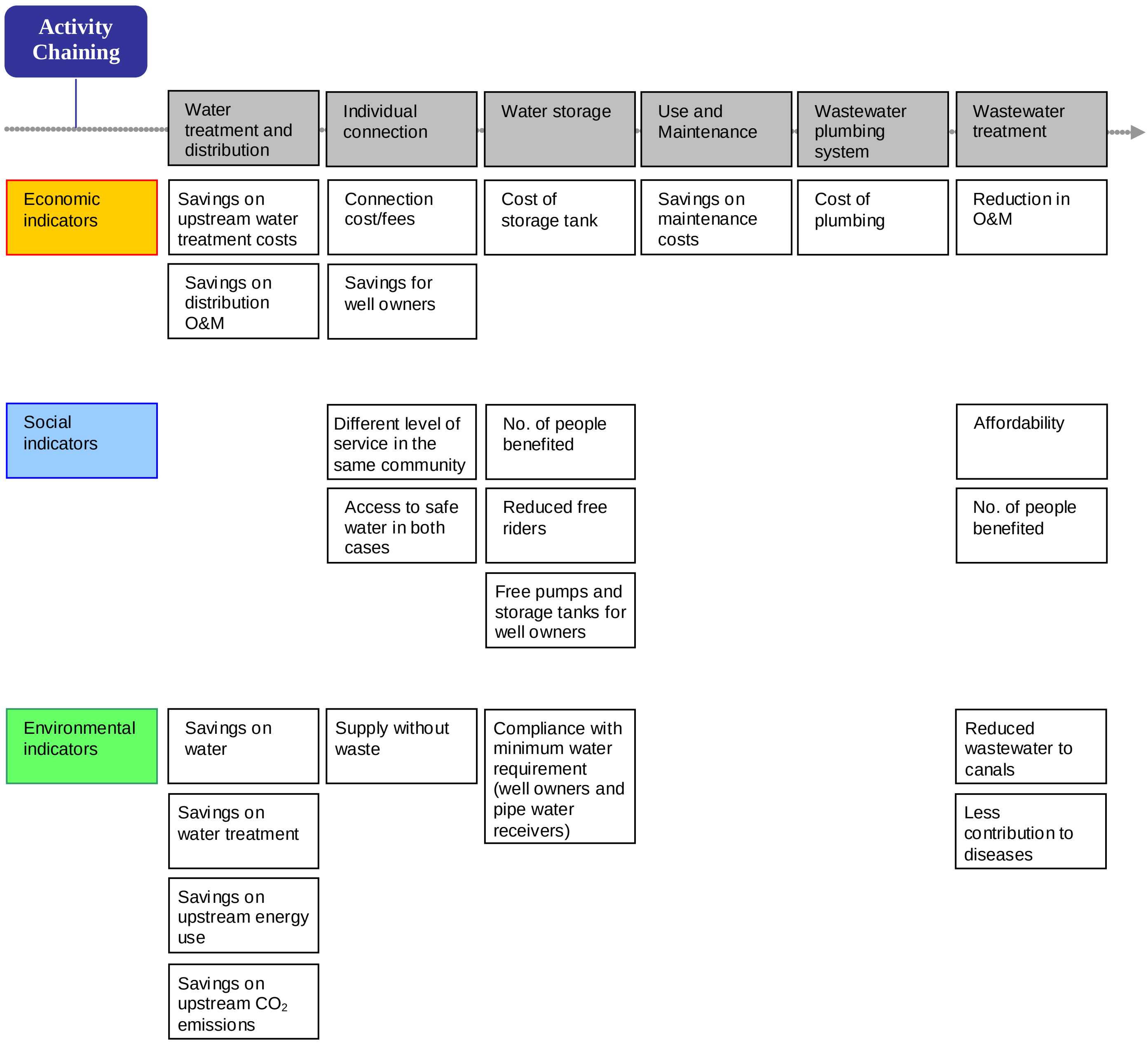


Figure 4-22. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding the provision of water through an individual piped connection for all households without an existing well

The quantitative and qualitative indicators which were used to analyze the potable water supply service levels are summarized in Table 4-1. Similar indicators were used in the option analysis comparing piped-water for all households to piped-water only for households without an existing well as the upstream and downstream activities were similar for the options, only the number of households that would be receiving piped water was different. The indicator values and cost benefit comparisons for some of the quantitative indicators for options are presented in Table 4-3. Detailed analysis is given in Appendix E.

Table 4-3. Quantitative data and net savings for two proposed piped water supply options

	Piped water (m^3)	Cost (Rs.)	Energy (kWh)	Energy cost (Rs.)	CO_2 (kg)
Option 1: Piped water for all households					
Consumption (daily)	94	1,413	19	66	0.01
Consumption (monthly)	2,825	42,381	565	1,978	0.4
Consumption (yearly)	34,376	515,636	6,875	24,063	4.8
Option 2: Piped water only for households without an existing well					
Consumption (daily)	192	2,876.25	38	134	0.03
Consumption (monthly)	5,753	86,288	1,151	4,027	0.8
Consumption (yearly)	69,989	1,049,831	13,998	48,992	9.8
Option 2 - Option 1					
Savings (daily)	98	1,464	20	68	0.01
Savings (monthly)	2,927	43,907	585	2,049	0.4
Savings (yearly)	35,613	534,196	7,123	24,929	5.0

In this exercise, it should be noted that the team has holistically thought through the problem. The team has examined the increased water and wastewater treatment, and the health and sanitation issues which are integral to the water supply infrastructure issue.

Therefore, it is clear that the successful implementation of this project would require the integration of stakeholders to coordinate and collaborate for sustainable results. Cleaning the polluted canal before improving the water supply infrastructure to the village would result in less stress to the less than ideal wastewater handling in the village. To properly address the water supply problem with appropriate levels of improved service, it is necessary to have identified the increased water consumption and resulting wastewater releases with respect to improved levels of service of water supply.

When formulating and implementing improved solutions for wastewater, it may be necessary to go back and examine related activities such as water supply, water use, and stormwater drainage to insure that they integrate with the proposed solutions. It is very important that this iterative process occur to insure that the team is working towards sustainable solutions.

Example 4 – option analysis for the wastewater issue

Wastewater back flow through toilets and overflowing septic tanks due to inadequate design and because of the high water table were common occurrences. A central waste water treatment plant with piped connections to the households is a good option. Although donors were willing to construct a treatment plant, neither the local authority nor the community could afford to pay for the associated operation and maintenance costs. One alternative type of toilet is called an Eco-sanitary toilet introduced and successfully implemented in many developing countries by Practical Action Consultants (Eco-solutions, 2007; Practical Action, 2008). Because a large number of toilets would have to be built, possible construction material options were included together with different toilet technologies.

- Step 1: Identify optional levels for improvement
    - Option 1: Commonly used traditional toilet with septic tank or seepage bed, following the specifications of the Sri Lanka Standards Institute (SLSI) (SLSI, 2003).
    - Option 2: Eco-sanitary toilet (composting toilet) as specified by the guidelines developed by Practical Action, Sri Lanka.
      Different material options are included. The summary of the options are tabulated in Table 4-4. The details of the two methods are given in Appendix G.

- Step 2: Chain the upstream and downstream options relevant to providing and maintaining the above optional levels of service.
- Step 3: Assess the components of proposed activities in terms of stakeholder participation, resources, costs, cost recovery, and benefits using relevant economical, social, environmental indicators (summarized in Table 4-5).

Table 4-4. Optional levels for black and grey water disposal

Option 1: Conventional toilet (4'x5'x6.5')		
Option 1 (i)	Option 1 (ii)	Option 1 (iii)
Rubble foundation	Rubble foundation	Rubble foundation
Cement block wall	Compressed stabilized earth block (CSEB) wall	Brick wall
Reinforced cement concrete (RCC) roof slab	RCC roof slab	Sheet roof
Brick rectangular septic tank ($5m^3$)	Brick septic tank ($5m^3$)	Pre-cast cylindrical septic tank ($2m^3$)
Soakage pit (1.5m3) SLSI Standards	Seepage bed (3mx15mx4m) SLSI Standards	Soakage pit (1 m^3) SLSI Standards
Option 2: Double vault Eco-sanitary toilet with urine and wash water diversion (4'x5'x6.5')		
Option 2 (i)	Option 2 (ii)	Option 2 (iii)
Rubble foundation	Rubble foundation	Rubble foundation
Cement hollow block wall	CSEB block wall	Brick wall
RCC roof and floor slab	RCC roof and floor slab	Sheet roof
Cement hollow block plant bed ($1m^3$)	Cement hollow block plant bed (1 m^3)	Brick plant bed
Brick vault	Brick vault	Brick vault

A graphical representation of the framework applied to formulating alternative options for toilets and wastewater treatment is presented in Figure 4-23 to 4-26. Figures 4-23 and 4-25 show the primary activities and related stakeholder mapping for options 1 and 2. Figures 4-24 and 4-26 show the economic, social, and environmental indicators related to the primary activities identified as required for implementing the options.

The quantitative and qualitative indicators which were used to analyze the toilet and wastewater treatment options are summarized in Table 4-5.

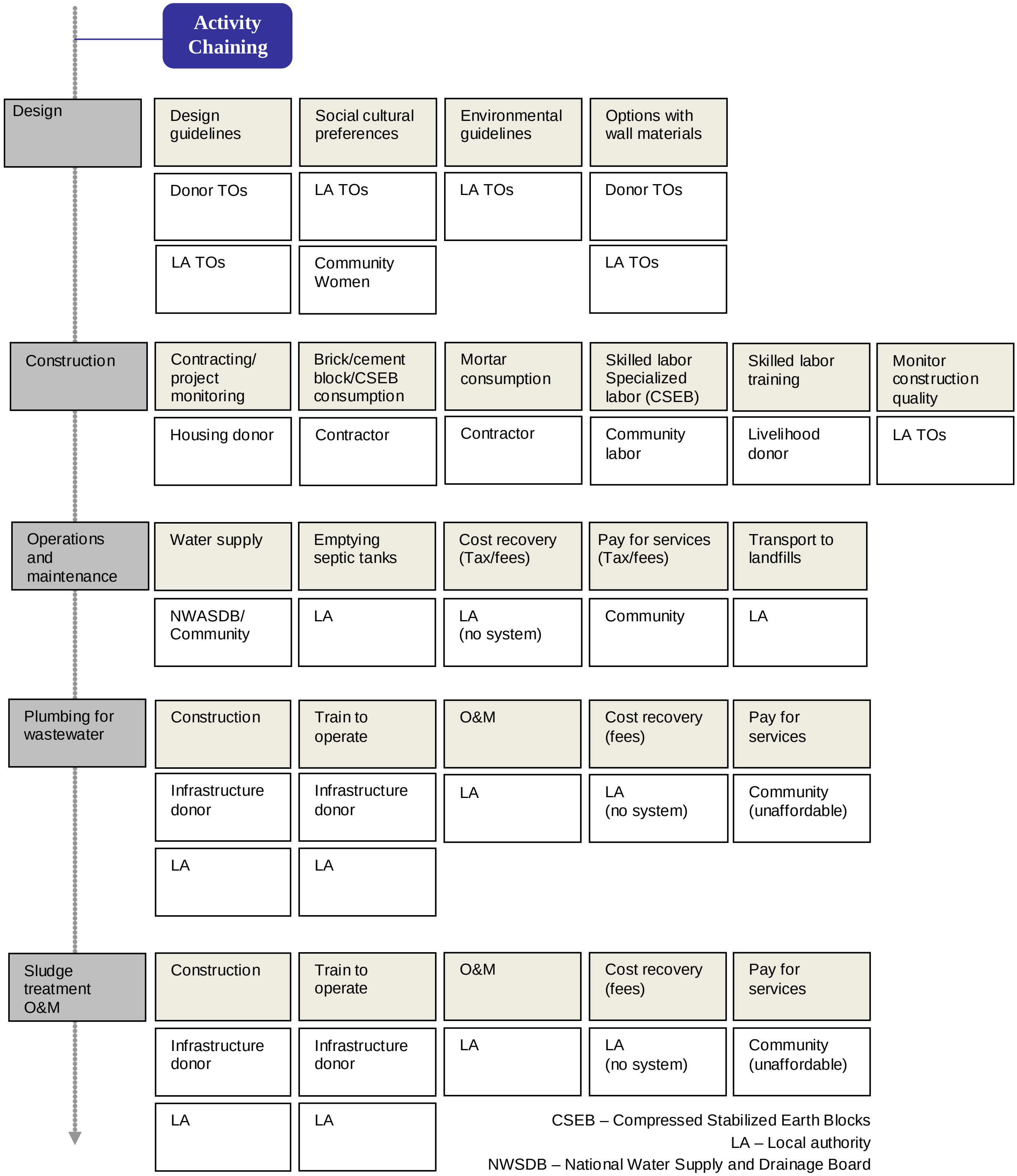


Figure 4-23. Breakdown of the activities and the respective stakeholder involvement for constructing a conventional toilet with a septic tank and seepage bed for grey and black wastewater treatment

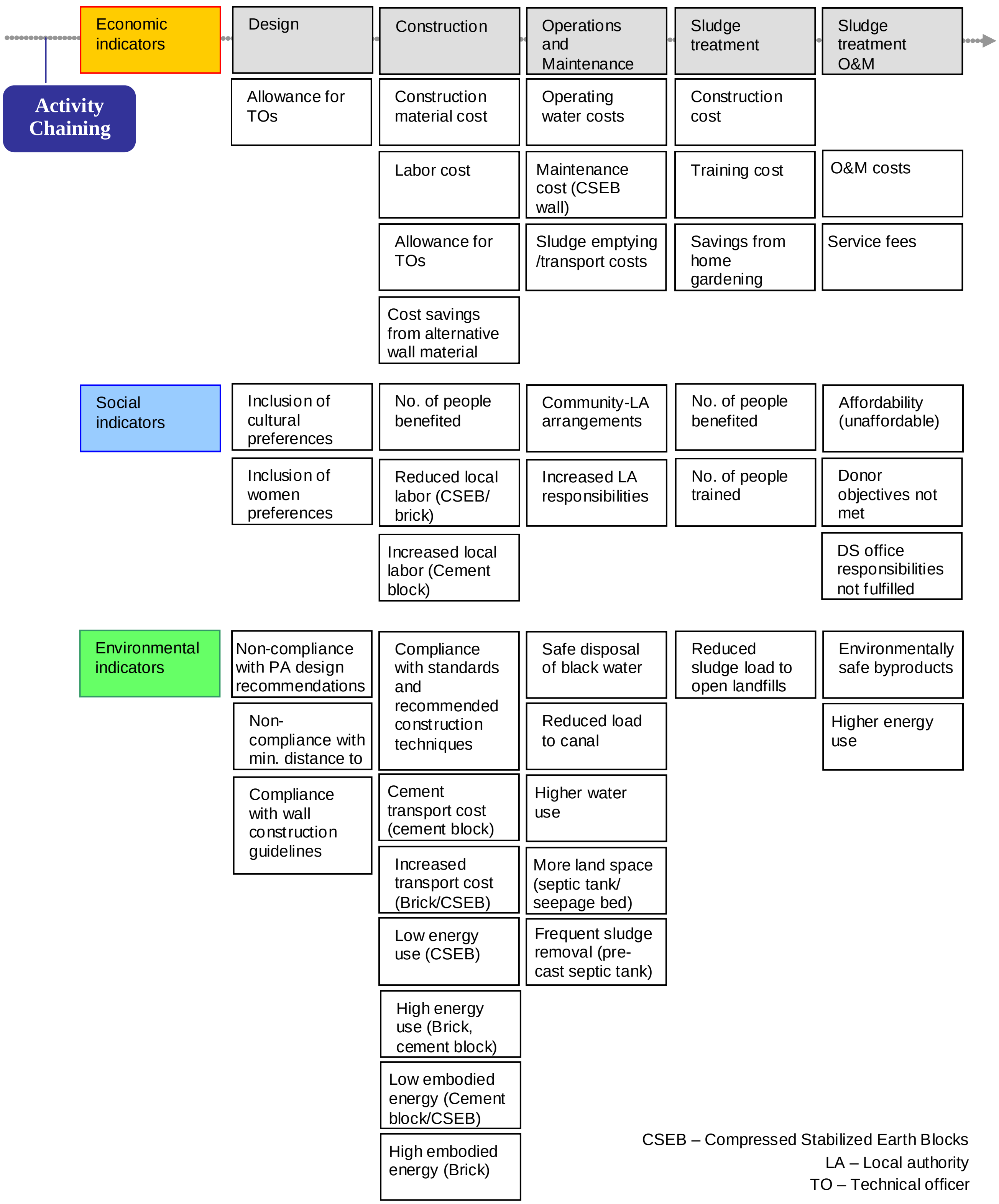


Figure 4-24. Breakdown of the activities and the respective economic, social, and environmental indicators regarding constructing a conventional toilet with a septic tank and a seepage bed for grey and black water disposal.

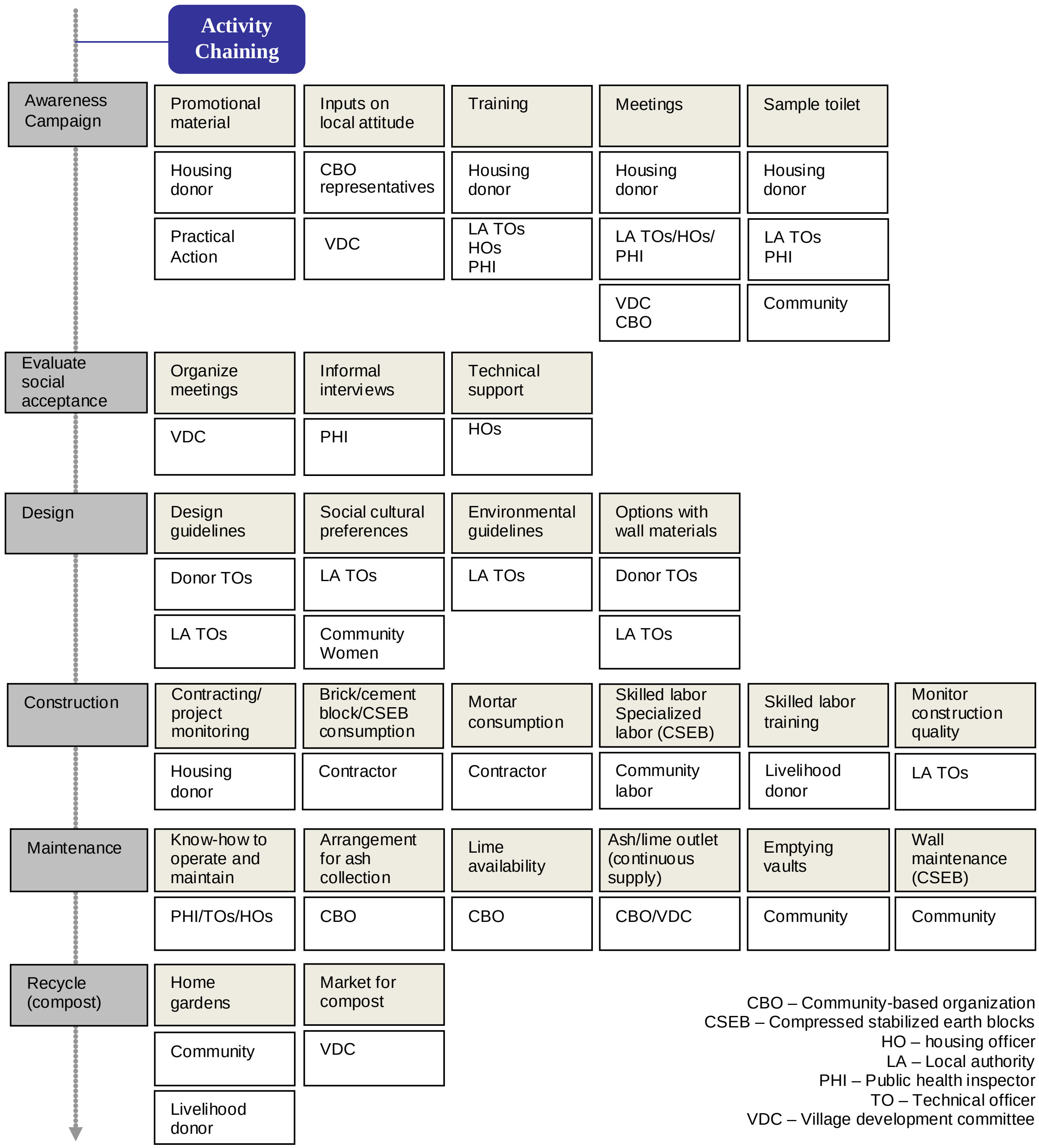


Figure 4-25. Unbundling the primary activities and the respective stakeholder involvement for constructing an Eco-sanitary toilet for grey and black wastewater treatment

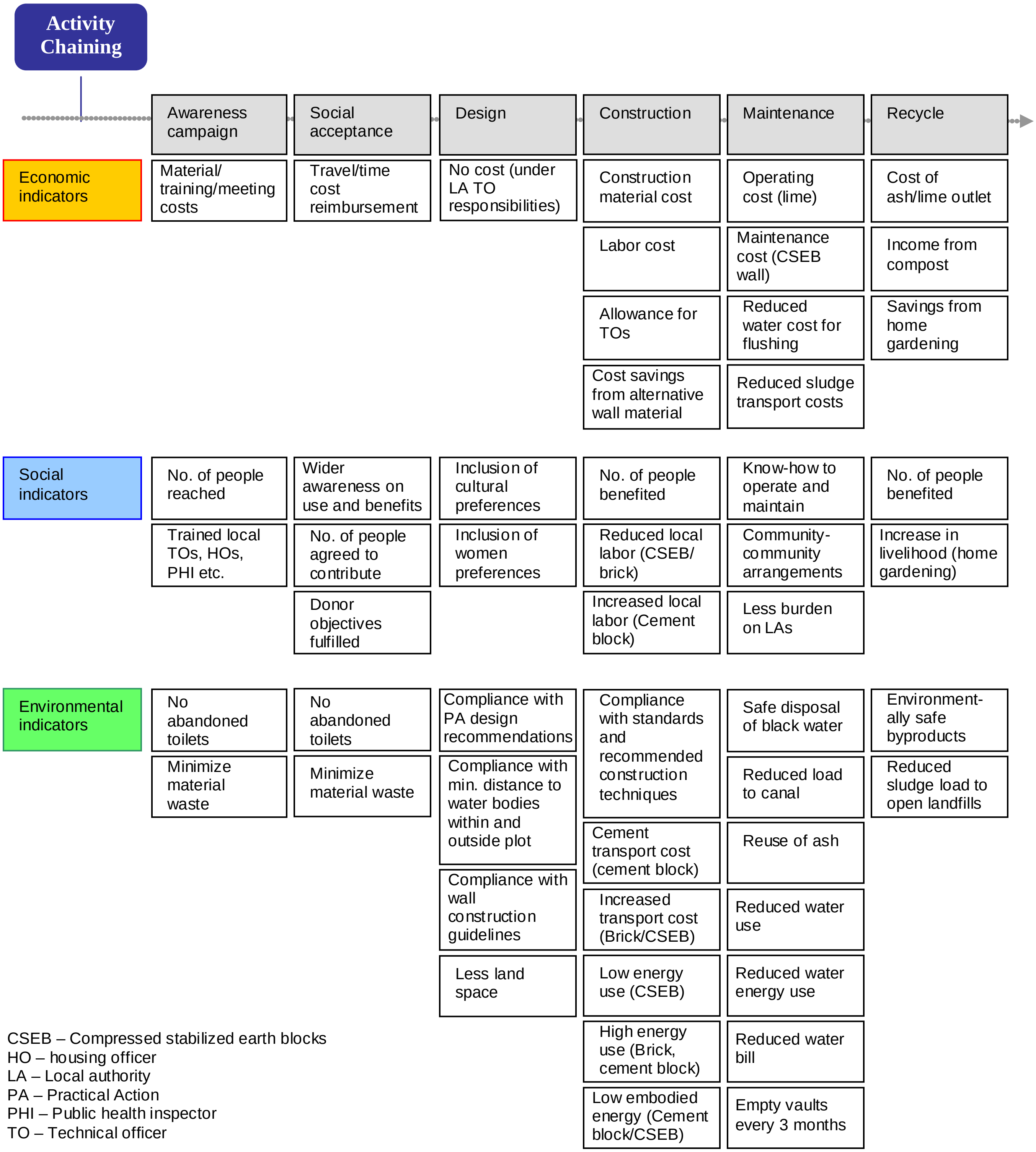


Figure 4-26. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding constructing an Eco-sanitary toilet for grey and black wastewater treatment.

Table 4-5. Summary of indicators for analyzing the options for improving the wastewater issue

Indicator	Option 1(i)	Option 1(ii)	Option 1(iii)	Option 2(i)	Option 2(ii)	Option 2(iii)
Initial cost – donor (awareness campaign)		-			Rs.100,000	
Capital cost – donor (toilet construction)	Rs.67,800	Rs.74,500	Rs.54,700	Rs.48,400	Rs.46,900	Rs.47,600
Capital cost – LA (gully bowsers and equipment)		Rs.2 million			-	
O&M cost – beneficiary (water+ sludge removal fees + protective coating)	Rs.153/month + Rs.2,000/2years + Rs.0	Rs.153/month + Rs.15,000/5years + Rs.300/2years	Rs.153/month + Rs.2,000/9months + Rs.0	Rs.50/month + Rs.0 + Rs.0	Rs.50/month + Rs.0 + Rs. 300/2years	Rs.50/month + Rs.0 + Rs.0
Income from compost		-			Rs. 25/kg of compost	
O&M cost – LA		Rs.2,000/2years			-	
Sludge treatment plant cost		Rs. 800,000			-	
Sludge treatment O&M		Rs.60,000/ month for 40 households			-	
Separate consideration for grey water	Directed to soakage pit (designed considering grey water load)	Directed to seepage bed (designed considering grey water load)	Rs.5,000 for plant bed (as pre-cast cylindrical septic tanks are available in one size)		Rs.5,000 for plant bed	
Energy consumption (considering only wall type)	2,350 MJ	1,100 MJ	16,570 MJ	2,350 MJ	1,100 MJ	16,570 MJ
Embodied energy (considering only wall type)	970 MJ	1,650 MJ	12,450 MJ	970 MJ	1,650 MJ	12,450 MJ

Table 4-4. Continued

Indicator	Option 1(i)	Option 1(ii)	Option 1(iii)	Option 2(i)	Option 2(ii)	Option 2(iii)
CO_2 considering wall type)	260 kg	160 kg	1,260 kg	260 kg	160 kg	1,260 kg
Reduced water use		-		2/3 reduction compared to conventional toilet		
Reduced water energy use		-		2/3 reduction compared to conventional toilet		
Reduced water costs		-		2/3 reduction compared to conventional toilet		
Land use for treatment	Land consuming; 15m clearance from all surrounding wells and surface water bodies	Land consuming; Spreads over 15m distance	Land consuming; 15m clearance from all surrounding wells and surface water bodies	Not land consuming; 15m clearance from all surrounding wells and surface water bodies (SLSI Standard)		
Material manufacture/ transport	Cement blocks can be locally obtained; Cement transported 50-100km	CSEB transported 30-50km;	Brick transported 100-150km; pre-cast septic tank Transported 100-150km;	Cement blocks can be locally obtained; Cement transported 50-100km	CSEB transported 30-50km	Brick transported 100-150km;
Labor	Local	Local and non-local	Local	Local	Local and non-local	Local
Compliance with health and sanitation standards	Not complied	Not complied	Not complied	Complied	Complied	Complied
Surface water pollution (canals)	-	-	-	-	-	-
Ground water pollution	Increased	Increased	Increased	-	-	-
Diseases	Increased	Increased	Increased	Reduced	Reduced	Reduced

From the above analysis, it can be concluded that a conventional toilet with a septic tank or soakage pit is not a sustainable solution in densely built coastal villages where the water table is high. Also, the analysis shows that downstream of the above solution, the LAs have to have the necessary equipment and suitable landfill areas to dispose of the sludge. Many rural LAs in Sri Lanka are not equipped to transport sludge and also do not have funds for contracting for the service. Arrangements between the LA and the community for maintaining septic tanks such as paying and collecting fees or taxes do not currently exist.

Introducing Eco-sanitary toilets requires background work to gain the social acceptance of the technology, else the technology will not be welcomed and accepted by the village residents. A donor must be ready to bear these upstream preparatory expenses if this technology is to become a viable option. An uninterrupted ash or lime supply is also a requirement for sustainable operation of the Eco-sanitary toilets.

In terms of building materials, it could be seen that compressed stabilized earth block (CSEB) walls are a better option considering material extraction, manufacturing, transport, and construction and end-of-life disposal, but it involves wall maintenance, which is not too costly. Capital cost-wise, construction material combinations for the toilets fall in a narrow range, but CSEB still has an economic advantage as the overall manufacturing and construction cost is lower, while the environmental benefits as measured by reduced energy use and reduced demand on heavily demanded materials such as cement and bricks. Construction with CSEB may require skilled labor not available in the village, which could mean either a loss of income opportunities within the village or an opportunity for a livelihood program.

Eco-sanitary toilets with CSEB walls can be seen as the best option because it scores the best on many of the economic, social, and environmental indicators. In a typical village development stakeholder forum for option analysis consisting of the village development team and other stakeholders such as community representatives and officials from the local authorities and donors, criteria for decision making can be ranked and weights can be agreed upon accordingly. Viability of the options could be assessed with stakeholders negotiating and agreeing to perform all necessary and clearly identified activities with the associated resource requirements. If certain activities and resource commitments are not forthcoming, then the next best option should be considered.

Given the baseline information produced by the multi-stakeholder analysis, strategizing solutions becomes easier because activity flows and responsibilities are already identified. Agreeing to a time line with a memorandum of understanding to perform each activity by respective stakeholders provides a way forward for sustainable implementation.

Indicator Development and Data Sources

As explained above, in the SBLCA framework, each activity resembles a process in a typical LCA, where environmental emissions and raw material depletion are inventoried based on a given functional unit and later converted to communicable impact indicators. Similarly, simplified quantitative and qualitative indicators covering stakeholder involvement, resource needs, and social, economic, and environmental costs and benefits were selected by stakeholders for each upstream and downstream activity identified as being related to an issue or solution. As processes in a typical LCA can have different emission inventory or impact categories, the activities in issues and solutions can also have different inventory or impact categories. The inventory categories can be quantitative or qualitative. Some could be typical LCA impact indicators, while others could be different. The main indicator categories used in these analyses are summarized in Table 4-6. The main data sources are given in Table 4-7. Table 4-8 and Table 4-9 outline the detailed stakeholder and expert inputs in compiling the economic, social, and environmental indicators. The intended objective of the indictors is to assist multiple stakeholders identify their roles, other stakeholders' roles, and costs and benefits to themselves and to the village as a whole in order to support collaboration toward achieving joint targets in an integrated village development process.

