Sustainable Sanitation

Practice

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- Introduction to CLARA
- O&M for sustainable dry sanitation
- Struvite production from source separated urine
- Additional water sources for multi storey buildings
- CLARA Simplified Planning Tool
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- Summary and Outlook

clara
Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas

The CLARA project

partner of:
sustainable sanitation alliance

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Sustainable Sanitation Practice (SSP) aims to make available high quality information on practical experiences with sustainable sanitation systems. For SSP a sanitation system is sustainable when it is not only economically viable, socially acceptable and technically and institutionally appropriate, but it should also protect the environment and the natural resources. SSP is therefore fully in line with SuSanA, the Sustainable Sanitation Alliance (www.susana.org). • SSP targets people that are interested in sustainable sanitation systems and the practical approach to it. • Articles are published after blind review only. • Sustainable Sanitation Practice is published quarterly. It is available for free on www.ecosan.at/ssp.

Sustainable Sanitation Practice (SSP) hat zum Ziel praxisrelevante Information in hoher Qualität im Zusammenhang mit „sustainable sanitation“ bereit zu stellen. „sustainable“ also nachhaltig ist ein Sanitärsystem für SSP wenn es wirtschaftlich machbar, soziokulturell akzeptiert, technisch als auch institutionell angemessen ist und die Umwelt und deren Ressourcen schützt. Diese Ansicht harmoniert mit SuSanA, the Sustainable Sanitation Alliance (www.susana.org). • SSP richtet sich an Personen, die sich für die praktische Umsetzung von „sustainable sanitation“ interessieren. • Artikel werden nur nach einer Begutachtung veröffentlicht. • Sustainable Sanitation Practice erschient vierteljährlich, kostenlos unter: www.ecosan.at/ssp.

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Editorial

During the last 3 years EcoSan Club Consulting was partner of the CLARA project. The CLARA project (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas) was a Collaborative Project funded within the EU 7th Framework Programme. CLARA's objectives were based on the main outcomes of the EU 6th Framework Programme projects ROSA (http://rosa.boku.ac.at/, see also Issue 4 of SSP from July 2010) and NETSSAF.

In Issue 19 of Sustainable Sanitation Practice (SSP) we present the highlights and main findings of the CLARA project. The 11 papers included in this special issue show specific aspects of the project as well as an outlook on future activities.

The thematic topic of the next issue (Issue 20, July 2014) is „Capacity development". If you are interested to submit a contribution please inform the SSP editorial office (ssp@ecosan.at). Contributions are due to 1 June 2014, the guide for authors is available from the journal homepage (www.ecosan.at/SSP). Please feel free to suggest further topics for issues of the journal to the SSP editorial office (ssp@ecosan.at). Also, we would like to invite you to contact the editorial office if you volunteer to act as a reviewer.

SSP is available online from the journal homepage at the EcoSan Club website (www.ecosan.at/SSP) for free. We also invite you to visit SSP and EcoSan Club on facebook (www.facebook.com/SustainableSanitationPractice and www.facebook.com/EcoSanClubAustria, respectively).

Günter Langergraber, Markus Lechner, Elke Müllegger

EcoSan Club Austria (www.ecosan.at/ssp)

Content

Introduction to CLARA

In this paper the basic concepts and ideas of CLARA are presented.

Authors: Günter Langergraber and Norbert Weissenbacher

Abstract

CLARA's objectives were based on the main outcomes from the FP6 projects ROSA (http://rosa.boku.ac.at/) and NETSSAF. CLARA's overall objective was to strengthen the local capacity in the water supply and sanitation sector as there is only limited local capacity to adopt, implement and operate integrated water supply and sanitation. The work was structured in three main parts: 1) field research in Arba Minch, Ethiopia, 2) the development of the CLARA Simplified Planning Tool (SPT), and 3) the work in pilot-communities in 5 African countries. Field research covered 3 main topics: i) operation and maintenance with emphasis on strengthening the incorporation of businesses in the sanitation service chain, ii) faecal sludge treatment and urine conditioning, and iii) solutions for multi-storey condominium houses. The SPT provides the missing link for the technical part of the overall planning process by supporting local planners to find the best solution for water supply and sanitation in an early stage of the planning process. Using the tool gives the planner (i.e. consultants and/or municipal planning departments) real costs of various alternative water supply and sanitation systems. The CLARA SPT was then tested and evaluated in different geographical African regions. For the five CLARA pilot-communities a full planning process for water supply and/or sanitation was carried out. As no money for implementation was available in CLARA, application documents were prepared as a final output that were submitted to donors for funding further detailed planning and/or implementation.

Introduction

There are a large number of small communities and towns in Africa that suffer from severe problems with water supply and sanitation. Small communities in rural areas and peri-urban areas of small towns have comparable settlement structures in which reuse of water and use of sanitation products can be utilized. However, there is only limited local capacity to adopt, implement and operate integrated water supply and sanitation systems.

CLARA's overall objective was to strengthen the local capacity in the water supply and sanitation sector. From a technological point of view, existing low cost technologies for decentralized water supply and sanitation systems were assessed and adapted for African conditions with the focus on reducing risks in use and reuse of water and sanitation products, and providing demand oriented water quality. Based on these technological improvements and the experiences from the FP6 projects ROSA (http://rosa.boku.ac.at/) and NETSSAF, a simplified planning tool for integrated water supply and sanitation systems for small communities and peri-urban areas was developed that incorporates the key factors for sustainable long-term running systems, i.e. operation and maintenance issues and reuse potential. These factors need to be considered form the beginning of the planning process and tailored to available local capacities. This CLARA Simplified Planning Tool was then tested and evaluated in different geographical African regions to incorporate different economic, cultural and social boundary conditions. For the communities participating in the planning process, application documents were prepared as a final output that served as basis to ask for funding of their implementation plans.

CLARA in a nutshell:

- CLARA (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas) was a Collaborative Project funded within the EU 7th Framework Programme, Theme „Environment (including Climate Change)" (Contract # 265676; duration: 1.3.2011 – 28.2.2014)
- CLARA's main activities have been
  - field research in Arba Minch, Ethiopia,
  - development of the CLARA Simplified Planning Tool, and
  - planning of water supply and sanitation systems in pilot communities in 5 African countries (incl. the testing of the CLARA Simplified Planning Tool).

Figure 1: African CLARA countries

The CLARA project (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas) started in March 2011 with duration of 3 years. CLARA was coordinated by BOKU University, Austria, and had 15 partners. Besides BOKU there were 3 more European partners that have been all partners in ROSA and/or NETSSAF: ttz Bremerhaven, Germany (the coordinator of NETSSAF), EcoSan Club Austria, and BIOAZUL, Spain. The African partners covered 4 geographical regions (see Figure 1): Eastern Africa (Ethiopia and Kenya), Southern Africa (South Africa), Western Africa (Burkina Faso) and Northern Africa (Morocco and Tunisia). From the African partners Egerton University (Kenya), Arba Minch University and Arba Minch Water Supply and Sewerage Enterprise (both from Ethiopia) have been partners in ROSA whereas WSA (Water and Sanitation for Africa, formerly CREPA, Burkina Faso) was partner in NETSSAF.

To include the relevant partners for the field research in Arba Minch besides the ROSA partners AMU (Arba Minch University) and AWSSE (Arba Minch Water Supply and Sewerage Enterprise) also the following partners have been included in the project:

- Arba Minch Town Municipality (AMTM)
- ‚Engan New Mayet' Compost Production Youth Association (EMN)
- ‚Wubet le Arba Minch' Solid Waste Collectors Association (SWCA)
- Arba Minch Health Office (AMHC)

The Ethiopian partners were responsible to carry out the field research in Arba Minch. The incorporation of two SMEs, EMN and SWCA, which have been already working and sanitation related activities (co-composting and transport of urine and faeces, respectively), is essential to get the micro enterprise view of the sanitation business. To include the business point of view in the process is essential for sustainable implementation of the sanitation systems.

The African partners WSA, Egerton University, ONEP (Office National de lEau Potable, Morocco) and WRC (Water Research Commission, South Africa) were responsible for the case studies in Burkina Faso, Kenya, Morocco and South Africa, respectively. CBS (Centre of Biotechnology of Sfax, Tunisia) was an African partner focussing on research aspects.

Overview of work performed

The work in CLARA was carried out in 3 main fields: i) field research, ii) development of the CLARA Simplified Planning Tool, and iii) case studies.

i) Field research

CLARA field research in Arba Minch was carried out in 3 main fields:

1. Solutions for multi-story buildings (MSBs) and health impacts

MSBs have been introduced in Arba Minch and other Ethiopian cities as condominium houses. They are usually constructed at the edge of the city boundaries and have a standardized design which includes flush toilets. Most of the time, such as in Arba Minch, 24/7 water supply is not available thus flush toilets are not working properly. Measures to reduce water consumption of the MSBs by resources-oriented solutions have been researched with the main aim to provide enough water for toilet flushing.

2. Sludge treatment, co-composting and urine conditioning methods

Within ROSA several types of toilets that allow reuse (i.e. UDDTs and fossa alternas) have been constructed in private houses, institutions and schools. Transport of urine and faeces was done by solid waste collectors. Faeces were transported to ENM for co-composting where experiments for optimising the process started. AMU researches urine conditioning methods (production of struvite from urine) which shall reduce problems in handling urine (e.g. large volume and nitrogen loss).

3. Operation and maintenance (O&M) and financing mechanisms

O&M is of high importance for sustainable implementation of sanitation systems. Based on the existing installations current O&M practices were analysed and optimized. The incorporation of private businesses as sanitation service providers and the barriers towards this were analysed by the means of e.g. business plans.

ii) Development of the CLARA Simplified Planning Tool

In CLARA we did not aim to define a new overall planning approach, however, the CLARA Simplified Planning Tool (SPT) aims to provide the missing link for the technical part of the overall planning process by supporting local planners to find the best solution for water supply and sanitation in the planning objective. By using the tool it is possible to compare the real costs of various alternatives of water supply and sanitation systems. Environmental, social and health aspects are not considered explicitly since it is assumed that these aspects are already considered in the framework conditions, i.e. it is assumed that all systems fulfilling the legal requirements benefit environment and health and are socially appropriate. That means that the tool cannot be used to compare a solution that fulfils legal requirements with e.g. the solution „no sanitation facilities" as these 2 alternatives do not have the same impact. However, the tool can be used to compare e.g. water-borne and dry sanitation systems.

iii) Case studies

The CLARA SPT was tested and evaluated in Arba Minch and in the CLARA pilot communities in Burkina Faso, Ethiopia, Kenya, Morocco and South Africa. At all case study sites a planning process for an integrated water supply and sanitation system for the pilot communities was carried out. Within the process the CLARA SPT was used for evaluating different alternative system solutions. After evaluating the results the African CLARA partners were in charge to prepare application documents that allowed the pilot communities to request donor money. The application documents were prepared in the format as required by the donors, e.g. the African Water Facility or similar.

The SSP special issue

This special issue of SSP highlights the key findings of the CLARA project. The following contributions are included in the special issue:

- The first 3 articles describe main results from the field research in Arba Minch, Ethiopia:

  - Müllegger et al. (2014) investigated the operation and maintenance aspects of a dry sanitation system with focus on the participating micro-enterprises,

  - Feasibility of struvite production from source separated urine was researched by Dalecha et al. (2014), and

  - Feki et al. (2014) investigated additional water sources for multi-story buildings (condominium houses).

- The CLARA Simplified Planning Tool is introduced by Lechner et al. (2014).

- The work carried out in all 5 CLARA pilot communities is summarised by:

  - van der Merwe-Botha et al. (2014) for South Africa,

  - Ketema et al. (2014) for Arba Minch,

  - Mutua and Gacheiya (2014) for Kenya,

  - Mahi and Jaait (2014) for Morocco, and

  - Coulabali et al. (2014) for Burkina Faso

- The final paper summaries the project and gives an outlook on future activities planned.

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Operation and maintenance strategies for a sustainable dry sanitation system in Arba Minch, Ethiopia

Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas

Sanitation services offered by SMEs are able to run at a profit, if different services are combined, the municipality subsidises the activity and fees are increasing.

Authors: Elke Müllegger, Endrias Olto, Mammo Beriso Bulbo, Amalework Wolde

Abstract

Given the rapid demographic growth, Arba Minch municipality is increasingly facing difficulties in meeting the sanitation needs of its population. Even if most people have access to an on-site sanitation facility, operation and maintenance receives slight attention. Among the consequences are poor or non-functioning systems, damage to the environment and people's health.

Since 2010, 80 urine diverting dry toilets (UDDTs) have been constructed in Arba Minch. For operation and maintenance of these facilities, people have been encouraged to use urine and faeces in their own gardens or burry the material. But experience has shown that many toilet users prefer a collection service and are willing to pay for the service offered. During the timeframe of the CLARA project two small and micro enterprises, which are involved in sanitation related activities, have been (financially) supported and their performance is monitored. ‚Wubet le Arba Minch' Solid Waste Collectors Association's (SWCA) and ‚Engan New Mayet' Compost Production Youth Association (ENM) are both offering services along the sanitation supply chain.

This paper presents the results of a two years study (2011 – 2013), with the specific objective to develop a sustainable operation and maintenance strategy for a dry sanitation system in Arba Minch. It clarifies the legal framework of sanitation in Arba Minch; describes the sanitation supply chain for UDDTs inclusive its strengths and weaknesses; provides a profound financial analysis of the two service providers inclusive a calculation if urine and faeces collection can be profitable, and presents business models developed for SWCA and ENM.

Introduction

It is a fact that operation and maintenance (O&M) of sanitation systems receives less attention compared to construction or is even completely neglected. Among the consequences are poor or non-functioning systems, damage to the environment and people's health. According to Solo (1999), the best way to help the poor in water and sanitation provision is to encourage more small-scale entrepreneurs to enter the market and to compete. Solo (1999) further states that "the small-scale entrepreneurs follow the recommended business practices far closer to the letter than the large-scale monopolies. They are certainly "demand responsive". They charge market prices, covering costs and respecting the willingness to pay. They provide appropriate solutions in appropriate places, assume all investment risks and they reach the poor."

This paper presents the results of a two years study (03/2011 – 03/2013), within the frame of the CLARA project. The study links the problem of missing O&M

Key messages:

- Only if the private sector and the municipality are working hand in hand, the sanitation situation can improve in the long run. Public-private-partnership can serve as model for future developments.
- An O&M service is crucial for the acceptance of UDDTs among the population of Arba Minch. Many UDDT users are willing to pay for a collection service.
- Sanitation services offered by SMEs are able to run at a profit, if different services are combined, the municipality subsidises the activity and fees are increasing.
- To guarantee a reliable service, it is important that each service provider can run its business independently.
- Diversification of services and activities offered by a service provider seems to be the solution to raise revenues and to reduce risks.

services for on-site sanitation with the solution Solo (1999) recommends. It has the specific objective to develop a sustainable O&M strategy for a dry sanitation system in Arba Minch, Ethiopia. This objective leads to four research questions, which will be addressed:

1. What is the role of Arba Minch Town Administration in providing sanitation services?
2. How are supply chains for sanitation services organised?
3. How is the financial situation of the service providers?
4. What will be required for sustainable financing of operational costs and for replacement of material? What kind of model could deal with this?

Materials and methods

Framework of the study

Arba Minch is one of the major cities in Southern Ethiopia. The city is located about 500 km from the capital Addis Ababa and has a total population of more than 85,000 inhabitants. There is a wide range of problems associated with sanitation in Arba Minch. As the town is one of the fastest growing cities in the country, the problem is expected to grow even bigger with time. According to a survey conducted during the CLARA project (CLARA Arba Minch Team, 2013) nearly 90% of the population use a pit latrine or an improved pit latrine. The remaining 10% spilt into (pour) flush toilets, urine diverting dry toilets (UDDTs), fossa alterna or open defecation.

During the timeframe of the CLARA project two small and micro enterprises (SMEs), which are involved in sanitation related activities, are (financially) supported and their performance is monitored. ‚Wubet le Arba Minch‘ Solid Waste Collectors Association‘s (SWCA) and ‚Engan New Mayet‘ Compost Production Youth Association (ENM) are both offering services along the sanitation supply chain. SWCA‘s main activity is waste collection and road cleaning. In 2011 the organisation has extended their business by transporting urine and faeces from urine-diverting dry toilets to the composting site of ‚Engan New Mayet‘ Compost Production Youth Association. ENM on the other side are producing compost from faecal matter, urine, organic waste, agricultural waste and cow dung. They are growing young in-door and out-door ornamental trees as well as plants and seedlings for sale.

Data collection and analysis

Various approaches have been used to collect research data in order to answer the different research questions. A team of national and international researches was active and supported the local CLARA team. This activity, which lasted 2 years (03/2011 till 03/2013) was carried out in the form of participatory observations, informal and key information interviews, document and literature review and workshops. Additionally the cash-flow of SWCA and ENM were monitored over a period of 15 month (07/2011 till 09/2012), which is the basis for the financial calculations in this report.

Sanitation service chain analysis

Within the framework of the CLARA project it was not possible to conduct a comprehensive sanitation supply chain analysis for both demand and supply side. Thus the research concentrated on the sanitation service chain for urine diverting dry toilets. The situation has changed several times over the research period of two years. Consequently, two different scenarios have been developed, which are described below.

Financial analysis

Financial investment costs are often stated as one of the major barriers to increasing sanitation coverage – next to the lack of political will. But for a sustainable financing of sanitation, it is not only important to know the purchase price or capital costs but also operation and maintenance costs, and the associated additional (direct or indirect) benefits to the user such as health, comfort and protection of the local environment (Parkinson et al., 2012).

Capital expenditure (CAPEX) and operational expenditure (OPEX) are the key parameters for both the financial and economic assessment of sanitation options. OPEX are the costs that are required to sustain the operation and maintenance of a system or facility (Parkinson et al., 2012). Within the CLARA project, the focus was on a financial analysis, specifically on expenditure and revenue streams of operational expenditure. As both SMEs‘ cover expenses with financial support from CLARA, the recorded data are reported separately. This data form the basis for a financial analysis, specifically for cash flow, a calculation if urine and faeces collection can be profitable and projected income statements.

Business plan development

A business model describes the rationale of how an organization creates, delivers, and captures value (Osterwalder and Pigneur, 2009). Business plans were developed for ‚Wubet le Arba Minch‘ Solid Waste Collectors Association and for ‚Engan New Mayet‘ Compost Production Youth Association. The method used is based on the “The Business Model Canvas” and the “Business Model Generation” described by Osterwalder and Pigneur (2009).

Results and discussion

The legal framework of sanitation in Arba Minch

The primary responsibility to implement the goals formulated in the „The National Sanitation and Hygiene Strategy of Ethiopia“ (Federal Democratic Republic of Ethiopia, 2005) lays with the Ministry of Health and on regional level the Regional Health Bureaus. On a local level the city councils are responsible for sanitation and hygiene. For Arba Minch the responsibilities are shared among:

- Arba Minch Town Municipality, which is mainly responsible for sanitation services, particularly solid waste management and on-site sanitation. The Town Municipality is formally in charge of the waste collection and the maintenance of the local waste disposal sites. However, in practise the municipality has outsourced the waste collection system to ten solid waste collection associations as well as on-site sanitation, which is mainly privately organised.
- Arba Minch Water Supply and Sewerage Enterprise (AWSSE), which is responsible for the town water supply. Additionally, the water utility is officially responsible in public toilet provisions and waste water management. But they have not taken over the full responsibility. AWSSE has also the mandate for sewerage, but for economic reasons no sewerage system is existing or planned for the coming years in Arba Minch.
- Arba Minch Health Office, which is mainly responsible for sanitation and hygiene promotion, budget and resource mobilisation and enactment of bylaws.

Nowadays the Arba Town Minch Municipality focus on three major activities, which are:

- Improvement of household sanitation in order to minimize open defecation. Within the frame of the SPA program, toilet construction is supported with focus on poor families.
- Support of ENM to strengthen compost production, with the main aim to minimize the amount of wastes to be dumped to the final disposal site.
- Support of SWCA and other solid waste collection associations to strengthen solid waste as well as urine and faeces collection.

Two other topics have been discussed within Arba Minch municipality: (i) responsibilities for waste water and (ii) institutional sanitation. Especially wastewater becomes an urging topic, as the amount of liquid waste water is increasing. Thus Arba Minch municipality is in negotiation with AWSSE, about responsibilities and policy gaps.

Sanitation service chains in Arba Minch

Since 2006 three projects have aimed to improve the sanitation situation in Arba Minch: the EU FP6 funded ROSA project (from 2006 to 2010), the Dutch funded SPA project (from 2009 to 2013) and the EU FP7 funded CLARA project (from 2011 till 2014). All three projects have in common, that they support the Arba Minch town council to develop sustainable sanitation supply chains with the thematic priority on sustainable sanitation. Thus since 2010, 80 UDDTs and 442 fossa alterna have been constructed in Arba Minch.

For operation and maintenance of the UDDTs, people have been encouraged to use urine and faeces in their own gardens or burry the material. But experience has shown that many toilet users prefer a collection service and are willing to pay for the service offered. Thus within the frame of the CLARA project, Arba Minch municipality is supported to develop a sustainable collection and treatment system for urine and faeces. However, during the two years of this study the situation has changed several times. The main developments can be summarised in two scenarios:

<u>Scenario 1: Collection, transport and composting of urine and faeces.</u>
In scenario 1 urine and faeces are collected and transported to the composting site for further treatment (Figure 1). The service of collection and transport of urine and faeces is provided by SWCA and was offered from 12/2011 till 07/2012. SWCA's area of operation is the upper town (Secha) of Arba Minch where in total 27 UDDTs have been constructed. Out of the 27 toilet owners, 18 have been under contract to SWCA. For further centralised treatment ENM is responsible, as they are operating the only composting place in Arba Minch which is located in lower town (Sikele). ENM receives the urine and faeces from SWCA and mix it into the compost produced of organic waste collected within the town.

Due to various internal organisational problems of ENM, the collection service was interrupted for nearly a year, in order to reorganise their association. Since 08/2013 they started composting again, thus SWCA is able to offer their collection and transport service for UDDTs.

<u>Scenario 2: No transportation and composting of urine and faeces.</u>
Since 08/2012, SWCA has stopped the collection of faecal fractions in Secha, because ENM stopped composting for three main reasons: (i) a shortage of costumers who are buying compost, (ii) heavy rainfalls from May to July 2012 which made composting very difficult and (iii) internal organisational problems at ENM. Since then, there was no need for urine and faeces. Consequently owners of UDDTs were again responsible by themselves for urine and faeces emptying. Urine was mainly soaked into the ground and faeces were buried into the soil.

In cases of no collection and transport, owners still continue using UDDTs. They are continuously approaching the municipality for consultation about filled containers of urine and faeces. However, the demand for new UDDTs is currently low. Instead, fossa alterna is favored by new households who look at the challenges of dealing with UDDT contents. However, the municipality expects a paradigm shift, if the market for compost has

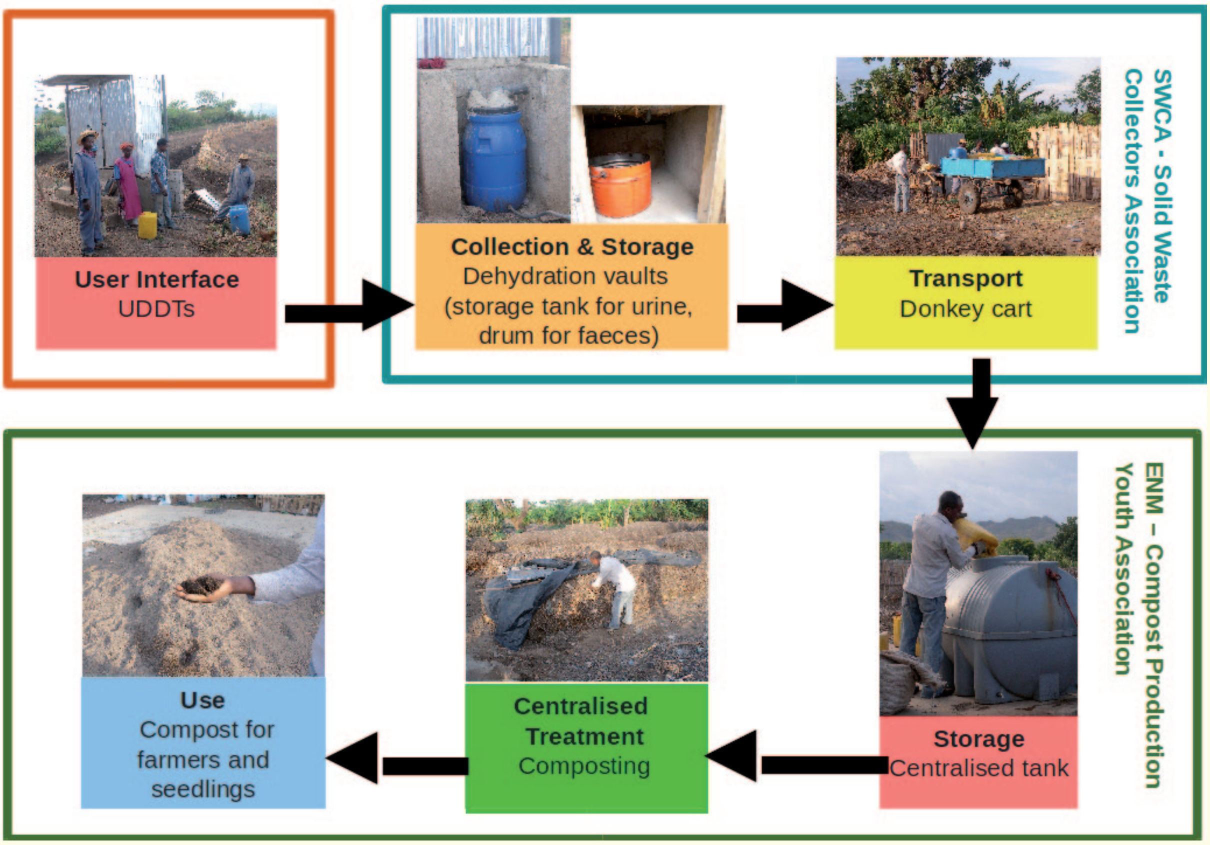

Figure 1: Sanitation supply chain for UDDTs in Arba Minch.

developed. In the meantime the municipality is encouraging other solid waste collection associations to get into sanitation collection, in order to expand the service to the whole town and not only for the UDDTs situated in Secha.