Table 4-6. Main indicator categories used

Indicator categories	Indicator	Quantitative or Qualitative
Economic	Capital costs	Quantitative
	Operation and Maintenance costs	Quantitative
	Cost savings/increases	Quantitative
	Cost recoveries – service fees/tax	Quantitative
	NPV	Quantitative/Qualitative
	Number of livelihood opportunities	Quantitative/Qualitative
	Number of local labor opportunities	Quantitative/Qualitative
	Institutional capacities inadequate/adequate	Qualitative
Environmental	Energy consumptions/savings	Quantitative
	Raw material depletions/savings	Quantitative
	CO2/GWP increases/reductions	Quantitative
	Environmental releases (wastewater, sludge, etc.) increases/reductions	Quantitative/Qualitative
	Contribution to spread of diseases more/less	Quantitative/Qualitative
	Per capita consumption increases/reductions	Quantitative/Qualitative
	Compliance with environmental regulations, standards, or recommendations	Quantitative/Qualitative
Social	Number of people affected/benefited	Quantitative
	Number of people with improved skills and capacity	Quantitative/Qualitative
	Vulnerable group preferences ignored/considered	Qualitative
	Historical/cultural preferences ignored/considered	Qualitative
	Stakeholder objectives unfulfilled/fulfilled	Qualitative
	Compliance with socio-economic regulations, standards, or recommendations	Quantitative/Qualitative
	CBOs inactive/active	Qualitative

Table 4-7. The data sources

Data	Sources
Sri Lankan electricity grid and related emission data	Greenhouse gas emission mitigation in the Sri Lanka-power sector supply side and demand side options, Energy Conversion and Management (Wijetunga et al., 2003):
Water production and distribution data	National Water Supply and Drainage Board public website (NWSDB, 2007)
Per capita income, water, energy use	CIA World Fact Sheet (CIA, 2007)
Water and sanitation standards	WHO public websites (WHO, 2007)
Wastewater release data and standard septic tank design data	SLSI Design and Construction of Septic Tank and Associated Effluent Disposal, Part 1 – Small System Disposing to ground – SLSI 745: Part 1 (SLSI, 2006)
Eco-san toilet design	Practical Action public website (Practical Action, 2008)
CSEB, cement block and brick wall energy and emission data	Comparison of Building Materials in Auroville Earth Institute India (Auroville Earth Institute, 2007)
Earth, cement block and brick wall embodied energy data	Estimating environment suitability of wall materials, Building and Environment (Emmanuel, 2004)
Village profile data	Village Officer Records
Village specific water consumption data	Public Health Inspector records
Transport emissions	Sri Lanka Emission Standards, Air Resource Management Center (AirMAC), Ministry of Environment And Natural Resources, Sri Lanka. (AirMAC, 2005)
Cost of design	Donor databases, Contractors data, Practical Action data
Cost of construction	Donor databases, Contractors data, Practical Action data
Labor requirements	Donor databases, Contractors, Practical Action data
Building and sanitation regulations, standards, and practices	Practical Action Local Authority and Housing Technical officer records
Construction material consumption data − cement annual demand (2006) − cement demand growth rate − sand annual demand − sand growth rate	Industries: Building blocks (Lanka Business Online, 2008) Mineral Industry of Sri Lanka, Eastern Economic Review (Chin.S.Kuo, 1999) Sri Lanka National Policy on Sand as a Resource for the Construction Industry (e-Law, 2007)

Table 4-7. Continued

Data	Sources
Annual production of mineral commodities	2005Mineral Yearbook, Sri Lanka (USGS, 2007)
Environmental regulations	Central Environmental Authority (CEA) of Ministry of Environment and Natural Resources publications (CEA, 2001) Geological Survey and Mines Bureau permits (GSMB, 2007) Local Authority Environmental Officer records
Health indicators	Country Health System Profile, Sri Lanka, (WHO, 2007) Public Health Inspector records (2007)

Table 4-8. Detailed steps of indicator development with stakeholder and expert contributions of data compilation for the water supply example

Indicator	Stakeholder inputs	Expert inputs	Description
Upstream water treatment and distribution costs	Domestic and commercial consumption specific to village	Per m^3 treatment and distribution costs from NWSDB	Compiled to give daily, monthly and yearly cost of treatment and distribution for village consumption
Collection time	Average time spent by a household		
Storage costs	Current market value of storage cans and tanks		
Water connection fees	Current fee charged by the NWSBD		
Water bill	Monthly bill paid by community; Monthly bill paid by LA	Average bill per m^3 per household or local authority	
Maintenance costs	Maintenance cost to the Las	Average estimate	
Safe water for community	LA bylaws	WHO standards	Compared against LA authority provisions and WHO standards
Convenience	Responses by the community		
Free riders	Number of common wells and taps; Number of people per common well or tap	Average estimate	Compiled to give the number of people benefit from common wells and taps without fees
Common property management	Responses by stakeholders	Common property management	Compared against LA bylaws and provisions

Table 4-8. Continued

Indicator	Stakeholder inputs	Expert inputs	Description
		measures	
Compliance with minimum water standard	LA bylaws	Compliance measures	Compared against LA bylaws and provisions
Per capita water consumption	Consumption per household, tourist guesthouse, and restaurant	Average consumption	Data for each entity compiled to give as average consumption levels
Wastewater generation		SLSI average data per household and commercial entities	Estimates based on SLSI unit discharge amounts for households, tourist guesthouses, and restaurants.
Number of people affected with wastewater and diseases	PHI’s records on hospitalizations for 2005-2007	Number of people hospitalized related to waterborne diseases	Compiled using the available records on hospitalizations in 2005-2007 and proximity of wells to polluted canals and septic tanks
Number of people benefited	Number of people served with well water, common taps, and individual taps		Compiled using village officer’s records on wells, common and individual water connections
Cost to the end users	Cost to the individuals and LA who pay fees	LA data	Compiled using individual water bills and LA’s water bills
Amount of upstream water treatment required	Consumptions per household, tourist guesthouse, and restaurant		Compiled using per capita household and commercial unit consumptions
Upstream energy use	Consumptions per household, tourist guesthouse, and restaurant	Energy required for treating 1m^3 of water from NWSDB	Compiled using community consumption data and NWSDB energy data
Upstream CO_2 releases		SL electricity grid and CO_2 emission data from Wijetunge et al., 2003	Compiled using community consumption data, NWSDB energy data and Wijetunge et al., 2003 data

Table 4-9. Detailed steps of indicator development with stakeholder and expert contributions of data compilation for the wastewater discharge and treatment example

Indicator	Stakeholder inputs	Expert inputs	Description
Initial cost – donor (awareness)	Total cost of a awareness campaign		Compiled costs on information fliers, meetings, allowances for field officers, sample toilet construction, etc.
Capital cost – donor (toilet construction)	Total cost of constructing a traditional toilet with a two chambered septic tank or a soakage pit	Total cost of constructing Eco-sanitary toilet with a plant bed	Compiled estimate using Practical Action bill of quantities (BOQ) on Eco-sanitary toilets and SLSI specifications using current market prices and contractor cost data
Capital cost – LA (gully bowsers and equipment)	Total cost of gully bowsers and equipment for sludge removal		Compiled using LA estimates
O&M cost – beneficiary (water+ fees + protective coating)	Cost of sludge removal; Sludge removal intervals; Cost of protective coating for 10m^2 of wall area; Durability of protective coating	Approximately 1/3 of household water cost for toilet flushing	Compiled as monthly cost of water for toilet flushing, fees charged by LA per sludge removal interval based on the size of septic tank, and cost of protective paint for CSEB wall maintenance.
Income from compost	Demand for compost	Income per 1kg of compost as per Practical Action data	Compiled using Practical Action material on Eco-sanitary toilets and current market prices for compost
O&M cost – LA	Cost of sludge removal as per LA data		Compiled for regular septic tanks and precast septic tanks based on LA data
Sludge treatment plant cost	Total cost of constructing a sludge treatment plant based on LA data		Compiled using LA and contractor cost data based on yearly sludge estimates and

Table 4-9. Continued

Indicator	Stakeholder inputs	Expert inputs	Description
			corresponding size of treatment plants according to Practical Action data
Sludge treatment O&M	Operational energy, material and employee costs and annual expected repair costs		Compiled using LA contractor cost data and Practical Action energy and material data
Separate consideration for grey water	Cost of constructing a plant bed	Plant bed sizes	Compiled using Practical Action data
Energy consumption (considering only wall type)	Total wall area	Energy per m^2 of wall type	Compiled as per Emmanuel, 2004.
Embodied energy (considering only wall type)	Total wall area	Embodied energy per m^2 of wall type	Compiled as per Emmanuel, 2004.
CO_2/GWP (considering wall type)	Total wall area	CO_2 releases per m^2 of wall type .	Complied using energy per m^2 of wall type as per Emmanuel, 2004 and SL electricity grid and CO_2 emission data from Wijetunge et al., 2003.
Reduced water use		Fraction of reduction	Compiled comparing the water use based on mode of supply
Reduced water energy use		Fraction of reduction	Compiled comparing the water use based on mode of supply
Reduced water costs		Fraction of reduction	Compiled comparing the water use based on mode of supply
Land use for treatment	Size of toilet with septic tank or seepage bed and compost toilet with plant bed; distance from wells		Compiled using design data and SLSI specifications
Material manufacture/ transport	CSEB, brick and cement clock transport distances	Material manufacture energy and emissions	Compiled using Auroville public data and actual transpiration distances.

Table 4-9. Continued

Indicator	Stakeholder inputs	Expert inputs	Description
Labor	Local labor opportunities		Compiled using LA TO data
Compliance with health and sanitation standards	LA bylaws	WHO standards	Compared against LA authority provisions and WHO standards
Surface water pollution (canals)		Current wastewater discharges to canals	Expressed as increased or reduced
Ground water pollution		Descriptive details on wastewater contaminant intrusion into groundwater	Expressed as increased or reduced
Diseases		Descriptive details on resulting mosquito and waterborne diseases	Expressed as increased or reduced

Application of the Rating and Ranking Method

The rating and ranking methodology was developed after the case-study as a generic way to potentially structure a variety of indicators and related information in negotiation with multiple stakeholders with different interests. This is to mainly identify the better performing options among several alternatives taking into account how important the indicators are to the stakeholders, and how well each option does on the indicators according to the quantitative or qualitative criteria.

Although the indicators are classified into economic, social, and environmental categories, this classification could be overlooked when rating the importance of the indicators as certain economic, social, and environmental indicators could have equal importance to different stakeholders. The method can be conducted in a group in a manner such that discussion and negotiation are promoted in reaching consensus on weights for the indicators that reconcile the interests and needs of the different stakeholder groups. For example, capital cost to plan a social awareness campaign on Eco-sanitary toilets maybe important to the donors and local authority officers for meeting their objectives, but the communities could assume that it is not a very relevant indicator or a criterion for them. Hence, a higher weight could be proposed by the donors and local authority groups while a lower weight could be proposed by the community groups. However, it is expected that the stakeholders having gone through the detailed option assessments prior to this step, and being able to visualize the indirect effects holistically, could discuss and agree upon a weight for an indicator that would reflect the fact that without donor investment in social awareness, the Eco-sanitary toilet may not be acceptable to the communities and hence, the implementation would not meet the desired objectives.

The rating and ranking method is applied for two sets of indicators extracted from the case-study examples presented above. One example is to assess the set of indicators related to levels of water supply in the community, and the second example is to assess the indicators related to the wastewater treatment options. The analysis can be conducted in a group using two main steps:

- Step 1: Assign weights and rank indicators
    - Rate every criterion (r_i) from 0 to 10: 0 = not important at all; 10 = very important; the rating has to be assigned comparing the criteria pair-wise, so that the rating reflects the preference or the importance.
    - Calculate the weight for a criterion (w_i), which is the rating received for an individual criterion divided by the sum of ratings of all criteria.
    - Rank criteria according the weights and evaluate to determine if they are agreeable
- Step 2: Assign scores and rank options based on the weighted scores
    - Score each option against every criterion (S_{ik}) from 0 to 10 comparing the relative performance within that criterion; the best performance could be assigned with a score of 10 and work backwards in giving a relative score to the others.
    - Calculate the total weighted scores ($Z_k = \Sigma w_i * S_{ik}$) of options against all criteria and the percent total weighted scores for the options ($R_i\%$).

- Rank options according to the resulting total weighted scores or percentages received by the options.

The application of the above steps in analyzing indicators related to the case-study example of the current water supply in the community is summarized in Table 4-10 and Table 4-11, and the application to the proposed wastewater treatment options are summarized in Table 4-12 and Table 4-13. The ratings for criteria and scores for the options are hypothetical. They were assigned in a normative manner.

Table 4-10. Step 1: Assign weights and rank indicators related to current water supply levels

Indicator/Criteria *(A_i)*	Rate for criteria *(r_i)*	Weight for criteria $w_i=r_i/R$	Rank for criteria
Upstream water treatment costs	6	5%	11
Treatment costs	5	4%	14
Distribution costs	5	4%	14
Collection time	6	5%	11
Storage costs	3	2%	20
Connection fees	4	3%	18
Cost to end users	9	7%	3
Water bill	8	6%	5
Safe water for community	10	8%	1
Convenience	7	5%	9
Free riders	7	5%	9
Number of people benefited	8	6%	5
Common property management	9	7%	3
Per capita water consumption	8	6%	5
Compliance with minimum water standard	6	5%	11
Amount of upstream water treatment required	5	4%	14
Wastewater generation	8	6%	5
Number of people affected with wastewater and diseases	10	8%	1
Upstream energy use	5	4%	14
Upstream CO2 releases	4	3%	18
Totals	133	100%	

Table 4-11. Step 2: Assign scores and rank current water supply levels based on the weighted scores

Indicator/Criteria (A_i)	Rank for criteria	Option scores (S_{ik})			Weighted options scores (w_i*S_{ik})			
		Common well	Common tap	Individual tap	Common well	Common tap	Individual tap	Total $\Sigma\ w_i{*}S_{ik}$
Safe water for community	1	5	10	10	0.38	0.75	0.75	
Number of people affected with wastewater and diseases	1	10	5	3	0.75	0.38	0.23	
Cost to end users	3	10	5	2	0.68	0.34	0.14	
Common property management	3	2	2	10	0.14	0.14	0.68	
Water bill	5	10	5	2	0.60	0.30	0.12	
Number of people benefited	5	5	5	3	0.30	0.30	0.18	
Per capita water consumption	5	10	5	2	0.60	0.30	0.12	
Wastewater generation	5	10	5	3	0.60	0.30	0.18	
Convenience	9	5	5	10	0.26	0.26	0.53	
Free riders	9	3	10	3	0.16	0.53	0.16	
Upstream water treatment costs	11	10	5	2	0.45	0.23	0.09	
Collection time	11	3	5	10	0.14	0.23	0.45	
Compliance with water standard	11	3	3	10	0.14	0.14	0.45	
Treatment costs	14	10	5	2	0.38	0.19	0.08	
Distribution costs	14	10	5	2	0.38	0.19	0.08	
Upstream water treatment	14	10	5	3	0.38	0.19	0.11	
Upstream energy use	14	10	5	3	0.38	0.19	0.11	
Connection fees	18	10	5	2	0.30	0.15	0.06	
Upstream CO_2 releases	18	10	5	3	0.30	0.15	0.09	
Storage costs	20	2	2	2	0.05	0.05	0.05	
Totals					7.34	5.28	4.64	17.26
% Totals					43%	30%	27%	
Ranks of options					1	2	3	

Table 4-12. Step 1: Assign weights and rank indicators related to proposed water treatment options

Indicator/Criteria (A_i)		Rate for criteria	Weight for criteria	Rank for criteria
A	Initial cost – donor (awareness)	9	6%	5
B	Capital cost – donor (toilet design and construction)	10	7%	1
C	Capital cost – LA (gully bowsers and equipment)	9	6%	4
D	O&M cost – beneficiary (water, sludge removal fees, and protective coating for CSEB)	8	5%	6
E	Income from compost	4	3%	20
F	Sludge treatment plant capital cost	7	5%	8
G	Sludge treatment O&M	7	5%	8
H	Separate consideration for grey water	5	3%	15
I	Energy consumption (considering only wall type)	5	3%	15
J	CO_2/GWP (considering wall type)	5	3%	15
K	Reduced water use	6	4%	12
L	Reduced water energy use	5	3%	15
M	Exergy	5	3%	15
N	Reduced water costs	6	4%	12
O	Land use for treatment	7	5%	8
P	Material manufacture/ transport	6	4%	12
Q	Labor	8	5%	6
R	Compliance with health and sanitation standards	7	5%	8
S	Surface water pollution (canals)	10	7%	1
T	Ground water pollution	10	7%	1
U	Diseases	10	7%	1
	Totals	149	100%	

Table 4-13. Step 2: Assign scores and rank proposed water treatment options based on the weighted scores

Indicator/ Criteria (A_i)	Rank for criteria	Option Scores (S_{ik})						Weighted Options Scores (w_i*S_{ik})						Total $\Sigma\ w_i$*S_{ik}
		1(i)	1(ii)	1(iii)	2(i)	2(ii)	2(iii)	1(i)	1(ii)	1(iii)	2(i)	2(ii)	2(iii)	
B	1	2	5	3	7	10	8	0.13	0.34	0.20	0.47	0.67	0.54	
S	1	0	0	0	10	10	10	0.00	0.00	0.00	0.67	0.67	0.67	
T	1	0	0	0	10	10	10	0.00	0.00	0.00	0.67	0.67	0.67	
U	1	0	0	0	10	10	10	0.00	0.00	0.00	0.67	0.67	0.67	
A	5	10	10	10	0	0	0	0.60	0.60	0.60	0.00	0.00	0.00	
C	5	0	0	0	10	10	10	0.00	0.00	0.00	0.60	0.60	0.60	
D	7	3	0	3	10	8	10	0.16	0.00	0.16	0.54	0.43	0.54	
Q	7	10	0	7	10	0	7	0.54	0.00	0.38	0.54	0.00	0.38	
F	9	0	0	0	10	10	10	0.00	0.00	0.00	0.47	0.47	0.47	
G	9	0	0	0	10	10	10	0.00	0.00	0.00	0.47	0.47	0.47	
O	9	0	0	0	10	10	10	0.00	0.00	0.00	0.47	0.47	0.47	
R	9	0	0	0	10	10	10	0.00	0.00	0.00	0.47	0.47	0.47	
K	13	0	0	0	10	10	10	0.00	0.00	0.00	0.40	0.40	0.40	
N	13	0	0	0	6	6	6	0.00	0.00	0.00	0.24	0.24	0.24	
P	13	5	10	3	5	10	3	0.20	0.40	0.12	0.20	0.40	0.12	
H	16	10	10	0	0	0	0	0.34	0.34	0.00	0.00	0.00	0.00	
I	16	4	10	2	5	10	2	0.13	0.34	0.07	0.17	0.34	0.07	
J	16	4	10	2	5	10	2	0.13	0.34	0.07	0.17	0.34	0.07	
L	16	0	0	0	10	10	10	0.00	0.00	0.00	0.34	0.34	0.34	
M	16	4	10	2	5	10	2	0.13	0.34	0.07	0.17	0.34	0.07	
E	21	0	0	0	10	10	10	0.00	0.00	0.00	0.27	0.27	0.27	
Totals								2.38	2.68	1.66	7.72	7.99	7.25	29.68
% Totals								8%	9%	6%	26%	27%	24%	
Rank of options								5	4	6	3	1	2	

Applying the above method to compiling indicators related to water supply shows that well-water supply is better compared to the other options in the village context where resources for upstream water treatment is limited and downstream wastewater discharge is problematic. Similarly, applying the method to indicators related to options for wastewater treatment shows that Option 2 (Eco-sanitary toilet) is clearly better. Among the wall options, CSEB has scored the highest, but the construction material options do not show a great deal of variability in scores.

In this method, stakeholder interests and priorities are reflected in the weights for the indicators. When there is a large set of indicators, assigning weights that add up to 1.0 or 100% is an iterative and time consuming task. Instead, rating the indicators according to their importance in the 0-10 scale first, and then converting them into weights makes it easier for the stakeholders to discuss and negotiate a score, as compared to assigning a weight directly. The performance of the options related to the indicators is reflected in the scores assigned to the indicators. The scores should be discussed and assigned according to the quantitative or qualitative values derived through the assessment process. Assigning a relative score should be a straight forward task for the stakeholders with the above information. The weighted scores reflect the performance of the options with stakeholder interests and priorities taken into account.

As mentioned above, this method is to structure and compile the economic, social and environmental indicators according to their importance to the stakeholders to reflect better performing options. Hence, the best options may not be the most viable options, but the stakeholders would be in a position to strive to negotiate on committing resources for strategizing and implementing the best options according to their context.

Complementary Methods and Tools Used in the Case-Study

Systems Assessment Tool in Understanding Current State and Formulating Options

In its simplest sense, systems thinking gives a more complete picture of reality so that planners can work with a system's natural forces in order to achieve the desired results. When it is necessary to address certain issues in the system, ideally all components, but at least the main components in the system need to be examined, and interdependencies should be understood. There can be strong effects or influences as well as weak effects or influences from interrelations among system components. Issues need to be addressed accordingly to make sure the efforts result in desired outcomes. The influences and interdependencies can be identified together with the stakeholders.

Also, one should keep in mind that there can be influences or effects from outside the systems. For example, depending on the boundary of the analysis, a polluted canal running through the village system under consideration could have been polluted by a community upstream, and similarly, the respective system can have influences and effects outside of the system boundary under consideration, i.e., solid waste dumped at a neighboring village. Setting the appropriate boundary for the analysis is an important activity in the analysis process. For instance, if the issue is urban services, cp. Figure 4-27, the interconnectivities, effects, and implications of the following components should be addressed when workable and sustainable solutions are sought.

- Life style of the communities
- Community livelihoods
- Community income levels
- Community organizations
- Related infrastructure facilities
- Structure of the public administration, institutions and service delivery
- Political structures
- Natural environment

- Communication channels
- Possible donors

Example for a village system - interacting, interrelated, and interdependent components that form a complex and unified whole

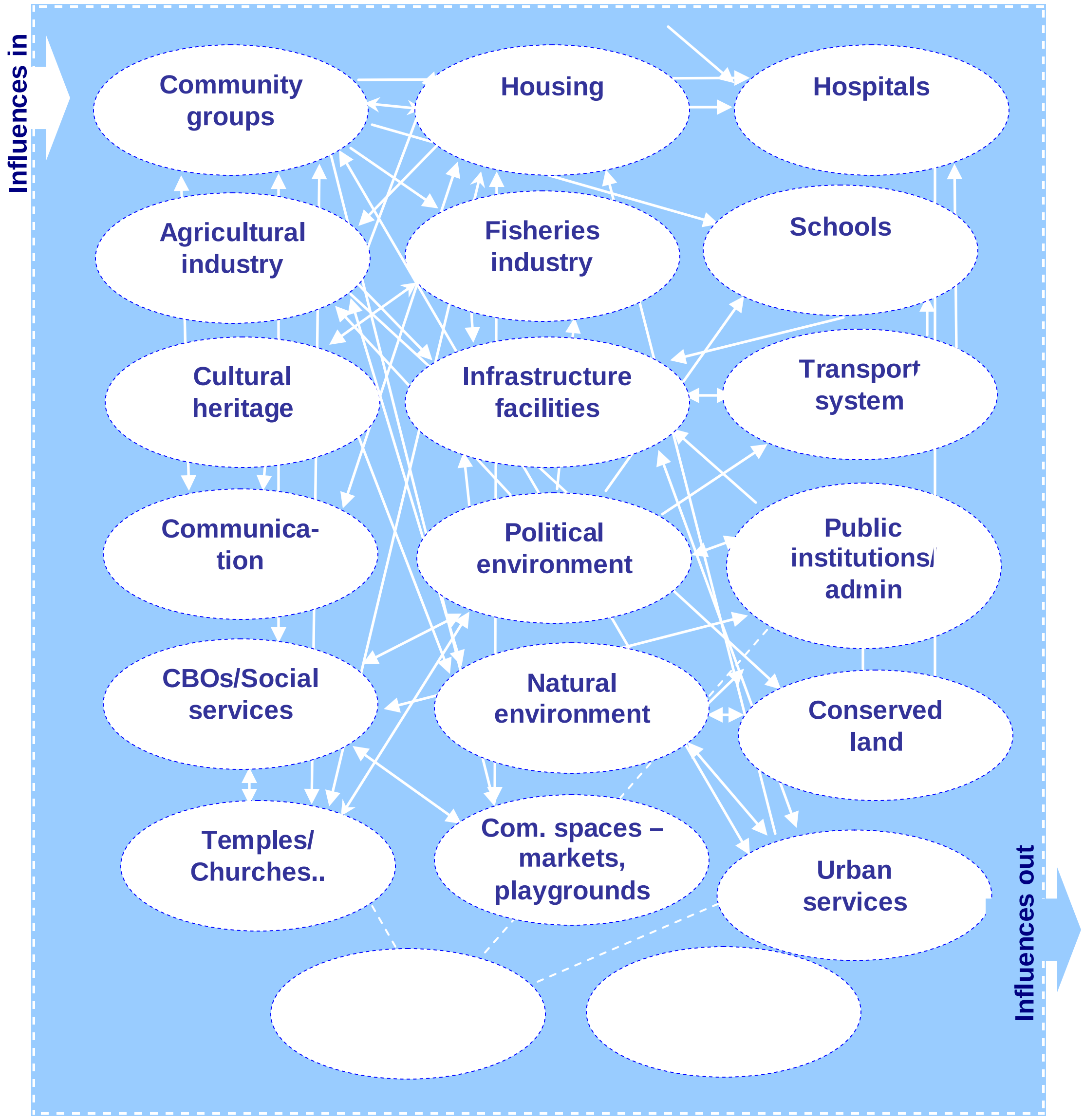


Figure 4-27. Illustration of village system

Systems can be of any scale. A component of a bigger system can be another system that can be broken into smaller components for closer analysis. Coupled with Appreciated, Influenced, and Controlled (AIC) model thinking explained in the latter part of this section, the concept can give a very clear picture of what elements in a system can be affected and therefore select the appropriate basis for strategies (World Bank Group, 2008).

The following system analysis method called Quantitative System Analysis (QSA) developed by NSSI at ETH provides a useful basis for analyzing the influences in a systematic manner (Stauffacher, 2006; Spörri, 2007). The method is used in a simplified manner to identify interlinked system elements and level of influence. The following example from the case-study elaborates the use of the method where the village water supply system needs to be analyzed in a generalized manner revealing the interconnectivities of the system components, prior to detailed upstream-downstream LCT/A based option analysis for solutions focused on immediate implementation.

First, the important components of the system should be identified, a process called case faceting. The facets in terms of water supply in the village are as follows:

- Water treatment
- Piped water supply
- Well water supply
- Water distribution Water consumption
- Paying for water
- Wastewater
- Wastewater treatment
- Toilets Storm water drainage
- Tourism
- Diseases
- Maintenance
- People's participation

Secondly, it would be useful to identify influences due to interconnectivities among the components or facets. The components can influence other components defined as being active or an 'Activity' while they could be influenced by other components, defined as being passive or a 'Passivity'. To get a clear perception of this, stakeholder teams perform the following simple matrix analysis:

- Work out a square matrix with same set of facets on columns and rows
- Define influence scoring system: e.g., 0 = no influence; 1 = moderate or indirect influence; 2 = strong influence
- Fill the matrix using above scores reading from row to column as a row's influence on a column. Hence, rows become Activity, while columns become Passivity. For example, the influence of water treatment capacity (cf. row 1 in Figure 4-28) on piped water supply (column 2) is given a value of 2 or a strong influence.
- Add all rows and find the average (mean value). This value gives an indication of the facet's ability to influence other facets.
- Add all columns and find the average (mean value). This value gives an indication of how much it could be influenced by other facets.

A sample matrix from working in a community on water is shown in Figure 4-28. The results can also be presented in a graph for visualization (cf. Figure 4-29). According to the graph, it can be interpreted that 'people's participation' has the highest Activity score. This means community participation can have a strong influence on most of the other facets in general. 'Diseases' has the lowest activity score, meaning that it has the lowest influence on other facets in consideration. However, 'diseases' has the highest Passivity score, indicating that it could be strongly influenced by other facets in the system.

This is a realistic indication as increased water supply, increased water consumption, less maintenance and community participation, improper toilets and waste treatment, and storm water have direct and strong effects on increases in diseases in the village. Similar influences can be noticed on tourism, as a poor wastewater situation and prevalence of disease can reduce the attractiveness of the village to tourists. 'People's participation' has a lower Passivity score, as the majority of the other facets considered do not have much effect on community participation. Interpreting each facet in the same way, can be clearly communicate the influences among facets.

Activity

Pasivity	Water treatment	Pipe water supply	Well water supply	Water distribution	Water consumption	Paying for water	Wastewater	Wastewater treatment	Toilets	Stormwater drainage	Tourism	Diseases	Maintenance	People's participation	*Sum Activity*
Water treatment	x	2	1	0	1	1	1	0	0	0	0	0	0	0	*6*
Pipe water supply	2	x	1	2	2	2	2	1	1	1	1	1	1	1	*18*
Well water supply	1	1	x	1	2	0	2	2	1	1	1	1	0	1	*14*
Water distribution	0	2	1	x	2	1	1	1	1	1	1	1	2	0	*14*
Water consumption	1	1	1	1	x	2	2	2	2	2	2	2	1	1	*20*
Paying for services	2	2	0	2	2	x	1	1	1	1	1	1	2	0	*16*
Wastewater	0	0	1	0	0	0	x	2	0	2	2	2	2	0	*11*
Wastewater treatment	0	1	1	1	0	1	0	x	0	2	1	2	2	0	*11*
Toilets	1	1	1	1	2	2	2	2	x	2	2	2	2	1	*21*
Stormwater drainage	0	0	2	0	0	0	1	2	0	x	1	2	2	0	*10*
Tourism	1	1	1	1	2	1	2	1	1	0	x	0	1	1	*13*
Diseases	0	0	0	0	0	0	0	0	0	0	2	x	0	1	*3*
Maintenance	0	2	0	2	1	0	0	0	1	2	2	2	x	0	*12*
People's participation	1	1	1	2	2	2	2	2	2	2	2	2	2	x	*23*
Sum passivity	*9*	*14*	*11*	*13*	*16*	*12*	*16*	*16*	*10*	*16*	*18*	*18*	*17*	*6*	

Activity = potential influence on other facets
Passivity = potential to get influenced by other facets

0= No influence
1= Moderate/indirect influence
2= Strong influence

Figure 4-28. Activity - Passivity matrix of the village water system

Figure 4-30, based on the Activity-Passivity matrix, shows that wastewater has a strong influence indicated by thick arrows in the figure, on well water due to ground water contamination, wastewater treatment, storm water drainage, and disease. Wastewater has an indirect impact, indicated by thinner arrows, in the figure, on tourism in the village.

The wastewater amount can be strongly influenced by the type of water supply, which affects water consumption, the number and type of toilets, and the level of tourism in the village. Again, people's participation has a strong influence, which means that the stakeholders believe that positive actions by the community could contribute to reducing the wastewater problem. Similar flow charts could be worked out for all facets to clearly visualize and understand the natural forces in the system.

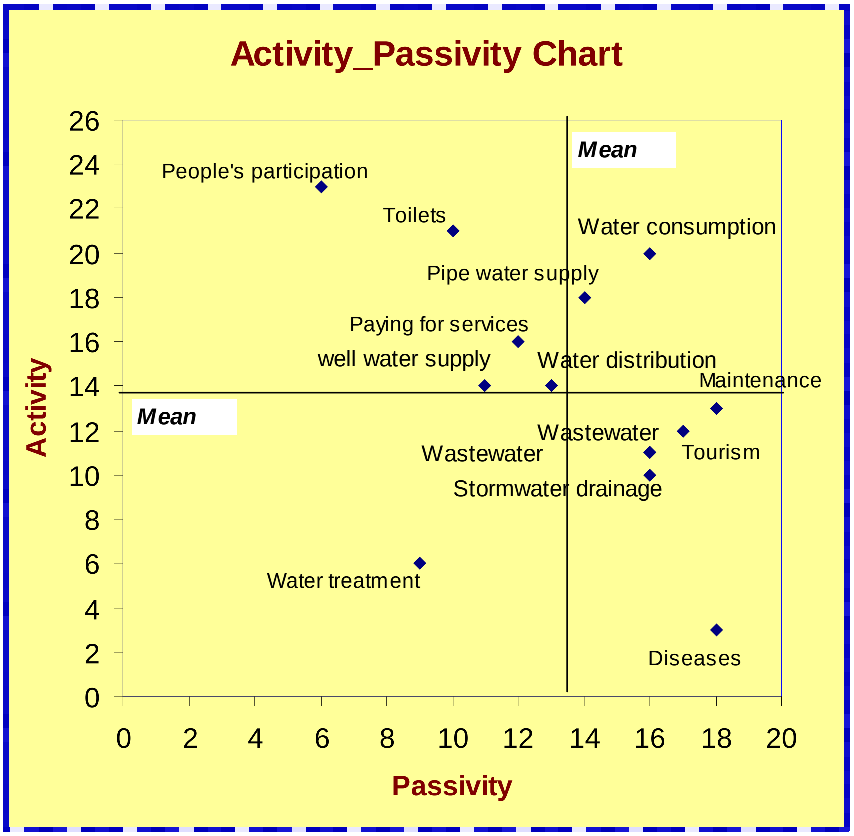


Figure 4-29. Activity - Passivity Chart (System Grid) of the village water system`

Figure 4-30. A flow chart showing active and passive influences on wastewater

Spider-Web Tool for Graphical Presentation

The spiderweb tool in general is used to present the status of elements of a current or desired system. In a development planning context, the tool can be used to graphically present the current status of issues in the village as perceived by the stakeholders. The magnitude of the issues can be worked out in a simplified manner, either in a quantitative, semi-quantitative, or qualitative manner. The following example from the case-study shows the application of tool to graphically present the development issues in the village identified by the stakeholders. The scale used is qualitative such as poor – fair – good scale (Figure 4-31).

The spokes of the spiderweb represent the issues, while the intensity or the magnitude of the issue is identified as a point along the spoke. A line linking the magnitudes of the issues forming a rim away from the center would mean a well-balanced development condition in the village; a skewed rim close to the center would mean an unbalanced poor development condition in the village.

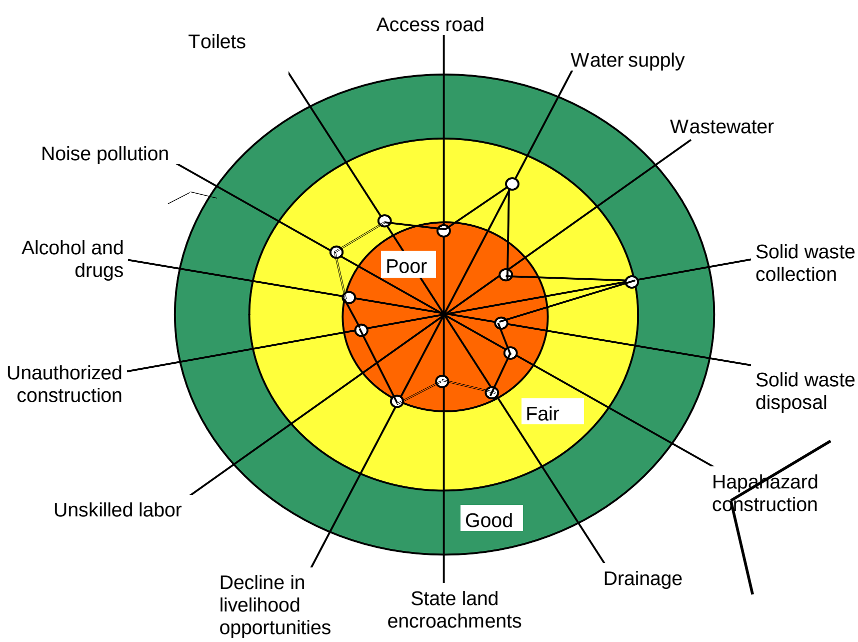


Figure 4-31. The village issues and the intensity of the issues identified by the stakeholders

AIC Framework to Support Prioritizing Issues for Action

Appreciation, Influence and Control (AIC) Framework is a useful tool in recognizing the complexities of communities and the importance of power relationships within those community systems. This framework puts the purpose of an initiative in relationship to different levels of control and power. The name AIC originates from the "fundamental and universal relationships" involved in the design of a purposeful system (Smith, 1998), which is the relationship of the part to the whole (Appreciation), the relationship between the parts of the whole system (Influence), and the relationship of the individual parts to themselves (Control).

Using this framework helps to focus on the objective at hand while understanding the complexity of the system and concentrating on working out feasible processes among the key stakeholders (World Bank Group, 2008; GTZ-THSP, 2007). For example, in the case-study, haphazard construction in the village was found to be a major issue. The village development committee and the local officers did not have the control or power over finding solutions to the situation, as the remedy to this issue was a national level task, namely reorganizing the Urban Development Authority regulations and enforcement strategy. But village development committees were in a position to influence or pressure the higher level authorities by collectively requesting action, even though the results may not be immediate. Another example was the political influence over allocating resources to the LAs where the village stakeholders do not have any control, but appreciate. This framework has the potential to help the stakeholders to prioritize issues where they have the control to take immediate action, and also get an understanding on what is possible and not possible as well as look into avenues where solutions could be made possible (Figure 4-32).

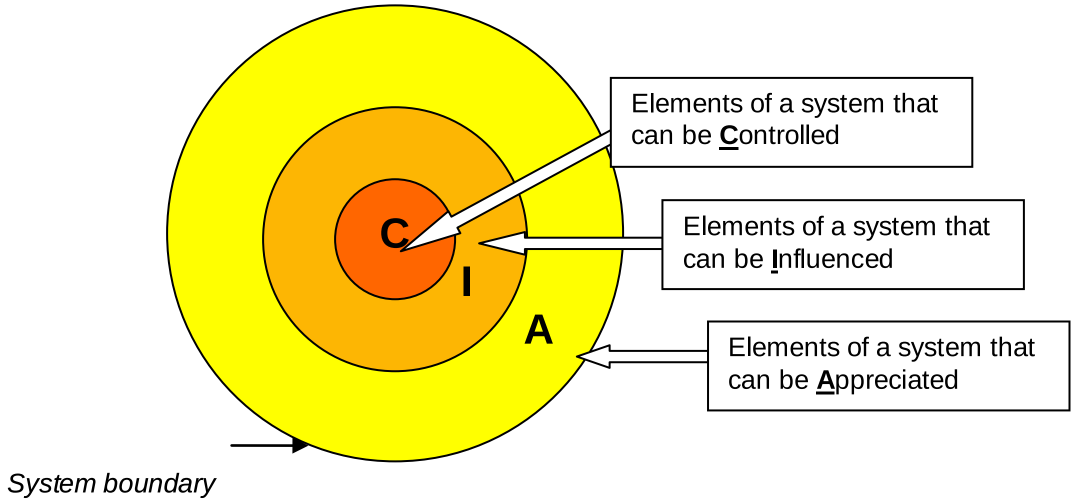


Figure 4-32. AIC Framework

Summary

The background to the research work was laid in 2005 when post-disaster housing reconstruction guidelines were developed to integrate housing construction with the necessary infrastructure, social services and livelihood opportunities. The research partners included MIT, ETH, and SLHF. The project was initiated and funded by the Tsunami Housing Support Project of the German Technical Cooperation.

In the post-disaster reconstruction guidelines, a bottom-up integrated development planning approach was introduced. Some methods and tools for transdisciplinary learning and planning for integration of reconstruction programs and cross-sectoral stakeholders were outlined. The pilot case-study was developed as part of operationalizing the post-tsunami reconstruction guidelines at local scales in line with the government's nation-wide grassroots level village development program. The pilot case-study was conducted at a tsunami affected coastal village in the Galle District of Sri Lanka. In the case-study, the bottom-up integrated and transdisciplinary development planning approach was introduced and SBLCA and other complementary tools were applied.

SBLCA was applied in the planning steps – assessing the current status of issues and prioritizing, and formulating, assessing and strategizing options for implementation. The application of SBLCA is elaborated using four case-study examples addressing the water supply and wastewater issues and potential options for solutions. Context specific economic, social and environmental indicators were developed integrating stakeholders' and experts' knowledge and in assessing current status of issues and formulating and assessing options.

A rating and ranking based decision technique was introduced to structure the indicators related to service levels incorporating the stakeholder interests and priorities and performance of the levels as could be observed under indicators. The method was applied to two indicator sets from the case-study examples on water supply levels and wastewater treatment options.

The complementary tools used in planning steps along with stakeholder-based life cycle assessment includes a systems thinking method called Quantitative System Analysis, a graphic method called Spiderweb tool, and decision framework called Appreciate Influence Control to analyze power related constraints and opportunities in a community system. The Spiderweb tool was used to compile and show the scale of the current issues and the Appreciate Influence Control tool was used to prioritize issues that can be addressed by the community. The Quantitative System Analysis tool was used in analyzing and formulating options for wastewater treatment.

CHAPTER 5
APPLICATION IN OTHER PLANNING CONTEXTS

Integrated Watershed Management

Background of Problem

A watershed is defined as the land area where precipitation, i.e., rainfall or snow runoff drains into common surface water bodies. For example, a river system with all its tributaries is one large watershed. Many smaller watersheds referred to as sub-basins can be found in large watersheds (EPA, 2007; USGS, 2008). Watershed boundaries are natural boundaries and typically cross political boundaries such as municipal, county, state, or country boundaries. Hence, integrated management of watersheds around the world has been a challenging task involving multiple stakeholders. Whereas policies and action should be negotiated and agreed at top political scales, action should be implemented at lower political levels. In order for the action to be viable and sustainable, the current issues of the watershed should be comprehensively understood and acknowledged by the respective stakeholders, and the solution should be developed collaboratively with due consideration to the interests and priorities of the stakeholders as well as the essential needs of the river systems (Feldman, 2008; Leitman, 2008).

In this particular problem, the focus is on Apalachicola – Chattahoochee – Flint (ACF) watershed management, which lies in three states. Alabama, Florida, and Georgia have been involved in water negotiations since about the early 1970s leading to some successes and some failures (Leitman, 2008). The three river watershed system which runs in part through each state has become a focal resource for economic and social development in Georgia, for environmental conservation and preservation in Florida, and for continued agricultural and future industrial and social growth in Alabama (Leitman, 2008). The ACF watershed area covers over 19,800 square miles within the three states. The Apalachicola River is the southernmost river and is formed by the confluences of the Chattahoochee and Flint Rivers to the north of the Florida border. About 75% of the ACF basin area is within the state of Georgia, 10% of the basin is in Alabama and another 10% in Florida. Georgia is responsible for more than 80% of the total withdrawals of the watershed, while Alabama and Florida account for the balance of 20%. A snapshot of the ACF basin is given in Table 5-1 (Abram, 2007) and the boundaries of the watershed is given in Figure 5-1 (USGS, 2008).

Table 5-1. ACF Basin snapshot.

	Georgia	Alabama	Florida
Population	90%	7%	3%
Basin area	74%	15%	11%
Withdrawals	82%	11%	7%
Area	19,600 sq. mi. or 12.3 million acres		
Population in 1995	4 million		
Estimated population in 2050	7 million		
Land use	6% residential, 2% commercial, 25% agricultural, and the balance is mainly undeveloped forested		
Reservoirs	hundreds of reservoirs with 16 major reservoirs on the three principal river main stems (5 federal reservoirs and 11 non-federal)		
Storage area	W.F. George 45,000 surface acres (27.0% of the total storage area of the watershed) and Lake Lanier 38,500 surface acres (30.0% of the total storage area of the watershed)		
Storage capacity	W.F. George 123,219 cfs-days (15.0% of the total storage of watershed) and Lake Lanier 583,332 cfs-days (66.5% of total storage of watershed)		

Water decisions made in Georgia and Alabama have tremendous effects on the quantity and quality of water that reaches the Apalachicola, which are considered critical factors for the health of both the Apalachicola River and the Bay (Lietman, 2005). Urbanization and industrialization in metropolitan Atlanta has contributed greatly toward reducing the Chattahoochee’s flow and subsequently, flow in the Apalachicola River. The Apalachicola River supports the highest diversity of freshwater fish species in the state. The river’s basin holds the second highest concentration of amphibian and reptile species in North America. Pine woodlands provide habitat for the world's largest population of red-cockaded woodpeckers. The Bay's barrier islands are nesting grounds for sea turtles and shore birds and provide a critical resting and feeding area for migrating birds and butterflies (ARROW, 2008). The shellfish industry based at the Apalachicola Bay is valued at approximately $10-14 million which accounts for 90% of the Florida supply and 10-15% of the nation's supply of shellfish (Florida Department of Agriculture and Consumer Services, 2004-2009). Upper watershed reservoir operations and water withdrawals from the Flint and Chattahoochee rivers have changed the Apalachicola's natural flow, threatening the survival of native species and cutting off the state's largest forested floodplain. Rapid development, deforestation, and navigational channel dredging have contributed to river bank erosion and the ecological disruption of the Bay area. The dams along the rivers have altered the river flow disturbing fish movement to and from important spawning and nursery habitat, and the seasonal flood patterns essential for maintaining ecological services. Excessive ground water pumping and uncontrolled issuance of water withdrawal permits have led to serious low flow conditions especially along the Flint River. Clearing land for increased development and farming opportunities are recognized as serious threats to the Flint River and the surrounding ecosystems. Water quality in the ACF Basin is negatively impacted by Atlanta's old inefficient stormwater and sewer systems and inefficient irrigation practices across states. Large built areas with impervious surfaces have disrupted groundwater infiltration and the natural treatment of the runoff water. When flow is reduced in a drought period, water quality is considerably reduced along the river systems.

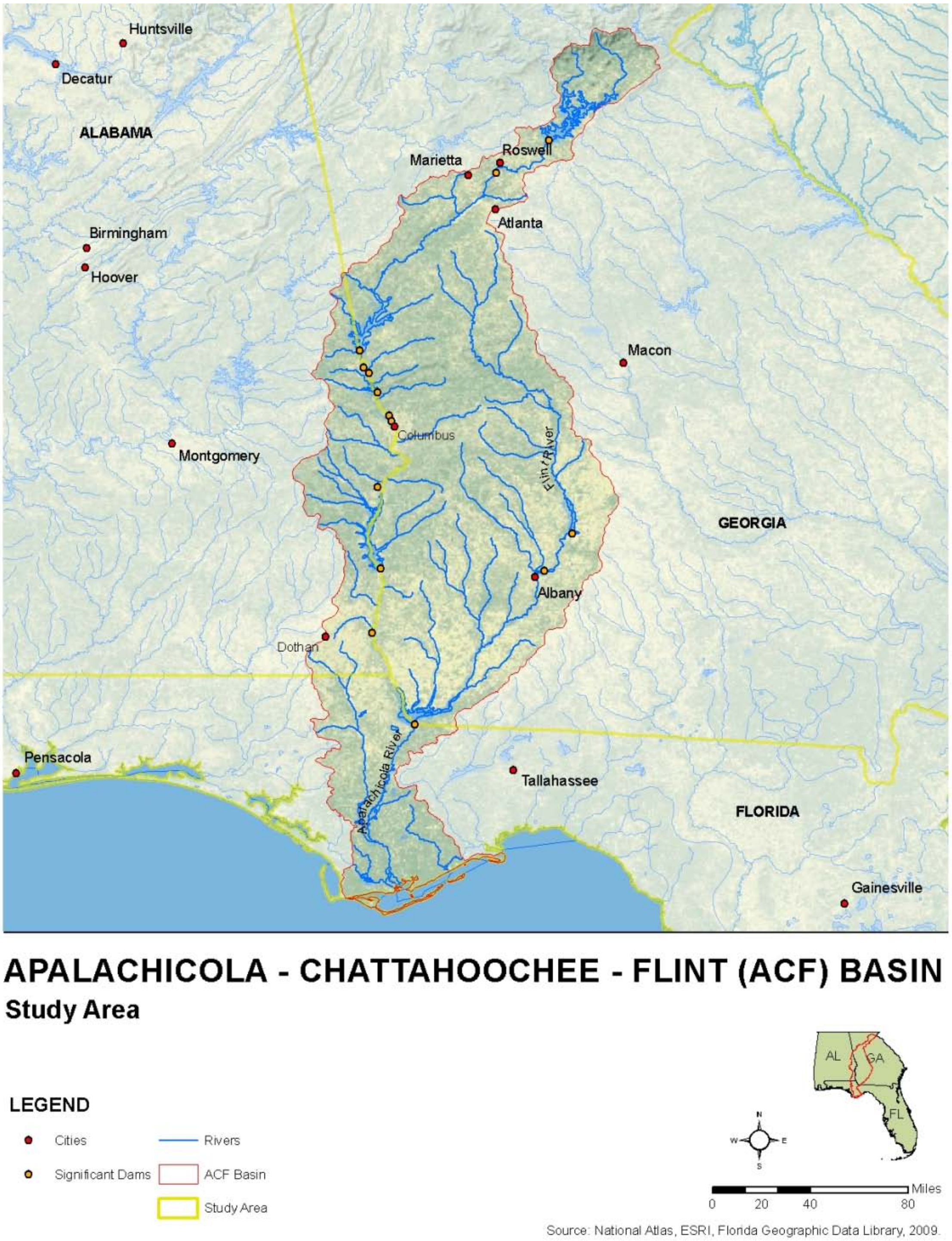


Figure 5-1. Apalachicola-Chattahoochee-Flint watershed boundaries and the respective state boundaries

Main upriver water uses include municipal and industrial water supply, irrigation, generation of thermal and hydroelectricity, flood control, wastewater dilution, navigation, and recreation. Near the headwaters of the Chattahoochee River is the city of Atlanta, where population has grown from less than 500,000 in 1950 to more than 5 million in 2000. By 2015, it is expected to increase by another 2 million (Giacomini and Hadley, 2005; BEBR, 2008). Water demand is expected to grow extensively due to this rapid urbanization and industrialization around the area. Georgia's primary concern is to have sufficient and cheap water supply to allow this massive urban and economic growth. Lake Lanier, the primary reservoir and the main resource for water supply in the Atlanta area, maintains storage even during drought periods to safeguard meeting water needs in the region. A higher level of reservoir storage is also important for Georgia to sustain the major recreational activities based around Lake Lanier. Insufficient water releases is a major hindrance to Alabama's interest in having navigation to the Gulf of Mexico, which could potentially contribute to economic growth in the region. Alabama withdraws a large amount of groundwater for irrigation, which in turn contributes to reducing water flow in the Apalachicola River.

The core of the ACF issue has been conflicting interests of the stakeholders in the three states. So far the states have not been able to agree on how to equitably allocate water resources to meet the current and future needs of the three states. The history of the dispute and the legal procedures are summarized in Ruhl, 2005. The comprehensive study conducted upon the courts request by the Army Corps of Engineers (ACE) has been continuously attacked for credibility. The ACE operates 5 of the 11 major dams in the watershed. According to Leitman, 2008, some of the key reasons for failure in consensus building among the states include the following: a planning process that extensively involves the respective stakeholders in assessing and compiling data and information had not been worked out. There had been no integrated approach to finding the solutions. The three states had individually worked out the water allocation formulas only considering the individual state agendas, and no trust or agreement was built upon the data used for modeling and analysis by the individual parties. In working out formulas and reaching consensus, the working groups of the stakeholders had not been facilitated by an impartial third party.

An agreeable water allocation formula that could contribute towards balancing and optimizing the human needs as well as the needs of the ecosystems in the ACF and comprehensively captures the economic, social and environmental costs and benefits to the individual states and to the watershed as a whole has not been worked out to date.

Planning Scales and Recommended Action

A symposium was organized by the University of Florida (UF) and the National Academy of Environmental Design (NAED) on the topic Water and Sustainability taking the ACF watershed as an exemplary case-study to investigate the issues and potential recommendations for sustainable watershed management involving design professions along with scientists and engineers including members of the National Academy of Engineering (NAE) and the National Academy of Sciences (NAS). The specific focus of the case-study was to investigate how the human settlements including urban infrastructure and building planning, design, and management have vastly changed the historic patterns of river flows, water quantity and quality, and life-supporting ecosystems across the ACF basin. A team of faculty and students from UF extensively explored the available material on the issue and created a website to make all the necessary background information available for the participants of the symposium (UF and NAED, 2009). Participants, which included academia and practitioners from various disciplines presented, discussed, and developed recommendations on how the design professions could influence water consumption by humans and associated issues of quantity and quality, mitigate water-related disasters, meet expectations for community aesthetics and ensure that natural systems are valued for their services. The discussions were conducted on three scales: 1) the watershed, 2) the community and the site, 3) the building or unit (Figure 5-2).

Watershed scale: included discussions on three rivers, bioregion, and the human environment over the entire basin.

Community and site scale: included discussions on elements of specific regions within the basin, for example, Atlanta metropolitan area and Apalachicola Bay.

Building or unit scale: contained discussion on human use including residential, industrial and agricultural activities.

A brief summary of the discussions and recommended action at the symposium includes the following (UF and NAED, 2009):

- Addressing the watershed issues requires comprehensive knowledge developed by the scientists as well as relevant practitioners in an integrated manner.
- Additional research is needed on unknown yet essential elements of the watershed such as relationship of stream and groundwater flow, hydrological and geological effects, evaporation, and siltation within the entire watershed.
- Refined estimates of ground water extraction through private wells throughout the watershed.
- A working method to connect the scale of the site with the scale of the watershed region. e.g., horizontally and vertically integrated planning methods and implementation strategies.
- Action to address extensive water withdrawals and consumption.
- A new strategy to “do business” by the experts and stakeholders within the ACF setting a framework to:
    - visualize system-wide alternatives using trans-disciplinary scenario modeling and appropriate tools.

- use design charrettes, demonstrating policy and physical design scenarios, to examine alternatives such as removing dams, redesigning golf courses, lawns, or the shoreline of waterfront properties, or to reconsider agricultural practices.
- use comprehensive models including cost of ecosystem services, and benefits of human impacts and ecosystem services to develop adaptive management plans.
- identify implementation gaps and problems utilizing best practices, new policies, particularly in local ordinances or trans-jurisdictional circumstances.

Application of the Planning Process

According to the discussions and recommendations above, it was clear that integrated planning and mutual learning among the stakeholders at different strategic scales on taking appropriate action is key towards achieving sustainable water management. While some current issues are common sense to one segment of the stakeholders, they are not seen as problematic for another segment of the stakeholders. For example, increasing water demand in the upper regions of the basin has a direct effect on the often insufficient water flow and consequent salt water intrusion at the Gulf of Mexico. This not only disrupts the oyster industry, but also other essential ecosystem functions for life support in the estuary and the mangroves along the Apalachicola River. Similarly, Lake Lanier experiencing record low levels of storage during the recent drought cycles and fears of a water crisis in metropolitan areas in Georgia is seen as irrelevant for Florida and Alabama. Certain bounded rationalities of the stakeholders on important issues of the Basin have led to opportunistic behaviors by various key stakeholders ignoring the real facts about what is appropriate to protect the health of the AFC Basin.

Hence, stakeholder-based integrated planning at 1) the watershed scale, 2) the community and the site scale, 3) the building or unit scale would have immense potential to bring the stakeholders at these different scales with different interests and priorities to a common understanding of the current watershed issues and formulate options and strategies to solve the issues. Creating a transdisciplinary learning process integrating experts', practitioners', and stakeholders' knowledge at the above scales will enhance the ability to arrive at pragmatic solutions at each scale, which in turn would feed into a continuous loop of collaborative action (Figure 5-2). As described in IDP in the Literature Review, learning on data and other relevant information in a transparent manner from the very beginning of the planning process would enhance fostering consensus among the stakeholders. The planning process could be similar to the process presented in Figure 4-5. Learning from best practices from similar watershed planning problems could also provide useful insights to the stakeholders at the different planning scales of the ACF basin (Figure 5-2). The NAED or other potential impartial organizations may be in a position to assume the role of facilitators in the transdisciplinary integrated planning process at appropriate scales. Examples of respective stakeholders at different scales of planning may include the following:

- The watershed scale stakeholders may include: State regulatory bodies, State Development Authorities/Councils, State Departments of Watershed Management, ACE, NRC, State Departments of Agriculture and Natural Resources, United States Fish and Wildlife Service.
- The site and community scale stakeholders may include: Municipalities and local governments, water conservation and floodplain management agencies, representatives from major industries and commercial services, investors, local regulatory bodies, scientists, planners, designers, and community organizations.
- The building or unit scale stakeholders may include: Municipalities and local governments, conservation and floodplain management agencies, building or unit owners, planners, designers, contractors, and community.

Application of SBLCA

SBLCA can be used at different planning scales and planning steps within an integrated planning process, such as identifying upstream and downstream of the current issues and their interconnectivities, and similarly formulating and assessing future scenarios for solutions together with the respective stakeholders. The expert knowledge and information from different disciplines and knowledge and experience from practitioners and stakeholders can be mapped along the upstream and downstream events of the issue or solution being analyzed. The information could be quantitative, qualitative, descriptive, or graphical. Depending on the planning context, the level of details and complexity of the analysis could be determined.

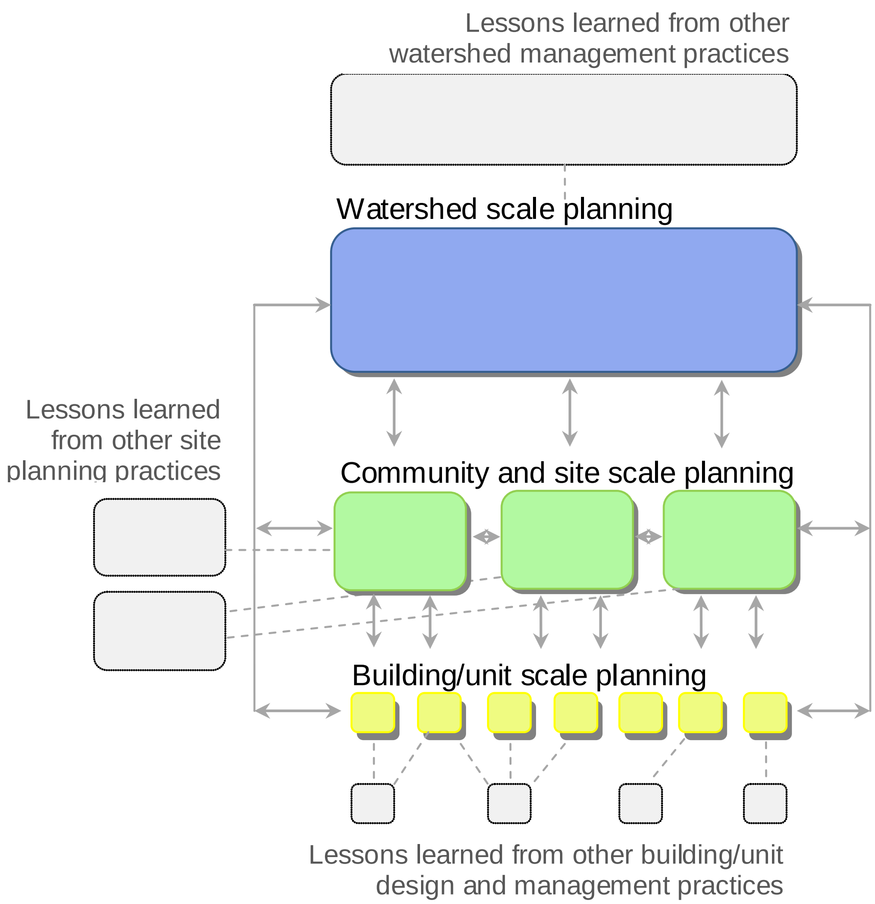


Figure 5-2. Proposed integrated water management planning scales

Application of SBLCA at Watershed Scale

The watershed scale describes the entire river basin with the three rivers, the bioregion, and the human environment. Ideally, decisions need to be made with the broadest sense possible and consider the entire watershed's requirements. Two of the main issues identified in the watershed are water flow (quantity) and water quality. In terms of holistically analyzing the primary issues, it is necessary to identify the current level of the issues. A level would define the reference unit, i.e., functional unit, where analysis can be conducted. In the ACF case, a suggestion for the reference unit for the current state analysis of flow could be levels of dam operation which directly controls the flow of the river by changing the levels of storage at reservoirs. It may be appropriate to consider the levels of five federal reservoirs which hold more than 95% of the total storage in the basin. In the option analysis phase, various scenarios could be assessed for alternative levels of dam operations including extreme scenarios such as no dam operation or natural drought and flood cycles that better mimic nature.

Example – current state analysis of basin river flow

- Step 1: Identify current levels of dam operation
    - Minimum storage at major reservoirs during drought period
    - Maximum storage at major reservoirs during rainy season
- Step 2: Chain the upstream and downstream activity phases relevant to the above levels of flow.
- Step 3: Unbundle and assess components of upstream and downstream phases in terms of stakeholder involvement, resources, costs, benefits, impacts using relevant economical, social, environmental indicators.