Financial analysis

‚Wubet le Arba Minch' Solid Waste Collectors Association

The cash flow consists of the total income minus the total expenditure. The results show clearly that SWCA's business is a permanent loss if the total expenditure are deducted from the total income. The average loss per month amounts to 15,437 ETB (ETB: Ethiopian Birr; 1 EUR = 23.98 ETB (8 July 2013). The total income is composed of income from solid waste collection, which is the main share, from urine and faeces collection and other income. Expenditure is separated in expenses covered by SWCA's income and CLARA project money. If only monthly expenditure paid by SWCA are deducted from the income, ‚Wubet le Arba Minch' Solid Waste Collectors Association has a positive cash-flow in 14 out of 15 month, which amounts in average to 1,770 ETB.

SWCA has used the financial support from the CLARA project to prepare for the period after the project, i.e. from March 2014 onwards. SWCA is aware of their financial situation. However, their total income has doubled over the recording period from 3,688 ETB (07/2011) to 7,850 ETB (09/2012). In the same period the number of clients has increased from 218 to 868.
They have used the donor money to develop a sustainable business by employing an office coordinator and an assistant. Their main activities, beside day-to-day administrative issues, are public relation activities and association development including business plan development.

Financial analysis of urine and faeces collection

The collection of urine and faeces is one of the services SWCA offers to their clients. From 12/2011 till 07/2012, 18 out of 27 UDDT owners in Secha made use of the service. But only in May, June and July 2012 the activity generated income. In the previous months the collection service was offered for free as promotion activity. However, SWCA received financial support from CLARA to start and develop the business of urine and faeces collection. During these three months SWCA earned in average 46 ETB from urine collection. That amounts to a service charge of 2 ETB per 20 litre jerry can in May and June as well as 4 ETB in July.

Table 1 shows various calculations for a theoretical income with urine and faeces collection. It is based on the current emptying schedule of every 3 month for faeces and every 2 month for 100 litre of urine respectively. As SWCA aims to charge 5 ETB for a 20 jerry can of urine and 20 ETB for a 50 kg barrel of faeces, the calculations are based on these figures.

For faeces collection, SWCA could earn in average per month 7 ETB and for urine collection 13 ETB per household. That amounts to an income of 126 ETB for faeces and 234 ETB for urine, if 18 UDDTs are emptied on a regular basis. Assuming that all 27 household with

Table 1: Theoretical income of urine and faeces collection

	basics		per year / household		per month / household		income SWCA / month	
	emptying schedule	fee	amount	fee	amount	fee	18 UDDTs	27 UDDTs
FAECES	50 kg / 3 month	20 ETB / 50 kg	200 kg (= 4 barrel)	80 ETB	17 kg	7 ETB	126 ETB	189 ETB
URINE	100 l / 2 month	5 ETB / 20 l	600 l (= 30 jerry cans)	150 ETB	50 l	13 ETB	234 ETB	351 ETB

ETB: Ethiopian Birr; 1 EUR = 23.98 ETB (8 July 2013).

UDDTs in Secha make use of the toilet emptying service offered by SWCA, the income could increase to 189 ETB for faeces and 351 ETB for urine respectively. That is in total a monthly income of 360 ETB for 18 UDDTs and 540 ETB for 27 UDDTs.

According to the recorded expenditure for September 2012, a labourer employed by SWCA earned 276 ETB per month, with an extra income paid by CLARA of 344 ETB. This means that already with the income of 360 ETB from 18 UDDTs nearly half of the personnel costs for a labourer are covered, if they have an average income of a solid waste collector which is about 500 ETB per month.

On a theoretical basis, urine and faeces collection is an extra income for SWCA of 360 ETB (18 UDDTs) and 540 ETB (27 UDDTs) for 3 and 4 days of work respectively. Additionally there is still potential for an optimisation of the service. The trip from Secha to Sikele is about 7 km one way and takes in one direction more than an hour with a donkey cart. If either the means of transport or the distance to the composting site can be reduced, the service can be even more profitable.

Financial analysis of ‚Engan New Mayet‘ Compost Production Youth Association

The financial analysis of ‚Engan New Mayet‘ Compost Production Youth Association shows that the composting business of ENM is currently a loss and heavily supported by the CLARA project. The average total expenditures per month are more than 23‘000 ETB, compared to an average monthly income of about 6,000 ETB. In other words, ENM covers only 15% for their expenses from income generated by business activities. However, ENM receives currently intense support from the Arba Minch Town Municipality in order to develop a sustainable composting business. As the municipality is aware of the solid waste problems in the town, they are interested in finding solutions. Enhancing composting is part of these solutions.

Business model development

The case study in Arba Minch proves what Sijbesma (2011) has stated, that the major difficulty is the financing of operational costs, rather than investment costs. For both SMEs the major share of the total expenditure are operational costs, with 91% for SWCA and 81% for ENM respectively in average per month. However, to cover the expenditure without any donor support is a prerequisite for a sustainable business. Currently they cover their expenditure with income from different sources:

- Self-financing / Financing by fees

Table 2 shows that SWCA‘s main source of income are fees from solid waste collection (3,775 ETB from households and 4,520 ETB from commercial), fees from street cleaning (500 ETB) and urine and faeces collection (54 ETB). ENM generates income in three main branches: (i) Sale of seedlings, (ii) sale of plants and (iii) sale of compost. The branch sale of seedlings is with 44% the most profitable one, followed by sale of plants with 42% and sale of compost with 12%. Other income is negligible with only 2%.

SMEs are fully responsible to cover their expenses, both investment and operational cost. In practice they receive occasional support from the municipality, but mainly in terms of infrastructure like the composting site for ENM. According to the cash flow of SWCA and ENM, they are currently not in the position to cover their costs by collected fees.

- Municipal or governmental subsidies or transfers

The municipality of Arba Minch has no regular subsidy program to support sanitation which is in line with the National Policy Direction. But the town municipality allot some amount of money to support sanitation activities. With ENM they signed a Memorandum of Understanding in order to expand composting in Arba Minch. The municipality provided land, fenced the area and provided drainage. SWCA is supported on an irregular basis for example to borrow them a tractor or to pay fuel costs. SWCA and Arba Minch municipality have a verbal agreement that the municipality will allocate budget to take over the responsibility to transport waste to the final disposal site after CLARA phases out. Generally, there is commitment from the municipality and the town administration to support sanitation programs in future. Within the frame of the SPA program, costs for toilet construction are already shared between SPA (50%), the municipality (40%) and the beneficiaries (10%) since 2012.

Table 2: Current income during the research period and the planned income after the CLARA project (from 03/2014).

	Average fee [ETB]		Number of costumers		TOTAL INCOME per month [ETB]	
	Research period	Starting March '14	Sept '12	Starting March '14	Research period	Starting March '14
Household solid waste collection	5	8	755	1,000	3,775	8,000
Commercial solid waste collection	40	70	113	113	4,520	7,910
Street cleaning	500	1,000	1	1	500	1,000
Emptying of 18 UDDTs	3	20	18	18	54	360
TOTAL					8,849	17,270
Municipal subsidy	--	1,500	--	1	--	1,500
TOTAL					8,849	18,770

ETB: Ethiopian Birr; 1 EUR = 23.98 ETB (8 July 2013).

- External donor funding

CLARA is a typical donor funded project. Support is provided for a specific topic (water and sanitation), a specific location (Arba Minch) and for a limited time period only. In contrary to many other externally supported projects, the objective of CLARA is not the financing of infrastructure. Investment costs are only covered to a very small extent. CLARA supports, among other issues, SWCA and ENM to defray operating costs in order to build up operational structures for a sustainable sanitation supply chain.

- Public-private-partnerships

The town administration is currently experiencing with public-private-partnerships, in order to solve the problem of uncollected solid waste. They have signed several Memorandum of Understandings with solid waste collection SMEs and the composting association.

Business plan development

The business plans develop for SWCA and ENM cover a timeframe of two years from 09/2013 till 08/2015. The approach is based on the model of public-private-partnerships (PPP), in which the public and private sector cooperate in order to provide services to users. Both SMEs combine different services and link activities: SWCA combines solid waste collection with urine and faeces collection and street cleaning. ENM combines composting with plant and seedling production.

In the PPP model of 'Wubet le Arba Minch' solid waste collection association three different groups of stakeholders are involved:

- Households and institutions, which pay a fee for the solid waste collection.
- SWCA, who operates their business as a private enterprise. Thus they have to cover their operational expenditure as well as investment costs and
- Arba Minch Town Municipality, who subsidises investments as well as operational costs.

The financial analysis shows that financial sustainability can only be achieved by combining different sources:

- Waste collection fee from solid waste and excreta generating households and commercial establishments;
- Municipality subsidy by offering waste transport from transfer stations to final disposal site and a reasonable street cleaning fee.

By March 2014, SWCA aims to double their income from current about 8'850 ETB to 18'800 ETB. If it's possible to realise this ambitious goal, they shall be able to cover almost their average monthly expenditures of 21,300 ETB. Anyhow, SWCA are already planning to reduce their costs after the CLARA project. If the association is not able to afford the two employees that are currently fully paid by CLARA (an office coordinator and her assistant) they will not employ them any longer. This will reduce the costs already by more than 4,000 ETB monthly. The municipality has additionally agreed to cover the costs of solid waste transport, which is the second highest cost factor in SWCA's cash flow.

Consequently, SWCA's business is able to run at a profit, if different services are combined, the municipality subsidises the activity and collection fees are increasing. Policy-makers could act on the collection fees and can support the diversification of the activities. Moreover, it is important that SWCA helds their expenditures low. It is further recommended, that they carry out at least two times per year a financial planning in order to adjust the association's performance.

The PPP model of ‚Engan New Mayet' Compost Production Youth Association includes three main stakeholder groups:

- ENM, who operates their business as a private enterprise. Consequently, they have to cover their operational expenditure as well as investment costs;
- Arba Minch municipality, who subsidises capital investments on the composting site and operational costs in form of transporting sorted non-compostable solid waste to the final dumping site;
- Farmers and costumers, who buy compost, seedlings and plants from ENM.

The financial analysis shows that ENM has hugh operational cost. Financial sustainability can only be achieved if operational costs are reduced by 35% and income increases. That can be a combination of the following:

- Increased income by sell of compost and tree seedlings up to 50%.
- Capital investment cost for compost site development are mainly covered by the municipality.
- The municipality further covers part of the sorting cost (estimated at 2,000 ETB per month) and transport to the final disposal site.

By November 2013, ENM planned to increase their income from about 6,000 ETB to more than 15,000 ETB monthly. They have planned to double the amount of compost sell from 400 kg to 800 kg, the sell of seedlings from 50 to 100 pieces and they start with the UDDT emptying service in Sikele. Additionally, Arba Minch municipality has agreed to support ENM's activities by subsidising waste sorting with 2,000 ETB monthly. To realise this aim, ‚Engan New Mayet' receives, other than financial subsidy, intense support from the municipality, especially with compost marketing. However, even if ENM increases their income, they are not able to cover their average expenditure over the research period of 23,700 ETB per month. Above all, personnel costs are the biggest share of expenses with 14,300 ETB per month. With ENM's planned income, they can only cover these costs, but they are not able to cover additional expenses.

In addition to the financial sustainability, the business plan also suggests improvement in the organisational structure of ENM. The administration of projects (project manager) shall be separated from the main enterprise work. The enterprise shall also have a non-member office assistance, like the office coordinator for SWCA, to facilitate the day-to-day business.

Conclusions

Financial figures do not say everything. It is moreover important to have an all-inclusive look on the small and micro enterprises. In order to answer the research question "How can sanitation services in Arba Minch be managed profitable and sustainable?" the following conclusions can be drawn:

- O&M services for on-site sanitation and solid waste collection in Arba Minch are ensured by small and micro enterprises, which are facing various difficulties to guarantee their balanced operation. Thus Arba Minch municipality has to take over the responsibility and has to strengthen organisations dealing with sanitation. Only if the private sector and the municipality are working hand in hand, the situation can improve in the long run. Public-private-partnership can serve as model for future development in the sanitation sector in Arba Minch.
- The acceptance of UDDTs depends among others on the availability of an O&M service. Many UDDT users prefer a collection service and are willing to pay for the service offered.
- The sanitation supply chain in Arba Minch is offered by two service providers, who are fully dependent from each other. If one of the activities stops operation, the whole supply chain is not functioning any more. Thus, for a sustainable operation it is of utmost importance, that the service providers are able to run their businesses independently.
- Sanitation services offered by SMEs are able to run at a profit, if different services are combined, the municipality subsidises the activity and fees are increasing. Policy-makers could act on the collection fees and can support the diversification of the activities. For solid waste collectors, urine and faeces collection can be a profitable extra income as they have already the necessary infrastructure and extra investments are low. The compost producer's main difficulty is the development of a compost market, from which they are extremely dependent.
- Diversification of services and activities seems to be the solution to raise revenues and to reduce risks. That means for SWCA, that they still have income from solid waste collection if urine and faeces collection comes to a standstill. In the case of

ENM it implies that the sale of seedlings and trees ensure income, if there is no or a limited market for compost.

- Sanitation marketing is key in order to increase the demand for sustainable sanitation systems among Arba Minch's population.
- But also to increase the request for sanitation products like compost or for hardware like toilets.
- For a sustainable development in the sanitation sector a interdisciplinary dialog among various stakeholders active in the sanitation sector is necessary. Working hand in hand for a common goal can increase the efficiency dramatically.

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Struvite production from source separated urine: Application and economic feasibility in Arba Minch, Ethiopia

Struvite production from source separated urine and subsequent use as fertilizer is technically feasible in Arba Minch, however, not (yet) economically sustainable .

Authors: TeshaleDalecha, Eshetu Assefa, Kristina Krasteva, Kathrin Meinhold

Abstract

Source separated urine is a potential source of nutrients which can be used as a substituent for commercial fertilizers. Nutrient recycling technologies are promising options not only to improve existing sanitation, but also to address problems such as the increasing depletion of phosphorus resources. In this case study, struvite production for fertilizer usage and its economic feasibility was assessed fitting conditions in Arba Minch, Ethiopia. Struvite precipitation was found to be technically feasible (67.3% of phosphorus was recovered from urine) and when applied to maize comparable results to chemical fertilizer in terms of plant growth and crop yield could be achieved. Without including environmental benefits, however, struvite production was not found economically feasible. Nevertheless, struvite from urine is a locally available fertiliser from non-renewable resources. Furthermore, potential process improvements through further research as well as the rising prizes for artificial fertilizers could make struvite a viable option in the long run.

Introduction and Background

For a lot of peri-urban and rural areas in the developing world extensive sewer networks combined with large centralized wastewater treatment plants are simply not feasible, due to high investment and operating costs, dependency on increasingly scarce resources, high maintenance needs, etc. Therefore, there is a growing demand for novel, decentralized sanitation systems which better suit the requirements of the local population and the environmental settings. Using wastewater as a resource is an interesting concept which can not only contribute to improve current wastewater treatment, but also potentially create novel business opportunities through the generation of value-added products.

Against this background, this study analysed the potential of struvite derived from human urine as a substitute for commercial fertilizer. Nutrients excreted by humans via urine are vital for plant growth and, therefore, urine has got major potential for nutrient recycling. One of these nutrients is phosphorous. Phosphorus can also be found in specific ore deposits, most notably in so-called rock-phosphate. However, this mineral phosphorus is a finite resource and supplies are expected to peak around 2030(Cordell et al., 2009).Considering its indispensability for food production and therefore human life, it is essential that sustainable phosphorus recovery methods are researched. In this connection, urine conditioning technologies such as the production of struvite have high potential when adapted to local conditions.

Struvite is a white crystalline powder consisting of equi-molar amounts of ammonium, magnesium and phosphate and 6 hydration molecules ($MgNH_4PO_4 \cdot 6H_2O$). It can precipitate spontaneously in hydrolysed urine of

Key messages:

- A maximum phosphate recovery efficiency of 67% was achieved with a locally produced struvite reactor
- Cropping trails show a similar fertilizing effect of artificial fertilizer and struvite – an important information to convince farmers for usage
- Struvite application is currently not yet economically feasible when compared to artificial fertilizer via nutrient value analysis
- Future research is necessary to improve the struvite production process and issues such as subsidies for or prize rises of artificial fertilizers need to be closely monitored

pH 9. The addition of magnesium to urine enhances struvite precipitation and has been proven to be a robust and effective method to recover phosphorus from urine. The product does not form a hazard for public health with respect to heavy metals and micro-pollutants. The economic feasibility of struvite production at household level was checked in Nepal, but not found feasible (Etter et al., 2010). Whether this holds true for Ethiopian conditions as well, i.e. at community level in Arba Minch, was to be analysed in this case study.

Urine Diverting Dry Toilets (UDDT's) have been introduced in Arba Minch since the beginning of the ROSA (Resource-Oriented Sanitation concepts for peri-urban areas in Africa, Langergraber et al., 2010) project in 2006. Since then they have proven to be widely accepted in the community and the demand for further units is increasing. This gives an ideal starting point for struvite generation for fertilization proposes based on source-separated urine in Arba Minch.

Methodology

Urine collection, transportation and analysis

Source separated urine was collected from different households and institutions in Arba Minch using UDDT's. These toilets have tanks attached to the toilet foundation walls for obtaining the urine. The Wubet le Arba Minch solid waste collectors association was in charge of collecting and transporting these tanks via donkey cart to the site of the Egnan New Mayet (ENM) compost producing association where the struvite reactor was installed. A small reimbursement was paid to the collectors to increase their motivation (long distance (8km) from upper town to the site).

The following parameters were analysed (for both fresh and stored urine): pH, EC as well as nutrient concentrations (PO_4-P, NH_4-N, Ca^{2+}, Mg^{2+}, etc.). Additionally, a questionnaire was distributed among UDDT owners in order to deduct the maximum amount of urine that could potentially be collected in Arba Minch.
Struvite production

The low-cost struvite precipitation reactor (Figure 1) consists of a stainless steel vessel, stand, ladder, stirrer, valve, and a filter bag and was constructed based on the open-source drawings and specifications resulting from Nepal's experience (Zandee et al., 2011, Meyer et al., 2011).

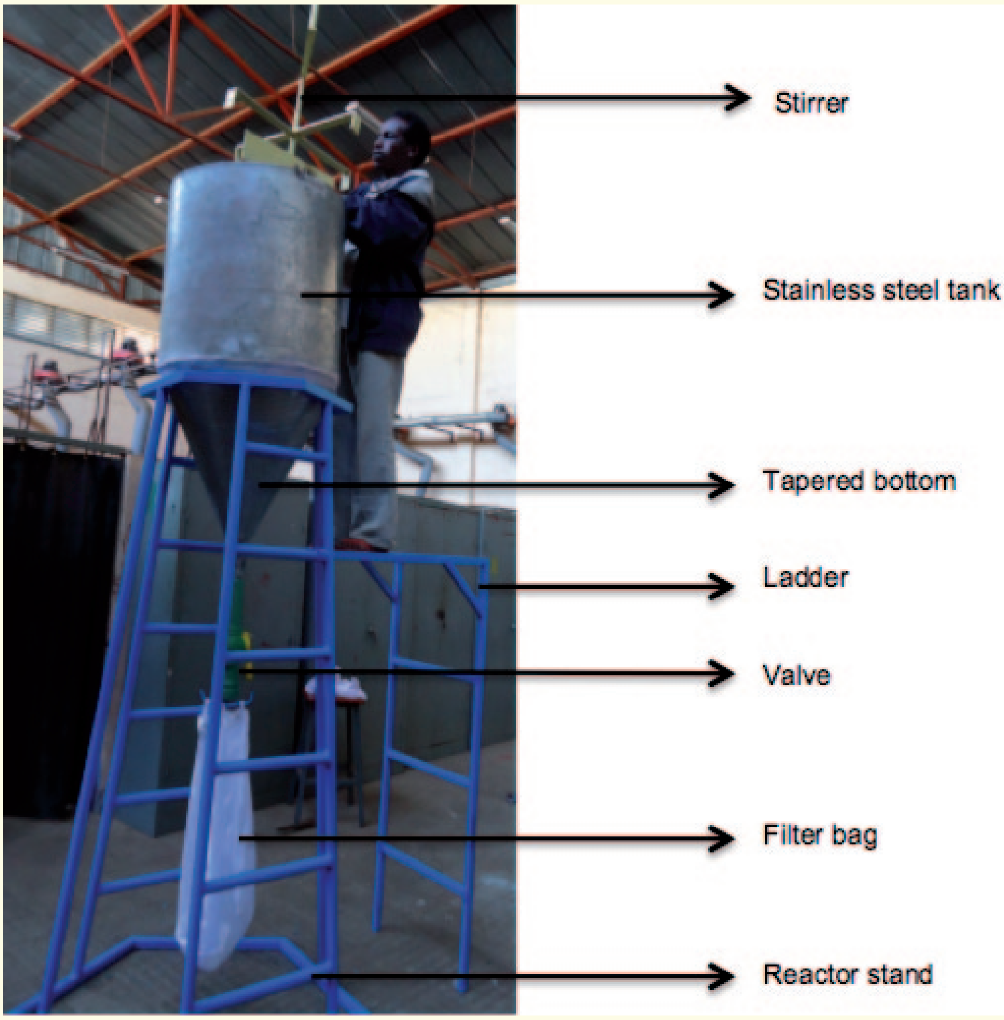

Figure 1: Struvite precipitation reactor

Struvite precipitates in this reactor when the urine is mixed with a magnesium source. Due to the cheaper price, magnesium oxide (MgO) was used in this experiment. The necessary amount of MgO was determined based on the phosphate concentration in the urine, the trial molarity of Mg:PO_4-P, and the volume of the urine per batch. After a mixing time of 15 minutes, the solution was filtrated and the obtained precipitate exposed to the sun for drying. A number of trial molarity ratios were used in order to try and improve the phosphate recovery efficiency (1:1, 1.2:1, 1.5:1 and 1.8:1)

Crop trials

The fertilization capacities of the generated struvite were tested on maize cultivations and compared with the effects of chemical fertilizer. For this purpose, an area of 11 m x 5.6 m was subdivided into three small trial plots, each being the size of 1.6 m x 11 m. A micro-tube drip irrigation system was used for all three trial plots to supply water based on estimated crop requirements.

Plot 1 (chemical fertilizer): chemical fertilizer (Di-ammonium phosphate DAP and Urea) was applied according to current practices of farmers from Arba Minch. DAP was applied during the planting date of the crop and urea as a source of nitrogen was applied when the crop was in developmental stage.

Plot 2 (struvite): As struvite is a slow-release fertilizer, it was applied at the planting date of the crop (rate of application: 200kg per hectare). The application of struvite could not be performed with the drip system but had to be manual, since the substance is not readily soluble in water and can clog the dripper. Diluted effluent urine with a factor of 1:3 was applied during the developmental stage of the crop through the drip irrigation system. This was necessary, in order to supply the plants with a nitrogen source - plant available nitrogen in struvite is not enough for optimal growth.

Plot 3 (control): In this plot no fertilizer was applied, solely water for irrigation purposes, in order to obtain control values.

Figure 2 summarizes the overall methodology used in this case study as described in the text above.

Results and discussion

Urine analysis

Table 1 displays average concentration of selected compounds in fresh and stored urine from UDDT tanks in Arba Minch. Storage increases the pH of urine and reduces the amount of available nutrients. Due to spontaneous precipitation during storage potentially available calcium and magnesium get consumed and the volatility of ammonia reduces the concentration of ammonium nitrogen. In general, the concentrations of nutrients in urine from UDDTs in Arba Minch were higher than those observed in the case of Nepal's case study (Etter et al., 2010).