A graphical representation of the framework applied to assessing the current levels of dam operation is given in Figure 5-3 to Figure 5-5. Figure 5-3 shows the primary upstream and downstream phases and related stakeholder mapping for the current levels mentioned above. For both levels, upstream and downstream activity phases and responsible stakeholders are the same, while the other components such as costs, benefits, and impacts would be different at each phase. Figure 5-4 and Figure 5-5 show the economic, social, and environmental indicators related to the primary activity phases of the two levels mentioned above. The indicators which are variable with the seasons are highlighted in yellow in Figure 5-4 and Figure 5-5.

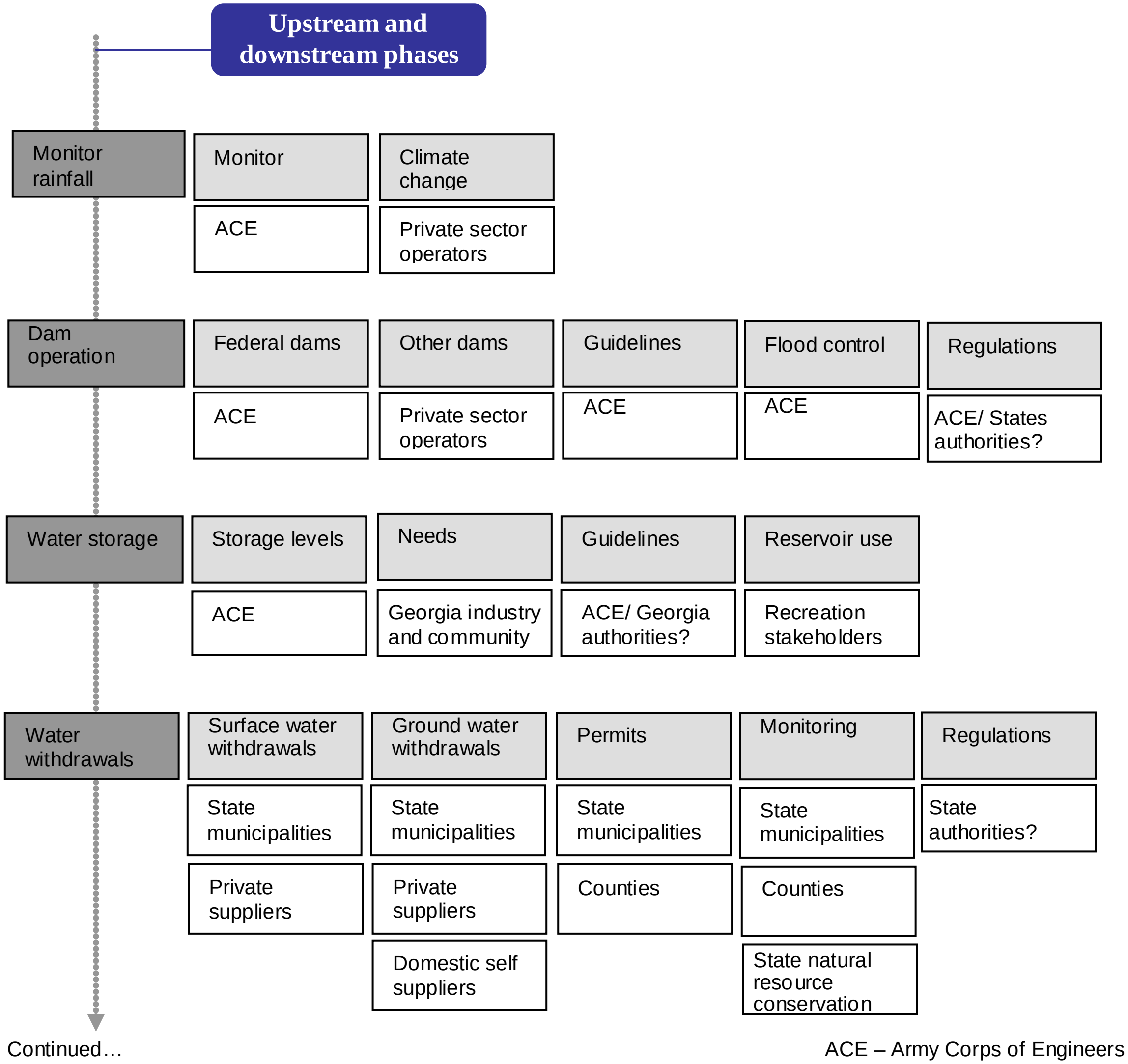


Figure 5-3. Activity chaining and unbundling the primary activities mapping the respective stakeholder involvement in dam operation in the ACF watershed

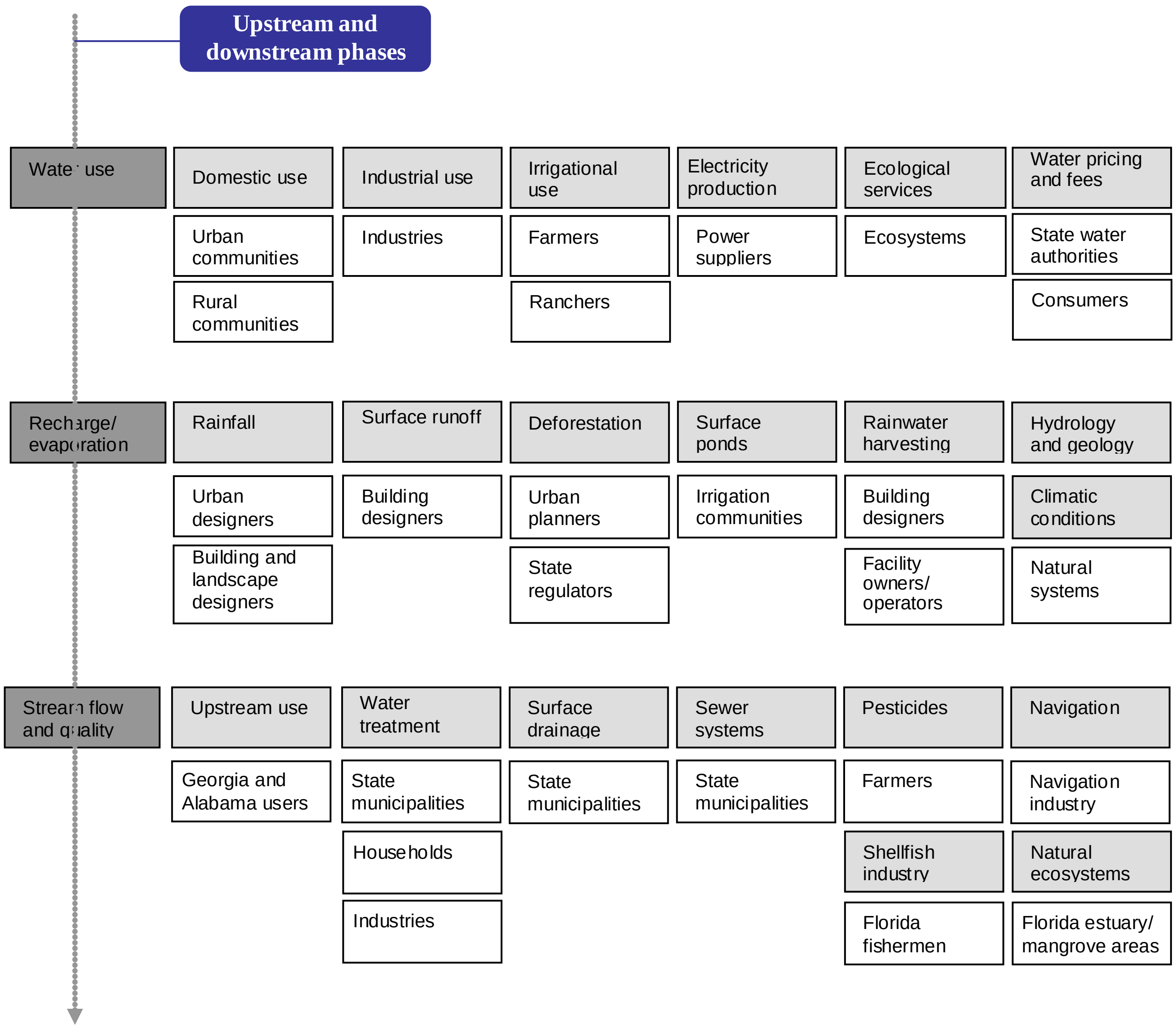


Figure 5-3. Continued

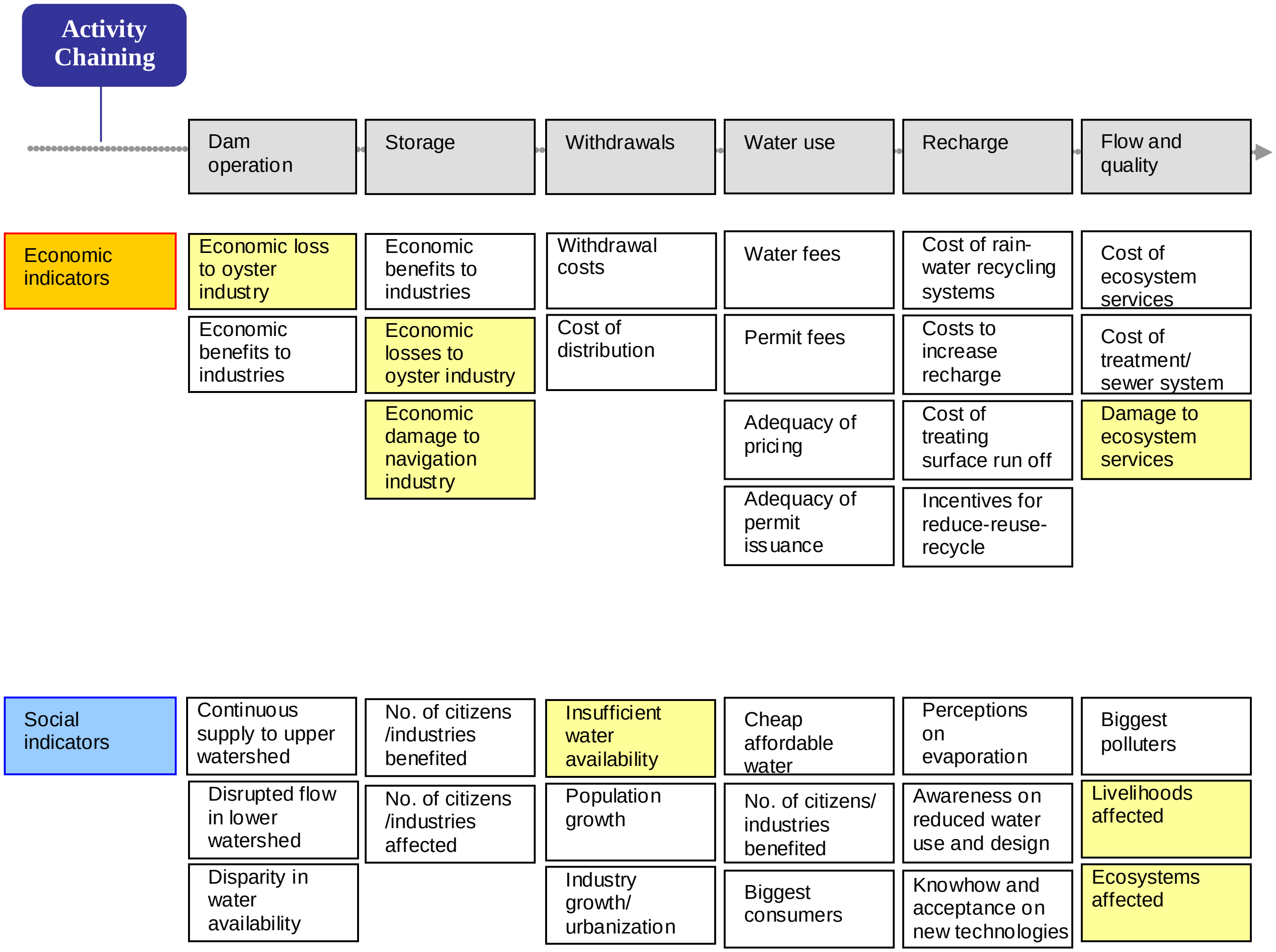


Figure 5-4. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding dam operation during drought cycle (Minimum storage).

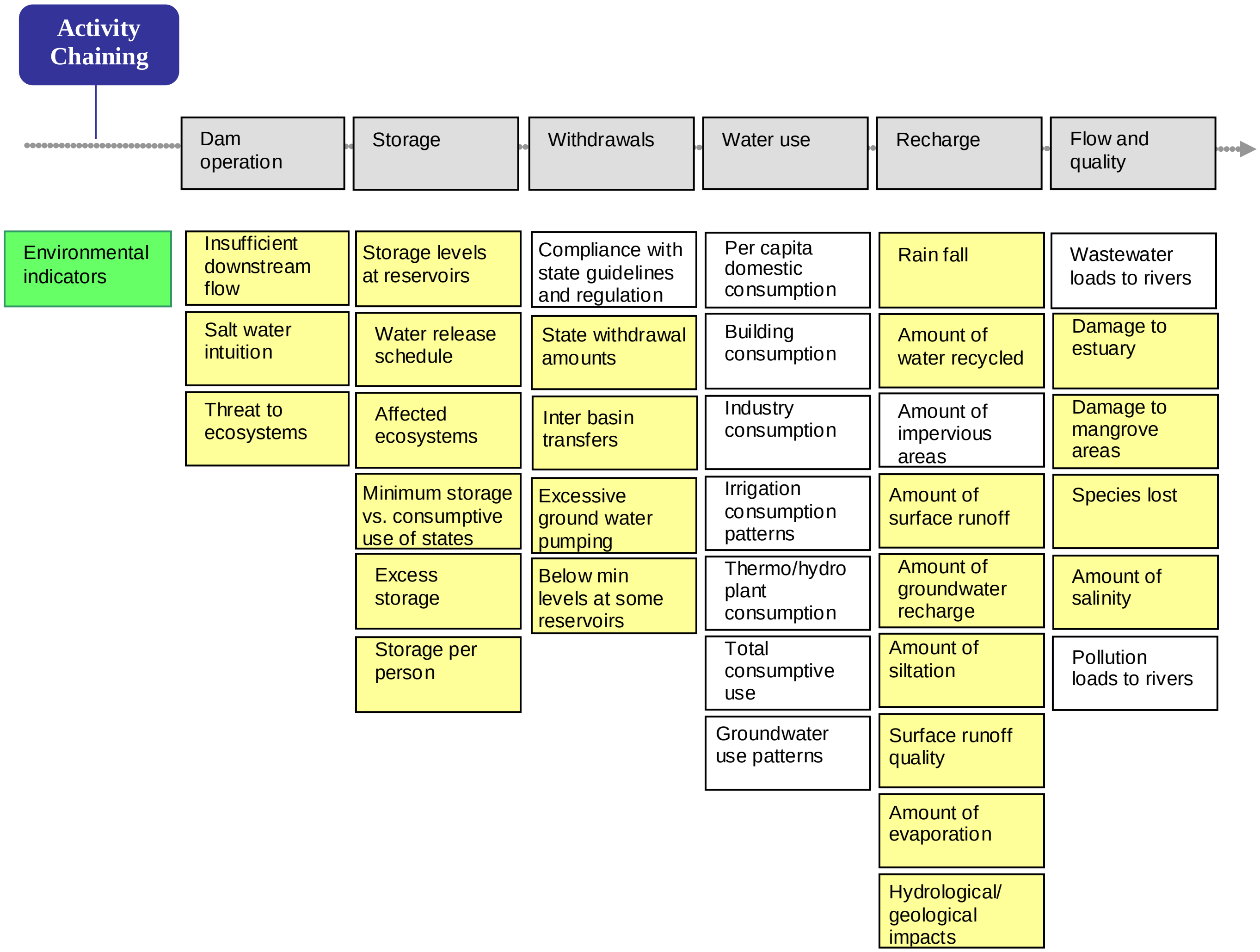


Figure 5-4. Continued

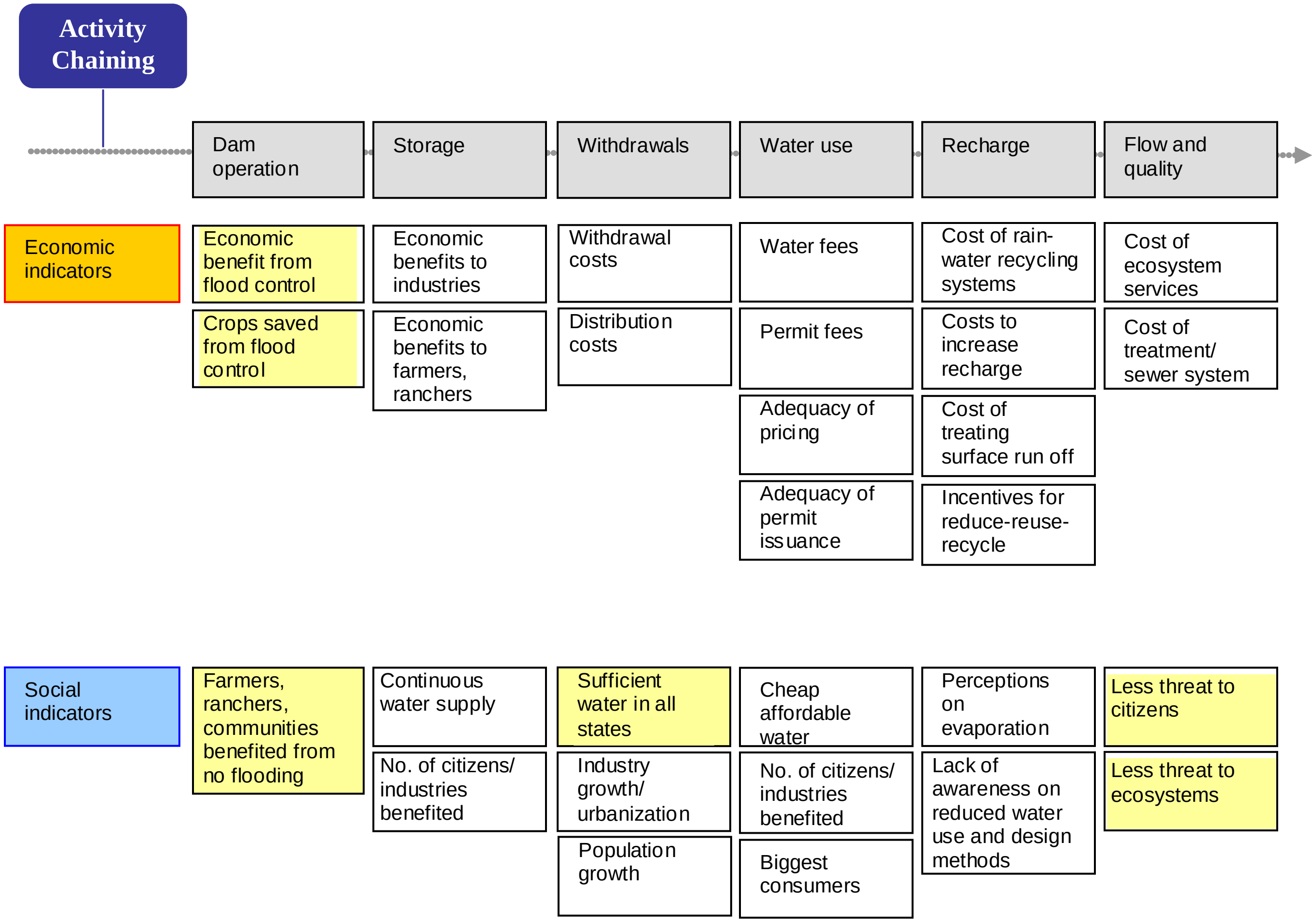


Figure 5-5. Unbundling the primary activities and the respective economic, social, and environmental indicators regarding dam operation during flood cycle (Maximum storage).

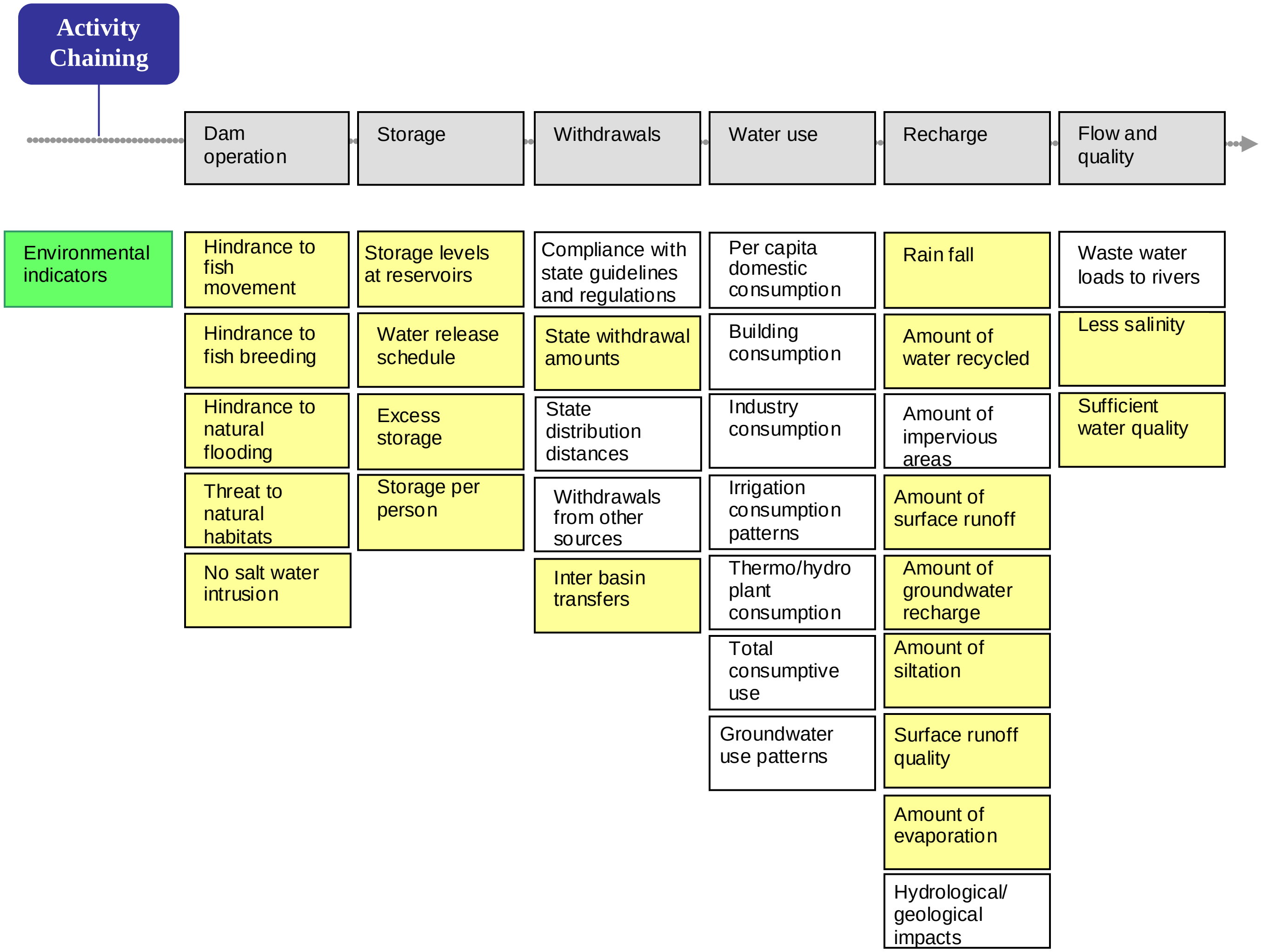


Figure 5-5. Continued

The above example is a hypothetical outcome of a current state analysis exercise using SBLCA conducted together with the stakeholders facilitated by experts. Some of the knowledge missing may have to be generated using the stakeholder, practitioner, or expert knowledge in a real planning situation. As facilitators, the experts would need to go through the background steps of gathering available information as much as possible on the issues and solutions to have thorough knowledge pertaining to the planning scale prior to assessments together with the stakeholders, while being open to integrating the knowledge brought into the process by the stakeholders.

Certain information given above could be communicated using different graphical methods. For example, population, industry, urban growth, damage to mangrove areas, and water withdrawals and consumption can be communicated using GIS maps with data validated by the stakeholders. The number of people benefited or affected from certain activities can be graphed or numerically presented. The amount of siltation and evaporation could be communicated using real-time graphics using simple hydrological modeling software such as STATA with available and agreeable data demonstrating the uncertainties.

According to the exercise above, the water flow issue would be investigated considering the relevant upstream and downstream activity phases. It can be clearly seen that the dam operation can have a significant effect on many downstream phases. Analyzing the different levels of operation in the seasons reveals that dam operation does provide benefit to human society. For example, flood control in rainy season and essential water supply in the drought period despite the fact that there are significant effects to ecosystems, natural cycles, and species. It also shows that how the water quality is very much linked to the water flow.

It also brings out the building and landscape issues such as impervious areas and turf grass which reduce rain water infiltration to the ground and increases evaporation, which eventually reduces river recharge. Evaluating the population growth and urbanization patterns could reveal the potential for these issues to increase in the built environment, and the need for more rainwater harvesting systems and better urban, building, and landscape designs. It could be seen that to discuss certain issues such as geology and hydrology with certainty, not much information is available for the entire basin which could prevent formulating future options for dam operation, changes in design and construction practices, groundwater withdrawals, and alternative measures to increase recharge to the rivers in the basin that suits the basin conditions.

As is apparent from the indicators, in the current context, the benefits to the human system are entangled with the negative impacts to the ecological systems. Even though state guidelines and laws are available to safeguard human needs, laws and regulations to protect the needs of the ecosystems are not as prominent in the ACF discussions. Hence, when mapping the stakeholders with respective upstream and downstream phases of the above levels, natural ecosystems and species could also be rightfully represented as stakeholders in the watershed system. Finding an ethical balance between the essential human needs and ecological needs with thorough learning regarding system interactions could lead to sound policy negotiations and decisions.

Similarly, alternative scenarios of dam operation and water consumption types could be assessed at the watershed scale. Comparative indicators such as minimum storage amounts with consumptive use in the states could be used to examine excess or deficit storage amounts in the reservoirs to understand how the dam operation or water consumption of the states could be optimized. Eliciting the cost of ecological services and respective benefits to the human environment, and also, damage to the natural systems and subsequent costs and losses to the humans would also encourage the stakeholders to evaluate their net benefits in a somewhat comprehensive manner.

These discussions could bring out the fact that further research needs to be conducted to estimate the cost of ecological services and damage to ecosystems in a simplistic manner that could be easily communicated to the stakeholders and responsible policy makers.

Application of SBLCA at other Planning Scales

As SBLCA methodology suggests, some of the sub-issues can be further analyzed in detail. For example, if excessive water withdrawals and stormwater runoff are sub-issues, the current status of those issues could be unbundled to identify the upstream and downstream activities, resources, causes, effects, and stakeholders. Another example is, if retrofitting building and sewer systems is an alternative scenario or a future option to reduce water consumption and increase water quality, different levels of building and sewer systems could be assessed as above. When all relevant sub-issues or potential options for solutions are evaluated in the same manner, the not so apparent interconnectivities could be identified. This could lead to prioritizing issues to address with due consideration to their interconnectivities and collaborative contributions necessary. Detailed analysis could be more useful in smaller scales such as site and community scale planning, which is more focused on regional level collective action. Then the issues, scenarios, analyses, indicators, strategies would be more specific to a region.

Along with water management in a region, other related issues such as regional economic and social development programs and activities need to be addressed simultaneously. With such assessments, stakeholders would be able to visualize costs, benefits, and strategies related to water management activities that would increase the health of the ACF Basin, while contributing to the regional development activities in a meaningful manner.

As discussed at the Water and Sustainability symposium, there are various design methods and approaches which have been developed to reduce water consumption, evaporation, surface water runoff, and siltation at building or unit scale. Improved building designs, efficient irrigation methods, appropriate pricing of water, and incentives for reduced consumption and recycling were a few of those methods and approaches included in the discussion. Most methods were designed context specific and applications were limited. They were discussed as successful projects in design, construction, and operational phases, but it was unclear whether the upstream energy, material, and water consumption were less than the savings downstream, i.e., whether significant life cycle net benefits were achieved. It was also unclear whether the designs would be suitable or acceptable when applied in a broader scale. The impacts from manufacture, transport, construction, and maintenance requirements are unknown. Furthermore, cost effectiveness, technical knowhow and capacities, social and cultural preferences, and stakeholder activities and commitments are essential elements in assessing the sustainability of new methods and technologies comprehensively, which are also unknown in this case.

While improving the flow and quality issues of the ACF, the methods used should not create other forms of adverse effects in or outside the ACF system. Hence, at building or unit scale planning, the relevant stakeholders and experts together could use SBLCA to unify the necessary practical and scientific knowledge in working out comprehensive strategies acceptable to and within the capacities of the stakeholders that would eventually contribute to minimizing the issues in the watershed.

Summary

ACF water management was identified as an exemplary case-study for the Water and Sustainability symposium organized by UF and NAED to investigate the issues and develop potential recommendations for sustainable integrated watershed management involving design professions and scientists from relevant disciplines. The specific focus of the case-study was to investigate how the human settlements including urban infrastructure and building planning, design, and management have vastly changed the historic patterns of river flows, water quantity and quality, and life-supporting ecosystems across the AFC basin.

In this particular watershed management issue, the states of Alabama, Florida, and Georgia have been involved in water negotiations since about the early 1970s leading to some successes and some failures with no agreeable solution to date. The major issues identified in ACF watershed are the water flow and quality.

This exercise examined how SBLCA could be applied at different planning scales (watershed, site and community, and building or unit) to visualize upstream and downstream of current issues, their interconnectivities, gaps in laws and regulations in meeting management objectives of the watershed, and formulating and strategizing future options that suits ACF basin management. A hypothetical example of the application of SBLCA in assessing the current state of the water flow issue at watershed scale is presented. The levels investigated were the current dam operations during the flood and drought cycles. The economic, social, and environmental indicators presented are exemplary and assumed to be as discussed at stakeholder-expert forums or workshops. The indicators developed during a real planning exercise could be different or more comprehensive compared to those presented in the example. Application of SBLCA in site and community, and building or unit scale is also discussed.

CHAPTER 6
DISCUSSION CONCLUSIONS AND RECOMMENDATIONS

Discussion and Conclusions

A decision framework using the fundamental concept of upstream and downstream thinking inherent in life cycle assessment was developed and applied in a multi–stakeholder context to support decision making for sustainable development strategies. Using the framework to evaluate the current state of issues and developing and analyzing future options gave a transparent picture of the inter-linkages between issues, the involvement of stakeholders from different sectors, and the required resources. The economic, social, and environmental cost-benefit indicators, along with applicable standards, regulations, and recommendations were used to benchmark the alternatives. Analysis of the upstream and downstream activities related to the alternative solutions created a platform for both sustainable planning and formulating sustainable strategies for regional development. The analogies and indicators used were quantitative and qualitative, and importantly, they were relevant and easily understood by different stakeholders from different backgrounds and sectors.

A simplified rating and ranking based method was developed after the completion of the pilot field study in Sri Lanka. The purpose was to introduce a method to organize information derived from assessment processes and further support prioritizing development issues and selecting among alternative solutions by the stakeholders in a participatory manner.

Application of SBLCA in Post-Disaster Development Planning

The examples presented in Chapter 4 were developed based on the outcomes of the pilot field study conducted in Sri Lanka. The examples were worked out from the exercises conducted at workshops involving community, field officers, and experts. The methods tested in the planning approaches applied in the field study were developed into training material to train the government field officers on the community based participatory approaches along with other useful method and tools. One of the main methods tested in the field study included SBLCA. In addition, the QSA, AIC, and Spiderweb tools were also tested to identify in the stakeholder capacity to apply, interpret and identify appropriate planning phases to be used.

The transdisciplinary knowledge produced with the involvement of the stakeholders and the experts in a mutual learning process had practical value. For example, when addressing certain development issues, relevant social and cultural values, needs, preferences, and facts specific to the area were better known by the stakeholders in the region. In addition, existing standards, regulations and enforcement issues were better known by the local technical officers in the relevant fields, such as housing, infrastructure and environmental services. Transdisciplinary learning among experts and stakeholders was much promoted in the pilot project and expected to be practiced in the village development programs by the field officer teams. Necessary technical knowledge and soft skills were included in the training programs. The application of SBLCA and the systems thinking frameworks opened avenues for knowledge sharing among the local experts, who were also a subset of stakeholders of village development, and the other stakeholders. The village development teams consist of stakeholders from various disciplines, such as housing technical officers, waste management technical officers, and environmental officers. The LCT/A framework required them to process information from their individual field and other stakeholders' fields in applying the framework in their planning and implementation process.

The assessment process was grasped by the field officers. From the initial planning steps, village officers were able to conduct the stakeholder meetings up to assessing the current system and prioritizing issues. At the point of option analysis, where in most cases technical solutions and therefore specific expertise were required, the village officers needed assistance from the LA or National Housing Development Authority (NHDA) TOs. Therefore, TOs having good working knowledge of participatory approaches, methods, and tools for analysis were found to be very important to promote village level planning and implementation. THSP initiated a collaborative project with the Performance Improvement Project (PIP) of GTZ Sri Lanka directed toward improving the service delivery and soft skills as well as the technical capacities of the LAs. This project was in the proposal phase. Life cycle thinking and unbundling levels was expected to be a key topic in the training program, apart from other communication, leadership, and teamwork skills.

Since the responsibilities of the LA TOs outlined above would be in addition to their current duties, the LAs were expected to modify and update the TO duties in a manner which would allow the TOs to take part in village development planning and implementation activities.

Much of the village specific data were available to the Village Officers, Public Health Inspectors, NHDA and LA Technical Officers. Energy use, CO_2 releases, raw material consumption patterns, water purification, and wastewater treatment data needed to be extracted through research and face-to-face meetings with relevant professionals. As the proposed training for field officers includes basic email correspondence and internet use, links for useful data sources can be incorporated in the training modules for TOs.

The purpose of the modules was to introduce several participatory planning methods and tools which can be used for different purposes in village-level development planning. Measuring how well teams utilize these techniques for sustainable planning and implementation would be useful in order to evaluate the program and identify its strengths and weaknesses. THSP had launched a project together with the Ministry of Public Administration and Home Affairs for the purpose of rewarding the village development teams who have applied participatory approaches, methods, and tools and achieved positive contributions towards sustainable development. A village to national level scheme was developed by THSP to assess the above. According to the rewards scheme, every village and workshop meeting is supposed to be documented according to a standard format. The details on approaches, methods and tools applied with scheduled outcomes are expected to be reported to the divisional secretariat. A data base was developed at each district level to store the records for evaluation by a panel of judges at district and national level. The successful field officer teams were expected to receive carrier advancement certificates from the Ministry of Public Administration and Home Affairs and foreign exposure visits to enhance the knowledge on successful strategies in other countries such as Thailand. These records from the database were expected to be used to validate the usefulness of the decision frameworks introduced. Since, the database records monthly activities of the village development team activities covering sustainability aspects addressed in the process, in situations where the above tools have been applied could be compared against similar situations where different techniques have been used to identify potential contributions towards planning and implementing sustainable solutions in villages. The project is currently underway.

Based on this field experience, the environmental indicators together with economic and social indicators made considerable impact on decision making. Cost factors were always the governing and deciding factors. Illuminating future economic costs as a result of lower initial investments, especially those which resulted in environmental damage, supported improved decision making with a focus towards the environment. Social standards such as number of people affected and stakeholder objectives and responsibilities not fulfilled also supported changing some of the decisions initially driven by economic considerations.

Application of SBLCA in Integrated Watershed Management

ACF watershed management was an exemplary case-study conducted on investigating issues and potential recommendations for sustainable watershed management involving the relevant academic professionals and practitioners. At the symposium held on water and sustainability with the ACF as a case-study, various recommendations were made on how human settlements, including urban infrastructure and building planning, design, and management, river flows, water quantity and quality, and life-supporting ecosystems across the AFC basin could be improved. Available material was extensively researched to understand the history and the conflicting issues of the entire watershed. The economies, interests and priorities of the stakeholders, needs of the ecological systems, growth patterns, and legal issues of the three involved states were also explored.

ACF watershed management was identified as a multi-scale, multi-discipline, and multi-stakeholder problem. Even though the planning could happen at several strategic scales, certain decisions on the watershed has to be made considering the entire basin system. Sustainable action requires collaboration among multiple stakeholders in the watershed. Hence, application of SBLCA at different planning scales has the potential to communicate holistic information to the stakeholders belonging to various activity phases and foster consensus on sustainable decisions and collaborative action.

The information investigated above was used to formulate the hypothetical example on the application of SBLCA in an integrated planning process in a watershed scale. The example examined the current levels of dam operation in the watershed in the flood and drought cycles. In a real planning situation, once the main issues of the watershed have been identified, stakeholders and experts could chose the appropriate levels and upstream and downstream activity phases that should be included in the assessment. The indicators in the example were introduced in generic form as all the indicators presented were not investigated for their actual values within the first phase of the study. The indicators applicable in this example could be quantitative, semi-quantitative, qualitative, descriptive, or graphical. When the indicators are compared with reference to their levels, the effects of the dam operation on various phases could be examined. Especially in the case of comparing alternative levels of dam operation, once the actual values for the full set of economic, social, and environmental indicators were worked out with stakeholder input, they could be organized to further analyze, discuss, and negotiate which levels perform better. Accordingly, sustainable strategies for sound policies and action could be negotiated at the watershed scale.

From the SBLCA example, it could become clear to the stakeholders how certain decisions upstream affect may affect activities and ecosystems downstream. Certain implicit costs and benefits and required organizational inputs along the activity phases could be understood. Quantified direct benefits from protecting the ecosystems are not readily available for the ACF watershed. In this tri-state battle, not being able to find common ground identifying mutual benefits to the stakeholders has been a crucial problem. For example, protection of ecosystems in Apalachicola Bay does not have apparent direct benefits to the stakeholders in Georgia or Alabama. The needs of the state of Florida could even be seen as an attempt to protect the oyster industry. In most situations, the needs of the ecosystems are not interpreted as important compared to the needs of the human society, even though the functions of the ecosystems and their services have significant direct and indirect effect on the human environment. The cost of ecosystem services is largely unknown. Hence, configuring links of human activity to disruption of the ecosystem and being able to communicate the adverse impacts using simplistic indicators would have a greater effect in educating stakeholders to make ethical decisions where monetary benefits are not governing. To do so, further multidisciplinary research may be required to make such analyses more transparent, stakeholder-oriented and communicable.

Considering the above, at each planning scale of the watershed, it is important that the planning process is more of a transdisciplinary learning process involving relevant stakeholders and experts. The SBLCA framework as demonstrated has the potential to bring in and integrate knowledge from different disciplines and sectors to promote a learning process. The framework has the ability produce transdisciplinary knowledge and information which would be more transparent and relevant to the decision makers in the watershed.

In the scope of this study, other scales of planning (site and community scale, or, building or unit scale) were not investigated in detail. The recommendations of the symposium helped to identify innovative ways to address water reductions at the building scale, yet how to expand and integrate its application to the regional scale was not yet investigated. Hence, example applications of the SBLCA framework were not presented for the above planning scale. One of the recommendations at the symposium was to use design charrettes to visualize system-wide alternatives using transdisciplinary scenario modeling and appropriate tools demonstrating policy and physical design scenarios such as removing dams, redesigning the shoreline of waterfront properties, improving building and landscape designs, or reconsidering agricultural practices. Along these lines, some of the potential issues were identified at the site and community, and building or unit scale. How the SBLCA framework could be meaningfully applied in these contexts was briefly outlined and discussed.

Evaluation of SBLCA

To evaluate the use of SBLCA, the same criteria that were used to assess other commonly used development assessment methods are used. The criteria are discussed relative to the methodological flexibility and stakeholder participation introduced in Chapter 2 under Literature Review of the assessment methods. Example applications of SBLCA are used for the evaluation discussion.

Methodological flexibility criteria

1) SBLCA can adapt to data scarce situations (vs. full data sets)

In many developing countries, the lack of data for detailed analysis is a common problem. One of the challenges mentioned above is to have a method that can work with available data. The analysis could begin as simple quantitative and qualitative data and information using existing knowledge, and then proceed into more quantitative and advanced analyses, with the data requirements depending on the life cycle of the issue. In certain instances, gathering and presenting the information in a structured manner itself would create new useful information that would enable a broader perspective of problems, and more appropriate decisions among the stakeholders. After reaching consensus on the need for broader analysis, local universities and research organizations could undertake these tasks with aid from donors. Country- and region-specific data and information can be reused in other projects, gradually lessening the data collection required for sustainable decision making. In many cases, this process would be incremental, with the full application of the life cycle framework occurring over time.

2) SBLCA considers a holistic view of the issues, upstream and downstream consequences (vs. analysis limited to a few obvious phases)

For example, in the wastewater treatment optional analysis example, implementing eco-sanitary composting toilets, decisions regarding the construction phase are insufficient. Some of the principal points that could be examined in parallel in this holistic framework are determining how to build awareness and establish the social acceptance of the technology, how skilled labor and technical assistance should be developed in design and construction, the type of construction material to be used, how materials are transported, what maintenance and operational aspects, and what to do with the recycled waste (compost). Therefore, a comprehensive view of the respective upstream and downstream needs and consequences is possible.

3) SBLCA can deal with cross-sectoral issues (vs. sectoral focus) highlighting cross-sectoral inter-linkages

As shown in the example illustrated in Figures 4-24, even though the issue of household waste disposal and constructing toilets and plant beds were linked to the housing sector, it can be observed that the livelihood sector also has a major role to play by contributing to community training programs to engage in skilled labor in quality construction, and capacity building for housing authorities. Application of the framework enables the stakeholders to identify the importance of their roles and the others' in the process.

4) SBLCA allows for assessing all dimensions of sustainability (vs. one dimension of sustainability)

The examples on SBLCA application highlights the close collaboration required among stakeholders in different sectors and disciplines in order to address the economic, social, and environmental aspects of sustainable development. For example, simplified indicators provide insights to the stakeholders for economic aspects such as the total cost of activities and individual costs to the stakeholders; social improvements, such as income generation opportunities and skill development for the labor workforce and housing authority personnel; environmental issues, such as the use of different types of construction material and construction methods for increased durability of construction, minimized raw material depletion and transportation distances.

5) SBLCA has the ability to assess alternative scenarios (vs. status quo assessment)

LCA is a method for evaluating alternatives. As shown in the examples for water supply and wastewater treatment, different levels of services can be examined together with the indicators covering relevant economic, social, and environmental aspects to select the optimum solutions that best fit with local conditions, technologies, and available resources. Stakeholders can give inputs in developing and assessing scenarios.

6) SBLCA accommodates strategy building (vs. limited to assessment)

Once the options are assessed, strategies could be constructed, identifying the upstream and downstream activities, specific stakeholder and community involvement and responsibilities, resource allocation, and the synergies of the processes to fully interpret the collaboration necessary in joint projects. The viability of the options is assessed with the stakeholders negotiating and agreeing to perform all necessary and clearly identified activities with the associated resource requirements. When the activity flows and responsibilities are already identified with relevant information produced by the multi-stakeholder analysis, strategizing solutions becomes easier. Agreeing to a time line with a memorandum of understanding to perform each activity by respective stakeholders provides a way forward for sustainable implementation.

Stakeholder participation criteria

7) SBLCA allows for stakeholder interaction at all stages of the process

Starting from defining the sustainability goals, examining the current status, constructing scenarios, building strategies, and developing indicators for monitoring and evaluation, stakeholders are expected to be involved in the process. For example, stakeholder participation may include providing details on current construction, recognition of prevailing issues in the stages considered, prioritizing issues, contributing knowledge and best practices from specific fields for constructing scenarios, assessing the viability of options, and strategy development, and giving inputs to developing and ranking indicators useful for supporting decisions.

8) SBLCA promotes consensus building for joint projects

Because stakeholders are involved throughout the process, and the framework allows them to clearly visualize the relevant activities in the relevant life cycle stages, the role of other stakeholders, the resource requirements, and therefore the net benefits, SBLCA is expected to support consensus building within the planning process. For example, stakeholders can decide on whether the CSEB, cement block or the brick walls optimize the local conditions by assessing and ranking or rating indicators with expert facilitation.

9) SBLCA communicates results and impacts to the stakeholders clearly and easily

With simplified versions of indicators such as raw material depletion considering ecological sensitivities, transportation distances and costs, and livelihood opportunities, the life cycle experts and stakeholders are in a better position to clearly and easily communicate and interpret the results during the development planning process.

10) SBLCA provides transparent access to information so that stakeholders can examine the assumptions made and the projected outcomes of decisions

Following the traditional LCA requirement of recording and presenting all assumptions, the results and assumptions of each step would be recorded for use by the stakeholders. More or less, data should be collected, communicated and validated with the stakeholders prior to analysis. In the examples given, some of the results would be quantitative while some would be qualitative or even graphical. The project data can be expected to evolve over the course of the planning process, and it is conceived that local research groups would commit to conducting some of the more detailed quantitative analysis required to improve data quality.

Simple Rating and Ranking Method

Typically in development related assessments, the indicators, i.e., criteria used to evaluate issues or alternatives, are diverse and are often a large number. Furthermore, in a group of multi-stakeholders, the relevance or the importance of the indicators to the individual stakeholders would be different. Hence, a method is required to facilitate further negotiation on weighting the indicators to identify which issue needs to be prioritized, or which alternatives would perform better under a given set of indicators.

The method developed was similar to SMART, with slight modifications to perform the weighting and ranking in a simplistic manner. Rating the indicators with 0 to 10 or 0 to 100% scale prior to converting them to weights is expected to avoid the tedious iterative process of making sure the total adds up to 10 or 100% during stakeholder negotiations on values for the indicators according to their needs, priorities and preferences. Equally important indicators would receive the same ratings within the above scales irrespective of whether the indicators are economic, social, and environmental, or, whether they are quantitative or qualitative. Similarly, all indicators are rated considering the relative importance of the indicators to the stakeholders. Once the set of indicators are rated, the individual ratings are divided by the totals to obtain the respective weights for the indicators. With this approach it can accommodate a large set of indicators in the analysis. However, when the number of criteria is too large, it would be better to eliminate the obviously less important indicators. It is estimated that an indicator set of 10 to 15 would be a manageable.

The scores for indicator performance were also expected to be assigned together with the stakeholders. The scale can be 0 to 10 or 0 to 100% as above. The scores, however, are easier to assign according to the indicator values. Assigning the highest score in a given scale to the best performing alternative and relative scores to the rest would increase the margin of difference of total weighted scores among the alternatives. Since the focus is selection of alternatives, rather than identifying the overall utility of an alternative to the stakeholders, assigning scores as above would not require them to know the minimum and maximum indicator values that would match their extreme preferences. This allows consistent scoring of the alternatives across the indicators. The importance of the indicator is decided on the weights given by the stakeholders. Hence, the total weighted average of the alternatives is a good approximation of the performance of the alternatives.

This analysis directs the stakeholders to identify their priority issues or best alternative solutions systematically with respect to their needs and preferences. As explained in the previous section, the alternative that receives the highest rank may not be the strategically implementable solution. But nevertheless, it would give stakeholders an idea of the alternatives that may perform better in their context and the motivation to strive for the better performing alternatives, or at least to avoid alternatives which ranked in the lowest bracket.

The method was applied to two indicator sets derived from applying SBLCA in the field study in Sri Lanka. Since, the method was developed after the field study the scores and rates were assumed adopting a normative basis. Method application in the above examples indicated that the outcome was logical. For example, eco-sanitary toilet construction with CSEB walls was found to be the best option compared to eco-sanitary toilets constructed with other wall material such as cement blocks and regular fired bricks, and traditional toilets with similar wall options. Irrespective of the wall material, the traditional toilet options received considerably lower scores. Application in real planning situations is necessary to identify any necessary modifications to the procedures or certain soft skills that may be required in multi-stakeholder situations.

Concluding Remarks

By its definition, sustainable development requires integrating social, economic, and environmental aspects. Therefore, when the goal is sustainable development, cross-sectoral integrated project planning is the desirable approach. However, currently used tools for environmental decision making are limited in their ability to adequately address the needs of the stakeholders in these situations. This leads to challenges in planning and implementing projects, particularly when stakeholder collaboration across traditional planning sectors is required.

Criteria were developed in terms of methodological flexibility and stakeholder participation and used to evaluate and identify limitations of EIA, SIA, and RA methods, as well as identify the attributes required for supporting decision making in these cases. The analysis indicated that the method must be flexible and work with limited as well as rich data sets, have a life cycle perspective while identifying the dependencies between sectors, assess multiple aspects of sustainability and be able to generate alternative scenarios and strategy building for implementation. The method must also allow for stakeholder interaction at all stages, promote consensus building, foster transparent access to information and clearly communicate implications of development to the stakeholders. SBLCA was proposed as an innovative instrument to support development planning and implementation. SBLCA provides decision support and can be used to structure and analyze stakeholder associations and map those potentially affected by the various economic, social, and environmental aspects of the proposed development. Generating information both quantitative and qualitative together with the stakeholder knowledge contributes significantly to improved understanding and increased transparency contributing to reduced bounded rationalities and opportunistic behaviors. This may lead to reduced uncertainty and transaction costs, and build consensus among stakeholders. SBLCA with its underlying concept of life cycle thinking can be both an assessment as well as a consensus building tool in an integrated development planning process. The evaluation of SBLCA based on the above criteria discussed is summarized in Table 6-1.

Table 6-1. Evaluation of SBLCA

	Criteria	Method
		SBLCA
1.	Adapt to data scarce situations	Yes
2.	Consider holistic view of issues	To a great extent
3.	Deal with cross-sectoral issues and highlight inter-linkages	To a great extent
4.	Assess all dimensions of sustainability	Yes
5.	Assess alternative scenarios	To a great extent
6.	Accommodate strategy building	Yes
7.	Stakeholder involvement in all stages	Yes
8.	Promote consensus building	To a great extent
9.	Transparent assessment and results	To a great extent
10.	Clear and easy communication of results	To a great extent

There are various methods used in current participatory planning processes to streamline the information on alternatives. Some of the key methods include Rating, Ranking, PCA, AHP, MAUT, and SMART. When the current methods were reviewed to check the suitability for multi-stakeholder planning contexts where stakeholders would be in the center of applying the methods, most of them were identified as tedious, time consuming, difficult to involve and communicate to larger stakeholder groups in development planning, especially when conducted in developing country contexts. The methodology developed is to be used as a support tool to structure the information derived from any participatory assessment methods and assist further negotiations in situations where prioritizing or selecting among alternatives which do not show a clear dominance over the other. The evaluation of the simple rating and ranking based method is given in Table 6-2.

Table 6-2. Comparison Evaluation of Rating and Ranking based method

Criteria	Rating and Ranking based method
How easy to communicate the methodology	Easy
How easy it is for the stakeholders to participate	Easy
How easy it is to conduct the analysis	Easy
How transparent is the analysis	Transparent
How easy it is for the stakeholders to interpret results	Easy
How useful it is when the alternatives to evaluate are too many	Useful
How relevant it is when the criteria to be considered are too many	Useful
How useful it is when the stakeholder groups are bigger	Useful

Recommendations and Future Work

According to the research experience from the pilot field study in Sri Lanka and investigating the current issues of ACF watershed management, the following general recommendations could be identified:

- In modern development planning situations, promoting cross-sectoral integrated planning and implementation is a necessity.

- Application of LCA/T and its underlying concept of upstream and downstream analysis in assessing decisions and action in development planning need to be promoted to ensure sustainability.

- In such planning exercises getting the stakeholders on common ground by exchanging and building up on each other's knowledge and expertise becomes a valuable first step towards responsible decision making towards collaborative action.

- Researchers are required to understand the nature of the sectors and disciplines and their underlying assumptions in order to integrate, translate, and implement research transcending, yet respecting, established norms.

- Specific training is required by the researchers to collaborate effectively with the multidisciplinary and cross-sectoral partners.

SBLCA Method Improvements

Improving decision support methods is always a challenge to balance between scientific robustness and simplicity. Especially when applied with multiple stakeholders with different backgrounds and levels of understanding, it is compulsory that the process is sufficiently simple and transparent, such that the stakeholders would be able to involve and trust the outcome of the analysis process. Hence, the improvements should not compromise the above.

The indicators used in the case-study were location specific, easy to develop (by local experts), and easy to communicate to the stakeholders. Additionally, it would be beneficial to evaluate the indicators and refine them when necessary such that they remain specific, easy to use and communicate, yet are more scientifically accurate. Especially, when the planning context is more sophisticated, for example, in ACF integrated water management, more scientifically accurate data may be required. How to include statistical, sensitivity, and uncertainty analyses such that they still remain transparent and participatory would need further research.

When the scale of the planning is broader, it would be beneficial to include researchers from other disciplines such as architecture, urban planning, psychology, sociology, and anthropology to improve the assessment process and the respective indicator development. The inputs would be useful to identify certain indicators that may be more relevant to the stakeholders. Developing an array of indicators including economic, social, and environmental that could be commonly used in development planning under potential issues would also be beneficial to promote the use of SBLCA among a wider audience in the development field. Guidelines with generic steps to activity chaining, stakeholder mapping , and developing non-traditional indicators including examples from developing countries as well as developed countries would also improve the potential use of SBLCA.

It would be useful to evaluate the methodology and assess its contribution in real world applications. In the pilot field study conducted, it was not possible to conduct an evaluation of the methodology, as the project is still on-going. An evaluation could be conducted based on data and information gathered from a database developed by THSP for documenting the participatory community development process. The database was for assessing the successful use of the methods and tools in participatory planning and implementation that were introduced in the government field officers training programs. The database was expected to contain the type of LCA activity analyses conducted, the indicators used, and the short-term outcomes. As outlined in Chapter 5, the methodology could be applied in relevant ACF planning scales, and measures could be taken to evaluate any positive or negative contributions towards sustainable action. It would also be beneficial to evaluate at which planning scales the SBLCA framework works better. Application of the methodology in design charrettes at UF to demonstrate upstream and downstream of urban infrastructure issues and solutions for sustainable water management in small scale regional watershed management planning could be a start.

In a planning process, participatory monitoring is also an important element in ensuring the intended activities are implemented as planned. If the actions need to be changed, then the upstream new requirements and resulting downstream requirements or outcomes need to be investigated. To assist this continuous feedback, a SBLCA framework could still be useful to investigate which upstream and downstream activities are moving as planned and which are not. This was not evaluated during the pilot field study in Sri Lanka. But, in a different multi-stakeholder planning context, how SBLCA can be used for evaluation and monitoring could be researched.

Development and use of appropriate information was found to be an incremental process. It was necessary to start with the data that was already available. Local universities can play a major role in working on gathering environmental data and information on building materials, construction processes and equipment, alternative building material and technologies. NHDA and LA can improve access to the environmental information by using the information to provide better technical assistance in planning and implementing sustainable solutions in the local regions.

Rating and Ranking Method Improvements

Rating and ranking method was tested for two data sets from the field study. Although the method clearly has the potential to be applied in multi-stakeholder contexts, it needs to be tested in a real development planning study. The method can be used not just as a way to prioritize and identify the best alternatives considering different priorities and interests, it could also be used for comparing and understanding perceptions of stakeholder groups and work towards reconciliation depending on the planning context. The application steps could be modified as necessary. The procedure should always be simple, transparent and easy to communicate.

As discussed earlier, as the weights could be automatically worked out without having to go through the iterative process and the scoring system is straightforward and consistent among alternatives, a comparatively larger set of indicators, i.e., criteria, could be accommodated in the analysis. However, real data should be used to validate the maximum range of criteria that would make sense in an analysis. Similarly, the maximum range of alternatives that should be included in an analysis should be appropriate to test for acceptable outcomes.

Summary

The fundamental concept of life cycle thinking and assessment can be effectively used to incorporate stakeholders in the assessment and decision making process, which can lead to more comprehensive, yet simple assessments together with the stakeholders. It is not just a way to examine environmental impacts of activities, but also a way to comprehend and visualize a broader set of upstream and downstream consequences of decisions in development planning and implementation.

Application of SBLCA in multi-sector and multi-stakeholder contexts has been able to meet the challenges of those development contexts. The method is evaluated against the criteria used to evaluate the other environmental decision support methods. Improvements include refining non-traditional indicators to suit the planning context, and applying the method in different integrated planning contexts such as ACF watershed management.

Improvements and future work for the rating and ranking based method includes testing the application in a real planning situation and practically applying it for different purposes such as for stakeholder perception analysis. The maximum number of criteria and alternatives to be used in the analysis should also be examined.

APPENDIX A
DEVELOPMENT INDICATORS

The criteria/Indicators given in Sustainable Infrastructure Development Framework (SIDF) are as follows:

Source: CAA, 2003

Table A-1. Economic indicators

A: SIDF for the Construction Sector: Economic Prosperity		
Theme	Sub-Theme	Indicator
Economics	SMMEs	% employed
	Ongoing costs	Service cost as a % of income
Consumption and production	Material consumption	Intensity of use
		Durability
		Ease of deconstruction
		Environmental impact
		Toxicity
		Levels of VOCs
		Recycling
		Storage
		Maintenance
	Energy consumption	% of energy consumed from non-renewable energy
		% of energy consumed from renewable source
		Intensity of use
		Embodied energy
	Waste generation	Volume of construction waste generated
		Volume of solid waste generated
		Volume of waste recycled
	Transportation	Distance travelled, materials
		Distance travelled, labor
		Distance travelled, users
	Efficiency of use	% useable space
		% occupied
		% downtime
		Buildability

Table A-2. Social indicators

B: SIDF for the Construction Sector, Social Well-being		
Theme	Sub-Theme	Indicator
Cultural heritage	Resources	Conservation of cultural resources
Community	Empowerment	Community involvement
Education	Adult	Human resource development
		Transfer of technology
		ABET
Equity	Poverty	% previously unemployed
		Jobs created
		% local labor
	Gender equity	% women employed
		Separate amenities
		Employment practices Safety
		Labor rights
		Amenities
Health	Preventative healthcare	HIV/AIDS awareness
		On-site health care
	Indoor environment	Noise abatement
		Daylighting
		Access to views
		Ventilation and thermal comfort
		Waste removal
		Inclusitivity
		User control
		Smoking
	Sanitation	Standard
		Treatment
		Disposal
	Drinking water	Access
		Reliability of service
		Hygiene
	Crime	Community programs
		On site measures
	Safety	Precautions
		Disaster management

Table A-3. Environmental indicators

Table C: SIDF for the Construction Sector: Environmental Stewardship		
Theme	Sub-Theme	Indicator
Atmosphere	Climate change	Greenhouse gases emitted
		Susceptibility to sea-level rise
	Ozone	Emissions of depleting substances
	Air quality	Pollutants during construction
		Pollutants in use
Biodiversity	Ecosystem	Selected ecosystems
	Species	Selected species
		Indigenous species
		Connectivity
Fresh water and groundwater	Water quantity	Intensity of use
		% rainwater harvested
		% recycled and reused
	Water quality	Watersheds protected
		Aquifers protected
Land	Trees	% retained
		% added
	Soft landscaping	CO_2 absorption
		Heat sinks created
		Ease of maintenance
	Hard landscaping	Heat island creation
		Light reflected
	Brownfield development	% rehabilitated
		Density of use
	Greenfield development	% open land retained
		Density of use
	Pollution	Leeching of chemicals
		Light
	Storm water	Erosion control

APPENDIX B
TSUNAMI HOUSING SUPPORT PROJECT

Overview of Project Activities

The Tsunami Housing Support Project (THSP) is a Sri Lankan – German Development Cooperation project that is in partnership with the Sri Lankan Ministry of Housing and Common Amenities and is financed by the German Federal Ministry for Economic Cooperation and Development. THSP's primary objective was to promote participatory approaches and sustainability in reconstruction by capacity building in the responsible government institutions. The project was formed in early 2005.

The Sri Lankan contribution of the project was implemented by a steering committee composed of a number of governmental organizations including the Ministries of Public Administration and Home Affairs, Provincial Councils and Local Government, National Housing Development Authority, National Building Research Organization and chaired by the Ministry of Housing and Common Amenities.

Objectives

THSP worked towards the objective that the responsible government institutions coordinate and implement the post-tsunami reconstruction activities in an effective and participatory manner. Towards achieving this objective, THSP supported stakeholder-based quality assessment of reconstruction and development of soft skills for public officers at various levels. To monitor the impacts of the inputs while providing incentives to use capacities developed, THSP supported an initiative for encouraging the achievements of sustainable development objectives. Figure A-1 summarizes THSP activities in brief.

Figure B-1. THSP capacity building projects towards sustainable post tsunami reconstruction (Source: GTZ-THSP Brochure, 2007)

APPENDIX C
SRI LANKA – COUNTRY PROFILE

Overview of Profile Data

When searching for sustainable solutions in development, the country context does matter. The geography, demography, economy, environment, consumption, for example, provide background and context to issues and influence the viability of solutions to a certain extent. Due to the differences mentioned above, and many other specific factors together, ‘what is sustainable’ in one country context can vary to a great extent in another country. Table C-1 is an attempt to gather some useful indicators to get a general overview of the country. The indicators are categorized under three aspects of sustainability - economic, social, and environmental; some of the important indicators are compared against corresponding statistics for India and the US.