In order to be able to optimize struvite generation based on urine it is essential that the phosphate concentrationis known as exactly as possible in order to facilitate an optimal magnesium dosage. Furthermore, this info is necessary in order to compute accurate financial compensations for urinedeliveries. Electrical conductivity measurements have been proven to be a rapid and cost

Table 1: Average concentration of selected compounds in fresh and stored urine from UDDT tanks in Arba Minch, Ethiopia

		Fresh urine			Stored urine		
Parameter	**Unit**	**Avg**	**STD**	**Median**	**Avg**	**STD**	**Median**
pH		5.50	1.05	5.63	8.6	0.09	8.6
EC	mS/cm	15.4	3.6	15.3	28.8	4.3	29.1
PO_4-P	mg/l	715	286	856	293	75	290
NH_4-N	mg/l	795	419	790			
Cl^-	mg/l	5779	2246	5640			
K^+	mg/l	2645	1033	2669			
Na^+	mg/l	3814	1767	3461			
Total Carbonate	mg/l	2221	586	23500			
Ca^{2+}	mg/l	56.8	26.3	54.1			
Mg^{2+}	mg/l	155	70	146			
SO_4^{2+}	mg/l	23.9	9.4	26.0			

Figure 2: Overall process of nutrient recovery from source-separated urine in Arba Minch

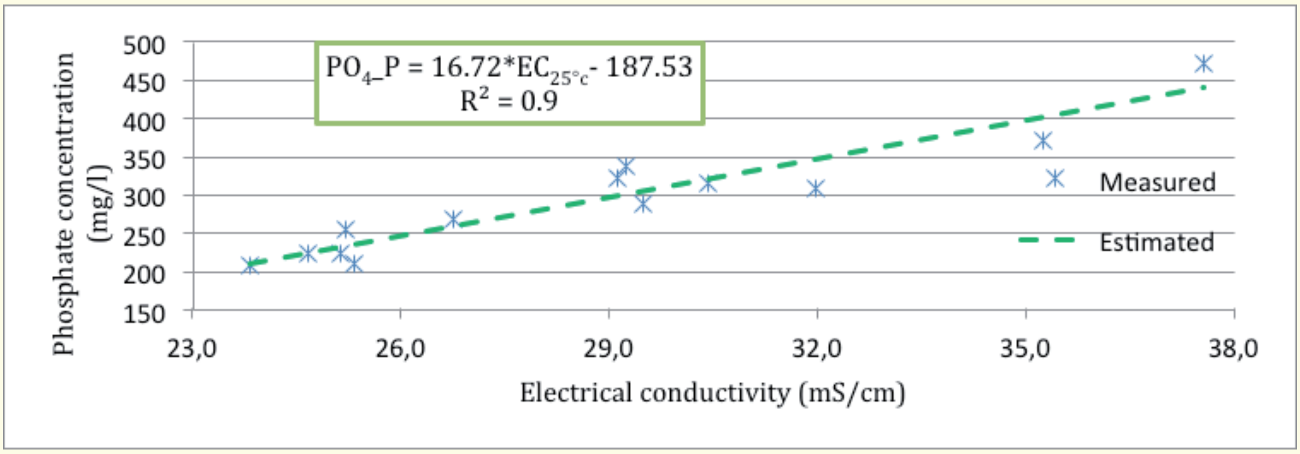

Figure 3: Correlation between temperature-compensated electric conductivity and phosphate concentration

efficient method for online phosphate monitoring in biological processes – this was able to be verified in the here presented case study (Figure 3).The temperature compensated electrical conductivity (25°C) and the phosphate concentration were determined in ten samples of stored urine and plotted against each other. The results show a very good correlation (r^2=0.9). Within the measured range, the phosphorus content can be estimated using the following formula:

$$[PO_4\text{-}P]=16.72*EC_{25\,°C}-187.53 \qquad [1]$$

Estimating the phosphate concentration via electrical conductivity has important advantages over the direct chemical determination of phosphate: it delivers an instantaneous result, it is much cheaper and it does not require careful handling of chemicals. However, the correlation between phosphate and electrical conductivity should be validated for every community anew to account for differences in the urine collection (e.g. composition changes due to ammonia volatilization).

Efficiency of struvite generation

Figure 4 shows the generated struvite during the field trials in Arba Minch. The phosphorous recovery efficiency of struvite production in literature typically is more than ninety percent for molar ratios of Mg to phosphate ranging from 1:1 to 1.8:1. However, the phosphate recovery efficiency in this experiment resulted to be low (max. 67%), for a number of trial molarities tested (see table 2).

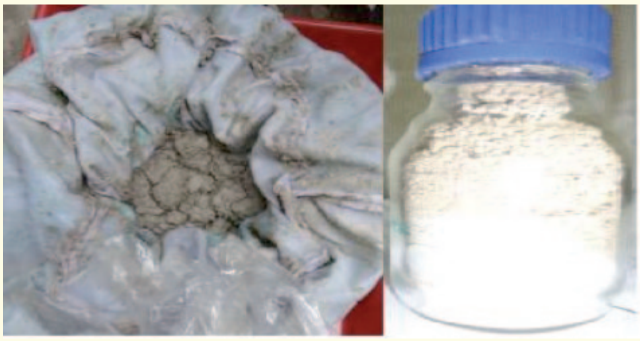

Figure 4: Struvite precipitate exposed to sun light and dried struvite in a glass bottle

To increase the recovery efficiency of phosphate from urine, process parameters (such as pH, temperature, stirrer type, filtration on phosphorous removal efficiency and average crystal size of the precipitate) should be investigated. In our experiment the pH, mixing time, temperature of the solution, and type of stirrer were within the required range. The type of filter used had no pore size specification, standard filter bags were not available at national markets. It was observed during the filtration time that very fine precipitates could not be retained in the filter bag. Hence, the low process efficiency of the struvite production in general and filtration process efficiency in particular is most likely due to the filter type used.

Table 2: Struvite production efficiency with respect to various molarity of Mg : PO4-P (based on the phosphorous concentration in the influent to the reactor and effluent urine out from the filter bag)

B.No	Molar ratio	Urine (liters)	Mg (g)	MgO (g)	Struvite (g)	Input PO_4-P conc.	Effluent PO_4-P conc.	PO_4-P recovery (%)
1	1 : 1	20	5.62	14.0	31.1	---	---	---
2	1.5 : 1	40	21.73	54.3	102.0	260	80	67.31%
3	1.8 : 1	40	26.07	65.2	105.7	702	232	66.90%

Figure 5: The growth status of maize after a growing period of approx. 2 months

Crop growth and yield

The growth patterns of crop maize given different treatments are depicted in Figure 5. A significant difference between the control and treated groups can easily be observed, however, not between the two treated groups (struvite + effluent and DAP + urea).

These results were further confirmed after a more detailed analysis of certain growth parameters of the maize after a fixed time period (Table 3). Parameters such as leaf diameter or height of the plant are dependent on several environmental factors, including the nutrient levels in the soil, and can, therefore, be used to compare the effect of phosphate from struvite and chemical fertilizer on the crop. The results indicate that struvite performs comparably to artificial Di-ammonium phosphate (DAP) fertilizer in terms of average plant height, leaf diameter, seed as well as straw weight.

In general, based on the response of maize to the three application trials above has shown that struvite and effluent application revealed comparable results to chemical fertilizer in terms of plant growth and crop yield. However, the importance of recovering nutrients like phosphorous and nitrogen from urine and application as fertilizer should not solely be seen in the connection of substituting artificial fertilizers. Minimizing the excessive pollution (eutrophication) of water resources and being a solution for global phosphate insecurity are further points needed to be brought into discussion.

Economic feasibility of struvite application

With the technical feasibility of struvite production and application well demonstrated, the next step was to analyse whether this process is viable from an economic perspective as well. The economic feasibility of struvite application in Arba Minch was evaluated via cost–benefit-analysis (CBA), a systematic process for calculating and comparing benefits and costs. For this purpose, the price for using struvite as a fertilizer had to be determined. This was achieved by means of nutrient value analysis.

Nutrient value analysis

The technical approach used in order to calculate the value of struvite is based on the values of its nutrient components. Locally available artificial fertilizer prices and their nutrient composition served as a baseline in order to be able to calculate the monetary values of individual nutrients. By correlating the fertilizer prices with their respective nutrient composition the value of single components can be estimated. The results of this market price analysis for different important nutrients contained in fertilizers are displayed in Table 4.

Nutrient component	Value in [ETB/kg]	Value in [EUR/kg]
Nitrogen [N]	61	3
Phosphate [P_2O_5]	49	2
Potash [K_2O]	0	0

Table 4: Estimated values for fertilizer nutrients

Finally, based on these nutrient values as well as the nutrient composition of struvite, the monetary value of struvite can be determined. Pure struvite contains 9.9 % Mg, 5.7 % N, and 12.6 % P, which as a fertilizer would be 5.7:29:0 for N:P_2O_5:K_2O plus Mg. Therefore, the current price of struvite fertilizer can be calculated at 17.64 ETB/kg (ca. 0.7 EUR/kg).

Cost–benefit analysis

The net profit of phosphorus recovery from urine via struvite production is the difference between benefits and costs. In this case study, the benefits consist of the income earned as a result of the sale of struvite fertilizer and the costs are the sum of investment costs in relation to struvite precipitation. These include reactor and shelter construction, processing cost (labour cost, operator cost, magnesium oxide cost), cost of filter bag and additional maintenance costs. Therefore, the profit raised can be calculated via the following formula:

$$NP = NP = \sum_{t=0}^{T}[(ASRt*SPPt)-(ICt+PCt+MCt)]$$

Where NP = net profit (ETB), ASR = annual volume of struvite precipitated (kg), SPP = present selling price of precipitated struvite (ETB/kg), IC = investment cost (ETB), PC = present processing costs (ETB), MC = present maintenance cost (ETB) and t = year.

In order to calculate the amount of struvite that could be produced per year, the volume of urine collected from UDDT users in the town was assessed. The investment cost for the struvite reactor was calculated based on the standard interest rate in Arba Minch (5%) and a return period of five years. Processing costs include labour costs as well as costs for magnesium oxide, while maintenance costs solely includes labour costs. The amount of magnesium oxide required annually and its cost was estimated from known volume of urine produced per year, its average phosphorous concentration and the best efficiency ratio for the conversion determined.

The calculated value of internal benefit by using above equation was found to be more than twenty-fold of the current price of struvite calculated from locally available fertilizers in Arba Minch. Even when excluding the labour costs, struvite production is still not profitable. In particular the high price of magnesium oxide is responsible for this result. Without considering the environmental benefit of phosphorous recovery, struvite precipitation for managing fertilizer demand is, therefore, economically not tailored to the local capacities under Arba Minch conditions even if the labour costs are not considered.

Conclusions and recommendations

The recovery of nutrients like phosphorus from urine involves important environmental benefits: it prevents eutrophication in the receiving environment, and increases the availability of a non-renewable resource. These positive externalities also need to be taken into consideration when assessing the feasibility of struvite precipitation for fertilizer demand. However, their monetary values are very difficult to assess. Due to lack of data, this could not be undertaken in this field research scope.

Despite the results from the economic feasibility assessment, the use of struvite as a fertilizer as well as its simplicity of production is quite promising. Further improvements in the production efficiency, i.e. especially phosphate recovery as well as the filtration process efficiency can enhance the competitiveness of struvite on the fertilizer market. Considering the continuously rising artificial fertilizer prices, it would be still a valuable option for the future if the state or other actors subsidize its production out of environmental or other considerations.

Therefore, struvite precipitation should not be put off as a not viable solution. The social acceptance of struvite was found to be good. Further research should be conducted in order to attain better process efficiencies. The purity level of struvite should be further analysed as well.

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Additional water sources for multi storey buildings in Arba Minch, Ethiopia

Think of water before installing flush toilets.

Authors: Firas Feki, Eshetu Assefa, Norbert Weissenbacher

Abstract

Multi storey buildings are spreading over Ethiopia's cities as sign of steady urbanisation. The increasing demand for housing comes with a substantial increase of demand for water. Together with wet sanitation as standard of these facilities problems are predictable. The article describes the work at a pilot plot in Arba Minch where water shortage leads to inappropriate sanitation. Within an overall concept, rainwater harvesting and greywater treatment and re-use were selected for technical and economical evaluation to show the feasibility of alternative water sources.

Multi storey buildings in Arba Minch

Current situation

Only 5'000 of the about 85'000 inhabitants of Arba Minch are currently living in multi storey buildings (MSBs) but the number will dramatically increase in the next decades. Like in many other places in Ethiopia and based on a national development plan condominium houses will play an important role in the settlement development in future (UN HABITAT, 2010).

The multi-storey buildings that are currently constructed at various places in the town of Arba Minch show a number of common design properties:

- Minimum of three levels,
- Every flat is connected to the town water supply,
- Water storage in tanks serve a group of houses,
- Water consumption is measured by water meters,
- Wastewater is collected in septic tanks,
- Rainwater is discharged to open soil.

Flush toilets are installed in the flats but due to frequent water cuts, their functionality is dependent on intermediate storage which is not operational in many cases. Hence, the sanitation systems are non-functional which impacts the hygienic situation. Therefore, the idea was to develop options based on resource orientation to improve the situation. A typical MSB site of Arba Minch, Bekele Mola, was selected for the investigations (28 houses with a total of 382 apartments). Approximately two thirds of the plots are available as outdoor space for the tenants. For the project relevant calculations 5 persons per household are taken on average. Figure 1 shows us a view of the MSB's at Bekele Mola.

Figure 1: Bekele Mola condominium houses (Kelly, 2008).

Key messages:

- Water shortage impacts sanitation in multi storey building with flush toilets
- Overall concept for sustainable use of water and space was developed
- Potential alternative water sources were identified
- Cost analyses of options were carried out for rainwater harvesting and greywater treatment and reuse

Figure 2: Site plan of the Bekele Mola condominium house area including supply and disposal structures (Augustsen and Hauso, 2012).

Water and sanitation of MSBs

Figure 2 shows the site plan of Bekele Mola with the positions of the elevated tanks (ET_1 and ET_2) for storing water. The two tanks with 25 m^3 and 125 m^3 volumes serve 103 and 279 households, respectively. The eleven septic tanks are marked in blue, representing a total treatment volume of about 370 m^3 for the whole plot. For the disposal of the treated wastewater, eight infiltration beds with varying surface areas between 60 m^2 and 220 m^2 have been implemented. As already stated above, all flats are equipped with standard flushing toilet systems. At the time of the investigations, public water supply was provided at a capacity of 20-30 L/C/d for three to four days a week.

Objectives

Since the construction of multi storey buildings gained increasing importance during the last decade and water related problems were evident, it was the aim of the project to look for resource oriented solutions that could improve the situation.

Concept development

As a first step of the investigations, a general integrated concept for the use of water and space had to be developed. This concept was meant to serve as basis for the selection of appropriate measures und technologies and finally for the economic evaluation of the selected approach.

In cooperation with the local CLARA team (Arba Minch Health Centre and Arba Minch University) Augustsen and Hauso (2012) carried out a survey where general data of Arba Minch and on-site data was collected. The general data included climatic data, biology and topography as well as the general situation of the water and waste management in Arba Minch. Interviews of the inhabitants provided specific information on the inhabitants of the Bekele Mola site including socio-demographic and socio-economic parameters, the health situation, water use and the situation of the existing infrastructure. The data analyses provided the information on the main problems and needs, the technical criteria required, design criteria and sustainability aspects. In total 51 of 181 inhabited households were chosen randomly for interviews.

The concept development included technical solutions that were related to the available outdoor space together with suggestions for organisational structures to enable sustainable implementation. The Sustainable Sanitation and Water Management Toolbox (SSWM) toolbox (www.sswm.info) was used as pool of potentially applicable sustainable water and sanitation options. A list of criteria was elaborated to account of potentials and limitations that applied for Bekele Mola.

Variant analysis

The purpose of the concept development was to create a number of potentially feasible sanitation systems that are locally appropriate and sustainable from which users may select (variants). The scenarios were developed using information gathered from the field study as described above.

Based on the problems identified from the results of the field study, a set of objectives was defined for the sanitation systems scenarios, which were put in for technology choice and a technology options list was drafted. This was then used to develop the scenarios. The general objectives were as follows:

- Human and environmental health protection
- Appropriate technology: low tech; low maintenance; socially acceptable
- Affordable: low capital and recurrent cost
- Reuse possibilities where applicable

For the water related part, the starting point in creating the variants was to define system conditions – determining the type of wastewater treatment technology (onsite, offsite, wet, dry, decentralised, centralised) to be applied in each potential scenario. This was followed by a decision on whether the treated wastewater will be reused or discharged into the environment and finally if the wastewater is to be separated at source or collected combined. Once these systems conditions were clarified, the system components were chosen and technologies appropriate for each system component were selected. For the economic variant analyses, BoQs and local market costs were prepared to estimate costs and benefits.

Options to improve water and sanitation

Observations and Concept

The main problems are related to the water availability. Water cuts hamper the use of flush toilets. As a consequence clear indications of health impacts could be observed. Further, inadequate wastewater treatment and disposal together with frequent flooding after stormwater events due to insufficient (ineffective) drainage keeps the hazards at the plot. Informal solid waste disposal adds up to the bad hygienic conditions. As described above, storage tanks are theoretically available to cover idle periods but they have not been operational at the time of the CLARA project. Further, the capacity to fill the tanks was in doubt.

Leakages could be observed at many places, water supply and wastewater lines in close vicinity leading to potential cross contamination of the drinking water on site. Leakage through ceilings and walls has been also observed. The outdoor space is currently used for animal feeding posing even more health problems and only some private gardening initiatives.

Augustsen and Hauso (2012) based their suggestions on a set of conditions for technology application and the use of space:

<u>Technical design criteria:</u>

- Average water consumption is 80 L/C/d
- The site is still under construction
- Water storage on-site is not in function
- Problems with water leakages and poor construction
- Small enterprises with little experience and poor construction abilities are conducting the construction work
- The site is located upstream the springs, which are the water supply source of the whole city
- Groundwater level is assumed to be 100 m below the ground surface

<u>Space design criteria:</u>

- Trees are in the existing drawings of the area, but it is not known if they will be planted.
- There are goats, donkeys and cows grazing freely on the site.
- Cooking and clothes washing have been observed as outdoor activities.
- Pedestrian patterns rarely follow the constructed paths.
- Private garden initiatives are already in place. Providing shade is one of the most valued functions of vegetation in Arba Minch.

The concept to use water and space in a common manner is based on the principle to adapt the available local resources to the needs (Figure 3). The fact that different water uses require different water quality allows defining wastewater and rainwater as resources that might be used for toilet flushing and/or irrigation. The space as third resource defined is related to the water use (e.g. for irrigation) and the retention/infiltration of stormwater to prevent flooding. Further, space is needed to apply extensive water treatment methods (e.g. wetlands).

The opportunity mapping and a further evaluation of technologies based on the SSWM toolbox led to selection of potentially feasible options for rainwater harvesting and reuse of used water. Technologies selected for further investigations were septic tank treatment, biogas reactor (anaerobic digester) and horizontal flow constructed wetlands.

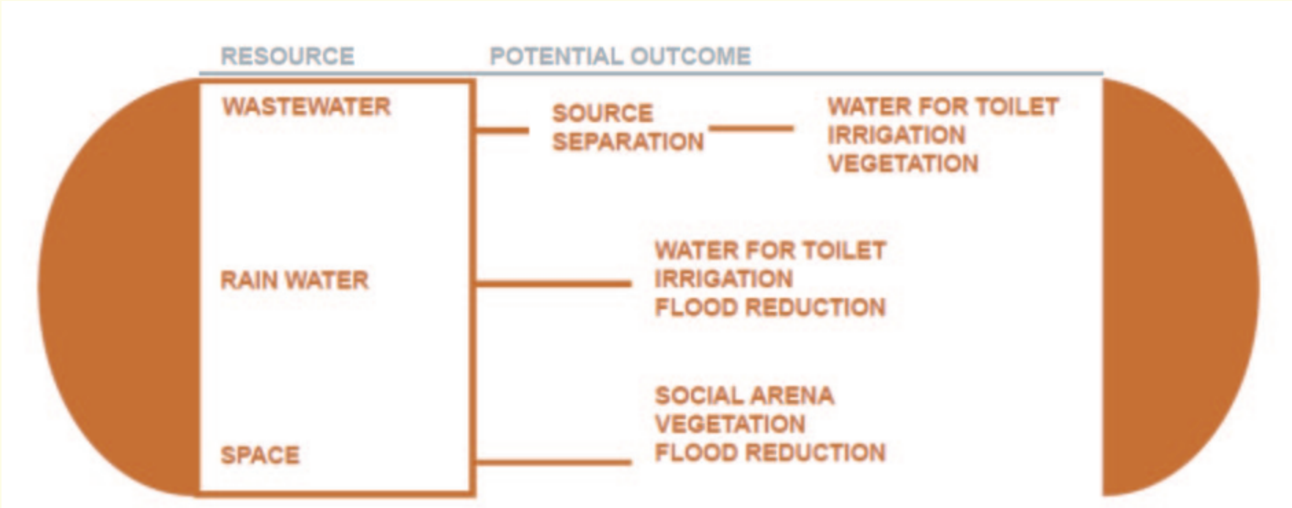

Figure 3: Potential adaption of local resources for use (Augustsen and Hauso, 2012)

Technical options

Out of the suggested technologies, rainwater harvesting and greywater treatment have been analysed in detail for their technical and financial feasibility based on one pilot MSB at Bekele Mola. Anaerobic digestion and wastewater re-use have not been considered due to their complexity and the risks in case of inappropriate operation.

Variant analysis and evaluation

The financial decisions on option selection should not primarily be made on capital costs, but on net present value or whole-of-life costs. These include the annual costs for operation and maintenance. The capital costs argument should be less important than the reliability and long-term sustainability of the treatment plant, including its financial sustainability which is strongly influenced by annual operation and maintenance costs. The cost estimates are based on bill of quantities derived from widely acknowledged design specifications and information on local unit costs (basis 2012). The cost estimation in Ethiopian Birr (ETB) takes into account the necessary storage and distribution system to utilize the additional water source from rainwater harvesting or greywater treatment:

- Option A: the additional water is distributed automatically from the underground tank to the flushing toilet reservoir, using 2 pumps, 2 elevated reservoirs and all necessary pipe connection for each toilet.
- Option B: the additional water is removed from the underground tank manually using a rope and a bucket. This water can be filled in 20 liter containers in order to be reused inside the house for flushing toilet using hand.

A life span of 30 years was assumed for each of the variants. Based on this time period a discount rate of 10% and assuming that no variations occur for the

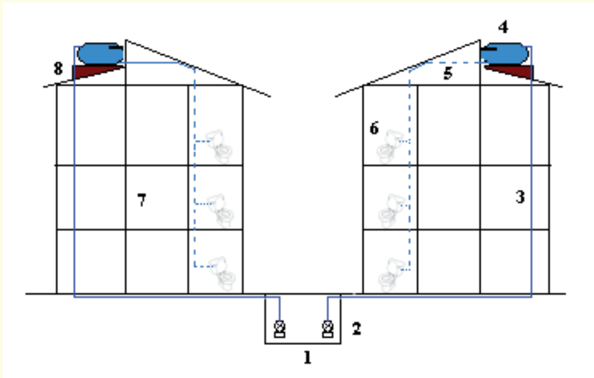

Figure 4: (1) Underground storage tank, (2) submersible pumps, (3) pipe connections, (4) elevated storage tank 2 m3, (5) pipe connection, (6) flush toilet reservoir, (7) multi-storey buildings, (8) support for elevated tank.

annual costs. The net present value (NPV) was derived by determining the NPV including the capital costs (initial investments) and the NPV of O&M (annual operating costs, replacement of equipment). The sum of these resulted in the NPV for each variant (LAWA, 2012). Table 1 summarises the estimated costs for rainwater harvesting (RWH A/B) and greywater treatment (GW A/B). The water recovery (in %) is reflecting the effectiveness of the options in fulfilling the demand for flushing the toilet. The implication here is that rainwater harvesting with simple storage and distribution is the least costly alternative. An increase in costs is observed when a more complicated storage and distribution system is selected. The increase in cost for these options arises from the cost of the automatic distribution system (pumping) of water to the flushing water to the top reservoir from the concrete storage tank. If the concrete storage tank is replaced by a plastic lined reservoir the associated cost could be reduced significantly. It has to be noticed that rainwater cannot cover the full demand of the flushing toilets, additional water saving measured would be needed to close this gap.

Table 1: Summery of options BOQs and costs for two MSBs with 26 households with 130 inhabitants

Options		Water recovery (%)	Saved water for life span 30 years (m^3)	NPV total Cost (ETB)	NPV total Cost (EUR)	NPV cost per household (EUR)	Specific cost (EUR/m^3)	Ranking
RWH	A	84	12'000	389'779	16'371	630	1.36	4
	B	84	12'000	188'673	7'924	305	0.66	1
GW	A	250	38'430	857'535	36'016	1'385	0.94	3
	B	250	38'430	682'715	28'674	1'103	0.75	2

The specific cost of the recovered water is the NPV per cubic meter saved over 30 years. Since the greywater yields much more water that rainwater harvesting, the higher investments are put into perspective. Rainwater harvesting with simple storage and distribution (RWH B) leads to the lowest specific costs with greywater use in second and third rank. Since greywater use produces more water than needed for flushing toilets the extra water has to be used for irrigation in the garden. This option increases the access to water and can improve functionality and design of outdoor space as suggested by Augustsen and Hausso (2012). Still, the specific water costs for such an additional water source remain high in comparison to the local water tariff.

Summary and suggestions

Due to the limited public water supply in Arba Minch at the time of the CLARA it was clear that water-borne sanitation posed significant health risks for the inhabitants of multi storey buildings. The water cuts hamper the flush toilet operation and require water self-storage to cover idle periods. An integrated concept to use water and space as a resources identified potential options to reduce risks and to increase life standards as MSBs.

A set of options for rainwater harvesting and greywater use was selected for investigations. Based on the conditions of a pilot MSB Bekele Mola, the systems have been designed and costs have been estimated based on BOQs and local market prices. Basically, both rainwater harvesting and greywater treatment and use can serve additional water. Rainwater harvesting is the cheapest option but cannot totally cover the demand for toilet flushing due to the dependence on precipitation (Feki et al, 2014). Only greywater re-use would be capable to fully cover the demand of the water borne sanitation. However, the costs and operation and maintenance efforts for greywater separation, treatment and re-use seem to limit the feasibility for Bekele Mola. That leaves rainwater harvesting as only realistic alternative so far. However, the costs for rainwater harvesting would be still substantial for a single household.

To achieve sustainable infrastructure at MSB more than an additional water source is needed. For the water infrastructure a reliable centralized coverage of the full demand seems the only safe solution. Efforts to enlarge the capacity of the public water supply are on-going. Anyway, self-storage shall be reduced and phased out on the long term. Due to the relative complexity of greywater treatment and the related O&M efforts to secure the required treatment performance this options is not feasible for the time being. Rainwater harvesting does not serve the necessary water amount needed but might be a reasonable option in combination to water saving measures such as low flush toilets. As the overall concept suggests, additional water sources such as rainwater can provide water for urban gardening and landscaping. Composting (not discussed here) might add up to resource orientation at MSBs.

Decentralized wastewater treatment will remain the only option for wastewater disposal since a centralized service will not be available even on the long term. Here, together with solid waste management, service provision from private entrepreneurs might be the only option to ensure O&M for decentralized or semi-decentralized systems. Re-use of treated wastewater is not an option since even more risky than greywater treatment and re-use.

As discussed, beside the technical aspects the organisational aspects of financing and – as crucial issue- operation and maintenance defines feasibility. A separate study on the operation and maintenance issues showed that different organisational structures might be applicable for MSBs and have been proven at other places in Ethiopia. This aspect has to be included in future planning of multi storey buildings in the same way as the technical infrastructure systems.

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The CLARA Simplified Planning Tool

The CLARA Simplified Planning Tool provides a tool to local planners which not only allows but even encourages the comparison of fundamentally different water and sanitation systems at a very early planning stage.

Authors: Markus Lechner, Alexander Pressl, Günter Langergraber

Abstract

The CLARA Simplified Planning Tool (SPT) is one of the main outcomes of the CLARA project. We did not aim to define a new overall planning approach. However, the CLARA SPT aims to provide the missing link for the technical part of the overall planning process by supporting local planners to find the best solution for water supply and sanitation. By using the tool it is possible to compare the real costs of various alternatives of water supply and sanitation systems. Environmental, social and health aspects will not be considered explicitly since it is assumed that these aspects are already considered in the framework conditions, i.e. it is assumed that all systems fulfilling the legal requirements benefit environment and health are socially appropriate. That means that the SPT cannot be used to compare a solution that fulfils legal requirements with the solution „no sanitation facilities" as these 2 alternatives do not have the same impact. However, the tool can be used to compare e.g. water-borne and dry sanitation systems. With this assumption the comparison of alternatives can justifiably be reduced to comparing the costs of the alternatives, i.e. for investment, operation and maintenance, and re-investments over a specific period (e.g. 50 years). Net present values of all costs are calculated and used for comparison. In this paper we introduce the main features of the CLARA SPT and show an example on the use of the Tool.

Introduction

The CLARA Simplified Planning Tool (SPT) aims to support local planners to find the most appropriate solution for water supply and sanitation in their planning objective. Simplified means that the software tool is based on numbers of assumptions, which allow the planner to use the SPT with the limited amount of data available at the pre-planning phase of a project.

The SPT compares full costs (investment, operation and maintenance, and re-investment costs) of various alternatives of water supply and sanitation systems. Environmental, social and health aspects are considered in the framework conditions, i.e. it is assumed that all systems fulfilling legal and client's requirements benefit environment and health and are socially acceptable. With this assumption the comparison of alternatives can justifiably be reduced to comparing the costs. Net present values of all costs are calculated and used for comparison.

Key messages:

- The CLARA Simplified Planning Tool (SPT) provides a tool to local planners which not only allows but even encourages the comparison of fundamentally different water and sanitation systems at a very early planning stage. Using the SPT requires a limited amount of effort from the planner and thus resulting in minimal cost for the client.
- Country-specific versions of the CLARA SPT (for Burkina Faso, Ethiopia, Kenya, Morocco and South Africa) versions can be downloaded as single zip-files. Each zip file comprises:
  - The SPT file itself (version 1.5 of the CLARA SPT is implemented in Microsoft Excel®, MS Excel® 2010 is required)
  - The user manual
  - The „Technology descriptions" that include the main assumptions made for developing the costs functions.
- The Moroccan and Burkina Faso SPT are also available in French.
- The CLARA SPT can be downloaded or free from http://clara.boku.ac.at/ and http://www.sswm.info/home.

The user of the CLARA simplified planning tool - the planner - is responsible for developing appropriate alternative solutions. Technologies are grouped in functional groups as defined in the Sustainable Sanitation and Water Management Toolbox (SSWM Toolbox; http://www.sswm.info). These functional groups include: Water sources, Water purification, Water distribution, Water use, Waste collection and transport, Waste treatment, and Reuse.

Technologies in the functional groups have to be compiled to systems. Examples of combinations of technologies to meet specific requirements in the functional groups Waste collection and Waste treatment are shown in the user manual (Casielles Restoy et al., 2014).

Cost functions that relate costs to input parameters have been developed for each technology implemented in the CLARA SPT. Therefore for each technology standard designs have been defined, designs have been made for several sizes, and the costs have been calculated from Bills of Quantities developed for these design sizes.

„Technology descriptions“ provided with the CLARA SPT include the main assumptions made for developing the costs functions and include: a short description of the technology, design assumptions, input data (in the SPT, the validity range of the cost function, the assumed lifespan of the technology and its components, and the assumptions for calculating O&M costs).

The CLARA SPT has been adapted to the different requirements of the African CLARA partner countries, i.e. Burkina Faso, Ethiopia, Kenya, Morocco and South Africa. Specific design requirements and unit prices have been considered for these countries before country-specific cost functions were developed. The country specific versions of the CLARA SPT have been prepared and tested during the planning process that is carried out in the pilot communities in the 5 African CLARA countries.

The country-specific CLARA SPT versions can be downloaded as single zip-files. Each zip file comprises:

- The SPT file itself (version 1.5 of the CLARA SPT is implemented in Microsoft Excel®, MS Excel® 2010 is required)
- The user manual
- The „Technology descriptions“

The Moroccan and Burkina Faso version of the SPT is also available in French.

Applicability

Figure 1 shows the position of the SPT in the planning process. Following project identification and definition it is the immediate next step to help decision making on a systemic level. It is separated into two parts, the first ("Developer") resulting in the pre-selection of technologies and processes which will then be used in the second part. This first part does not necessarily have to be repeated for different projects for a comparable region, e.g. for one specific country with similar framework conditions.

The SPT cannot be used for comparison of technologies in the preliminary and detailed technical design of sanitation infrastructure. However, obviously, the underlying principles are certainly applicable also at this point in the planning process but require far more detailed and accurate data and information as will be available at the pre-planning stage for which the SPT has been developed.

The tool cannot be used to compare

- alternative solutions that do not provide the same service (e.g. comparing a solution that fulfils the legal requirements with e.g. the solution „no sanitation facilities“),
- costs of single technologies during detailed planning, and
- environmental, social and health impacts (as they are considered to be fulfilled when the framework conditions are met).

The Simplified Planning Tool

Developer's Tool

Technology Screening

The first step is the decision regarding the technologies which will be used in the water and sanitation systems. Technology screening criteria are used to identify suitable technologies for given framework conditions. These criteria are derived from

a. country-specific laws, regulations and standards and

b. client's requirements (as long as they do not contradict a.)

All technologies which pass all these criteria will be eligible for inclusion in a water and sanitation system. As these criteria are "yes/no criteria", there will be no further differentiation among technologies based on these criteria – either a criterion is passed or not.

Cost functions

The calculation of the NPV in the next steps requires information on cost for investment, lifespan and operation and maintenance for all technologies which have passed the screening step. The most appropriate procedure is to derive this information from technologies already in operation in the country/region in question since a number of years. However, since the SPT includes a number of innovative technologies the number of real-life applications may be low or even zero. Therefore in these cases an alternative approach was used. Based on detailed technical design documents country specific Bills of Quantity were prepared and the cost of a particular technology used to derive cost

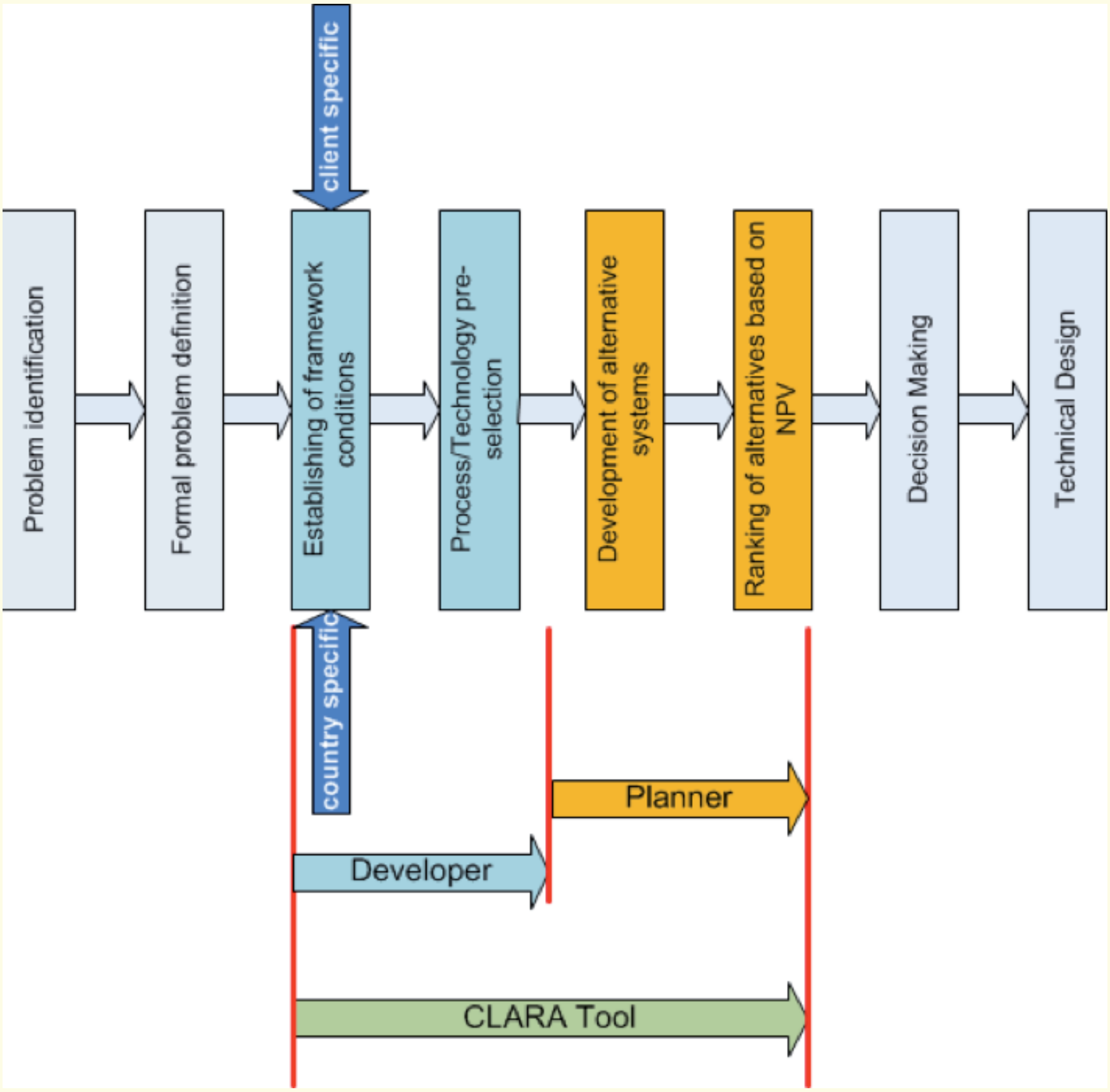

Figure 1: The Clara Simplified Planning Tool in the Planning Process

functions, describing cost as a function of a number (max. 4) critical (cost relevant) input parameters.

Planner's Tool

Combining Technologies to Systems

A professional planner will then combine technologies which are available in the SPT to sensible water supply and sanitation systems. Since this will take place at a very early stage in the planning process the objective is to identify the most appropriate system / system combination for a given problem situation. Therefore the system chosen shall be fundamentally different, e.g. comparing centralised with decentralised systems, water borne with dry systems, etc.. A comparison of, e.g. different types of wastewater treatment technologies cannot and should not take place at this phase of the planning process. These systems will then be entered into the SPT using pre-determined input parameters

Modifying assumptions

The SPT as mentioned above is based on a number of assumptions, in particular the method for the development of the cost functions not perfectly accurate. For this reason it is possible for the planner to modify these cost assumptions when using the SPT. However for the sake of objectivity these modifications will have to be justified, otherwise they will not take effect.

Comparison of Alternatives using NPV

As mentioned earlier only technologies which pass all technology screening criteria can be combined to water supply and sanitation systems. Therefore the only remaining criterion for comparing these systems is their NPV.

The NPV is calculated automatically by the SPT as the sum of the individual NPV's of the technologies used for one particular water supply and sanitation system.

Sensitivity Analyse

The Clara SPT is based on a number of assumptions regarding cost for investment, cost for o&m, discount rate, etc.. These assumptions will necessarily have a direct effect on the accuracy of the SPT's result. Therefore it is recommended to use the options of the tool for a simple sensitivity analyses, e.g. by increasing or decreasing cost or changing the discount rate, all within realistic margins. In case the ranking of water supply and sanitation systems changes by these modifications obviously at the current point in time and with the knowledge currently available there is no clear recommendation for one particular system based on its NPV.

Advantages

- Full costs (investment, operation and maintenance, and reinvestment costs) of different alternative system solutions can be compared
- Resource oriented water and sanitation systems included
- Only limited amount of input data required and thus applicably in the early pre-planning phase
- Assumptions made to develop costs functions are clearly described
- Costs based on real cost data from 5 African countries (Burkina Faso, Ethiopia, Kenya, Morocco and South Africa)
- Costs of single technologies can be changed by the planner to account for e.g. higher costs of energy, construction or the use of diesel generators to cope with power shortages (see example in the user manual, Casielles Restoy et al., 2014).
- Cost functions can be added and changed by the developer if more (detailed) information on real costs is available
- Adaptation to other (African) countries possible

Disadvantages[1]

- Software implemented in MSExcel® and thus requires MSExcel® (version higher than 2010)
- Limited amount of technologies implemented so far (those that have been classified by the CLARA project partners as relevant for their countries)
- Comparison of systems with different performance is possible (mass flow balance not yet implemented)
- Simplifying assumptions resulting in uncertainties of costs
- Cost functions based on BoQs and not real cost, due to lack of information/applied technologies
- Adaptation to other (African) countries requires some efforts (evaluation of specific design requirements and collection of unit prices)

[1] of the current status of the planning tool, not necessarily the planning tool as such.

Implemented technologies

In the CLARA SPT technologies are grouped in functional groups. A functional group is a group of technologies which perform a similar function in the water supply and sanitation system. For the CLARA SPT we used the functional groups as defined in the Sustainable Sanitation and Water Management (SSWM; http://www.sswm.info) toolbox. These are:

- Water source
- Water purification
- Water distribution
- Waste collection
- Waste treatment
- Reuse

For these functional groups the following technologies are implemented in the CLARA SPT:

Water sources

Extraction from spring
Groundwater extraction (Borehole)
Riverwater extraction

Water purification

Surface water treatment
Flocculation and Sedimentation
Chlorination

Water distribution

Water tank surface
Water tank elevated
Pumping station
Water transport main
Water distribution network
House connections (Supply)

Waste Collection

Water borne sanitation system

Cesspit
Collection of (faecal) sludge
Sewer
Sewage pumping station
House Connection (Sewer)

Dry sanitation system

UDDT chamber (larger urine storage tank)
Composting chamber toilet
Collection of urine
Collection of faeces
Collection of Solid Biowaste

Waste Treatment

Septic tanks
Imhoff tank
Screen
Buffer tank
Sequencing Batch Reactor (SBR)
Anaerobic baffled reactor (ABR)
Horizontal flow constructed wetland (HF CW)
Vertical flow constructed wetland (VF CW)
Sludge drying reed bed
Urine storage
Struvite production
Composting
Waste stabilisation pond
Upflow anaerobic sludge blanket (UASB) reactor
Phosphorus-Precipitation
Mechanical sludge dewatering (Belt filter press)
Sludge thickener

Reuse

Struvite use
Compost use
Irrigation water
Urine use

Sanitation systems

Technologies in the functional groups have to be compiled to systems. The following combinations of technologies to meet specific requirements in the functional groups Waste collection and Waste treatment are shown in the user manual (Casielles Restoy et al., 2014) as examples:

- Dry sanitation systems
  - with UDDTs
  - with composting toilets
- Water borne sanitation systems
  - Cesspits for blackwater, faecal sludge treated with sludge drying reed bed and treatment of greywater with HF CWs
  - Sewer
  - Wastewater treatment with SBR (without P elimination) and sludge treatment
  - Wastewater treatment with SBR with P elimination and sludge treatment
  - Wastewater treatment with WSP and FH CW for C elimination
  - Wastewater treatment with VF CW for nitrification

Example

Below we show as an example the comparison of the costs of a water borne sanitation system (sewer, wastewater treatment plant) and a dry sanitation system (urine-diverting dry toilets, collection of urine and faeces, struvite production from urine and co-composing of faeces). Figure 1 shows the user interface of the tool, Figure 2 the selection of technologies within a functional group. Figure 3 shows the results: The water-borne system has higher investment costs; however, the total costs over a period of 50 years for both systems are about the same (when not considering potential income from using liquid and solid fertilisers produced from human excreta).

References

Casielles Restoy, R., Lechner, M., Langergraber, G. (2014): CLARA Simplified Planning Tool v1.5, User Manual. http://clara.boku.ac.at/ [Accessed: 15.04.2014]

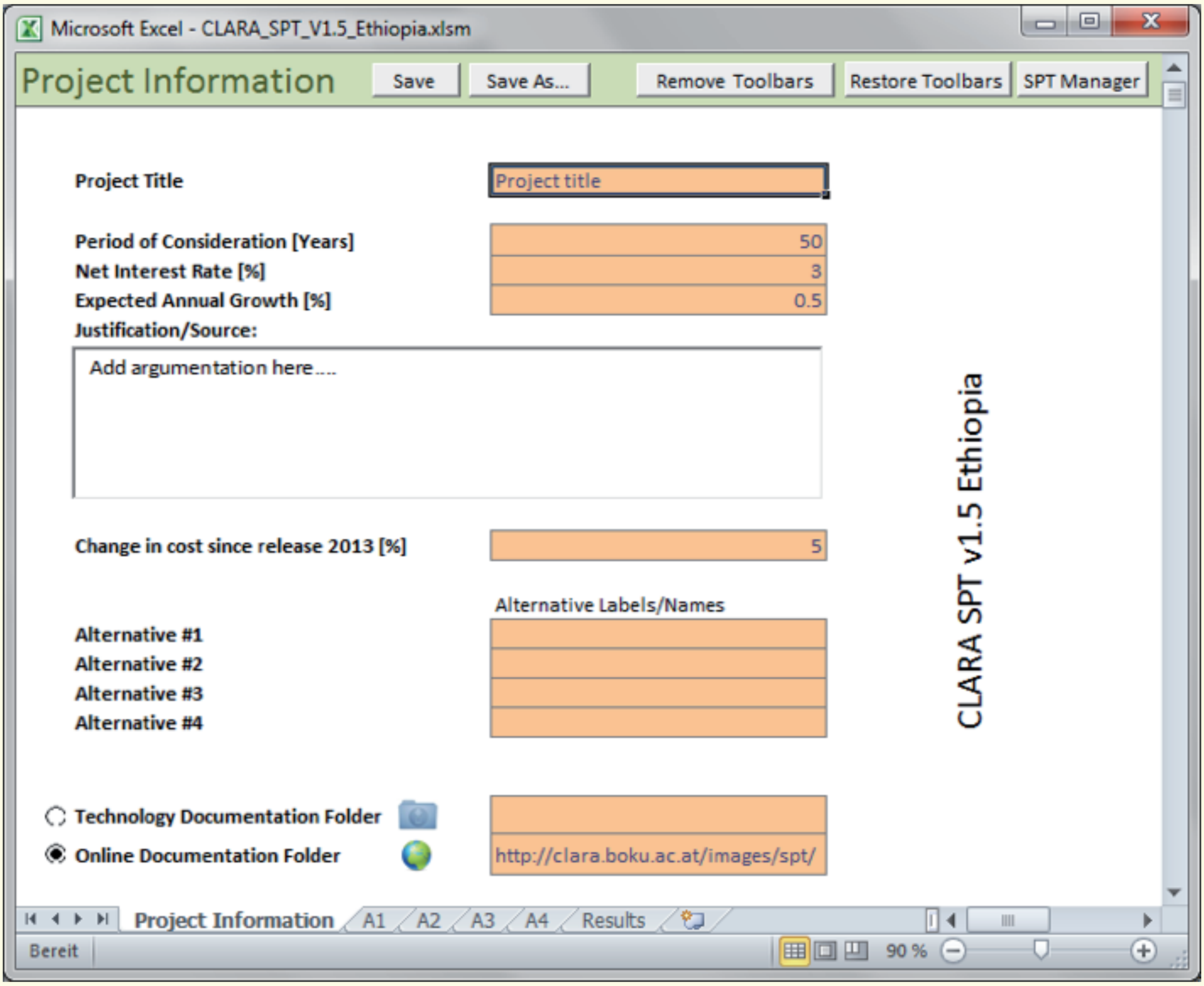

Figure 2: User interface of the CLARA Simplified Planning Tool

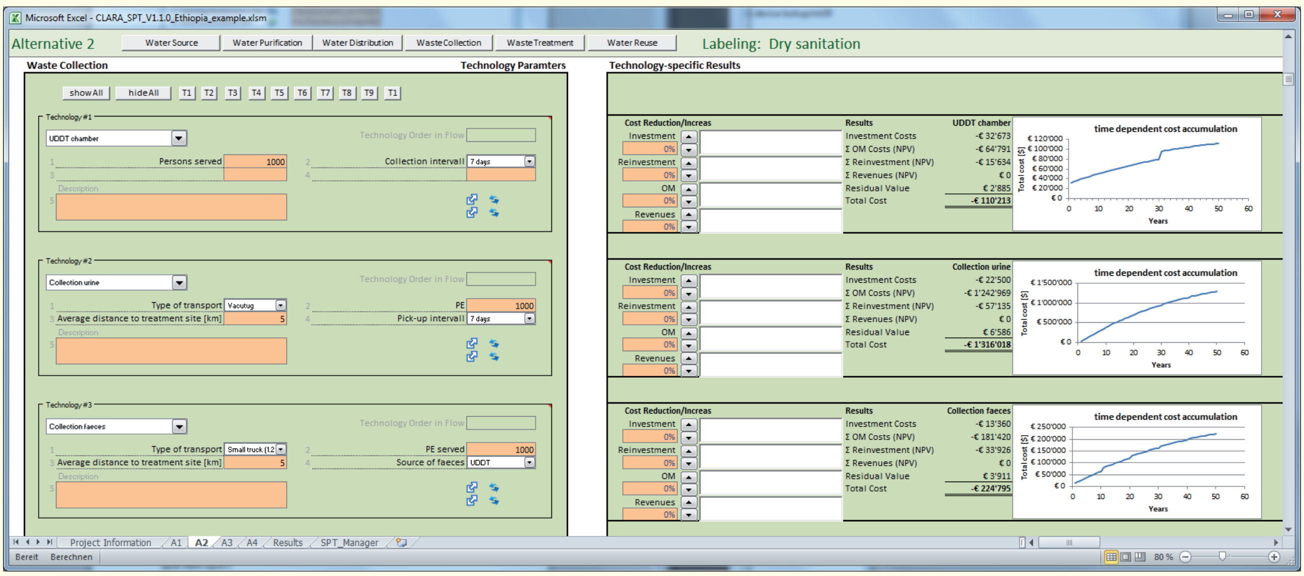

Figure 3: Technologies in the „Waste Collection" functional group.

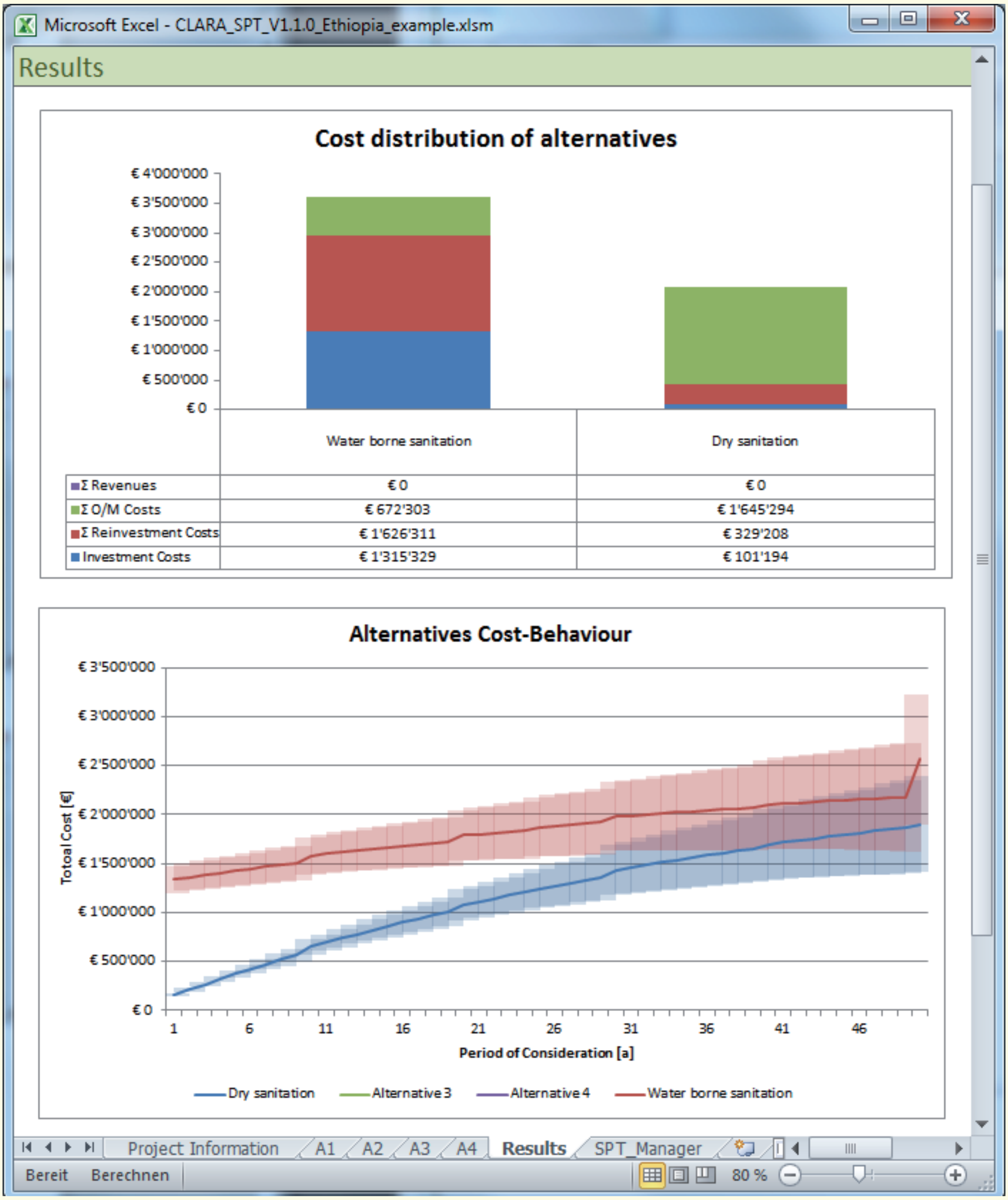

Figure 4: Comparison of life-cycle costs of a water-borne and dry sanitation alternative for 1000 persons

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Case study Frasers, Kwa-Zulu Natal, South Africa

This paper reports on the application of the CLARA Simplified Planning Tool (SPT) to assist local municipalities in assessing water and wastewater services options in a peri-urban settlement in Frasers in Kwa-Zulu Natal, South Africa.