Most of the statistics are extracted mainly from the Central Intelligence Agency’s (CIA) World Factbook, 2007 (CIA, 2007). Sri Lanka is still a developing country and has been affected by an ethnic conflict over two decades. Sri Lanka is ranked 110th in the world in terms of per capita gross domestic product (GDP). 80% of the wealth in the country is owned by 20% of the population, showing a clear disparity in social well-being. The economy has been predominantly agricultural; however, currently the agriculture sector has declined to 35% of GDP, while service and industry sectors have risen to 25% and 40% of GDP respectively. The public debt, which is more than 85% of annual GDP, and the inflation rate of 16%, explains the intense dependency on international funding for development activities. Low per capita income, and 22% of the rural population under the poverty line indicate the capacity of the people to afford basic needs including safe water, electricity, and taxes for services. For example, only 55% of the population has access to the national electricity grid, and 35% of the population has no direct access to potable water (UNDP Equator Initiative 2005, NWSDB, 2007). Hence, indicators such as per capita electricity consumption and water use are as small as 2KWh per day and 130 liters per day respectively (CIA, 2007). However, rainfall and year-round sunshine leave potential options for alternative solutions for water and electricity supply. The forest cover, which is approximately 30% of the land-cover, is decreasing at an annual rate of 1% due to weak enforcement of forestry regulations. Considerable numbers of indigenous species are classified as endangered. Much of this decline is due to biogas production, irrigation, and the wood industry (MONGABAY.COM., 2005; UN FAO, 2007). The air quality in the country is poorest in the capital city and the peripheries. According to United States Department of Energy's Carbon Dioxide Information Analysis Center (US DOE-CDIA) reports, per capita CO2 emissions average 0.6 tonnes per year, out of which 60% is from the transport sector (US DOE-CDIAC, 2005). 75% of the rural areas indicate good outdoor air quality. However, poor indoor air quality is prominent in all areas due to extensive use of biomass and LPG for household cooking purposes, fired brick manufacturing, and others (WRI's Earth Trends, 2003; WB's Environment, 2004).

In social terms, the main aspects such as health and education are free for all citizens in the country, although the facilities in rural parts of the country are barely sufficient. These policies have created an impact in two distinct ways in the society: higher health, sanitation, and literacy standards compared to other developing countries in the region, and higher dependency upon the government for providing services and managing common property, which hinders strategies for growth. However, the literacy rate of over 90%, life expectancy close to 75 years with GDP growth rate of 8.5% despite the civil war, positions the country for prospective future development.

Table C-1. General overview of economic, social, and country indicators

	Unit	Sri Lanka	India	US
Economic				
GDP (ppp), (2007)	US $	83.2 billion	2.97 trillion	13.86 trillion
Per capita GDP, (2007)	US $	4,100	2,700	46,000
Livelihood (agriculture:industry:services) , (2007)	% GDP ratio	35: 25:40	17:28:55	1:20:79
GDP growth rate, (2007)	%	6	8.5	2.2
Inflation rate, (2007)	%	16	5.9	2.7
Public debt , (2007)	% GDP	86	59	37
Social				
Population, (2007)	Number	20.9 million	1.3 billion	301.1 million
Rural:Urban, (2007)	ratio	75:25	72:28	21:79
Population growth rate, (2007)	%	0.9	1.6	0.89
Life expectancy, (2007)	years	74.8	68.6	78
Literacy rate, (2007)	%	92	61	99
Population below poverty line, (2007)	%	22	25	12
Environmental				
Land cover, (2007)	km^2	65,610	3,287, 590	9,826,630
Population density, (2007)	per km^2	316	336	31
Forest cover, (2007)	%	30	11	23
Deforestation rate, (2007)	%	1	1	1.3
Critically endangered/Endangered/Vulnerable , (2007)	number	78/73/129	50/98/98	?
Arable land, (2007)	%	14	49	18
Electricity consumption (2005)	KWh per year	7 billion	488.5 billion	4,062 billion
Per capita electricity consumption, (2005)	KWh per year	363	432	12,672
Access to electricity grid, (2007)	%	55	30	~100
Total fresh water withdrawal (domestic %), (2000)	km^3 per year (%)	12.6 (8)	645.8 (8)	477 (13)
Per capita domestic water consumption, (2000)	liters per day	130	128	438
Annual average rainfall (southwest, northwest)	mm per year	2550 (900 – 6000)	-	-
Access to Pipe water:Well water:No direct access to water, (2006)	% ratio	29:36:35	-	-

Table C-1. Continued

	Unit	Sri Lanka	India	US
Environmental				
CO_2 releases (2004)	tonnes per year	11.5 million	1,343 million	6,050 million
Per capita CO_2 releases (2004)	metric tons per year	0.6	1.2	20.4
GDP per CO_2	$ per tonnes per year	1,740	500	1,940
Solid waste generation (rural:urban) (2004)	ratio tonnes per year	1,800:2,500	-	-
Per capita waste generation (rural – urban) (2004)	kg per day	0.2 -0.85	-	-

ources: CIA World Fact Shee,2007; UNDP Equator Initiative ,2005; NWSDB, 2007; UN FAO, 2005; MONGABAY, 2005; US DOE-CDIAC,2005; WRI Earth Trends, 2003; WB Environment Department,2004.

When providing housing with access to water, electricity, and other basic sanitation, the country capacity and use patterns need to be considered. According to the statistics, in India and Sri Lanka, the urban rural population ratio remains approximately the same as 30:70, while in US it is the reverse (71:29). Population below the poverty line in India and Sri Lanka are around 25% of the population, which is approximately twice the amount in the USA (12%). Per capita GDP of Sri Lanka is 9% of the US GDP, and occupants consume 3% of the electricity and 30% of the water per capita compared to the US (Figure C-1). Per capita GDP of Sri Lanka is 1.5 greater than India, and the electricity and water consumption are in the same range. The dominating agricultural sector (35%) and service sector (40%) as compared to the industrial sector (25%) together with lower level of living conditions contribute to the differences.

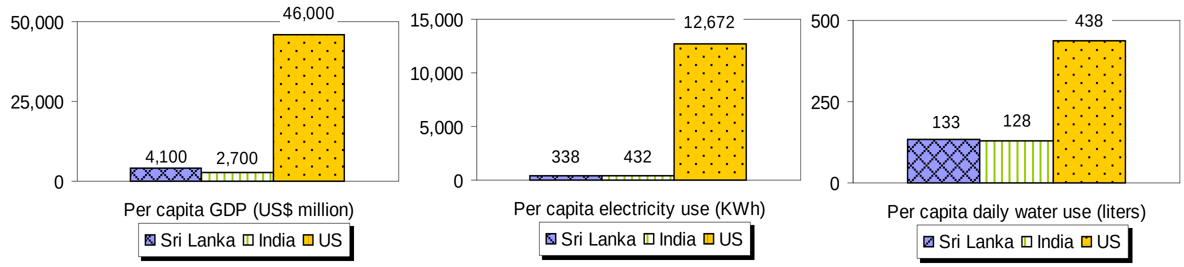


Figure C-1. Comparison of per capita GDP, electricity, and water consumption (Source: CIA World Fact Sheet, 2007)

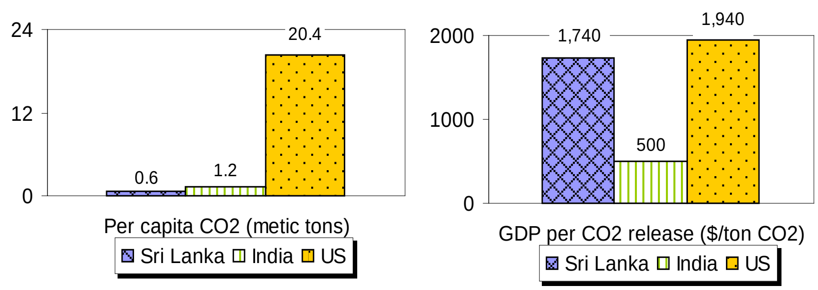


Figure C-2. Comparison of per capita CO_2 emissions per year and $GDP per ton of CO_2 emissions (Source: US DOE-CDIAC, 2004)

Also, due to the tropical climate, with temperatures ranging from 25 to 35 centigrade, and with the majority of typical housing units not exceeding two stories, energy for heating, cooling, and ventilation is comparatively insignificant. Per capita CO_2 emissions are 50% of India and 3% of USA per capita emissions. However, when comparing the GDP per release of CO_2, it can be seen that Sri Lanka and the US are in the same range, while in India it is approximately 70% less (Figure C-2). One of the major issues in the country includes solid waste disposal. Solid waste generated in most municipalities is mainly organic which exceeds 80% of the total waste. Household waste is not separated at the source; wastes are either burnt or buried on-plot in most rural areas. Waste collection is limited to urban areas, and it is transported to inadequately managed landfills (open dumping). Cost recovery systems in terms of taxes and fees are not well organized in the local authorities (GTZ-IFSP, 2006).

Housing Sector

A typical low income-house design in Sri Lanka is shown in Figure C-3. The minimum floor area regulated by the government for post tsunami reconstruction is $50m^2$. Typical floor area ranges within 550 – 1,000 square feet. According to the Chamber of Commerce in Sri Lanka, yearly building construction has ranged from 4,000 – 5,000 units for the 20 years before the tsunami. After the tsunami, it was expected to be increased to 13,000 per year. This is assuming that the government's expectation is to complete building 80,000 housing units within 10 years, adding 8,000 more housing units per year over usual construction. The current typical construction technologies do not comply with disaster resistance standards.

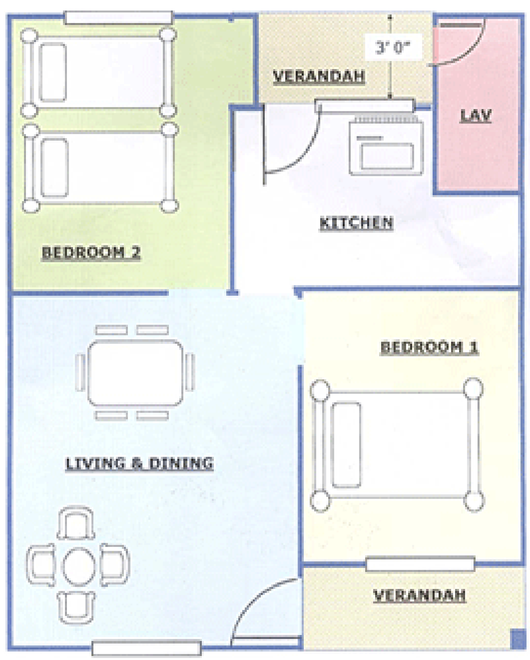


Figure C-3. Typical house design for low-income families

Construction materials in demand in the country are cement, sand, wood, steel, and asbestos (Ceylon Chamber of Commerce, 2007). The annual cement demand in the country in

2006 was 3.8 million tonnes with a growth rate of 7% in the past year; annual river sand demand has been 7,000 million m^3 with a growth rate of 10% after the tsunami. The Ministry of Environment and Natural resources has launched a restrictive policy for river sand extraction, and has drafted a stricter national policy in 2005, which is still under public circulation. With the above situation in the country, a greater need has evolved for promoting sustainable alternative building materials to reduce the burden on heavily demanded materials and respective massive price escalations. Sustainability issues in terms of present housing reconstruction are summarized in Table C-2 (GTZ-THSP, 2007):

Table C-2. Sustainability issues in housing reconstruction (Source: Quality Assessment Methods, GTZ-THSP, 2007)

Issue	Severity
Quality construction using quality material	Severe
Quality site management systems	Moderate
Unavailability of quality criteria and methods for assessment	Severe
Lack of infrastructure facilities (access roads, drainage systems, common spaces for recreational activities, schools, hospitals, markets, etc.)	Severe
Access to income opportunities	Severe
Lack of social and communication services	Moderate
Lack of transport facilities	Severe
Access to safe water	Moderate
Access to improved sanitation (functioning toilets, sludge treatment systems, wastewater disposal, solid waste management)	Severe
Access to electricity	Moderate
Continuous supply of skilled labor	Moderate
Lack of labor capacity to construct with alternative material	Severe
Lack of social acceptability to new technologies and materials	Moderate
Lack of participatory planning and involvement of the beneficiaries	Severe
Lack of community-community, community- local authority arrangements for operation and maintenance of essential services	Severe
Concern for surrounding ecological sensitivities	Moderate
Lack of capacity and motivation of Urban Development Authority to reduce haphazard construction	Severe

APPENDIX D
UNAWATUNA PILOT FIELD STUDY DOCUMENTATION

Overview

Geographical and Physical Characteristics

Unawatuna is a village located at the tip of the southern coastal belt of Sri Lanka. Its geographical boundary belongs to the Habaraduwa Division of the Galle District. Unawatuna village consists of four Grama Niladhari (GN), i.e., Village Officer, Divisions. They are called, Yaddehimulla, Unawatuna West, Unawatuna Central, and Buona Vista.

Unawatuna village exhibits unique characteristics in terms of its rich natural environment, strong cultural heritage, and cohesive social networks among the communities. Due to the tourism industry, the income of one segment of the community is relatively higher than the communities in the neighboring villages. Other than the fishing industry which has now collapsed due to excessive off-shore fishing by the outsiders, all other livelihood opportunities are centered around the tourism industry. The village has several temples with historic importance and deep ties to the life style of the communities. The natural beach environment with rich biodiversity is the main attraction to the local and foreign tourists. With the recent tsunami, many lost their homes as well as their restaurants and guesthouses. Unplanned haphazard reconstruction had resulted in destroying much of the natural environment of the village causing serious issues in the region.

For study purposes, the four GN Divisions were further divided into six distinct areas for easier analysis and presentation on physical characteristics and prevailing issues of the region. Figure C-1 shows the six main areas of Unawatuna included in this study. Table D-1 summarizes the features and characteristics of the above areas.

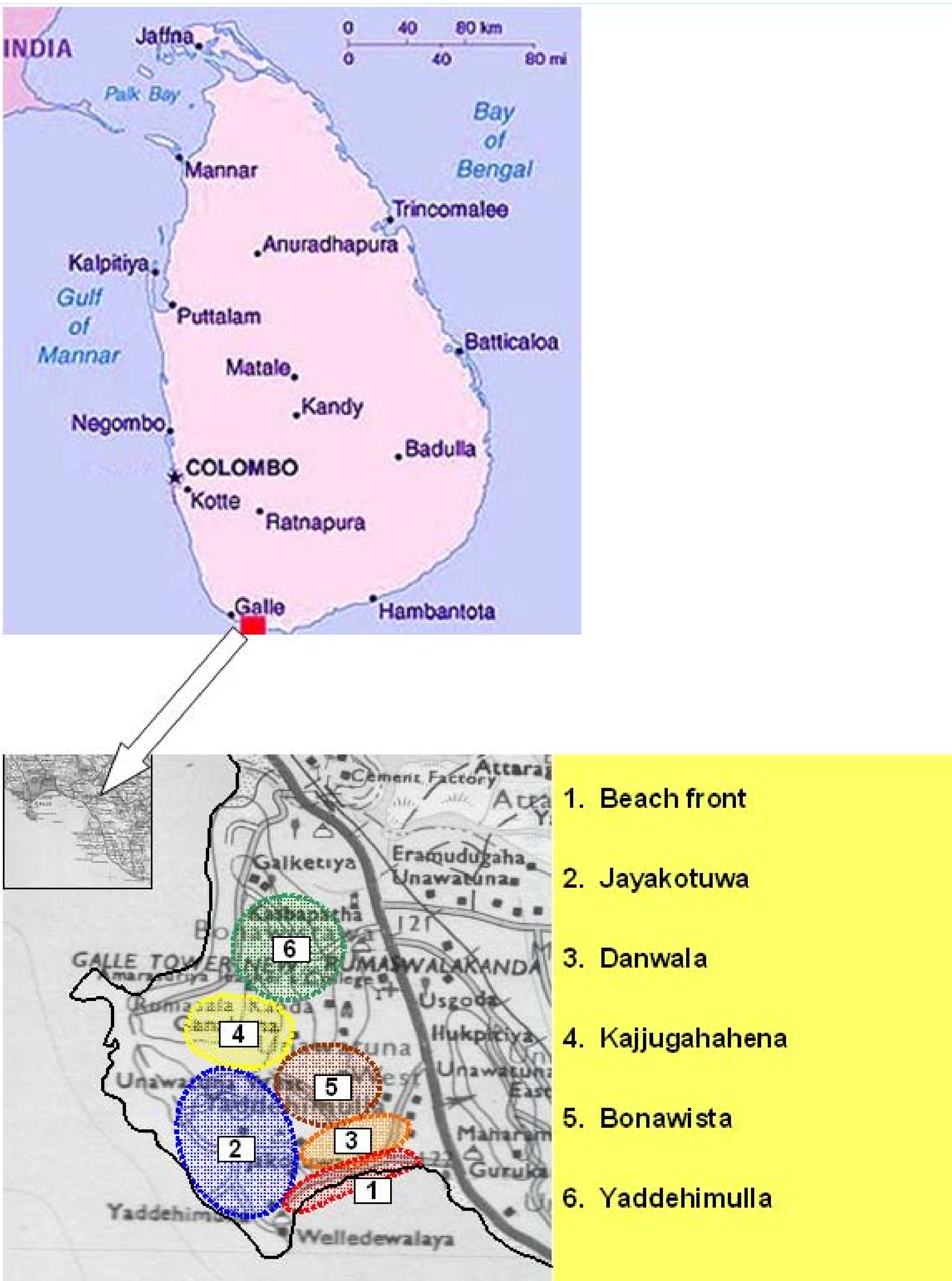


Figure D-1. Distinct areas in Unawatuna

Table D-1. Feature/Characteristics of the distinct areas in Unawatuna

Area		Features/Characteristics
1.	Beach front	Densely built-up area; rapid new construction activities
		Illegal construction in the coastal buffer zone
		Prime space for tourism based commercial activities
		Devalaya (Temple)
		Mainly occupied by restaurant owners
		Prime source of wealth creation in the area
		Main market place for tourism related products and services
		Low level of coastal zone management (severely damaged by tsunami)
		Water supply from common wells or taps outside the beach front area (expecting piped-water supply)
2.	Jayakotuwa	Located between Rummassala Hills and Beach front
		Relatively larger home plots
		Extensive unplanned new construction activities
		Mangrove area affected with siltation
		Mainly home based guest houses
		Encroached canal reservation, mangrove areas, and common spaces
		Water supply from private wells, common wells and taps, and individual piped-connections
		Poor access roads and drainage system
3.	Danwala	Densely built-up area
		Haphazard construction
		Main commercial activities include home-based tourism, kiosks and restaurants.
		Concentration of fisherfolk
		Mee gaha devalaya (Temple)
		Subject to water logging
		Blocked canals causing drainage and environmental problems

Table D-1. Continued

Area		Features/Characteristics
4.	Kajjugahahena	Large home plots in the hill terrain
		Mainly private and common well water supply
		Relatively low environmental issues
		Not yet connected to high earning tourism related activities
		Only through secondary services (e.g., cloth and trinket trading)
		Rapid change from non tourism to tourism occupations with Sevalanka (micro-finance organization)
		Occupied by the fishing community (low income)
5.	Bonawista	Large home plots in hill terrain
		Well water supply
		Relatively low environmental issues
		Rapid land use change due to scenic view over the bay
		Not yet connected to high earning tourism-based commercial activities; only through secondary services (e.g., cloth and trinket trading) and supporting services such as carpentry, masonry, painting
		Poor access roads
6.	Yaddehimulla	Relatively larger home plots
		Environmental issues due to drainage
		Rugged terrain less hospitable to housing and tourism
		Not yet directly connected to high earning tourism-based commeractivities
		Inhabitants commute to beach area for income opportunities

- The main stakeholder groups in the Unawatuna:
  - Beach restaurant owners
  - Guesthouse owners
  - Beach vendors
  - Fishermen

- The main institutions and CBOs active in Unawatuna:
  - Temple
  - Unawatuna Tourism Development Society
  - Welle Devala Pinkam Kamituwa
  - Fisheries Development Society
  - Samurdhi (Micro-finance scheme) Beneficiaries
  - Small Trade Association
  - Fisheries Corporation
  - Cost Conservation

Village Development Program

The present Sri Lankan government under the President's Mahinda Chinthana program (vision statement for the development of the country) has initiated a village development program called "Gama Neguma" to formalize and promote participatory approaches in village reconstruction and development programs. Gama Neguma is a multi-faceted development project covering 4000 GN divisions with 12,000 villages island-wide. All villages in the island are scheduled to be developed in three stages under the Gama Neguma program. The total number of GN (Village Officer) divisions to be developed within three years is 14,000 (MNBEID, 2006).

- Objectives of the Gama Neguma program:
  - Ensure community participation by motivation, organization and community empowerment for total development of the rural community based on self reliance
  - Introduce a formal mechanism for participatory decision making and project planning at village level
  - Obtain optimum benefits from the development program by implementing integrated village development plans to avoid duplication
  - Co-ordination of human resources which is crucial for rural development, other rural and external resources, through an efficient mechanism of resource allocation
  - Introduce a results based participatory progress review and evaluation mechanism at village level

- Ensure improvement of living standards of the village communities through development of the physical, economic, social and cultural environment
- Create total development of the village under a community based planned development program

- Proposed strategy of the Gama Neguma program:
    - Prepare integrated village development plans with community participation targeting all development efforts to achieve a common objective
    - Make opportunities for the rural community to participate actively in their economic, social, cultural and spiritual development efforts
    - Organize and empower rural community to ensure their total commitment and contribution in the development process
    - Pool all resources utilized in village development, and implement productive transparent integrated village development plans for proper co-ordination at village and divisional level
    - Transform the rural community to a group of activists with ideological and comparative thinking abilities and enhance self determination by developing their abilities and skills demand for sustainable development dependant on self help, while changing the subsistent mentality with an orientation towards achieving targets.
    - Simultaneous rural livelihood development, with infrastructure development for economic resurgence and social development
- Proposed activities of the Gama Neguma program:
    - Educate all state officers at village level and the rural community on Gama Neguma development strategy.
    - Identify village level problems, disparities, local resources, livelihood development and opportunities using surveys of resources and information, the methodology of participatory rural appraisal.
    - Establish a data base of
        - rural needs
        - rural resources and scarcities
        - identification of required external assistance

  - preparation of rural development plans
  - preparation and updating of profiles of families and village resources
- Co-ordination of financial allocations for project proposals
- Establishment of suitable mechanisms for implementation, evaluation and review of development projects
- Co-ordination of institutions involved in project implementation with divisional and district secretariats.
- Establishment of "Jana Sabha" (Village Development Committees (VDC))

Purpose of the Pilot Field Study to Unawatuna Village

One aspect of the field study was to contribute to the above national efforts, while assisting the local stakeholders to formulate a practical development program for the Unawatuna village. Due to resource limitations, involving resource persons or consultancy services in conducting and facilitating village development programs was not practically feasible. Hence, it was suggested that developing the skills of the local field officers who work close to the communities to involve in this process as experts would be an opportunity to commence this program in all affected villages.

Hence, in this pilot study, the capacity of the local field officers was tested to train them adequately for conducting and facilitating the above participatory development process. It was also expected that issues encountered, limitations, and possible solutions would be reported to design training material for skill development of local field officers, and to take necessary actions at different organizational planning levels. It was expected that this exercise would provide a useful framework for applying the integrated development planning process in other villages.

Approach

Guiding Principles

Unawatuna field study explored how participatory approaches, methods and tools could facilitate the stakeholders to develop their own development program for the village. It adopted the following guiding principles:

- Responsible involvement of stakeholders in fact finding, discussions and decision making throughout the process, facilitating ownership of concepts and strategies among stakeholders based on a well founded and structured participatory process.
- Continuous visualization of facts and ideas from different rationalities for mutual learning in an overall process of concept development to implementation, enabling integration of objectives, strategies and good practices, based on multi-stakeholder needs, priorities, capacities and resources.
- Community centered process, making the local community as the main entry point and the forum for conducting participatory development activities.
- Rights based approach to information, in striving to provide stakeholders with equal access to information to make informed choices and decisions through deliberations.

Planning Process and Activities

The participatory approaches are typically focused on creating awareness among the stakeholders, addressing needs and aspirations of respective parties, building consensus on issues, and establishing participation and commitment to sustain a development program within the communities. To establish such a participatory development program in a community, the following sequence of activities were proposed (Figure 4-5). It served as the planning strategy contributing to the Gama Neguma reconstruction and development program in Unawatuna. Since, this strategy was tested for the first time in Unawatuna, the process was assisted by resource persons from SLHF, GTZ, and UF. The main steps include the following:

- Background preparation (for fair and continuous representation of all community groups)
- Initiation (an introductory meeting to formally commence the development process with awareness building on sustainability and layout the next steps)

- Where are we now? (exploring the current status of issues and prioritizing them)
- What can we do? (formulating alternative options for solutions)
- How can we do? (assessing options and strategizing)
- Joint activity implementation program (fine tuning strategies and implementation)

Background preparation

This preparation was mainly required for appointing a VDC involving CBO representatives and active community leaders representing all community groups in the village. This step required sufficient time and effort for personally meeting the community, building interest, and getting them on board to initiate the process. In summary, the following tasks were included in the background preparation.

- Form lead teams: the active local field officers (GN, Samurdhi Officer, and Land Officer) formed a team to lead the development program in the village. In Unawatuna, it was a GN-based lead team.

- Establish support from community: the lead team personally met with the Unawatuna community leaders to discuss the need for a development program for the area and obtained consent and support to initiate the Unawatuna participatory development program.

- Meet key governmental officials: the lead team and the community leaders of Unawatuna met with the key government officials to inform the purpose, the scope, and the expected outcome of the program and to obtain necessary support and assistance for the proposed activities. The key officials included DS Galle, DSD, Habaraduwa, DSD development coordinators and TOs, and other GNs and Samurdhi Officers of the relevant divisions.

- Identify stakeholder groups: the lead team and the community leaders jointly identified the main stakeholder groups linked to Unawatuna. A preliminary analysis of different interests and priorities among and within different stakeholder groups was conducted by the team. The differences, for instance, the friction among these groups and the likely impact on the participatory process were also assessed by the local officials.

- Focal group meetings: the lead team conducted focal group meetings with the main stakeholder groups, i.e., community organizations such as the Unawatuna Tourism Development Society, Fisheries Development Society, Sumurdhi Beneficiaries, Welle Dewala Pinkam Kamituwa, and Parakum Sports Society, and made them aware of the purpose, the scope and the expected outcome of the development program which was scheduled to be initiated in the village. In these meetings, community representatives were appointed to participate throughout the development process. These community representatives were responsible for communicating needs and aspirations of their group and obtaining support and assistance towards the process.

Initiation

Community meeting: After background preparation, with the presence of key officials (DS Galle, and DSD, Habaraduwa) (2), religious leaders (1), local field officers (RADA area engineer, PHI, TOs) (5), community representatives (9), and resource persons (2), a meeting was organized to formally initiate the development program in the villages. The local field officers and the community representatives together formed the VDC. The content of this meeting included the following:

- Introduce Gama Neguma national village development program introduced by the Presidential Secretariat and its relevance to the Unawatuna development program.
- Explain representation and responsibilities of the VDC under the Gama Neguma program.
- Describe the process of the development program, and the need for stakeholder participation and representation of their interests throughout the process to develop a sustainable and feasible development strategy for Unawatuna.
- The following was established together with the participants of the meeting:
    - Identify special characteristics and features of Unawatuna
    - Identify objectives and scope of the development process
    - Introduce the development planning process that focuses on historical, environmental, economic, and social issues
    - Introduce aspects of sustainability (social, economical, and environmental) with relevance to main features and characteristics of the village, and how they are interlinked.
    - Identify the need for an integrated development process
    - Identify "What individuals could contribute to an integrated planning process?"
    - Identify participation and commitment that could be achieved within and outside Unawatuna

- Identify the opportunities and challenges for an integrated development process, in terms of specific features, social and institutional resources
- Organize field visits to identify problems and issues in general
- Identify representatives from stakeholders and community groups to organize interviews for identifying different perspectives of issues, specific problems for their activities, issues of vulnerable groups

* Document discussions and conclusions

Where are we now? (exploring the current status and prioritizing):

This phase was dedicated to investigating reconstruction and development issues in the village. The issues had to be identified and analyzed together with the stakeholders. Field visits, stakeholder interviews and a community workshop were organized by the lead team involving the members of the VDC and external resource persons as discussed at the introductory meeting. Field visits were organized for identifying development issues in the village in general, and stakeholder interviews were conducted and recorded for identifying the specific problems of different stakeholder or community groups and their perspective of the problems.

Field visits: As certain issues are common to different area of the village, field visits were organized to cover 6 distinct areas in the village. The main issues identified were documented as given in Table D-2.

Interviews: Stakeholder interviews were conducted with representatives from different community groups (fishermen, guest house owners, beach restaurant owners, beach vendors, etc.). During these discussions, information was gathered informally in terms of their activities, costs and resource utilization for these activities, and positive and negative benefits involved with these activities to get an understanding of their specific issues and their perspective of the issues. The following include the list of stakeholders interviewed:

- Galle GA, DS office
- Director Planning, DS office
- DSD, Habaraduwa
- Chairman, Habaraduwa PS office
- Assistant Director Planning, Habaraduwa DSD office
- Land Officer, Habaraduwa DSD office
- TO, Habaraduwa DSD office,
- TO, Habaraduwa PS office
- GNs – Yaddehimulla, Unwatuna Central, Unawatuna West, Bouna Vista
- Samurdhi Officer, Yaddehimulla
- Beach restaurant owner (3)
- Guest house owners (4)
- scuba diving training and boating owner (1)
- Fishermen (2)
- Beach vendors (1)

Community workshop: After the fact finding mission and informal visits to ensure attendance of members of the VDC, a two day workshop was organized to present the findings, analyze the current status of issues, and prioritize issues for action in the village development program. A cross-section of participation included representatives from community groups and businesses (12), local field officers (5), district and divisional government officials (3), and resource persons (4). The main purpose of this meeting was to enable the VDC to gain a holistic view of the issues to be able to stimulate the ability to understand the interlinks of certain issues, where to take necessary action, what may hinder taking action, and how to go about possible options for solutions under the present political structure and competition for limited resources. The expected outcome of this workshop was that the community gain a thorough understanding of their present system, issues, limitations, and distance to development standards to achieve consensus on the priority issues to be addressed in the village development program. The content of this workshop included the following:

- Recap on the introductory workshop.
- Identify issues and problems in the distinct areas in Unawatuna (add any issue missing from the observations made during field visits).
- Use Spiderweb tool to identify the magnitude of the issues (scale – poor, fair, good).
- Analyze and discuss the reasons for the above scale for the issues in each area (thoughts on the issues).
- Apply SBLCA to analyze upstream and downstream of the issues identified: chain upstream and downstream activities of current issues, map stakeholders, and unbundle each activity in terms of costs, resources, and benefits and effects.
- Identify cause, effects and interconnectivities in upstream and downstream activities of different issues
- Identify standards, regulations, and recommendations, if applicable, relevant to each activity
- Identify and distance to target in meeting stipulated standards, regulations, and recommendations
- Apply Appreciate-Influence-Control (AIC) tool to identify issues which are in control of VDC, could influence LA to take certain action, and leave out the issues that could only be appreciated
- Identify priority issues through a structured dialog considering the interconnectivities of issues, the urgency of an issue, and the potential for an issue to be implemented given local capacities.
- Document discussions and conclusions

What can we do? (formulating alternative options for solutions)

The scope of this planning step was to develop potential solutions for the prioritized issues in the form of a joint activity program. Since the solutions had to be worked out with due consideration to technical and other relevant standards, and aspects of sustainability, i.e., social, economic, and environment, the lead team required assistance from external resource persons. In Unawatuna, the resource persons together with the relevant TOs from different local institutions developed the alternative options for the prioritized issues. Necessary information was gathered using publicly available data and through personal communication. These options were presented at a community workshop for assessing viability as well as sustainability. The community representatives, field officials and respective Government officials attended this workshop.