Authors: Marlene van der Merwe-Botha, Gary Quilling, Valerie Naidoo

Abstract

A "Simplified Planning Tool' presents an ideal mechanism to provide a relatively quick and easy "broad brush" perspective of various alternative water and sanitation system options and their long- and short term cost implications on a site-specific basis. At present, the CLARA SPT is considered to be the only comprehensive tool with a comparative facility available in the South African market.

This case study focuses on the use of a SPT to compare 3 wastewater technology options for Frasers, a peri-urban informal settlement located in Kwa-Zulu Natal and documents the process followed with the stakeholders. In this settlement, sanitation is provided via communal ablution facilities, consisting of two shipping containers (males and females) as an interim solution.

Based on discussions with eThekwini Municipality, a baseline evaluation and a technology and system assessment were completed and three wastewater technology alternatives were compared using the SPT developed during the CLARA project.

The results show that a conventional service that links Frasers to the existing Tongaat bulk sewer system, over a 50 year period, is a more feasible option than the current selection of on-site sanitation. The complications which eThekwini Municipality must address during their decision process are land ownership, wetland protection and the nomadic nature of population which settles in Frasers.

Introduction

For South Africa, the Water Research Commission (WRC) was the project partner in the CLARA project and eThekwini Metropolitan Municipality was the project partner in whose jurisdiction the project was piloted. The Frasers settlement in Kwa-Zulu Natal was selected as the pilot community. The rationale for selecting the eThekwini Municipality as a project partner was that:

- eThekwini Municipality is a good representative of local government in South Africa, which is responsible for water and wastewater service provision in urban, rural and semi-urban areas;
- The municipality has adopted a resource-based water services management mindset and has partnered with non-governmental organisations (NGOs) and private sector entities in implementing dynamic and innovative water supply and sanitation to disadvantaged communities';
- The Frasers community is an ideal pilot site, with a community size of < 10,000 people
- A number projects are in place within the municipal area, whereby multiple technologies are evaluated, including urine diversion system (UDS), palletisation of sludge, recycling, rainwater harvesting, membrane technology, struvite value-adding, etc.
- eThekwini has the technical capacity, management commitment and academic associations to support and implement a project of this nature.

Key messages:

- The value of the CLARA SPT is apparent when investigating the alternatives and evaluating the differences between the alternatives. Adjustments can be made at various cost or input data levels to compare different perspectives within the same actual scenario.
- The tool has the potential to inform planners, engineers and municipal management of the longer term cost implications and thus the viability of various system options for a municipality and thus, contribute to the promotion of sustainable long term plans for communities.

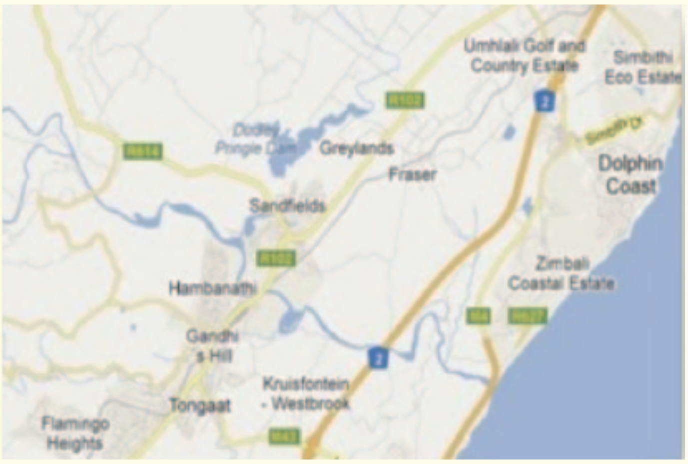

Figure 1. Location of Frasers settlement

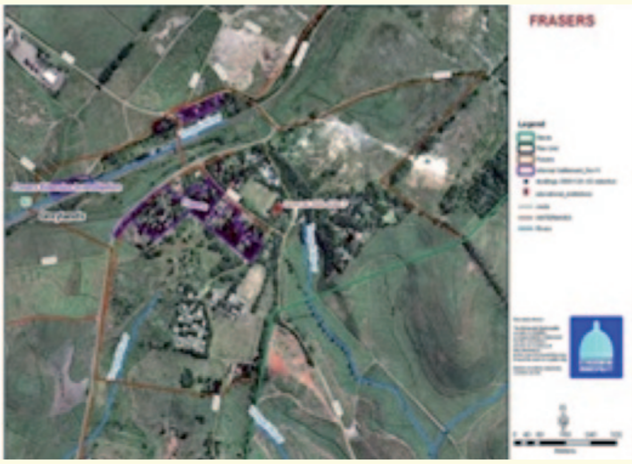

Figure 2: Settlement boundary and topography

Creation of the Enabling Environment

The project used a participatory approach to sensitize the various stakeholders to the objectives and gain support for the project. The project was initiated with the signing of a MoU between the WRC and eThekwini. Thereafter meetings were held with eThekwini, community stakeholders, academics and consultants to obtain data for the baseline study, conduct a technology assessment of possible alternatives and provide input data to the team developing the tool.

Baseline assessment of Frasers Community

Location and topography

Frasers is a peri-urban settlement within the Ethekwini Metropolitan Council jurisdictional area, in the Kwa-Zulu Natal (KZN) Province. It is located approximately 40km north of Durban's central business district (CBD) (Figure 1). The settlement is characterised by a relatively flat topography which is characteristic of the coastal plain east of Tongaat (Figure 2).

The Frasers population is low density and unevenly distributed. The majority of the inhabitants are migrant labourers from the Eastern Cape, doing mostly seasonal and contract work on the sugar cane plantations and farms. The majority of the people living in the settlement have a low income base or are unemployed and hence, unable to provide for their basic needs.

Wastewater services

eThekwini's EWS is the municipal engineering unit that is responsible to provide water and sanitation services to all customers and potential customers in the municipality. Due to the informal nature of the Frasers settlement, EWS provides water via communal stand pipes.

In order to improve the level of sanitation, EWS has established communal ablution facilities at Frasers. The ablution facilities have been constructed from shipping containers and are established at central points in the settlement. Two containers (one for males and one for females) are built next to each other (Figure 4).

Water is supplied to the facilities through the municipal main pipeline. The wastewater is dealt with on-site and is not connected or discharged to the municipal sewer network, as the closest network connection point is 4km away and passes sensitive wetland areas.

Figure 3: Typical Informal Settlement House

Figure 4: Communal ablution facilities

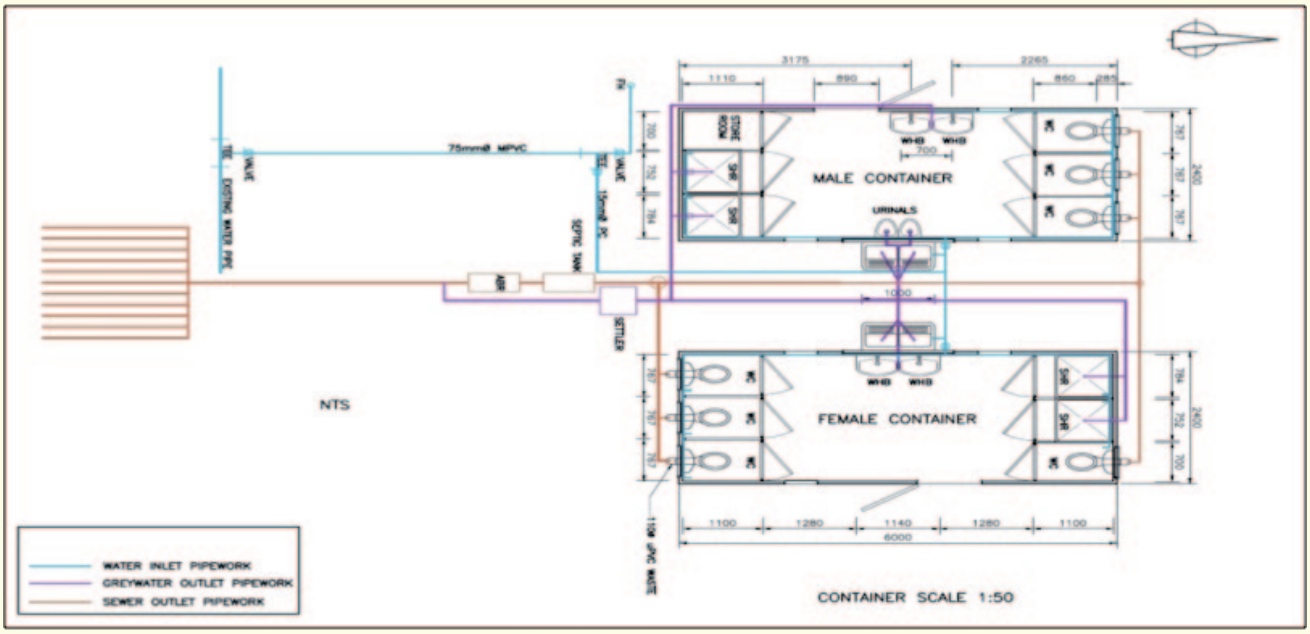

Figure 5: Process Flow Diagram of a typical CAB system

Gathering of Frasers comparative technical information for testing with the SPT

Current situation

<u>Water supply:</u> The existing rudimentary water service provision is seen to remain in place and no changes that impact on Frasers is foreseen in terms of water supply. Plans are in place to supplement supplies with rainwater harvesting in certain instances. Subsequently, water supply was not tested with the SPT, although this functionality is available.

<u>Sanitation:</u> Service is provided via communal ablution blocks (CABs) and limited on-site services. This is considered as an interim solution. The current system allows for the CAB effluent to be treated (on-site) via anaerobic baffle reactors (ABR) or septic tanks (in the case of the school) and evapo-transpiration fields (as polishing or secondary treatment).
Each CAB consists of two separate containers for male and female ablution facilities on a platform. A CAB services approximately 50-75 households (worked on 2.5 PE/household) at a walking distance of 250m. Water supply for the ablution facilities includes shower, hand basin, urinals, toilets and an outside wash trough. Figure 5 provide the layout of a typical ablution facility.

Planning assumptions:

Critical planning assumptions include:

- Increased poverty and unemployment in the pilot site
- Stable growth curve in community (1.8% /a)
- Continued seasonal influx of people (agricultural employment)
- Inability of community to pay for service
- Community unable to sustain requirements to operate and maintain system
- Vandalism to remain high in the area
- eThekwini Municipality to finance and install the services, and maintain system in future.

The design of the ABRs and septic tanks were based on previous in-house data. There are no effluent guideline values for CABs, nor do they fit in any of the scenarios presented in the guidelines SANS 10400 (2010), as the CABS include communal showers, basins, laundry facilities, toilets and urinals.

Sewage of 'low to medium strength' is produced, consisting of COD of 300 – 700 mg/l, ammonia of 28 mg/l and PO_4-P of 18 mg/l. Wastewater is generated mostly from laundry water (65%), showers (16%), toilet water (17%) and hand basins (2%). Vandalism is fairly general (absence of toilet seats, unsealed floors, cistern covers removed, etc.). Future alternatives in terms of wastewater management consist mainly of off-site sanitation.

Investigated alternatives

Due to the dispersed nature of the settlement, it was decided that five (5) CABs would in the interim adequately service the community in terms of water and sanitation requirements. For the purposes of this study they are referred to as CAB A to CAB E.
The three alternatives that were compared using the SPT are shown in Table 1 and can be summarised as follows:

- *Alternative 1: Current Situation: CAB and on-site sanitation: Sewerage Collection to septic tank & ABR*

  Historically, on-site sanitation via CABs was

Table 1: Description of the three alternative options.

Alternative 1 = Existing sanitation services	Alternative 2	Alternative 3
CABs and on-site sanitation: Septic tank, ABR & Leach Field	CABs linked Tongaat WWTW (centralised)	CABs linked to localized WWTW

considered to be the most effective short term option. For each CAB, the ablution block discharge sewage to a designated septic tank and ABR. From the ABR it is dispersed to a soak-away leach field. Most of the trenching was done within the sidewalk area and a minimal amount of road crossing was required to gain access for the leach field (CAB D & CAB E).

Each soak-away covers a 1680m² surface area. The SPT used did not provide a field for a leach field; hence these costs are not included in the calculations.

Faecal sludge is collected using a 5000 L tanker once every12-18 months. It is assumed that during one trip the tanker pick-ups sludge from only one CAB. Faecal sludge is disposed at Tongaat WWTW

- *Alternative 2: Conventional Sanitation System: Off-site Connect to Tongaat WWTW*

  Alternative 2 still includes the 5 CABs, as for Alternative 1. Due to no sewerage system in Frasers, and the low lying areas being protected wetlands, an off-site sanitation solution (conventional system in terms of WWTW) is difficult. For a conventional system to be put in place it would involve 3 secondary gravity sewer collector systems from the CABs to a main pump station. From the pump station the sewerage will have to be pumped along a 4 km pipeline to be connected to the existing Tongaat bulk sewer line. There are 4 Technology Components which makes up the system, which were applied in the SPT.

- *Alternative 3: Conventional Sanitation System: Off-site Connect to Localised WWTW*

  The same 5 CABs apply as for Alternatives 1 & 2. The Frasers community is in a low lying protected wetland area, thus permission for a localised off-site sanitation solution, such as the development of a WWTW is unlikely. However, if permissible, it would involve 3 secondary gravity sewer collector systems from the CABs to a main pump station. From the pump station the sewerage will have to be pumped along a 1.4 km pipeline to be discharged into a "new local WWTW" that consist of a septic tank, an ABR and a HF CW. There are thus 5 Technology component options which will make up the system, where Components 1, 2 and 3 are the same as for Alternative 2)

Certain input constants were required for the SPT for all three alternatives, these were:

- Period of consideration: 50 years
- Net interest rate: toll allows for default of 3% (should be 8.5% for SA)
- Expected annual growth: 1.8%

For each Alternative the steps followed and information required broadly, were as follows:

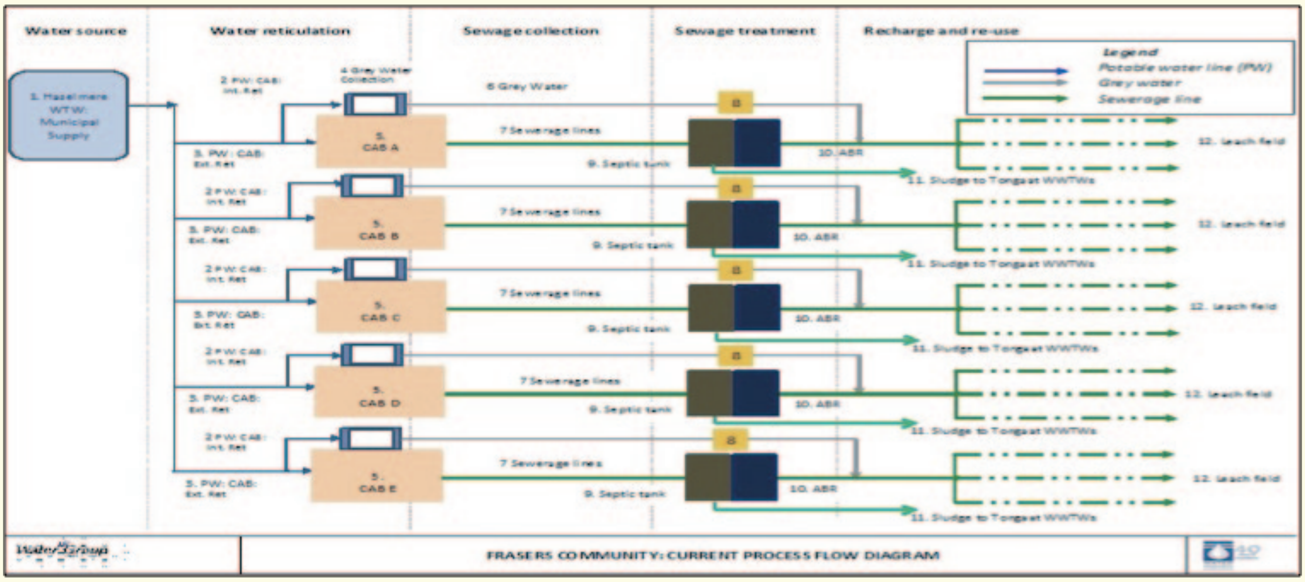

Figure 6: Alternative 1: Frasers Community Process Flow Diagram: On-site Sanitation

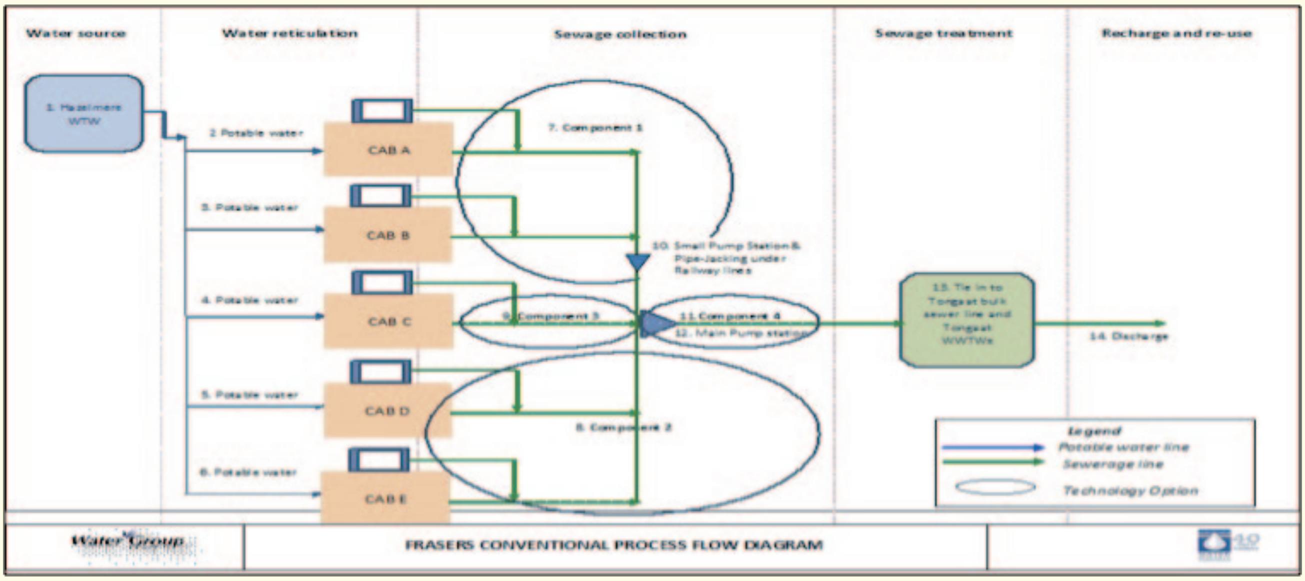

Figure 6: Alternative 1: Frasers Community Process Flow Diagram: On-site Sanitation

1. A system process flow diagram was developed for each alternative. Examples of these are demonstrated in Figures 6 and 7, for Alternative 1 & 2 respectively.
2. A system description was done. This consisted of identifying the Sewer Design Parameters & Flow rates and defining the various Functional Groups (eg water source, reticulation, collection, treatment and recharge and re-use) that form the specific Alternative. Examples of these are provided in Table 2 and Table 3, for Alternative 1 & 2 respectively.
3. The system was then divided in technology components with technical specification necessary for input into the tool. Examples of these are provided in Table 4 and Table 5, for Alternative 1 & 3 respectively.

Table 2: Technology components for alternative 1 – On site Sanitation:

Functional group	Technologies
Waste Collection:	***Technology 1, 3, 5, 7 & 9: Sewer for CAB A-E*** PE 200, trench depth 0.8m (1.2m where road crossing CAB D & E), Sewer length 66 – 113 m, depending on CAB ***Technology 2, 4, 6, 8 &10: collection of faecal sludge*** 5 pick-up points, 1x annum, 5 m3/a (Single 5000l tanker Vacuum Truck used) Due to size of tanker it is assumed that only one pick per CAB set. Discharge to Tongaat WWWT (12km - Average distance to treatment site)
Waste Treatment:	***Technology 1, 3, 5, 7 & 9: Septic tank for CAB A-E*** PE 200, 1x tank 6mx3mx2m ***Technology 2, 4, 6, 8 &10: ABR for CAB A-E*** PE 200, 1x ABR 6mx3mx2m

Table 3: Technology components for alternative 3 – Off site Sanitation Localized WWTW:

Functional group	Component & Description	Technologies
Waste Collection:	**Component 1:** • Gravity fed from CAB A & CAB B • Small pump station for pipe jacked section No provision in SPT for pipe-jacking.	***Technology 1: Sewer*** PE = 200 (municipal design use of the CAB), Average trench depth = 1.2m (Municipal standard - road crossings) Sewer length = 283m ***Technology 2: Sewerage pumping station*** Hourly water flow [m³/h] = 1.2 Pressure head [m]= 6m
	Component 2: Gravity fed from CAB D & CAB E to Main pump station	***Technology 3: Sewer*** PE = 400 (2 CABs input) Average trench depth = 1.2m Sewer length = 560m
	Component 3: Gravity fed from CAB C to main pump station	***Technology 4: Sewer*** PE = 200 (single CAB input) Average trench depth = 1.2m Sewer length = 700m
	Component 4: Pumped section from Main pump station to the discharge point at the planned local WWTW. Some lift will be required.	***Technology 5: Sewerage pumping station*** Hourly water flow [m³/h] = 3.04, Pressure head [m]= 8m ***Technology 6: Sewer*** PE = 1000 (input from 5 CABs) Average trench depth = 1.2m Sewer length = 1400 m
Waste Treatment:	***Component 5:*** New WWTW, planned capacity 1000PE, Consist of Septic tanks, ABR and a horizontal flow constructed wetland (HF CW). Land purchase necessary – (increased investment cost by 20%).	***Technology 1: Septic tank*** PE = 1000 (based on CABs) Number of septic tanks = 3 ***Technology 2: ABR*** PE = 1000 80% historic sludge removal assumed due to additional digestion in ABR ***Technology 3: HF CW*** PE = 1000 Specific Area (m^2/PE) = 1.2

Results

Original alternatives

The results from using the SPT (Table 4) indicated that the current selected option (on-site sanitation) is not feasible as a permanent service option over a 50 year period and that a conventional service provision (link to existing Tongaat bulk sewer system) will be more feasible. Although the comparison is conceptually correct, the tool does not make provision for specific cost items which could substantially impact on the cost comparison. These are:

- The required steel pipe jacked section under the railway line is a specialised and expensive activity. This requirement is based on the location of the CABs which needs to be within walking distance and wetland conditions. Although the initial investment cost can be averaged out over the 50 year period, replacement cost and maintenance might be more costly than normal.
- Rapidly increasing electrical cost in RSA will substantially impact of future cost viability of a pumping stations.
- Possible cost changes in Alternative 3 relating to land purchase (20% increase in investment cost).

The described costs amendments can be included in the SPT by the planner but have not been included in this study.

Table 4: Comparison of the 3 Alternatives

#	Alternative Description	Investment Costs	Σ Re-investment Costs	Σ O/M Costs	Σ Revenues	Total Costs/ Profits	Final Residual Values
1	Current - CABs and on-site sanitation:	€ 685 703	€ 699 222	€ 8 424 203	€ 0	€ 9 809 128	€ 81 126
2	Future - linked to neighbouring waterborne system	€ 182 923	€ 11 424	€ 202 013	€ 0	€ 396 360	€ 1 412
3	Future - linked to localised WWTW	€ 244 942	€ 94 709	€ 283 560	€ 0	€ 659 168	€ 2 495

Amended input parameters

It is noted that for alternative 1, de-sludging by tanker has been a major cost element as regular de-sludging mainly due to "abuse" of the CAB (inappropriate material flushed = reduced effectiveness of tanks). Effective community education programmes on the correct use of the CABs could reduce this costly requirement.

Negligible cost requirement for de-sludging could be achieved if the bi-annual de-sludging of tanks is outsourced in a resource orientated manner, e.g. utilised for pelletisation and composting. In RSA the "re-use" market for the sludge is still limited for its agricultural value.

Thus, if the cost of the tanker could be "taken out" of the equation then a very different scenario is presented, which is shown in Table 5 and Figure 8 below.

The above option shows the three alternatives moving closer in viability and also represents a closer alignment to what would be the 'expected' results. These 3 scenarios highlight the value of the tool in playing with components of the system to be installed and managed. The order of financial feasibility is shown in Figure 9.

Table 5: Comparison of the 3 Alternatives excluding de-sludging

#	Alternative Description	Investment Costs	Σ Re-investment Costs	Σ O/M Costs	Σ Revenues	Total Costs/ Profits	Final Residual Values
1	Current - on-site sanitation without de-sludging	€ 211 974	€ 92 901	€ 110 972	€ 0	€ 415 847	€ 1 881
2	Future - linked to neighbouring WWTW system	€ 182 923	€ 11 424	€ 202 013	€ 0	€ 396 360	€ 1 412
3	Future - localised WWTW	€ 244 942	€ 94 709	€ 283 560	€ 0	€ 659 168	€ 2 495

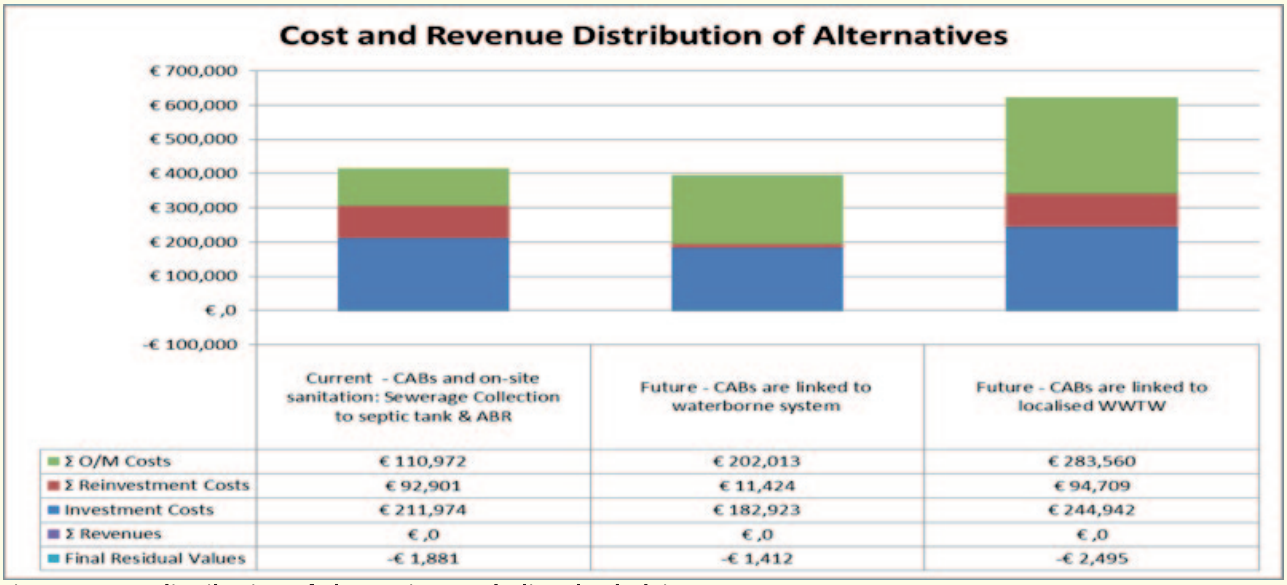

Figure 8: Cost distribution of alternatives excluding de-sludging

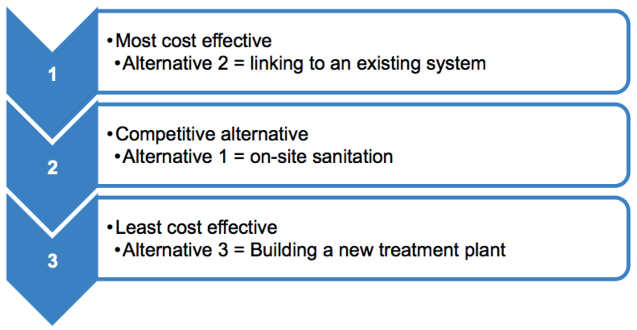

Figure 9: Cost distribution of alternatives excluding de-sludging

Feedback from stakeholder engagement on SPT results and use

A final engagement was held between the project team, academics and the technical staff at eThekwini. The feedback can be summarised as follows:

By its nature of being a "Simplified Planning Tool", the SPT provides an excellent tool to conduct direct comparisons between technologies across the water delivery value chain or water cycle. The results present valuable information that allow engineers and planners to come up with a first order indication of which of the systems tested present the most appropriate and viable option to the specific settlement.

The tool is the only known tool of this kind in the South African water service industry and carries a significant potential to be further developed and applied on a national basis. A number of elements may be addressed via further development, which mostly relates to specific cost items that could be included in the tool to allow enhanced cost comparison:

- Costs should be reflected in Rand (ZAR) instead of the Euro-based cost function;
- Lack of revenue collection and public demand, also detrimentally impacts on the viability of the service option. This tool therefore, allows municipalities to assess the long term financial viability of the options they are choosing. A broader range of technology options (i.e. rain harvesting, CABs, package plants, etc) could be included in the SPT, in particular systems that deals with resource-oriented technology. Appropriate technologies are often very different between rural / semi-urban areas as opposed to high density urban areas;
- Indirect cost elements, such as land purchases, need to be accounted for in order to present a straight non-skewed end result.

Overall, it is the finding from this study that the SPT presents an ideal mechanism to provide a relatively quick and easy "broad brush" perspective of various alternative technology options and their long term and short term cost implications. To the authors' knowledge, there is no current equivalent SPT available for the South African market that can provide such a comprehensive system comparative facility.

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Case study Arba Minch, Ethiopia

Water supply and sanitation system pre planning and CLARA Simplifying Planning Tool Application for Arba Minch, Ethiopia.

Authors: Atekelt Abebe Ketema, Teshale Dalecha, Eshetu Assefa

Abstract

Proper planning, implementation and prescheduled maintenance and operation of water supply and sanitation (WS&S) systems can significantly improve the lively hood of communities and assure system sustainability. However, in most of developing countries, like Ethiopia long term integrated WS&S planning for towns and even for mega cities is of the least priority. Introducing feasible WS&S alternatives through standardized planning steps is the main objective of this study, which is followed by economic performance evaluation using CLARA Simplifying Planning Tool (SPT). The pre-planning process resulted in two feasible water supply and three sanitation alternatives. In this paper we only show the SPT input parameters and results for the water supply alternatives. According to CLARA SPT comparison results, water supply from spring and borehole is economically viable solution for Arba Minch for 20 years planning horizon.

Introduction

Arba Minch town received its name for the abundant (about forty in number) spring resources producing a safe yield of 110 l/s (Zagie 2010). The town establishment dates back to 1940s with an official municipal establishment in 1955. Administratively it is located in Gamo Gofa zone of the Southern Nations, Nationalities and Peoples Region (SNNPR) at a distance of 500 km south of Addis Ababa (capital of Ethiopia). Based on the 2007 census the town population number was estimated to be 75,000 (CSA 2008; ROSA 2009) and projected to reach 121,000 by 2015 (Drewko 2007). The town occupies about 5566 hectares and its elevation various from 1200 to 1320 m.a.s.l. with average annual rainfall of 1200 mm and 23 °C annual average temperature (Assefa and Bork 2014). The town administratively divided in to four sub-cities called Shecha, Nechisar, Sikela and Abaya. Based on topographical setup and socioeconomic activities the sub cities categorized into "upper town administrative center" comprises Shecha and Nechisar and "down town commercial and residential area" encompasses Sikela and Abaya.

Even though the town has ample water resource potential, existing water supply coverage estimates only about 56% (AWSSE 2013). The country building design standard propose a diurnal domestic per capital water consumption rate of 60-100 l for house connection and 30-35 l for yard connection (EMWUD 1995).

It is difficult to find reliable sanitation coverage information specifically for Arba Minch town; but from field visit it was observed that the town residence live with poor sanitation condition. WHO and UNICEF joint monitoring program report also shows the improved sanitation coverage of the country is about 29% and 21% for urban and rural areas respectively in 2010 (WHO/UNICEF 2012).

Key messages:

- An Integrated water supply and sanitation system planning is fundamental to the food security, health, survival, social well-being and economic growth in developing countries
- The CLARA Simplifying Planning Tool can be used in the system pre-planning phase to preliminary evaluate economic performance of water supply and sanitation alternatives.
- The economic analysis for the planning horizon provide the whole financial figure of alternatives by concerning one time and recurrent expenses which aids decision makers and planners to foresee life time cost of possible WS&S systems.
- In Arba Minch operation and maintenance costs for a water supply relying only on boreholes have shown to be significantly higher than for a system served with hybrid source (spring and borehole).

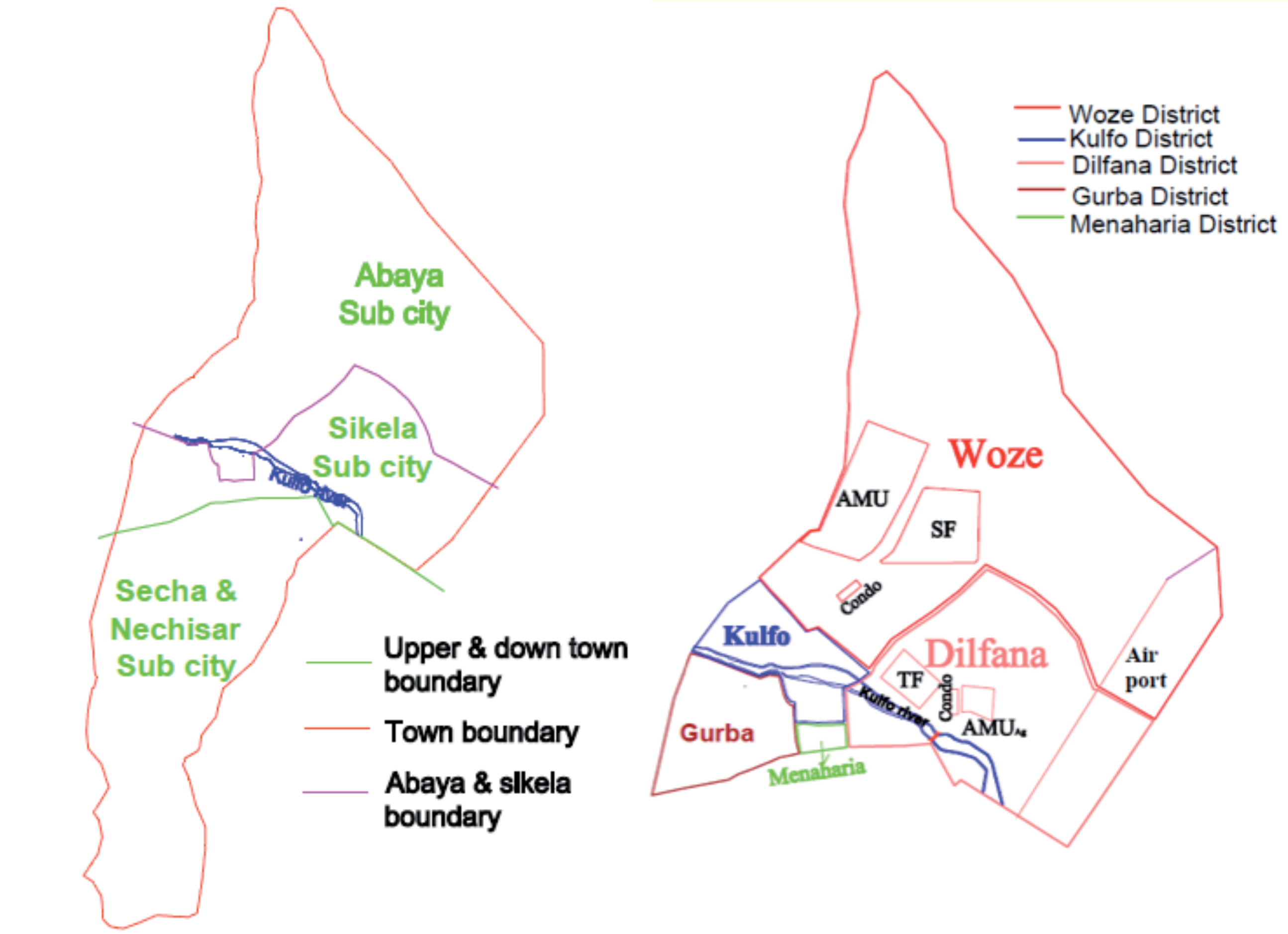

Figure 1 (a): Arba Minch town four administrative sub-cities; (b): administrative kebeles and main institutions with in Abaya and Sikea sub-cities

The technological option of WS&S is closely related to the availability of safe and adequate water supply potential, socio-economic activity, geographical and demographical information and waste water emission regulation of the intervention area. Ground water source, like spring development, boreholes and shallow wells are found the predominant water supply sources in the vicinity. For ground water source, chlorination is the principal purification method. Moreover surface and/or elevated reservoir, pumping station, and pipe networks are the common water distribution technologies in the region.

There is a big interest in simple, low-cost sanitation solutions, since average monthly household income is only about 727 ETB (ca. 30 EUR) in 2009 (Adedimeji et al. 2012). So that ventilated pit latrine (VIP), urine diversion dehydration toilet (UDDT), composting toilet, septic tank, gravity aided sewer system, composting, constructed wetland, waste stabilization pond and sludge drying beds were identified as feasible waste collection and treatment technologies.

Pre-planning process

Water supply and sanitation system planning process was done based on the three step simplified planning method (Frenoux et al., 2010). Detail data collection and analysis of the existing situation of the study area is the preliminary step for WS&S system planning. The data has been collected through household survey, responsible authorities and residents' interview and socio-economic and environmental condition assessment. Eventually the following three steps were followed:

Step 1: Study area characterization

Step 2: Best water supply and sanitation chain determination

Step 3: Appropriate technologies

Step 1: Study area Characterization

Beside to the town residence, main institutions like Arba Minch University main and agricultural campuses (AMU & AMUAg), state farm (SF), airport (AR), and textile factory (TF) were identified in the study area. There are also two newly constructed condominiums (condo) located at Dilfana and Woze districts. Unlike to currently utilize ground flats in the town, condominium houses are equipped with all the necessary sanitation interfaces in the house water connection hence more than 60 l/c/d water demand are needed which leads to significant volume of wastewater generated.

The intervention area is administratively further divided in to smallest unit called "Kebele". Abaya sub-city divided in to

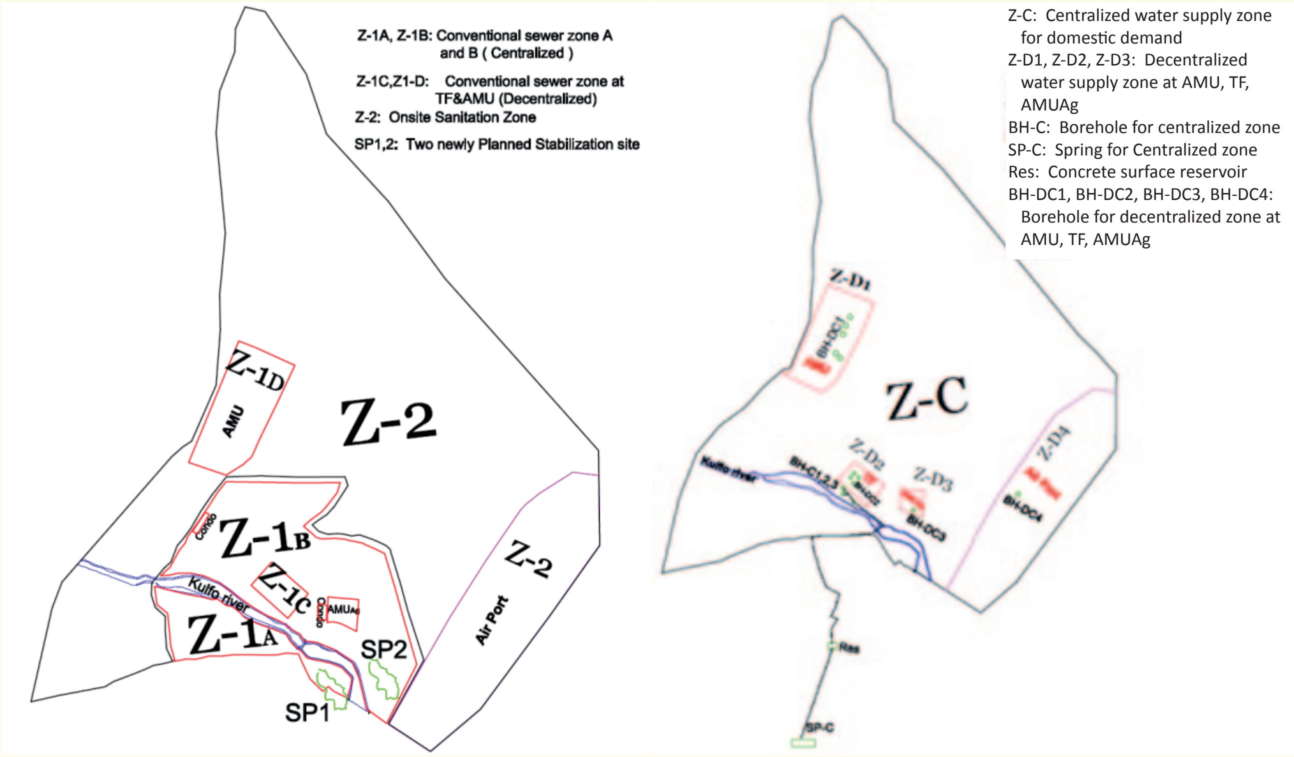

Figure 2 (a) sanitation system zones; (b) water supply system zones.

Kulfo and Woze, while Sikela sub-city encompasses Gurba, Menaharia and Dilfana (Figure 1). Detail demographic data (population size, annual growth rate, household no., household size, areal master plan, etc.), physical data (topography, soil type, ground water level, flooding extent, etc.), and socio-economic data (household income, daily water consumption rate, existing WS&S facilities, government policy and strategic plan direction, etc.) were collected to characterize the intervention area.

As the result of characterization the whole Menaharia, part of Kulfo, Woze, Dilfana are bounded as central business district, which are relatively economically active and densely settled area as shown in Figure while most of the other areas are used for residential and institutional service.

Step 2: Water supply and sanitation best chain selection

The collected data at step one have been used to propose feasible WS&S system chain for each homogenized district. The proposed sanitation alternatives are referred the existing and planned water supply systems. Hence, conventional sewerage sanitation chain considered as a possible alternative for densely settled central business district, multi-story buildings (condo) and for various institutions. While for the low income and sparsely settled areas on-site sanitation chains are the most probable solution for short term plan and scale up to sewerage system with time.

For water supply decentralized and centralized alternatives are proposed for institutions and domestic water demand respectively as of the demand characteristic and operational reasons. Inhabitant density, spatial water source location, socio-economic feasibility factors and master plan of the town lead to choose centralized water supply system for domestic demand. However, high water demand institutions and factories like Arba Minch University (AMU & AMUAg), Textile factories (TF) and Airport are proposed to have a separated (decentralized) water supply and waste water management system.

Due to significantly high wastewater generation rate of condominium houses and impermeable nature of the surrounding soil, currently practiced on-site sanitation technologies: septic tank + soak away pit was found to be environmentally and technically infeasible option and therefore it is recommended to connect condominium houses to conventional sewerage system.

Step 3: Appropriate technologies selection

The best suited set of technologies is selected for already proposed sanitation chains (onsite and offsite) and water supply chains (centralized and decentralized). Based on the following most dominant criterion: soil type, income level, land availability, ground water depth, land status, treatment efficiency, willingness to pay ,energy demand, professional manpower requirement and availability and etc WS&S technologies are evaluated by applying multi criteria analysis (MCA) method. As the result feasible WS&S technologies are selected for each functional groups (i.e. water source, purification, distribution, waste-collection, treatment and recharge/reuse), which are summarized in Table 1.

Table 1 Short listed suitable water supply and sanitation technologies for intervention area

System	Functional group	Selected feasible technologies
Water supply system	Water source	Spring
		Borehole Or Shallow well
	Water purification	Disinfection by chlorination
		Slow sand filter(SSF)
	Water distribution	Piping network
		Pumping station: surface centrifugal pumps
		Surface and elevated reservoirs
Sanitary system	Waste collection	Fossa Alterna
		Single /double VIP + Collection of faecal sludge
		UDDT chamber + Collection of urine and faeces
		Gravity aided sewer
		Septic tank + Collection of faecal sludge + effluent collection
	Waste treatment	Urine treatment (with storage or struvite precipitation)
		Composting
		Waste stabilization pond
		Sludge drying reed bed
		Constructed wetland
	Reuse	Irrigation use
		Compost use
		Struvite use

Proposed water supply and sanitation alternatives

As the result of the pre-planning process the selected WS&S technologies under each functional group are clustered in order to find out the potential technological alternatives (solutions), which are a complete set of technologies. Consequently two water supply alternatives and three combined sanitation alternatives are proposed, which are summarized in Table 2 & 3 to improve the WS&S coverage of the area.

Input parameters

Projected population number of the area estimates 87,509 in 2033 based on 4% annual growth rate. Consideration period of 20 years (planning horizon) and net interest rate of 3% are taken as general input values of the tool. An average of 4hrs/day electric power interruption has been experienced in the town; hence diesel generator is required to maintain pumping station functionality during electric

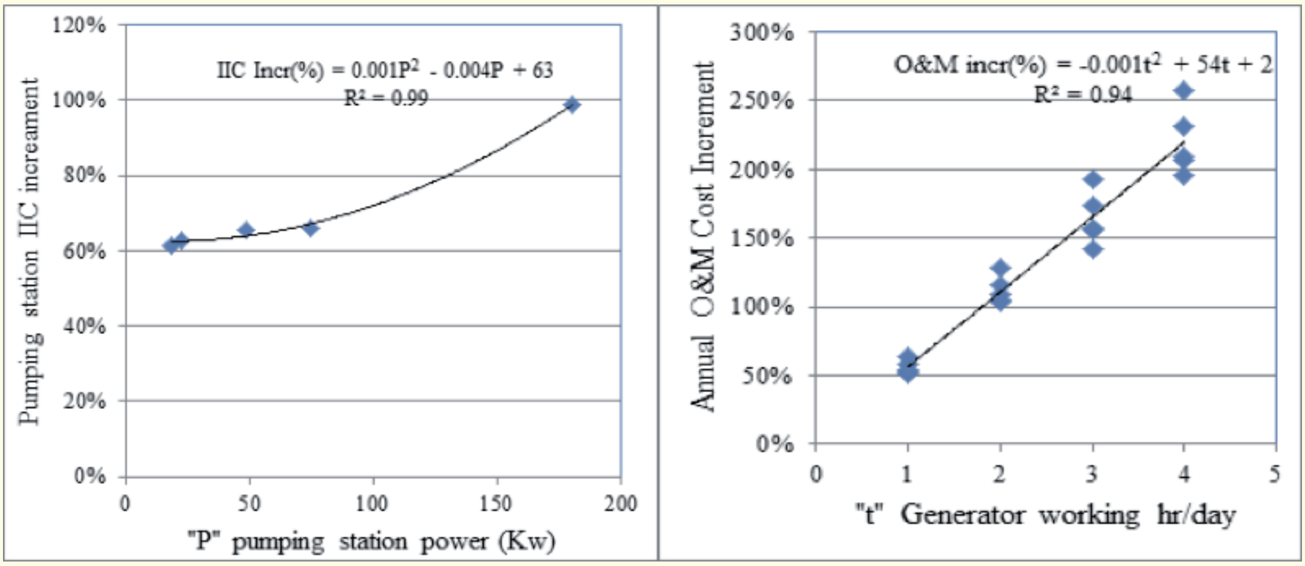

Figure 3 Initial investment costs (ICC) and annual O&M costs increment due to diesel generator use (database from Ethiopia)

Table 2: Proposed water supply alternatives

Zone name	Proposed system		Sanitation technological options		
			Water source	Water purification	Water distribution
Z-C: Centralized zone PE = 87,509	centralized water supply: sourced from spring and borehole	Alternative 1	Spring + ground water extraction (Borehole)	Disinfection	Water transport main+ Water pumping station + Surface water tank+ Water supply network
Z-D1, Z-D2, Z-D3: Decentralized zone for AMU, TF and Airport	Decentralized water supply: sourced from borehole		Borehole	Disinfection	Water pumping station+ Elevated water tank + Water supply network
Z-C	centralized water supply: sourced from spring and borehole	Alternative 2	Borehole	Disinfection	Water transport main+ Water pumping station + Surface water tank+ Water supply network
Z-D1, Z-D2, Z-D3	Decentralized water supply: sourced from borehole		Borehole	Disinfection	Water pumping station + Elevated water tank + Water supply network

Table 3: Proposed sanitation alternatives

Zone name	Proposed system		Sanitation technological options		
			Waste collection	**Waste treatment**	**Reuse**
Zone 1: (Menaharia, part of Dilfana, Kulifo and Woze) PE = 49708	Centralized treatment system	Alternative 1	House connection + Gravity sewer	Waste stabilization Pond +Sludge drying bed	Compost use Irrigation use
Zone 2 : (Gurba, part of Dilfana, Kulfo and Woze) PE = 37801	Sewerage system with urine diversion and composting toilet	Alternative 1	**40% of PE:** (UDDT + Collection of urine(motorized) + Collection of faeces (motorized)) + **60% of PE:** (composting toilet)	**40% of PE:** (Struvite production + Composting)	Compost use Struvite use
Zone 1	Centralized treatment system	Alternative 2	House connection + Gravity sewer	Waste stabilization Pond + Sludge drying bed	Compost use Irrigation use
Zone 2	Black water treatment system with sewerage	Alternative 2	Septic tank + Solid free sewer (Effluent) + Collection of faecal sludge (Vacuum truck)	Vertical flow constructed wetland + Sludge drying bed	Compost use Irrigation use
Zone 1 **Zone 2**	Centralized treatment system	Alternative 3	House connection + Gravity sewer	Waste stabilization pond + Sludge drying reed bed	Compost use Irrigation use
Zone 1D: Arba Minch University (AMU), PE = 20,000	Semi- Centralized treatment system	Institutional option for each Alternative	House connection + Gravity sewer	Waste stabilization Pond + Sludge drying reed bed	Compost use Irrigation use
Zone- 1C: Textile Factory(TF)	Semi- Centralized treatment system	Institutional option for each Alternative	House connection + Gravity sewer	Special treatment as of the waste quality	Irrigation use
Arba Minch Airport	Black water treatment system with sewerage	Institutional option for each Alternative	Septic tank + Solid free sewer (Effluent) + Collection of faecal sludge (Vacuum truck)	Horizontal/vertical constructed wetland Sludge drying bed	Compost use

Table 4: Technology components for alternative 1 –Centralized water supply system from borehole (67%) and spring (33%)

Functional group	Technologies
Water Source:	***Ground water extraction (borehole1 and 2):*** *extraction for* 20 hours per day - Daily water demand: 2160 m^3/d for each - Depth of ground water: 174 and 176 m for borehole 1 and 2 respectively - Borehole diameter : 20 inch for each - 30% Investment, reinvestment cost Increment and 220% O&M cost increment for each ***Spring water extraction :*** *extraction for* 24 hours per day - Daily water demand: 2394 m^3/d for each - Hydraulic conductivity: 0.00001 m/s
Water Purification:	***Disinfection*** - Daily water demand: 6708 m^3/d - Disinfectant type: Calcium Hypo chloride
Water Distribution:	***Water transport main :*** *from boreholes to reservoir* - Average daily water flow = 4320 m^3/d - Pipe length = 4720 m - Average trench depth = 1.5 m ***Water pumping station 1 and 2 :*** *from spring to reservoir and boreholes to reservoir, respectively* - Daily water demand : 2394 and 4320 m^3/d, respectively - Pressure head for : 140 and 100 m, respectively - Type: surface and subsurface, respectively - 50% Investment, reinvestment cost and 220% O&M cost increment for each ***Water transport main :*** *from spring to reservoir* - Average daily water flow = 2394 m^3/d - Pipe length = 2004 m - Average trench depth = 1.5 m ***Surface water tank*** - Daily water demand = 6708 m^3/d ***Water transport main :*** *from reservoir to distribution network* - Average daily water flow = 6708 m^3/d - Pipe length = 3516 m - Average trench depth = 1.5 m ***Water supply network :*** *from reservoir to distribution network* - Average daily water flow = 6708 m^3/d - Pipe length = 18850 m - Average trench depth = 1.4 m

power cut off time. As of the country standard hourly maximum flow rate is equal to 1.8 times maximum daily water demand.