Lead team meetings: A series of meetings were held by the lead team (3) involving technical officers from the LAs (3) and resource persons (2) prior to the workshop to develop options for water supply, wastewater, stormwater drainage, and solid waste management. The portable water supply options included piped-water for all households expecting individual connections and piped-water for households which do not have well water supply. These options had to be considered due to upstream water treatment constraints in some parts of the Galle district which were beyond the control of the VDC, and downstream wastewater disposal issues, as revealed in the current state analysis. For wastewater treatment, options were considered along with the poorly designed toilet issue as well. The options included the traditional toilet with septic tank and soakage pit or seepage bed and Eco-sanitary toilets with plant beds. Different material types were also included in the analysis. Canal reconstruction for adequate stormwater drainage in the area was also included. The following activities were conducted during lead team meetings.

- Introduce “six thinking hats” concept to prepare the lead team and the TOs to effectively engage in analyzing facts, creative thinking and building scenarios (LA TOs already had training on the above concept through the PSTI program). The intention was to promote developing solutions that could promote cross-sectoral integration.
- Identify future scenarios and potential options.
- Apply SBLCA to analyze upstream and downstream of potential solutions.
- Chain upstream and downstream activities related to implementing potential options and unbundle each activity in terms of costs, resources required, and benefits and effects.
- Use design and construction standards, regulations, recommendations, guidelines.

- Formulate indicators (estimate costs, resources, benefits, and effects in quantitative or qualitative form).
- Prepare information in graphical forms where necessary.
- Identify standards, regulations, recommendations and guidelines relevant to implementing activities.
- Identify potential stakeholders who could contribute for joint activities.

How can we do it? (assessing options and strategizing)

In this step, the focus was to actively engage stakeholders in assessing the options developed for prioritized issues at the previous community workshop. Stakeholder inputs were expected in finding necessary modifications and identifying whether all upstream and downstream activities could be fulfilled by the stakeholders. The donor agencies that were expected as possible contributors were invited for the community workshop through the DSD office, Habaraduwa.

Community workshop: In this workshop the alternative options were presented to VDC by the lead team (3) and the TOs (2). The DS, Galle, DSD, Habaraduwa, RADA area engineer, PHI, LA environmental officer, Donor TOs (1), community representatives (12), and representatives from GTZ and SDC (2) participated in this workshop. When presenting the options with relevant information, the stakeholders actively involved themselves in assessing the viability and sustainability of the options. Proposed options represented different levels of service meeting acceptable standards, regulations and recommendations. The local stakeholders took a central role negotiating and identifying what levels of development would be feasible within their capacities, resources and local conditions. To achieve a certain level, and to contribute to achieving that level, the stakeholder had to realize the forthcoming costs and benefits forthcoming. Also, they needed to understand the upstream and downstream of activities and net benefits and effects to get a better picture of who should contribute, take responsibilities and commit to achieve a preferred level. The following activities were included in the workshop.

- Introduce a brief six thinking hats exercise to encourage stakeholders to assess options in a positive and beyond conventional manner.
- Introduce “do no harm” principle
- Present options with activity-stakeholder mapping and relevant information, i.e., indicators, to the whole group
- Assess different options in detail in groups, and present and discuss at a plenary session
- Discuss, negotiate and identify necessary modifications or additions to the proposed options
- Organize information, i.e., indicators and rank them to identify better performing options
- Discuss, negotiate and identify viable and sustainable options in a plenary session
- Discuss and negotiate strategies
- Document discussions and conclusions

How can we do it? (developing strategies for suitable options)

In this step, the focus was to build consensus on the optimum course of action for the joint activity programs in order to implement it with available resources and capacities, and to a specific timelines. The lead team and the TOs who were involved in formulating options organized a meeting to incorporate the stakeholder inputs and necessary modifications discussed at the previous community workshop. Only the preferred options by the stakeholders were considered at this stage. When the options were assessed for viability, the options were more or less strategized, as who could contribute what and which way were negotiated and agreed. However, at this stage, the strategies need to be discussed in detail and fine-tuned for implementation. Evaluation and monitoring process throughout the implementation phase needs to be identified.

The strategies identified at the previous workshop for selected options were expected to be further reviewed to be implemented within a joint action plan. A detailed mapping of “who will do what?” was expected to be negotiated involving the respective stakeholders. The stakeholders who would decide to actively participate and commit resources were recommended to apply unbundling concepts on respective activities within their organization. It was intended, with unbundling at this stage, that internal members of each stakeholder organization would gain a reasonable understanding of the required activities, the resources their organization would have to provide, and the corresponding costs and benefits.

However, due to unavoidable circumstances in the country at the time, the international donor agencies withdrew support for new interventions in the country. As a result, the project could not hold the next planned community workshop on fine-tuning strategies to finalize joint activity programs within a workable timeline. However, the DVC committee could come up with implementable strategies for their wastewater and stormwater issues, which could be taken up as donors resume development assistance to the country.

In strategy building, SBLCA was a key instrument in planning as it enabled the stakeholders to view the environmental, social as well as economic inputs, and likely impacts on different stakeholders in following a particular strategy for implementing a selected option. It was expected that an understanding of each other’s future activities and corresponding resource requirements and the way in which they are interlinked among different stakeholders would facilitate willingness to exchange resources at the implementation stage as well.

Lessons Learned

The following are the lessons learned from the pilot study, which were communicated to GTZ-THSP to assist program development:

Application of SBLCA

- Listing the issues together with the community is a good starting point for the analysis of the current issues.

- Chaining of upstream and downstream activities and unbundling may not necessarily be applied to all issues. Choosing the important issues could be a decision of the facilitators together with the participants.

- Stakeholder participation should be anticipated when chaining and upstream and downstream of activities and unbundling levels of services.

- The exercise should happen in a plenary session as all community representatives of different stakeholder groups should be aware of different observations, magnitude, and perspectives of the problems in different areas of the village, and who is contributing to the problems.

- The exercise may have to be limited to no more than one day as the community representatives participate on voluntary basis and most of them are businessmen.

- The facilitators should have the practice to perform SBLCA with skills to identify interlinks of issues and their social, economical, and environmental factors.

- For developing options including the technical details considering social, economic, and environmental factors would need substantial involvement of resource persons.

- TOs, Environmental officers, planning officers from DSD office, PS office, NHDA, UDA, NWSDB, CEB, and PRDA are capable of providing some of these inputs, provided they are given training and skills to be able to work with the local stakeholders and have the know-how to assist in providing the correct technical inputs where necessary.

- Games (introduced at PSTI trainings) can be incorporated to build trust on gains from stakeholder coordination and cooperation, but conducting these games during the workshop should be decided depending on the mood, time, and atmosphere of the workshop.

Application of Process

- Organizing informal meetings at early stages of the process for approaching community leaders to get them involved in the VDC is a must in the process.

- The lead teams have the capacity to lead the VDC, provided they have received the PSTI raining on leadership and facilitation.

- When the needs and problems are common to several adjoining GN divisions (e.g., roads, water supply, and drainage systems), the lead teams need flexibility and guidance from DSD level to corporate and coordinate their activities across GN divisions.

- The lead teams has the capacity to carry out the tasks up to exploring the current status, but from there onwards, to build alternative options for solving issues in an integrated manner, they need assistance from resource persons who could provide technical, managerial and operational inputs.

- For developing options for various issues, resource persons with different knowledge bases and with training in working in multi-stakeholder contexts and open for mutual learning would be needed.

- For understanding needs and problems and also building options and formulating strategies for most preferred and suitable options, the officials from the relevant responsible agencies (e.g., NWSDB, PS and UDA) need to be present and available.

- The presence of these officials in the above meetings and workshops should be included in their mandated tasks and responsibilities.

- During these meeting, the officials should not be allowed to be confronted by the local communities, but to seek inputs to jointly understand the issues, practical solutions and funding for activities.

- Possible actions towards implementation should be initiated while the process is continuing to sustain the interest of the community and other stakeholders.

- The communities and other local stakeholders must be made aware of the practical limitations in human and material resources right from the background preparation stage.

- As the DSD office is coordinating the development programs in and among GN divisions, more support and involvement from DSD office is required.

- Local officials were able to grasp SBLCA, but need practice and assistance from resource persons (for instance TOs who can be trained easily and will also remain as resource persons) for chaining upstream and downstream of activities and unbundling in terms of stakeholders responsible or impacted, resources, costs and benefits.

- The assistance may come from more than one TO as the required expertise of these resource persons may be different. When necessary obtaining specific professional inputs (e.g. solid waste disposal landfill, counseling for those affected by drug abuse) has to be arranged through coordination with DSD and DS offices and other stakeholders (e.g., INGO and UN)

- The alternative options for improvement should be more focused on exploring things that could be done with active involvement of the community.

- For “exploring options” and “building strategies”, community prefers to have relevant Government officials to be present to make them aware of their preferred options, their contribution, and how the officials may support in their strategies.

- Field officers, especially GNs do not have sufficient resources to fulfill the responsibilities of the Gama Neguma program (traveling for meetings, meeting community, stationery and other materials for community meetings and workshops).

- Even though the responsibilities of Gama Negume are additional to GNs' current duties related to serving about 30 Government Ministries and Departments, how they would be receiving more resources and rewards for this additional work needs to be identified.

Table D-2. Issues identified in Unawatuna Area (jointly with the community representatives)

Issue	Beach Area	Yaddehimulla	Jayakotuwa	Danwala	Kajjugashena	Buona Vista
Lack of drinking water supply	No wells No piped-water supply	Well water supply No piped-water supply	Well water supply Piped-water supply to some households and businesses	Private and common well water supply Limited access to water in dry season	Common well and tap water supply No wells in the area due to rocky terrain	Private and common well water supply
Poor access roads	Encroached road Major potholes Floods during rainy reason	Encroached road Major potholes Floods during rainy reason	Encroached road Major potholes Floods during rainy reason Dusty during dry season	Narrow roads – poor access	Narrow roads – poor access	Narrow roads – poor access
Overflowing septic tanks (black water) and non-functioning toilets	Small home plots and high water table	Small home plots and high water table	Relatively larger plots and high water table	Hilly terrain and larger home plots – Moderate issue	Hilly terrain and larger home plots – Moderate issue	Hilly terrain and larger home plots – Moderate issue
Lack of arrangements for wastewater disposal	Densely built up plots – released to beach	Densely built up plots – released in home plots and to canal	Densely built up plots – released in home plots and to canal	No arrangement – released in home plots	No arrangement – home plots	No arrangement – home plots
Lack of arrangements for stormwater drainage	No provision for drainage along main roads Waterlogged area	No provision for drainage along main roads Waterlogged area Stagnant canal	No provision for drainage along main roads Waterlogged area Stagnant canals	Not arrangements Stormwater drains to surrounding areas	Not arrangements Stormwater drains to surrounding areas	Not arrangements Stormwater drains to surrounding areas

Table D-2. Continued

Issue	Beach Area	Yaddehimulla	Jayakotuwa	Danwala	Kajjugashena	Buona Vista
Solid waste collection	Limited collection by LA Open dumping locations	Limited collection by LA Open dumping locations	Limited collection by LA Open dumping locations Dump to sea	No service by LA	No service by LA	No service by LA
Solid waste disposal	Dump to sea No landfill area	Dump to sea or canal No landfill area	Burry or burn in backyards No landfill area	Burry or burn in backyards	Burry or burn in backyards	Burry or burn in backyards
Unauthorized constructions	Unauthorized constructions in conserved beach area	Unauthorized constructions – encroached state roads and canal reservation	Unauthorized constructions – encroached state roads and canal reservation	Unauthorized constructions – encroached state roads	Unauthorized construction in conserved forest land	Unauthorized construction in conserved forest land
Haphazard construction	No compliance with UDA or LA standards and regulations	No compliance with UDA or LA standards and regulations	No compliance with UDA or LA standards and regulations	Some compliance with UDA or LA standards and regulations	Some compliance with UDA or LA standards and regulations	Some compliance with UDA or LA standards and regulations
Declining livelihood opportunities	Due to reduced tourism activities	Due to reduced tourism activities		Due to reduced tourism activities And collapse of fishing industry	Due to reduced tourism activities And collapse of fishing industry	Due to reduced tourism activities

Table D-2. Continued

Issue	Beach Area	Yaddehimulla	Jayakotuwa	Danwala	Kajjugashena	Buona Vista
Unskilled labor (preventing value added services)	Kiosk and eatery operators Youth engaging in low skilled jobs	Guesthouse and other service providers Youth engaging in low skilled jobs	Guesthouse and other service providers Youth engaging in low skilled jobs	Fishermen (no activity) Unskilled for construction labor, or other valued added services	Beach vendors Unskilled for construction labor, or other valued added services	Beach vendors Unskilled for construction labor, or other valued added services
Drug and alcohol abuse	Largely affected	Largely affected	Largely affected	Not yet affected	Not yet affected	Not yet affected
Noise pollution	New open discos (night clubs) Affected	New open discos (night clubs) Affected	New open discos (night clubs) Affected	Not yet affected	Not yet affected	Not yet affected
Lack of trust among communities (e.g., between castes) and business groups (e.g. beach eatery and guest house operators)	Walle Devalaya based community Not much interaction with Meegaha Devalaya based community	Walle Devalaya based community Not much interaction with Meegaha Devalaya based community	Meegaha Devalaya based community Not much interaction with Walle Devalaya based community	Not largely affected	Not largely affected	Not largely affected

APPENDIX E
ANALYSIS OF WATER SUPPLY IN UNAWATUNA

Data

Table E-1. Water energy, costs, and CO2 emission data

Item	Amount	Source
Water treatment cost (Rs./m^3)	15	National Water Supply and Drainage Board website
Energy(KWh/m^3)	0.2	National Water Supply and Drainage Board website
Energy cost(Rs.)	3.5	National Water Supply and Drainage Board website
CO_2 (kg/KWh)	0.0007	Wijetunge et al., Energy Conversion and Management, 2003
CO_2 (kg/thousand m^3)	0.14	Estimated
Village data		Village Officer, Public Health Officer records

Table E-2. Well-water supply breakdown in the community

Village group	Households	Restaurants	Guest houses
Yaddehimulla	197	48	38
Unawatuna Central	252	62	57
Unawatuna West	165	4	12
Buona Vista	153	6	3

Table E-3. Expected piped-water connections in the community

Village group	Households	Restaurants	Guest houses
Yaddehimulla	113	41	29
Unawatuna Central	164	47	42
Unawatuna West	0	0	0
Buona Vista	0	0	0

Table E-4. Water supply and consumption data in the community

	Number units		
Service and consumption data	Households	Restaurants	Guest houses
Pipe water supply	0	0	0
Well water supply	767	120	110
Expecting pipe water connection	277	88	71
Avg. daily demand per unit(m^3/day)	0.17	0.6	3
Total avg. daily well water demand (m^3/day)	130	72	330
Total avg. daily well water demand per unit (m^3/month)	3,912	2,160	9,900
Total avg. daily well water demand per unit (m^3/yr)	47,592	26,280	120,450

Analysis

Table E-5. Option1: piped-water supply only for households with no wells

Option 1	Number units Households	Restaurants	Guest houses	TOTAL
Pipe water supply	277	88	71	
Well water supply	84	7	9	
Expecting pipe water connection	37295	559429	7459	
Avg. daily demand (m^3/day)	0.34	1.2	4.5	
Total avg. daily pipe water demand (m^3/day)	94	106	320	519
Total avg. daily pipe water demand per unit (m^3/month)	2,825	3,168	9,585	15,578
Total avg. daily well water demand per unit (m^3/yr)	34,376	38,544	116,618	189,537

Table E-6. Option 2: piped-water supply only for all households

Option 2	Number units Households	Restaurants	Guest houses	TOTAL
Pipe water supply	767	120	110	
Well water supply	84	7	9	
Expecting pipe water connection	0	0	0	
Avg. daily pipe water demand (m^3/day)	0.25	1.2	4.5	
Total avg. daily pipe water demand (m^3/day)	192	144	495	831
Total avg. daily pipe water demand per unit (m^3/month)	5,753	4,320	14,850	24,923
Total avg. daily well water demand per unit (m^3/yr)	69,989	52,560	180,675	303,224

Table E-7. Option 1 consumption, energy, costs, and CO2 releases

Option 1	Piped water (m^3)	Cost (Rs.)	Energy (KWh)	Energy cost (Rs.)	CO_2 (kg)
Consumption (daily)	519	7,785	104	1,817	0.07
Consumption (monthly)	15,578	233,670	3,116	54,523	2.18
Consumption (yearly)	189,537	2,843,055	37,907	663,380	26.54

Table E-8. Option 2 consumption, energy, costs, and CO_2 releases

Option 2	Piped water (m^3)	Cost (Rs.)	Energy (KWh)	Energy cost (Rs.)	CO2 (kg)
Consumption (daily)	831	12,465	166	2,909	0.12
Consumption (monthly)	24,923	373,845	4,985	87,231	3.49
Consumption (yearly)	303,224	4,548,360	60,645	1,061,284	42.45

Table E-9. Difference of consumption, energy, costs, and CO2 releases between options

Option 2 - option 1	Piped water (m^3)	Cost (Rs.)	Energy (KWh)	Energy cost (Rs.)	CO2 (kg)
Savings (daily)	312	4,680	62	1,092	0.04
Savings (monthly)	9,345	140,175	1,869	32,708	1.31
Savings (yearly)	113,687	1,705,305	22,737	397,905	15.92

APPENDIX F
ANALYSIS OF WASTEWATER IN UNAWATUNA

The following tables summarize the wastewater releases according to current and future of portable water supply levels:

Table F-1. Wastewater release data

Category	Households	Restaurants	Guest houses	Data source
Number of units releasing grey water to canals	280	35	30	Village Officer, Public Health Officer records
Number of units releasing backwater to canals	115	0	0	Village Officer, Public Health Officer records
Approximate grey to black water ratio	3:1	3:1	4:1	Estimated using SLSI 745 : 2003

Table F-2. Current wastewater discharge breakdown in the community

Current wastewater releases	Households	Restaurants	Guest houses
Avg. daily demand per unit (m^3/day)	0.17	0.6	3
Grey water (bathroom and kitchen) (m^3/day)	0.13	0.45	2.4
Black water (toilets) (m^3/day)	0.04	0.15	0.6
Grey water released to canals (m^3/day)	35.7	15.75	72
Black water released to canals (m^3/day)	4.9	0	0
Grey water released to canals (m^3/month)	1,071	473	2,160
Black water released to canals (m^3/month)	147	0	0
Grey water released to canals (m^3/year)	32,130	14,175	64,800
Black water released to canals (m^3/year)	53,518	0	0

Table F-3. . Future wastewater discharge breakdown in the community

Future option: piped-water for all	Households	Restaurants	Guest houses
Avg. daily demand per unit (m^3/day)	0.34	1.2	4.50
Grey water (bathroom and kitchen) (m^3/day)	0.26	0.9	3.60
Blackwater (toilets) (m^3/day)	0.09	0.3	0.90
Grey water released to canals (m^3/day)	71.4	31.5	108
Black water released to canals (m^3/day)	9.8	0	0
Grey water released to canals (m^3/month)	2,142	945	3,240
Black water released to canals (m^3/month)	93	0	0
Grey water released to canals (m^3/year)	4,260	28,350	97,200
Black water released to canals (m^3/year)	107,036	0	0

Table F-4. Expected wastewater increase with piped-water connections for all units in the community

Wastewater increase	Households	Restaurants	Guest houses
Grey water released to canals (m^3/day)	36	16	36
Black water released to canals (m^3/day)	5	0	0
Grey water released to canals (m^3/month)	1,071	473	1,080
Black water released to canals (m^3/month)	147	0	0
Grey water released to canals (m^3/year)	32,130	14,175	32,400
Black water released to canals (m^3/year)	53,518	0	0

APPENDIX G
BLACK AND GREY WASTEWATER TREATMENT

Treatment Options

Typical Conventional Toilet and Rectangular and Cylindrical Septic Tanks

Septic tanks constructed below ground level are the most common black water treatment method found in Sri Lanka. They are not the solution that people often believe them to be when designed poorly. Even good septic tanks alone do not remove all pathogens. Septic tanks discharge almost the same volume of water that they receive. This effluent is only partially treated and still contains pathogens. The effluent has to soak away into the ground. In Sri Lanka, one of the common problems in individual houses as well as urban settlements is that there are many poorly designed and built septic tanks without proper soakage pits or seepage beds. The situation is particularly worse when the septic tanks and pit latrines penetrate the water table, especially in the rainy season. In coastal areas where the water table is almost at the ground level, the septic tank for black water treatment is not a solution. This could easily pollute the wells, surface water bodies and also the ground water (Figure G-1).

Typical design of toilet and rectangular and cylindrical septic tanks are shown in Figure G-2. The rectangular septic tanks built with fired clay bricks are the most commonly used. The cylindrical ones are precast concrete and available in only standard one size. Sludge removal period is much shorter compared to the rectangular ones which could be sized according to the effluent load. Cylindrical septic tanks are not popular among the communities and hence, no large scale construction that could accommodate varying wastewater loads.

The design details including daily black and grey water flows for households and other small commercial entities, working capacities of the septic tanks, typical septic tank and soakage pit or seepage bed arrangements need to be in compliance with Draft Sri Lanka Standard (SLS

745: 2003), a code of practice for the design and construction of septic tanks and associated effluent disposal systems. The code of practice also covers construction, testing and maintenance of septic tanks and several other black water and grey water treatment systems. It recommends guidelines for the selection, design, construction and maintenance of systems for the on-site disposal of effluents from septic tanks. The systems recommended are soakage systems for the disposal of septic tank effluent below ground (soakage pits, seepage trenches and seepage beds), and anaerobic bio-filters, constructed wetlands and percolation beds for the disposal of septic tank effluents above ground, or for on-site effluent reuse. The design details are as shown in Figure G-2 and Figure G-3.

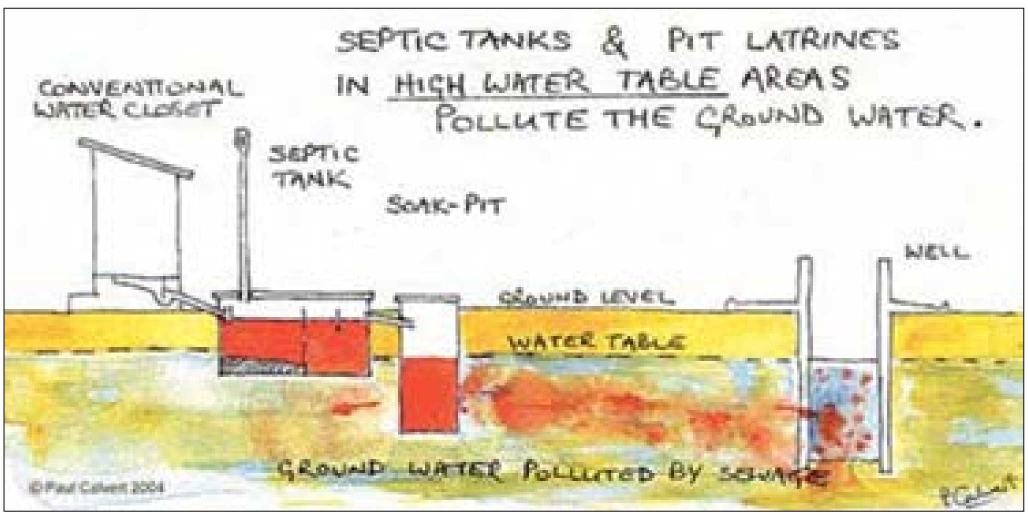
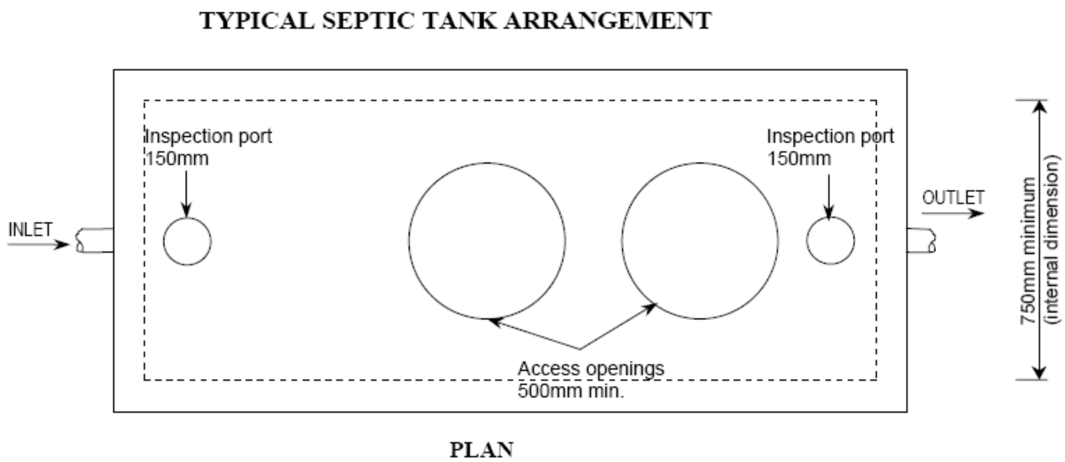


Figure G-1. Septic tanks in high water table conditions (Source: Practical Action, 2005)

Figure G-2. A typical conventional toilets structure. A) A front view of the typical conventional toilet. B) A pit latrine. C) A rectangular septic tanks. D) A precast concrete septic tank.

A



B

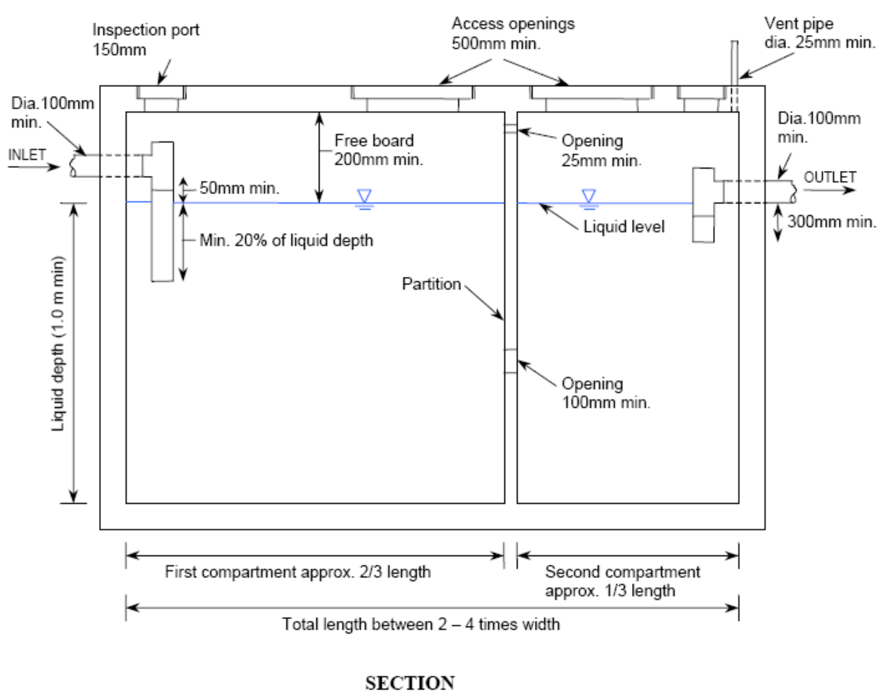


Figure G-3. Design details of a typical septic tank arrangement. A) Plan view of a typical septic tank arrangement with design parameters. B) A section view of a typical septic tank arrangement with design parameters.