Alternative 1: Centralized water supply system from borehole (67%) and spring (33%)

Table 4 shows the technology components for alternative 1. The SPT considers that a pumping station is fully operated with electric power, but in most of developing countries the availability of electric power at 24-7 is uncertain. Therefore a standby diesel generator is commonly installed as a part of pumping station to substitute the conventional electric power source during off time. Figure 3 shows the increase of initial investment costs (ICC) and annual O&M costs in relation to pumping station power and generator working time, respectively.

For alternative 1 it is assumed that the pump power = 78.4 kW. The initial investment costs of the pump are about 45% of total borehole cost. Hence Initial borehole investment cost increase is 0.45*68% = 30%. Four hours per day electric power interruption are recorded in Arba Minch on average. According to Figure 3 this leads to an average of 220% annual O&M cost increase.

Alternative 2: Centralized water supply system from borehole only

Table 5 shows the technology components for alternative 2. Similar to alternative 1, standby diesel generator presence results increment of ICC, reinvestment and annual O&M costs in a certain percentage Figure 3 in relation to pumping. All the three boreholes, which are sited at similar ground water aquifer area, are connected to a reservoir located at higher elevation via transportation main. Water distributed from reservoir to distribution network through gravity.

Table 5: Technology components for alternative 2 –Centralized water supply system from borehole

Functional group	Technologies
Water Source:	***Ground water extraction (borehole1,2 and 3):*** extraction for 20 hours per day - Daily water demand: 2160, 2160 and 2394 m3/d, respectively - Depth of ground water: 174 ,176 and 186 m , respectively - Borehole diameter : 20 inch for each - 30% Investment, reinvestment cost Increment and 220% O&M cost increment for each
Water Purification:	***Disinfection*** - Daily water demand: 6708 m^3/d - Disinfectant type: Calcium hypo chloride
Water Distribution:	***Water transport main :*** *from all boreholes to reservoir* - Average daily water flow = 6708 m^3/d - Pipe length = 8526 m - Average trench depth = 1.5 m ***Water pumping station 1:*** *from boreholes to reservoir* - Daily water demand : 6708 m^3/d - Pressure head: 100 m - Type : Subsurface - 50% Investment, reinvestment cost and 220% O&M cost increment ***Surface water tank*** - Daily water demand = 6708 m^3/d ***Water transport main :*** *from reservoir to distribution network* - Average daily water flow = 6708 m3/d - Pipe length = 3516 m - Average trench depth = 1.5 m ***Water supply network :*** *from reservoir to distribution network* - Average daily water flow = 6708 m^3/d - Pipe length = 18850 m - Average trench depth = 1.4 m

Results

The results from using the CLARA SPT show initial investment costs of those two alternatives are almost comparable, however, O&M cost of the second alternative is considerably higher than the first alternative. Therefore, as we can see from Figure 4, the second alternative (100% form borehole) is an expensive option based on 20 years economic life time performance assessment. From the result we have learnt that planning horizon based economic analysis and comparison provide the full financial picture of possible alternatives by taking in to account a one time and recurrent expenses within the defined time. As the result the planners or decision makers should be able to account the required capital and annual O&M cost of the fevered solution.

Conclusion

Profound and integrated WS&S infrastructure planning is a pillar to provide improved water supply and sanitation service for dwellers and maintain system sustainability. Economic performance evaluation of proposed alternatives is mandatory to select an optimal solution concurrently with environmental and social criteria based evaluation. It is important to look at the entire time expenses and benefits of WS&S systems, in order to assess economical preference of solutions. CLARA SPT provides an opportunity to estimate life time economic value of alternatives by analyzing one-time cost (initial investment cost) and recurrent costs (annual O&M, reinvestment cost and revenues) as well as salvage/residual value. The tool aids decision makers and planners to select economically most advantageous solution for both utility providers and service users.

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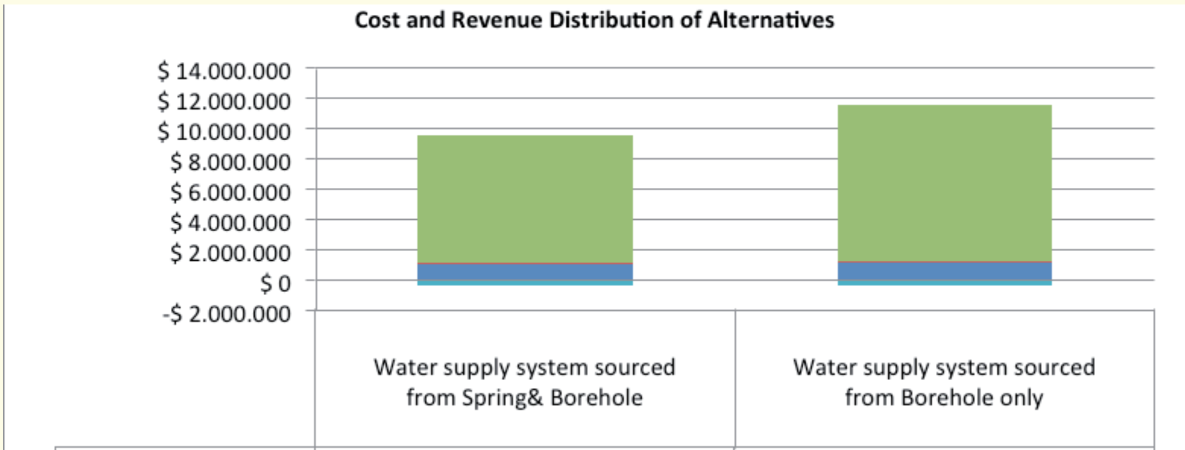

	Water supply system sourced from Spring& Borehole	Water supply system sourced from Borehole only
Σ O/M Costs	$ 8.410.260	$ 10.319.270
Σ Reinvestment Costs	$ 60.791	$ 81.317
Investment Costs	$ 1.069.951	$ 1.142.468
Σ Revenues	$ 0	$ 0
Final Residual Values	-$ 316.991	-$ 319.612

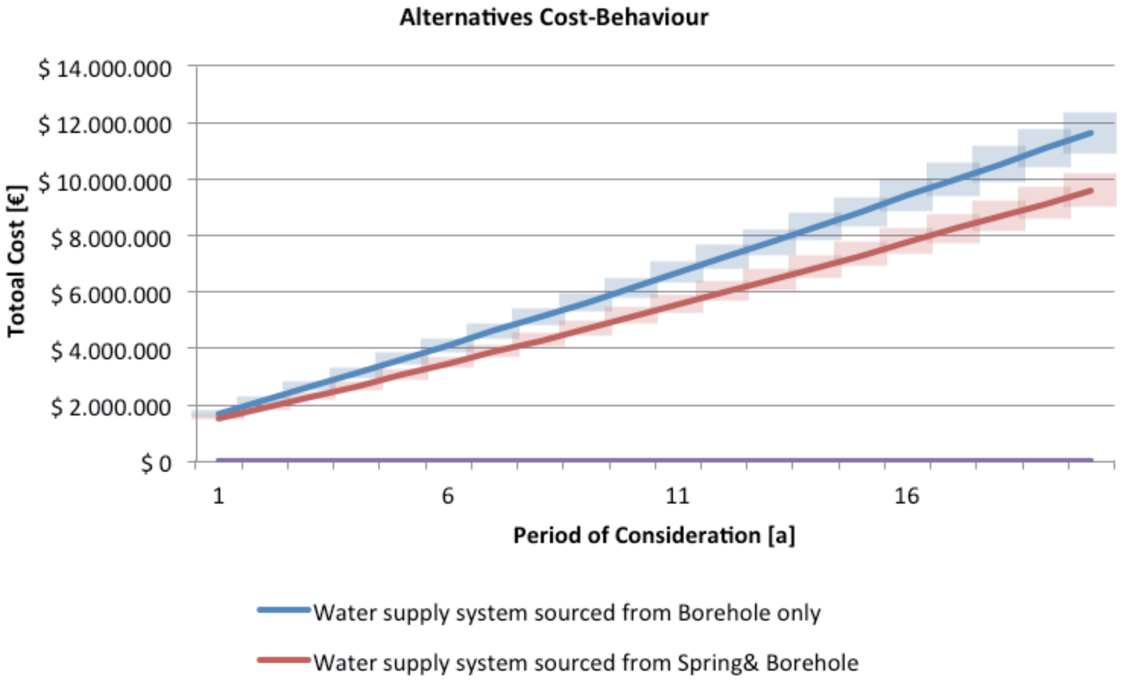

Figure 4: 20 years' time cost distribution of two water supply alternatives

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Case study Njoro Township, Kenya

This paper describes the application of the CLARA Simplified Planning Tool for integrated water supply and sanitation systems in Njoro Township, Kenya.

Authors: Mutua, B. M. and Gacheiya, R. M

Abstract

The demand for water supply and provision of sustainable sanitation in Njoro Township has increased rapidly as a result of the increasing population growth and the subsequent socio-economic pursuits. However, the township does not have any integrated water supply and sanitation systems in place. In addition, the township lacks local capacity to adopt, implement and operate these systems. Therefore, a comprehensive strategic planning process that addresses local capacity building and sustainable integrated water supply and sanitation solutions for the township is required. We used the CLARA Simplified Planning Tool (SPT) for comparing various alternatives of water supply and sanitation systems. From the baseline studies and the situational analysis that were carried out, Njoro Township was demarcated into three areas urban, peri-urban and rural farm lands. Different water and sanitation alternatives for the township were then compared using the SPT. The results show that the best sanitation and water supply alternatives are a Waterborne sanitation with sewer and Wastewater Stabilisation Ponds (WSPs), and Surface water (river source) respectively. In addition to selecting the systems, the study assisted in training the technical staff from the NARUWASSCO on the use of SPT for the pre-planning processes.

Introduction

A large number of small towns in Kenya evidently do not have any integrated water supply and sanitation systems in place. One such town is Njoro Township which in addition to lacking the systems itself lacks local capacity to adopt, implement and operate water supply and sanitation systems. With the increasing growth in population and the subsequent socio-economic pursuits within Njoro Township, the demand for water supply and provision of sustainable sanitation has increased rapidly. In the recent past, the supply of water has been characterised by chronic shortages. Many residents depend on multiple sources because no one source is completely reliable and sufficient. Some households draw water from community bore holes, Njoro River and a few households harvest rainwater.

Currently, Njoro Township does not have any strategic plan for water supply and sanitation. The township has no sewerage connection or any wastewater treatment plant. Within the town centre, disposal of wastewater is done through septic and through cesspools in some areas within the urban areas. The peri-urban and the rural farm lands rely on pit latrines for the disposal of wastewater. However, most of the existing pit latrines are unhygienic. Open dumping is evident in most areas of the township. Therefore, there is need for a comprehensive sustainable sanitation planning is inevitable. In Njoro, household, commercial and industrial activities generate a lot of waste both as wastewater and solid waste that requires treatment before its safe disposal. A few areas especially within the town centre rely on private waste collection and disposal services. However, these services are still inadequate even though they are limited to the main town.

Key findings for Njoro Township:

- Njoro Township does not have a water supply and sanitation systems neither a strategic plan to improve services. The population is rapidly increasing and the demand for improved water supply and sanitation is crucial
- The CLARA STP can be used by planners and technical staff in pre-planning processes for integrated water supply and sanitation. The SPT provides the planner with an easy way of comparing different solutions based on the costs.
- There is lack of technical capacity to design and implement integrated water supply and sanitation systems. Within the project the CLATA SPT was used to train technical staff, engineers and planners in Njoro

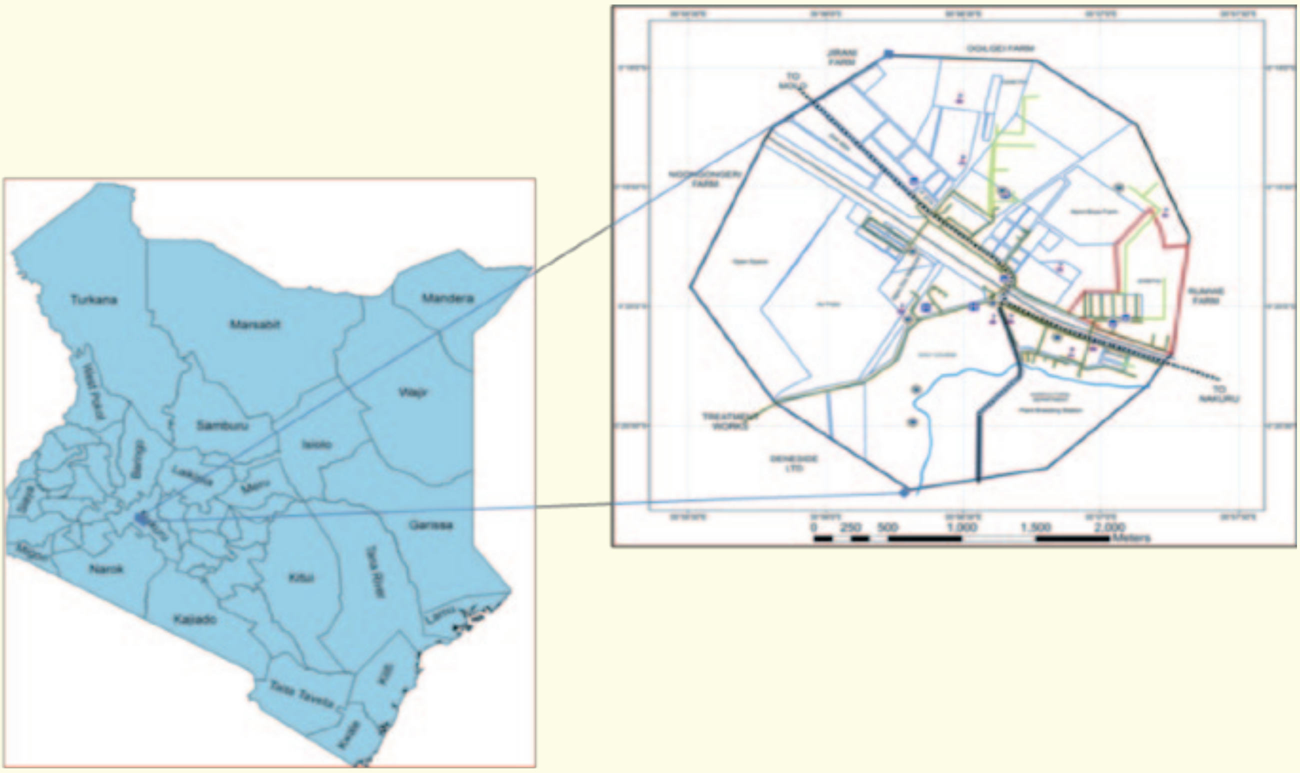

Figure 1: Map of Kenya showing Njoro Township

Figure 2: Current water source in Njoro Township

Figure 3: Commonly used sanitation systems and waste disposal in Njoro Township

Njoro Township

Njoro Township (Figure 1) is located within Njoro District which is one part of the Nakuru County on the eastern edge of the Mau Forest Complex. It lies within the Great Rift Valley and borders four other districts namely; Nakuru North to the North-East, Molo to the West, Rongai to the North and Narok to the South. The area lies between the forest and Lake Nakuru National Park. The district is divided into five divisions namely Njoro, Kihingo, Lare, Mauche, and Mau Narok. Njoro stands at an altitude of 1,800 m (6,000 ft) above sea level and has a mild, agreeable climate. The district covers an area of 798.01 km² and is located between Longitude 35º45’ and 35º46’ East and Latitude 0º16’ and 1º10’ South. Farmers practice mixed farming where they grow crops and keep animals. The main crops grown in the area are maize, wheat and horticultural crops (Walubengo, 2007).

Temperatures range between 17- 22ºC. The climatic conditions of the study area are influenced by altitude and physical features where it receives an average rainfall of approximately 1,270 mm annually. The township does not have an integrated water supply and sanitation. Many residents therefore depend on multiple sources because no one source is completely reliable and sufficient. Figures 2 and 3 show some of the current water and sanitation systems being used in the township.

Water and Sanitation alternatives for Njoro Township

From the baseline studies and the situational analysis, the Njoro Township was dermacated into urban, peri-urban and the rural farm lands (Figure 4). To compare the economic performance of the different water supply and sanitation alternatives, the complete technological chain for each alternative with respect to its input parameters was identified. The choice of the alternatives was informed by the current status of the water supply and sanitation systems. In addition, the topography, land availability, population growth, ground water table, water demand and waste generation, geology and the technological skills (human capacity).

The selected water and sanitation alternatives for Njoro Township were compared using the cost function which was calculated based on the Net Present Value (NPV) using the unit price for Kenya. A list of different technologies and their related cost functions was provided by the tool developer. These alternatives were then tested using the CLARA Simplified Planning Tool.

Groundwater and surface water from Njoro River were selected as the two alternative sources of water. Table 1 presents the functional groups, technologies/processes and the input parameters that were used in the SPT. For sanitation the following alternatives have been selected: dry Sanitation with urine diverting dry toilets (UDDTs), waterborne sanitation with cesspits and faecal sludge treatment, and water-borne sanitation with sewer and Wastewater Stabilisation Pond (WSP). The Technologies for each of the alternatives are shown in Tables 2 to 4.

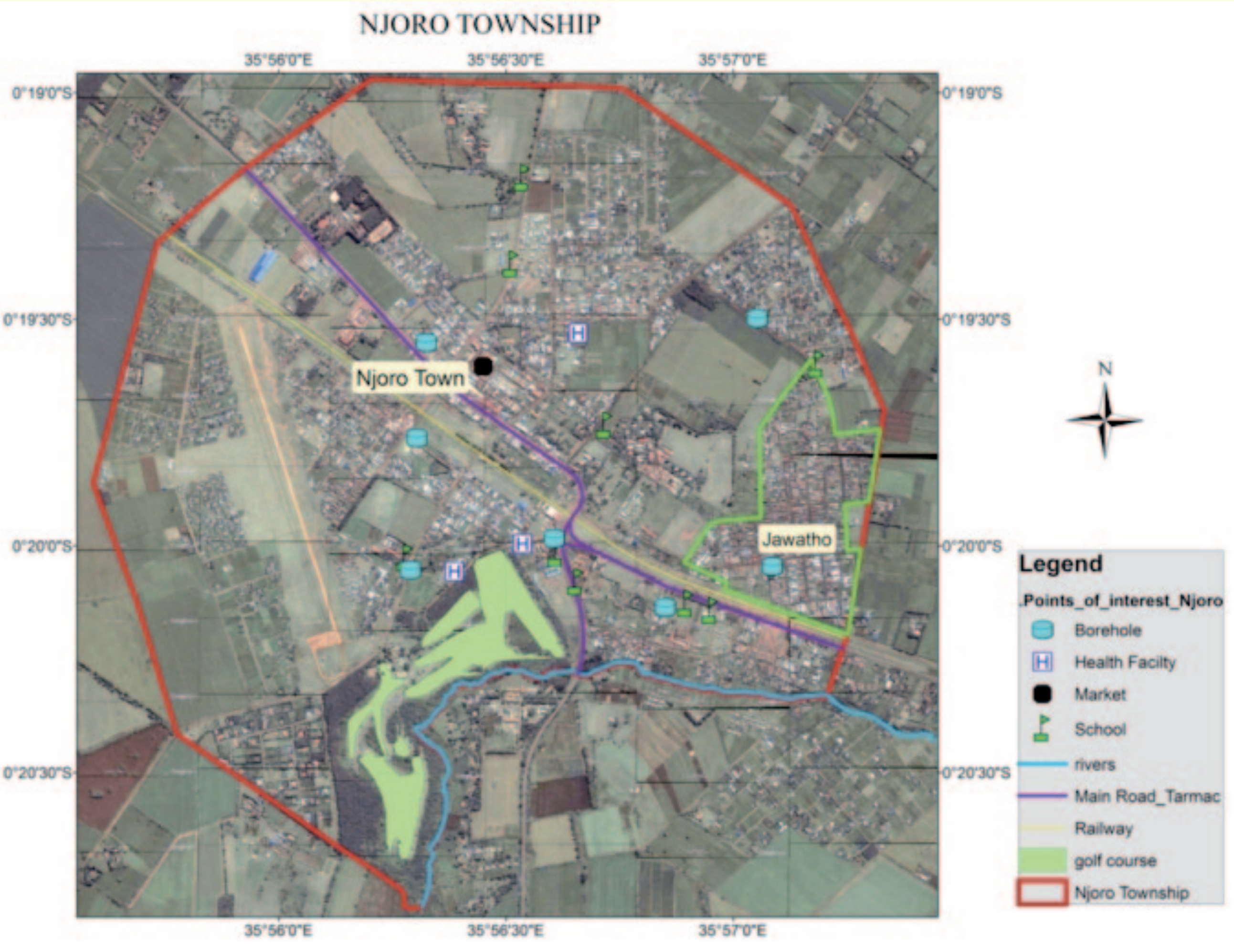

Figure 4: Urban, Peri-urban and Farmland areas in Njoro Township

Table 1: Water Supply Alternatives

Water source	Functional group	Technologies	Input parameters
Groundwater	***Water source***	Groundwater extraction	Daily water demand (m^3/d) = 4500 Maximum hourly demand (m^3/h) =187.5 Depth of Groundwater level (m) = 180 Diameter of borehole (inches) = 20 Disinfectant: Calcium hypo-chloride Pipe length for water transmission (m) = 5000 Average Trench Depth (m) =1.5 Water pumping Pressure head (m) = 200 Elevated Tanks (m) =20 Number of houses connected = 1120 Average trench depth (m) = 1.2 Average length (m) = 10
	Water purification	Disinfection	
	Water Distribution	(i) Water pumping station (ii) Elevated Tank (iii) Water transport main (iv) Water supply network (v) House connection water supply	
River water	***Water source***	River water extraction	Daily water demand (m^3/d) = 4500 Maximum hourly demand (m^3/h) =187.5 Purification: Flocculation and sedimentation Flocculent = Alum Disinfectant = chlorine gas No. of water lines = 1 Pumping head (m) = 20 Diameter of borehole (inches) = 20 Pipe length for water transmission (m) = 5000 Average Trench Depth (m) =1.5 Water pumping Pressure head (m) = 180
	Water purification	(i) Surface water treatment (ii) Flocculation and sedimentation (iii) Disinfection	
	Water Distribution	(i) Water pumping station (ii) Surface water tank (iii)Water transport main (iv) Water supply network (v) House connection water supply	

Table 2: Dry Sanitation with UDDTs (Alternative 1)

Wastewater	Functional group	Technologies	Input parameters
Black water	Waste collection	UDDT	People served: 50,000 Urine emptying interval: 14 days
		Faeces collection	People served: 50,000 Distance to treatment (km): 5 Type of transport: Small trucks Source: UDDT
		Urine collection	People served: 50,000 Distance to treatment (km): 5 Type of transport: Vacuum truck Collection intervals: 14 days
	Waste treatment	Composting	Faeces from UDDTs (m^3/yr): = 50,000*(50)*0.8/1000= 2,000 Other biosolids (m^3/yr): 0.0 Dewatered sludge from WWT (m^3/yr):0.0 Price of bulk material (EUR/m^3):0.2
		Urine storage	Amount of urine (m^3/yr): 50000*(500/1000)=25000 Storage period (d): 90 days
	Reuse	Compost use	Amount of compost (kg/d): 0.5*(2*2000+1.67*0+0)*500/365=2740 Market price of compost (EUR/kg): 0.12
		Urine use	Amount of Urine (m^3/d): 25000/365= 69 Market price Urine (EUR/m^3): 0.01*1000=10
Greywater	Waste collection	Sanitary sewer (Greywater)	No. of implementation: 250 PE served: 0.75*266.67=200 Length (m): 10m/HH*20HH= 200 Average trench (m): 1.5
	Waste treatment	Horizontal Flow CW (Greywater)	No. of implementation: 250 PE served: 0.75*50000/250=150 (20HH) Required area (m^2/PE): 1
	Reuse	Irrigation water use	Amount of irrigation water (m^3/d): Assume treated Greywater from 100 HF CWs is used for irrigation: 100*150*0.06= 900 Market price of irrigation water (EUR/m^3): 0.03

Table 3: Waterborne Sanitation with Cesspit (Alternative 2)