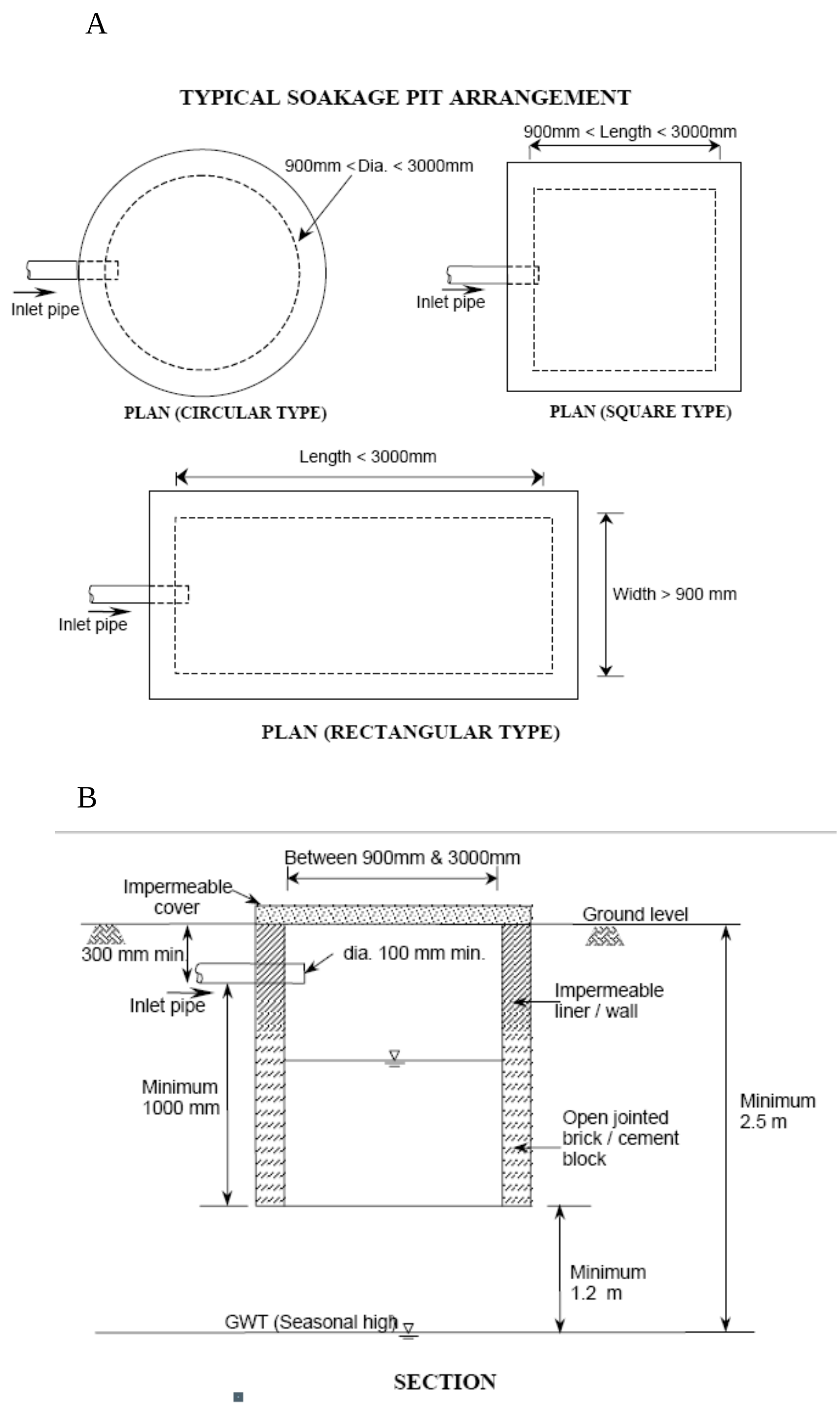
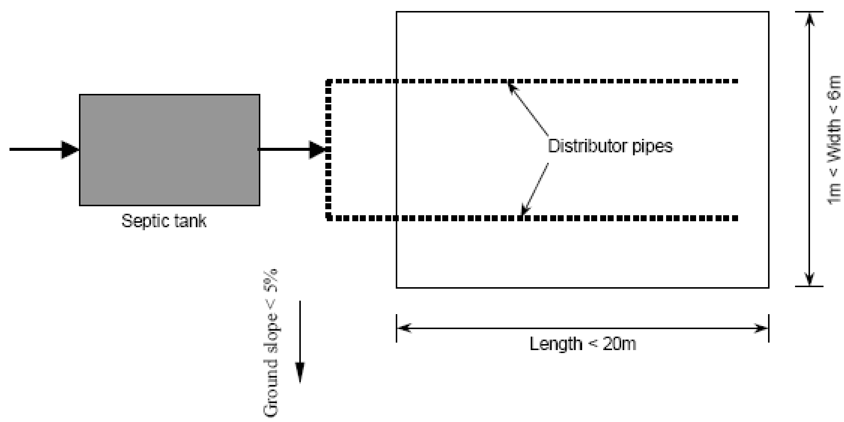


Figure G-4. Design details of a typical soakage pit arrangement. A) Plan view of a soakage pit arrangement with design parameters. B) A section view of a typical soakage pit arrangement with design parameters.

A

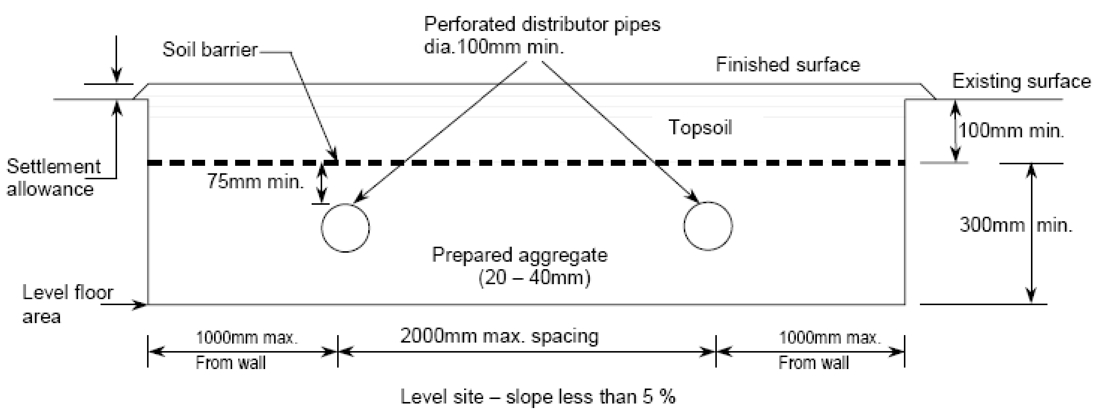
TYPICAL ARRANGEMENT OF A SEEPAGE BED



PLAN

B

PLAN



SECTION

Figure G-5. Design details of a typical seepage bed arrangement. A) Plan view of a seepage bed arrangement with design parameters. B) A section view of a typical seepage bed arrangement with design parameters.

Typical Double Vault Eco-sanitary Toilets with Plant Beds

The ecological sanitation concept, also known as eco-san is viewed as an approach that recognizes human excreta and household wastewater not as just waste, but as resources that can be recovered, treated where necessary, and reused. Unlike most conventional sanitation methods, ecological sanitation processes seek to protect human health and the environment while reducing the use of water in sanitation systems, and recycling nutrients to help reduce the need for artificial fertilizers in agriculture. Ecological sanitation is often explained as a four-step process that includes source-separation, containment, sanitization and recycling (Practical Action, 2008). It is recognized as a financially and environmentally effective solution for reducing groundwater pollution in water logging regions in developing countries (Figure F-6).

Figure G-6. Septic tanks in high water table conditions (Source: Practical Action, 2005)

Ecological Sanitation techniques available on the market include toilet designs ranging from low-flush- to dry urine-separating toilets that separate urine and faeces at source. Because these techniques reduce large quantities of black water, it reduces the need for pipelines that is regarded as one of the most expensive part of the conventional sewer system. Also, it reduces enormous costs associated with sludge collection and treatment logistics to the municipalities.

There are two main types of Eco-san toilets. They are dehydrating and composting toilet systems. Within these types, there is a distinction between urine diversion which separate urine from faece and systems which mix both urine and faeces. Many favor systems that separate the urine component from the faeces. Urine contains more nutrients and less pathogen. Keeping urine relatively free of pathogens from faeces allows reduced volumes of dangerous material and avoids odors making facilities more pleasant for the users. Urine and wash water could be diverted to specially constructed plant-beds, or wetlands. Various techniques have been developed to operate in slightly different ways depending on the field requirements. Specific details about a form of Eco-sanitary toilets are given in the Practical Action technical brief 'Compost toilets and eco-sanitation toilets' (Practical Action, 2008).

Double vault toilet systems consist of two water-tight chambers, which are referred to as vaults, to collect faeces. Urine is collected separately as the contents of the vaults have to be kept relatively dry. Initially, a layer of absorbent organic material is put in the vault and after each use, the faeces needs to be covered with ash or lime to absorb the excessive moisture and improve carbon-nitrogen ratio, which ensures that sufficient nitrogen is retained to make a good fertilizer. When the first vault is three quarters full, the remaining space is completely filled with dry earth and sealed to allow the components to decompose in anaerobic conditions. The second vault is used similarly until it is three quarters full. At this point, the first vault needs to be emptied manually. The contents can be used as a fertilizer. According to the design, the intervals for emptying the vaults would vary. The toilet structure is built over both the vaults with a squat-hole over each vault which can be sealed-off. The latrine can be built any at desired location as there is no pollution to the surrounding environment from the water-tight chambers (UNICEF, 2005).

While there are many advantages of using Eco-sanitary systems, there could be potential problems and risks associated with the mismanagement of the systems, poor construction of facilities, or both. Proper operation and maintenance is key to the success of the technology and this requires responsible action from users.

Eco-Solutions systems have been introduced to Sri Lanka since 1994. The technique had proved to work among communities in Chennai the capital of Tamil Nadu in southern India. In Sri Lanka, the technology is still not well-accepted among rural or urban communities. In post-tsunami construction, Practical Action of Sri Lanka has contributed to promote Eco-san toilets in new settlements. Design and construction guidelines are available free of charge to be used by any interested contractors, developers or community.

Figure G-7 shows the typical construction of an Eco-sanitary toilet in a rural village in Sri Lanka. Design details of a typical design in South Asian countries are given in Figure G-8.

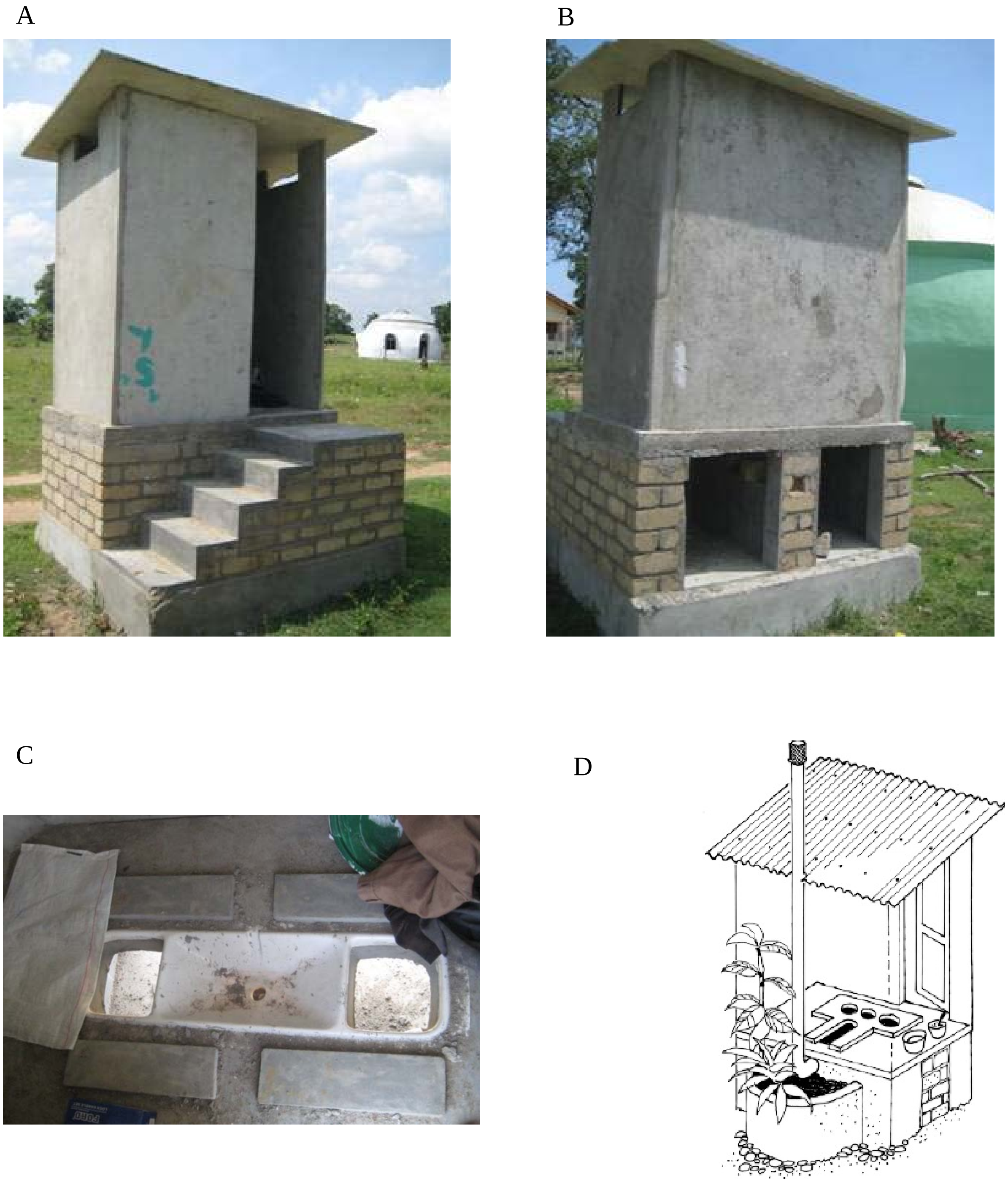


Figure G-7. A Typical Eco-sanitary toilet structure. A) A front view of a model Eco-sanitary toilet construction in Sri Lanka, B) Rear view of a typical Eco-sanitary toilet. C) Urine diverting pan. D) A typical plant bed for urine diversion and wash water disposal.

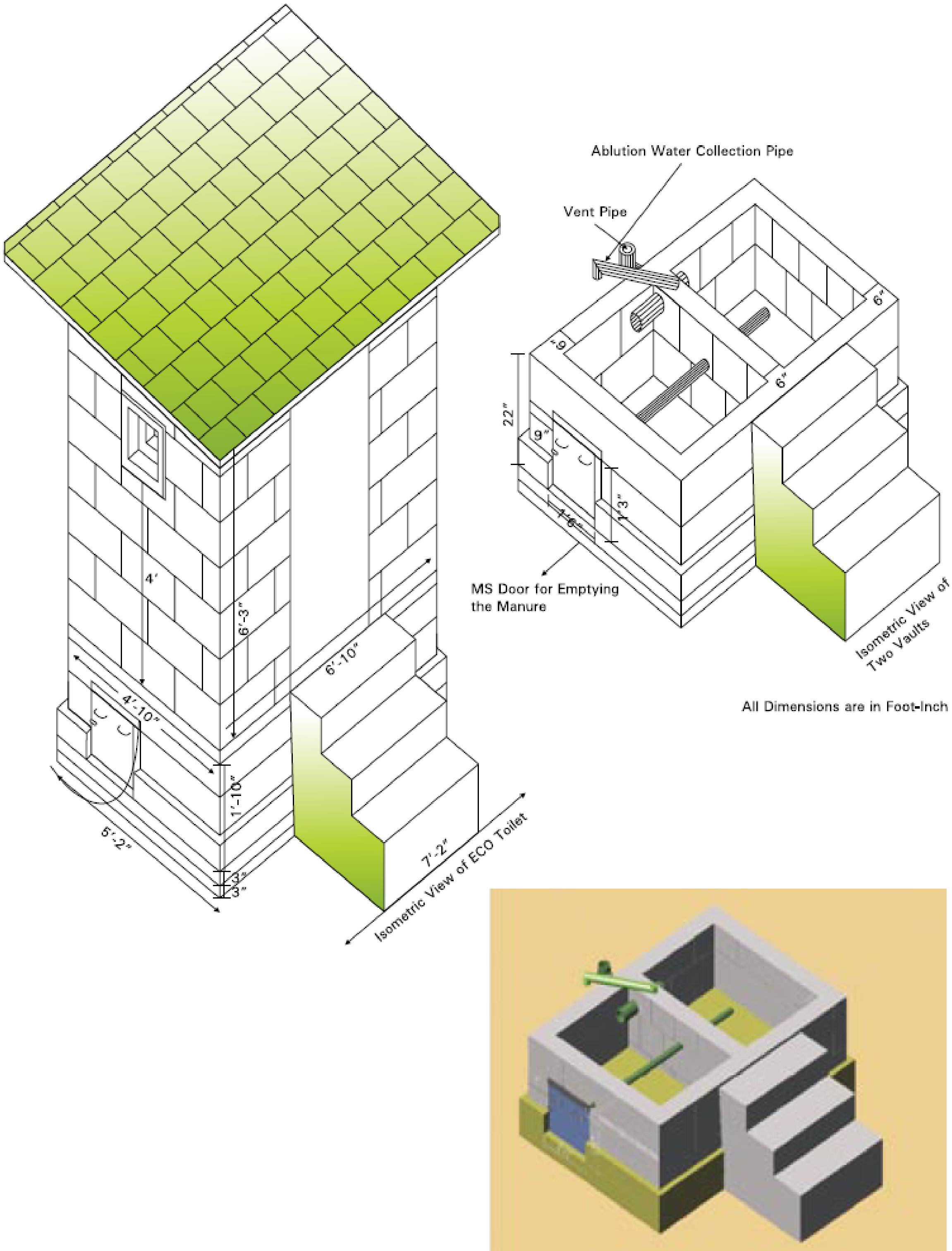


Figure G-8. Design details of a typical Eco-san Toilet (Source: UNICEF, 2005).

APPENDIX H
COST ANALYSIS OF WASTEWATER TREATMENT OPTIONS

Conventional Toilet with Septic Tank and Soakage Pit or Seepage Bed

Option 1 (i): Conventional Toilet and Rectangular Septic Tank with Cement Block Wall

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4’x5’x6.5’
Foundation: Rubble
Wall type: Cement block
Roof type: RCC roof slab
Floor type: RCC floor slab
Septic tank type: Brick rectangular septic tank (5m^3)
Secondary treatment: Soakage pit (1.8m^3)
Construction cost: in LKR as at 2007

Table H-1. Bill of Quantities (BOQ) for Option 1(i)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000	1,400.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1	630.00	630.00
2	Cement block wall				
	1. Cement block	numbers	220	28	6,160.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	2	630.00	1,260.00
	4. Red cement	kg	0.25	200.00	50.00
3	RCC Floor slab (2")				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00
	4. Steel shear links (10 mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	RCC roof slab (2")				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00

Table H-1. Continued

	Item	Unit	Qty	Rate	Amount
	4. Steel shear links				
	(10mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
5a	Septic tank				
	(rectangular, 5m3)				
	1. Brick wall (9")	item			14,000.00
	2. Roof slab (5")	item			5,000.00
	3. Bottom slab (6")	item			6,000.00
	Soakage pit				
5b	(rectangular, 1.8m3)				
	1. Brick wall (honey				
	comb)	numbers			1,400.00
	2. Roof slab (5")				5,000.00
6	Shuttering				
	1. 1" Timber plank	ft^2	40	26.00	1,040.00
	2. 2"x1" Reapers	ft^2	40	3.25	130.00
	3. 2"x4"x7' Timber	numbers	3	140.00	420.00
	Door, door frame and				
7	fixtures	item			2,214.50
	(2'x6', class II timber)				
8	Internal plumbing	item			100.00
	(PVC, 15mm, tap)				250.00
9	External plumbing	item			250.00
	(PVC, 100mm)				
11	Labor				
	skilled	days	5	1,000.00	5,000.00
	unskilled	days	7	600.00	4,200.00
12	Squatting pan	numbers	1	850.00	850.00
	Total cost				61,643.25
	Contingencies (10%)				6,164.33
	Estimated cost				*67,808*

Capital costs (LKR):

To beneficiary	67,808	For toilet construction
local authority	1,750,000	For gully bowser and other equipment

Maintenance cost (LKR):

To owner	2,000	For emptying septic tank per 2 yrs
To owner	153	Water bill per month
local authority	2,000	Transport and labor per 2 yrs per unit (10 - 12 units per day)

Option 1 (ii): Conventional Toilet and Rectangular Septic Tank with CSEB Wall

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4’x5’x6.5’
Foundation: Rubble
Wall type: CSEB
Roof type: RCC roof slab
Floor type: RCC floor slab
Septic tank type: Brick rectangular septic tank ($5m^3$)
Secondary treatment: Seepage bed (3mx15mx4m)
Construction cost: in LKR as at 2007

Table H-2. Bill of Quantities (BOQ) for Option 1(ii)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000	1,400.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1	3000	630.00
2	CSEB wall				
	1. CSEB	numbers	450	10.00	4,500.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.50	630.00	945.00
	4. Red cement	kg	0.25	200.00	50.00
	5. Protective coating	liters	1	300.00	300.00
3	RCC Floor slab (2")				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	,786	625.00
	3. Cement	bag (50kg)	1.5	30.00	945.00
	4. Steel shear links (10mm)	length	5	20.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25

Table H-2. Continued

	Item	Unit	Qty	Rate	Amount
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	RCC roof slab (2")				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.65	630.00	1,039.50
	4. Steel shear links (10mm)	length	5.5	120.00	660.00
	5. Binding wire	kg	0.275	85.00	23.38
	6. Wire nail	kg	0.1375	85.00	11.69
	7. Polythene	kg	0.275	150.00	41.25
5a	Septic tank (rectangular)				
	1. Brick wall (9")	item			14,000.00
	2. Roof slab (5")	item			5,000.00
	3. Bottom slab (6")	item			6,000.00
5b	Seepage bed (12'x30'x2')				
	1. Top soil	m^3	5	28.00	140.00
	2. Aggregate "	m^3	15	00.00	13,500.0
6	Shuttering				
	1. 1" Timber plank	ft^2	40	6.00	1,040.00
	2. 2"x1" Reapers	ft^2	40	3.25	130.00
	3. 2"x4"x7' Timber	numbers	3	40.00	420.00
7	Door, door frame and fixtures (2'x6', class II timber)	item			2,214.50
8	Internal plumbing	item			100.00
	(PVC, 15mm, tap)				250.00
9	External plumbing (PVC, 100mm)	item			600.00
11	Labor				
	skilled	days	5	,000.00	5,000.00
	unskilled	days	7	600.00	4,200.00
12	Squatting pan	numbers	1	50.00	850.00
	Total cost				67,719.69
	Contingencies (10%)				6,771.97
	Estimated cost				*74,492*

Capital costs (LKR):

To beneficiary	74,492	For toilet construction
local authority	1,750,000	For gully bowser and other equipment

Maintenance cost (LKR):

To owner	2,000	For emptying septic tank per 2 yrs
To owner	153	Water bill per month
local authority	2,000	Transport and labor per 2 yrs per unit (10 - 12 units per day)

Option 1 (iii): Conventional Toilet and Cylindrical Septic Tank with Brick Wall

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4’x5’x6.5’
Foundation: Rubble
Wall type: Brick
Roof type: Sheet roof
Floor type: RCC floor slab
Septic tank type: Precast cylindrical septic tanks (2m^3)
Secondary treatment: Soakage pit (1.8m^3)
Construction cost: in LKR as at 2007

Table H-3. Bill of Quantities (BOQ) for Option 1(iii)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000.00	1,400.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1	630.00	630.00
2	Brick wall				
	1. Bricks	numbers	600	7.00	4,200.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	2.30	200.00	200.00
	4. Red cement	kg	0.25	200.00	50.00
3	RCC Floor slab (2")				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00
	4. Steel shear links (10mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25

Table H-3. Continued

	Item	Unit	Qty	Rate	Amount
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	RCC roof slab (2")				
	1. Asbestos sheets	numbers	2	1,000.00	2,000.00
	2. Battens (2"x2")	ft	20.00	100.00	2,000.00
	3.Accessories				1,200.00
5a	Septic tank (cylindrical, 2m2)				
	1. Standard precast unit (1mx2.5m)	item			16,000.00
5b	Soakage pit (rectangular, 1.8m3)				
	1. Brick wall (honey comb)	numbers			1,100.00
	2. Roof slab (5")				4,000.00
6	(No shuttering)				
7	Door, door frame and fixtures (2'x6', class II timber)	item			2,214.50
8	Internal plumbing	item			100.00
	(PVC, 15mm, tap)				250.00
9	External plumbing (PVC, 100mm)	item			600.00
11	Labor				
	skilled	days	5	1,000.00	5,000.00
	unskilled	days	7	600.00	4,200.00
12	Squatting pan	numbers	1	850.00	850.00
	Total cost				49,763.88
	Contingencies (10%)				4,976.39
	Estimated cost				*54,740 00*

Capital costs (LKR):

To beneficiary	57,740	For toilet construction
local authority	1,750,000	For gully bowser and other equipment

Maintenance cost (LKR):

To owner	2,000	For emptying septic tank per 9 - 10 months
To owner	153	Water bill per month
local authority	2,000	Transport and labor per 2 yrs per unit (10 - 12 units per day)

Eco-sanitary Toilet with Plant Bed

Option 2 (i): Eco-sanitary toilet with Urine and Wash-water Diversion with Cement Block Wall

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4’x5’x6.5’
Foundation: Rubble
Wall type: Cement block
Roof type: RCC roof slab
Floor type: RCC floor slab
Plant bed: Cement hollow block
Vault: Double brick vault
Construction cost: in LKR as at 2007

Table H-4. Bill of Quantities (BOQ) for Option 2(i)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000.00	1,400.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1	630.00	630.00
2a	Cement block wall				
	1. Cement block	numbers	220	28.00	6,160.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	2	630.00	1,260.00
	4. Red cement	kg	0.25	200.00	50.00
2b	Brick vault				
	1. Brick	numbers	220	28.00	6,160.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	2	630.00	1,260.00
	4. Plaster (15mm)	m^2	2	150.00	300.00
3	RCC Floor slab				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00

Table H-4. Continued

	Item	Unit	Qty	Rate	Amount
	4. Steel shear links (10mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	RCC roof slab				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00
	4. Steel shear links (10mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
5	Plant bed				
	1. Cement block	numbers	60	28.00	1,680.00
	2. Sand, cement, 3/4 metal				450.00
6	Shuttering				
	1. 1" Timber plank	ft^2	40	26.00	1,040.00
	2. 2"x1" Reapers	ft^2	40	3.25	130.00
	3. 2"x4"x7' Timber	numbers	3	140.00	420.00
7	Door, door frame and fixtures (2'x6', class II timber)	item			2,214.50
8	100mm PVC pipe, fittings, for venting system	item			1,650.00
9	11/4 PVC pipe, fittings, for urine/wash water pipe	item			758.00
10	Railings for the step	item			3,000.00
11	Labor				
	skilled	days	4	1,000.00	4,000.00
	unskilled	days	5	600.00	3,000.00
12	Cost of eco pan	numbers	1	1,500.00	1,500.00
	Total cost				43,976.25
	Contingencies (10%)				4,397.63
	Estimated cost				*48,373.88*

Capital costs (LKR):

To beneficiary	48,374	For toilet construction
To local authority	No cost	

Maintenance cost (LKR):

To owner	No cost;	Possible income from compost
To local authority	No cost	

Option 2 (ii): Eco-sanitary toilet with Urine and Wash-water Diversion with CSEB

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4'x5'x6.5'
Foundation: Rubble
Wall type: Cement block
Roof type: RCC roof slab
Floor type: RCC floor slab
Plant bed: Cement hollow block
Vault: Double brick vault
Construction cost: in LKR as at 2007

Table H-5. Bill of Quantities (BOQ) for Option 2(ii)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000.00	1,400.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1	630.00	630.00
2a	CSEB wall				
	1. CSEB	numbers	450	10.00	4,500.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.50	630.00	945.00
	4. Red cement	kg	0.25	200.00	50.00
	5. Protective coating	liters	1	300.00	300.00
2b	Brick vault				
	1. Brick	numbers	220	28.00	6,160.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	2	630.00	1,260.00
	4. Plaster (15mm)	m^2	2	150.00	300.00
3	RCC Floor slab				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786.00	625.00

Table H-5. Continued

	Item	Unit	Qty	Rate	Amount
	3. Cement	bag (50kg)	1.5	630.00	945.00
	4. Steel shear links (10mm)	length	5	120.00	600.00
	Item	Unit	Qty	Rate	Amount
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	RCC roof slab				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786	625.00
	3. Cement	bag (50kg)	1.65	630.00	1,039.50
	4. Steel shear links (10mm)	length	5.5	120.00	660.00
	5. Binding wire	kg	0.275	85.00	23.38
	6. Wire nail	kg	0.1375	85.00	11.69
	7. Polythene	kg	0.275	150.00	41.25
5	Plant bed				
	1. Cement block	numbers	60	28.00	1,680.00
	2. Sand, cement, 3/4 metal				550.00
6	Shuttering				
	1. 1" Timber plank	ft^2	40	26.00	1,040.00
	2. 2"x1" Reapers	ft^2	40	3.25	130.00
	3. 2"x4"x7' Timber	numbers	3	140.00	420.00
7	Door, door frame and fixtures (2'x6', class II timber)	item			2,214.50
8	100mm PVC pipe, fittings, for venting system	item			1,650.00
9	11/4 PVC pipe, fittings, for urine/wash water pipe	item			758.00
10	Railings for the step	item			3,000.00
11	Labor				
	Skilled	days	4	1,000.00	4,000.00
	Unskilled	days	5	600.00	3,000.00

Table H-5. Continued

	Item	Unit	Qty	Rate	Amount
12	Cost of eco pan	numbers	1	1,500.00	1,500.00
	Total cost				42,562.69
	Contingencies (10%)				4,256.27
	Estimated cost				*46,818.96*

Capital costs (LKR):

To beneficiary	48,374	For toilet construction
To local authority	No cost	

Maintenance cost (LKR):

To owner	1,000	Wall maintenance cost Possible income from composting
To local authority	No cost	

Option 2 (iii): Eco-sanitary toilet with Urine and Wash-water Diversion with Brick Wall

(For an average household with five members in Unwatuna village)

Design parameters:
Size: 4’x5’x6.5’
Foundation: Rubble
Wall type: Cement block
Roof type: Sheet roof
Floor type: RCC floor slab
Plant bed: Cement hollow block
Vault: Double brick vault
Construction cost: in LKR as at 2007

Table H-6. Bill of Quantities (BOQ) for Option 2(ii1)

	Item	Unit	Qty	Rate	Amount
1	Foundation up to DPC				
	1. Rubble	m^3	1.4	1,000.00	1,400.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1	630.00	630.00
2a	Brick wall				
	1. Bricks	numbers	600	7.00	4,200.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	2.30	200.00	200.00
	4. Red cement	kg	0.25	200.00	50.00
	5. Plaster (15mm)	m^2	10	150.00	1,500.00

Table H-6. Continued

	Item	Unit	Qty	Rate	Amount
2b	Brick vault				
	1. Brick	numbers	220	28.00	6,160.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	2	630.00	1,260.00
	4. Plaster (15mm)	m^2	2	150.00	300.00
3	RCC Floor slab				
	1. 3/4 Metal	ft^3	7	40.00	280.00
	2. Sand	m^3	0.35	1,786.00	625.00
	3. Cement	bag (50kg)	1.5	630.00	945.00
	4. Steel shear links (10mm)	length	5	120.00	600.00
	5. Binding wire	kg	0.25	85.00	21.25
	6. Wire nail	kg	0.125	85.00	10.63
	7. Polythene	kg	0.25	150.00	37.50
4	Sheet roof				
	1. Asbestos sheets	numbers	2	1,000.00	2,000.00
	2. Battens (2"x2")	ft	20.00	100.00	2,000.00
	3.Accessories				1,200.00
5	Plant bed				
	1. Bricks	numbers	90	7.00	630.00
	2. Sand, cement				1,200.00
6	(No shuttering)				
7	Door, door frame and fixtures (2'x6', class II timber)	item			2,214.50
8	100mm PVC pipe, fittings, for venting system	item			1,650.00
9	11/4 PVC pipe, fittings, for urine/wash water pipe	item			758.00
10	Railings for the step	item			3,000.00
11	Labor				
	Skilled	days	4	1,000.00	4,000.00
	Unskilled	days	5	600.00	3,000.00
12	Cost of eco pan	numbers	1	1,500.00	1,500.00

Table H-6. Continued

Item	Unit	Qty	Rate	Amount
Total cost				43,246.88
Contingencies (10%)				4,324.69
Estimated cost				*47,571.56*

Capital costs (LKR):

To beneficiary	48,374	For toilet construction
To local authority	No cost	

Maintenance cost (LKR):

To owner	No cost;	Possible income from compost
To local authority	No cost	

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