Wastewater	Functional group	Technologies	Input parameters
Black water	Waste collection	Cesspit	People served: 50,000 Waste water or Black water: Black water
		Faecal sludge collection	Distance to treatment (km): 5 Type of Transport: Vacuum truck Number of pick up points: 50000/20=2500
	Waste treatment	Sludge drying reed bed	Amount of sludge (m^3/yr): 50000*20*365/1000=365000 TS content (%): 0.5%
Greywater	Waste collection	Sanitary sewer (Grey water)	No. of implementation: 250 PE served: 0.75*266.67=200 Length (m0: 10m/HH*20HH= 200 Average trench (m): 1.5
	Waste treatment	Horizontal Flow CW (Grey water)	No. of implementation: 250 PE served: 0.75*50000/250=150 (20HH) Required area (m^2/PE): 1
	Reuse	Irrigation water use	Amount of Irrigation water (m^3/d): Assume treated Greywater from 100 HCW is used for irrigation: 100*150*0.06= 900 Market price of Irrigation water (EUR/m^3): 0.03

Table 4: Waterborne Sanitation with Sewerage (Alternative 3)

Wastewater	Functional group	Technologies	Input parameters
Black water + greywater	**Waste collection**	House Connection	People served: 50,000 No. Of HCs with manholes (%): 20% Average length (m): 6m Average trench depth (m): 1.4
		Sanitary sewer	People served: 50,000 Average trench depth (m): 1.7m Length (m): 6.5*(PE)$^{0.83}$= 6.5*(50000$^{\wedge 0.83}$) = 51648
		Sewerage pumping station	No.of implementation : 4 Hourly water flow (m³/hr): 0.01*50000/4=125 Pressure head (m): 50
	Waste treatment	Screen	PE served: 50000 Screen type: Coarse
		Buffer Tanks	Buffer Tank volume (m^3): 50000*0.01*8/3=1333 Pump flow(l/s): 50000*0.021 = 1050 Jet aerator: No Daily flow (m^3/d): 50000*0.08= 4000
		SBR	PE served: 50000 Treatment level: Denitrification
		Sludge thickener	Sludge volume (m^3/d): 50000*0.008=400 Sludge type: SBR-Denitrification
		Belt Filter Press	Sludge volume (m^3/d): 50000*0.002=100 TS content (%): 4 Sludge origin: Unstabilised
		Composting	Faeces from UDDTs (m3/yr): 0 Other Biosloids (m^3/yr): 0 Dewatered Sludge from WWT (m^3/yr): 50000*0.12=6000 Price of Bulk material (EUR /m^3): 0.2
	Reuse	Compost use	Amount of Compost (kg/d): 0.5*(2*2000+1.67*0+0)*500/365=2740 Market price of compost (EUR/kg): 0.12
		Irrigation water use	Amount of Irrigation water (m^3/d): 50000*80*0.8/1000=3200 Market price of Irrigation water (EUR/m^3): 0.03

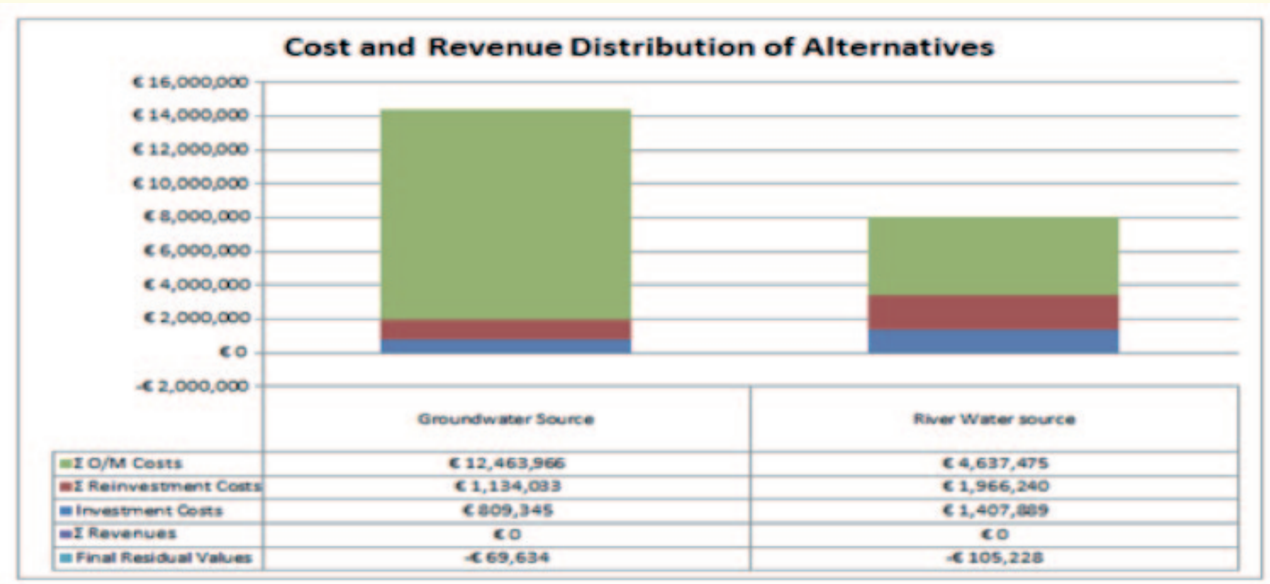

Figure 5: Cumulative costs of water supply alternatives for Njoro Township

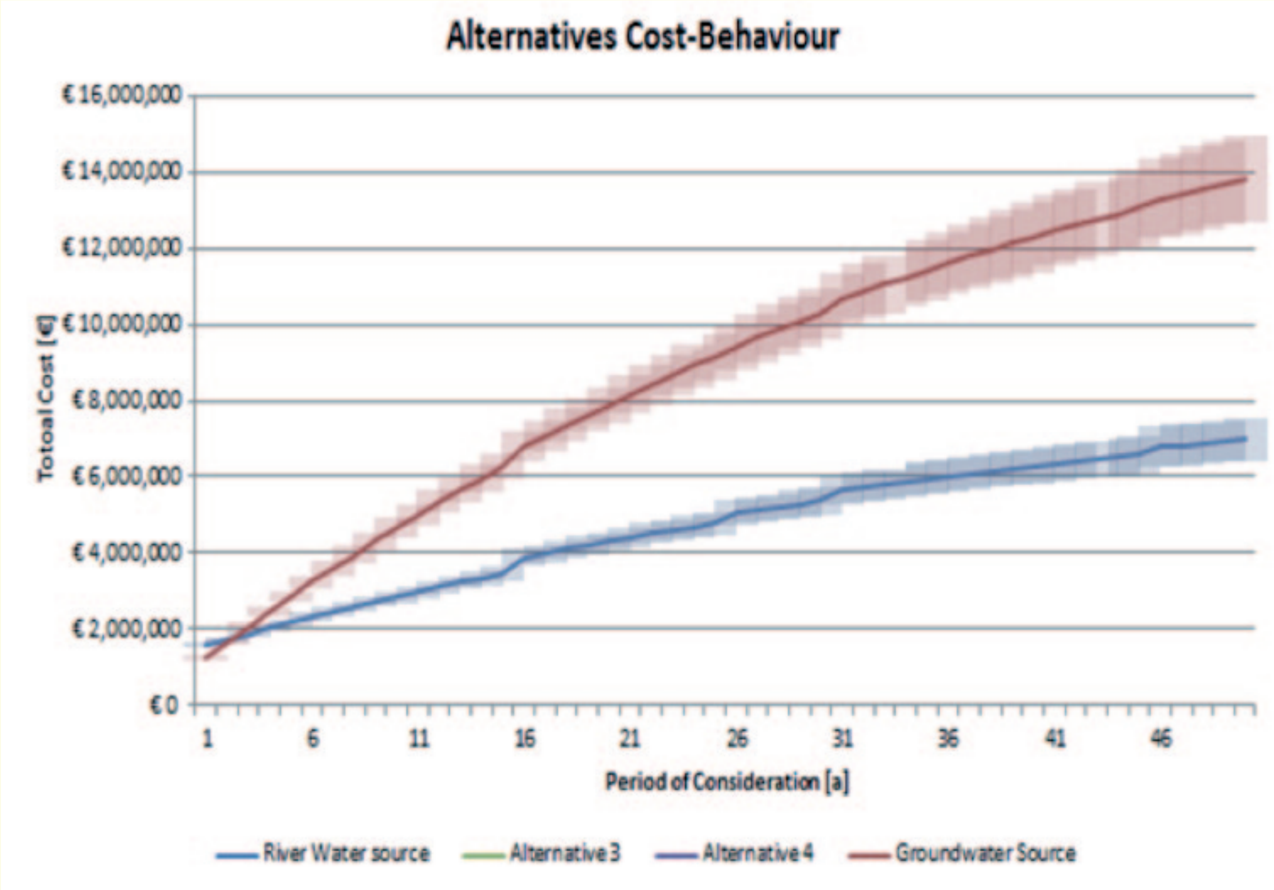

Figure 6: Comparison of Cost-Benefit results for Njoro Township water supply

Results

The results for the water supply alternatives (Figures 5 and 6) show that all the costs for the River water extraction are lower than those of groundwater extraction. In this case therefore, the River water extraction will be preferred as a water supply system for the Njoro Township. The result for sanitation show that water-borne with sewerage alternative is the best option in terms of total costs concerned. In terms of O&M costs, the dry sanitation (UDDT) alternative is very expensive compared to the other two alternatives. In general, the cesspit and faecal sludge treatment has extremely a high investment cost compared to the other two options.

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Case study Ait Ider, Morocco

This paper reports on the activities carried out and on the application of the CLARA Simplified Planning Tool (SPT) in Moroccan pilot community, the village Ait Ider within the Ait Sedra Jbel Soufla community.

Authors: Mustapha Mahi and Mokthar Jaait

Abstract

In Morocco, the history of sanitation is marked by an approach addressing the priority problems of urban sanitation marginalizing the issue of sanitation in rural areas, especially in small villages. However, the improvement of sanitary conditions of rural populations depends not only on the quality of water used for drinking, but also environmental health conditions.

The approach of ecological sanitation (ecosan) is new in Morocco and was adopted by the AGIRE program „Support to the Integrated Management of Water Resources" of the GIZ (German Society for International Cooperation), in cooperation with MEMEE (Ministry of Energy, Mines and Water Environment) to improve the organizational and institutional framework of the water sector in Morocco and implement actions concrete to ensure better protection of water resources and their rational use, economical and sustainable, considering the principles of social equity. In this paper we describe the work carried out within the CLARA project in the Moroccan pilot community, i.e. the village Ait Ider in the Ait Sedra Jbel Soufla community. The work in the pilot community was coordinated with the project SWIM (http://swim-sustain-water.eu/).

Introduction

The Dades Valley is the province of Tinghir extends along the Dades River, between the High Atlas and Anti-Atlas and more precisely between two great mountains: Jbel Sagho to the east and the mountains of the High Atlas in the West. The upstream portion of the city of Boumalne is the mountainous area and the form of a very narrow valley: the Dades gorges. The downstream part is wider and reaches two kilometers in some places. The circle consists of 4 Boumalne Dades caïdats with 12 municipalities which have the common Sedrat Jbel Soufla (pilot community) part.

The rural community of Sedrat Jbel Soufla (ASJS) is located to the east of the High Atlas chain. The common Aitr Sedrat Jbel extends over an area of 332 km² with 8 douars (small villages). Among those villages Ait Idir was selected as pilot community for the CLARA project.

The decision was confirmed with all national and local stakeholders, partners concerned in planning for the case study. The Morocco's CLARA project committee has held several meetings to establish mechanisms for implementation of the work. With the support of the GIZ the team of young engineers were spirited to conduct investigations etc. Awareness meetings were also conducted with local, regional and national partners support.

Since the beginning of the project, the team responsible for piloting the project was aware of the wishes and inspirations of all partners in term of planning. So there must be an ideal environment for the success of CLARA project, including: Authority, Hydraulic Basin Agency, Municipality, NGO, with the Technical team of ONEP-IEA and GIZ the first aim is consultation and harmonization: Coordination and involvement by all partners. The prerequisite documents and information for testing the CLARA SPT like the baseline study, BoQ and technology assessment have been produced by the CLARA project.

Ait Ider village

The pilot community selected for Morocco was Ait Ider in which also the SWIM project is operating. The village

Key messages:

- The CLARA SPT is a relevant tool and can help decision makers
- Using the CLARA SPT requires technical knowledge
- In the Moroccan case the planning process has to be incorporated within regional or national master plans

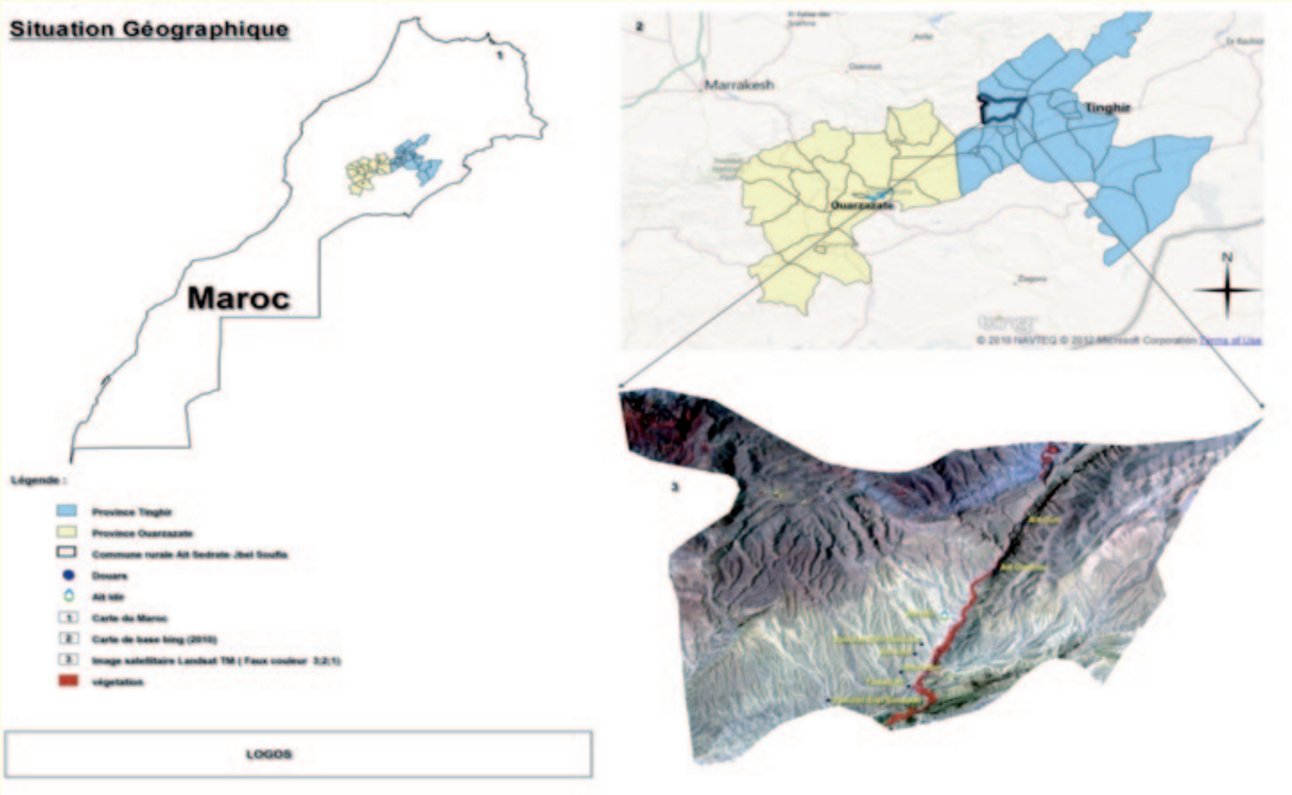

Figure 1: Localization of Sedrat Jbel Soufla.

Ait Idir is one if the 12 villages of the community Ait Sedrat Jbel Soufla that is located in the Dades valley in the province of Tinghir (about 120 km north-east of Quarzazate, Figures 1 and 2). The population of Ait Idir is about 1400 persons, the elevation ranges between 1300 and 1400 m.a.s.l.

Sanitation situation and alternatives

The existing water supply system in the pilot community, which covers the entire village, is working well. The water comes from the well is supplied via a reservoir located at high level altitude by pumping station. However, certain areas in the village suffer for lake pressure in the network. Due to the high coverage level of water supply at the pilot area, only the sanitation situation was assessed.

Regarding sanitation facilities the houses in the selected site are equipped with cesspits and sometimes septic tanks. Figure 3 shows areas in Ait Idir that potentially available for a wastewater treatment plant.

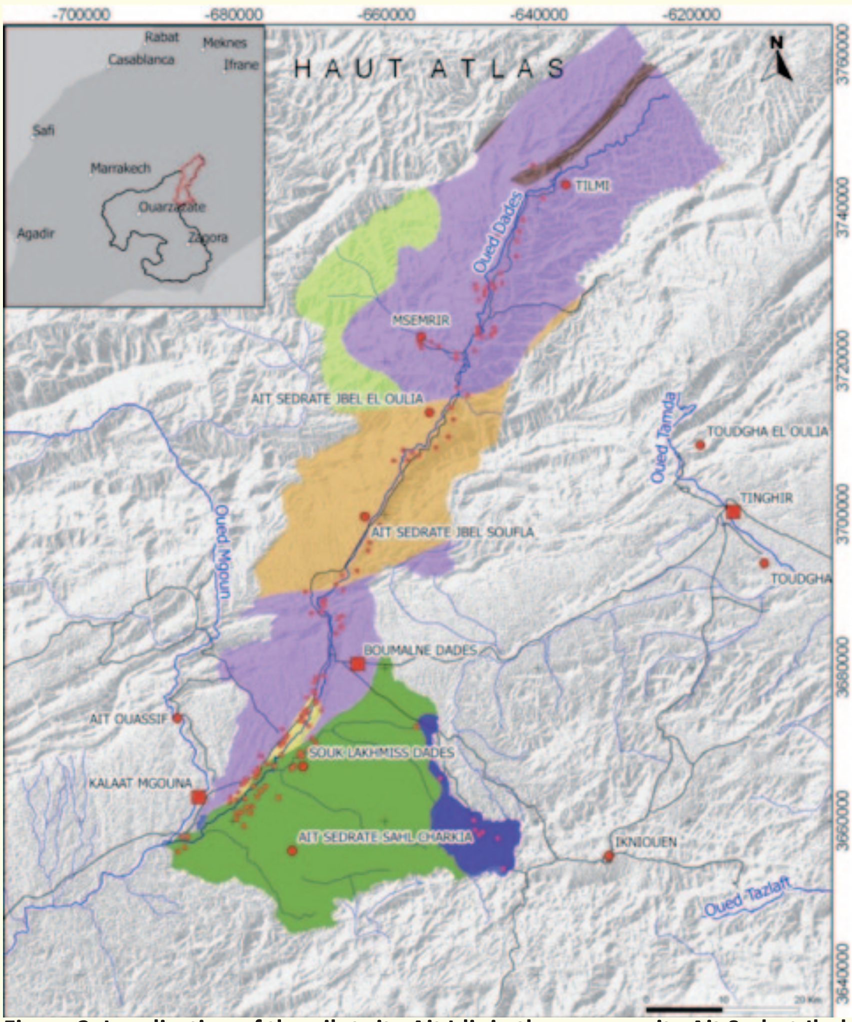

Figure 2: Localization of the pilot site Ait Idir in the community Ait Sedrat Jbel Soufla.

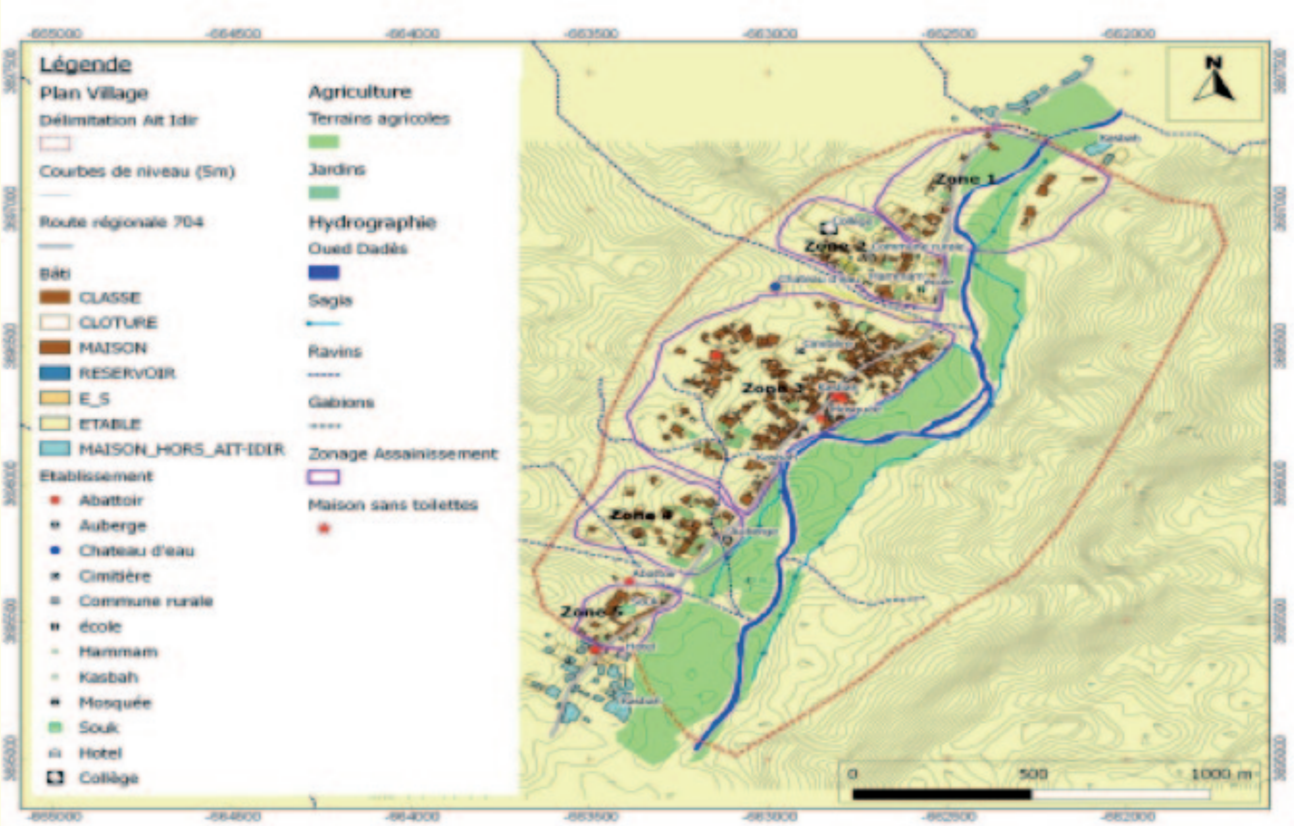

Figure 3: The green areas are potentially available for wastewater treatment plant in Ait Idir.

In the village the following zones have been defined:

- Zone 1: Households lying on the right bank of the river as well as some isolated households in the northern part to the left of the river, which are suitable for an individual / semi-collective sanitation.
- Zone 2: Neighboring households and public institutions that may be an individual or semi-collective sanitation or be connected to the planned consolidation for school (see Figure 4).
- Zone 3: Households lying in the middle of the village, part which is characterized by a higher density of population, which could be served by a sewer (treatment to small scale).
- Zone 4: Households with gardens and could use individual sanitation by UDDTs (with planted filter if clean water is considered for irrigation of vegetable crops) or individual digester with a planted filter / growing biomass.
- Zone 5: It includes the market place and some households.

Figure 4: Zone 2 – Neighboring households and public institutions with potential for ecological sanitation.

Table 1: Summary of alternatives and technologies used

Alternative	Functional group	Technologies
Conventional sanitation system	Waste Collection	Conventional sewer without pump
	Waste Treatment	UASB + HF CW
	Reuse	Irrigation
30% UDDT + 70% sewer	Waste Collection	30%: UDDT chamber + Collection of urine and faeces 70%: Conventional sewer without pump
	Waste Treatment	30%: Struvite production + composting 70%: HF CW
	Reuse	30%: Compost use + Struvite use 70%: Irrigation

Table 2: Cost distribution results in terms of life cycle costs

N°	Alternative Name	Investment Costs	Σ Reinvestment Costs	Σ O/M Costs	Σ Revenues	Total Costs/Profits	Final Residual Values
1	Conventional	€ 214 889	€ 12 631	€ 56053	€ 45066	€ 238507	€ 71513
2	30% UDDT + 70% HF CW	€ 176692	€ 630	€ 60444	€ 0	€ 237766	€ 51130

As there is no sewerage system in Ait Ider village, two options were prospected, based on the all solution recommended by the National Master Plan in Rural Area (PNAR) as means of providing sanitation services, they were:

- Alternative 1: Conventional sanitation system: Collection of wastewater in sewer and treatment in UASB and HF CW
- Alternative 2: 30% of inhabitants in remote areas use UDDTs, for 70% a sewer network transport the wastewater that is treated in a HF CW (reedbed)

Results

The following inputs were constant when used in the planning tool:

- Period of consideration: 20 years
- Net interest rate: 3 %
- Expected annual growth: 2 %

The results (Table 2) indicate that the cost progressively increases with the adding on of additional service options. In terms of using the SPT, Alternative 2 includes the potential of selling the composted sludge, based on estimated current cost of purchasing compost. One must be careful about the results, the SPT only gives first idea about the life time cost components of proposed options but detail study and design should be done for the uppermost alternatives (economically feasible) in order to prepare a complete planning actions.

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Case study Ouagadougou, Burkina Faso

Applying the simplified planning tool for a sustainable water supply and sanitation systems in peri-urban areas of Ouagadougou in Burkina Faso.

Authors: Yacouba Noël Coulibaly, Ali Dissa, Adama Kone, Noëlie Pitroipa

Abstract

Peri urban areas in Burkina Faso are subjected to water and sanitation issues. Planning affordable water and sanitation systems in these areas is crucial. To address this, CLARA project developed the Simplified Planning Tool (SPT) which has been used to test and select the best alternatives systems to solve the issue of water and sanitation in sectors 27 and 30 of Ouagadougou. The SPT allows comparing two or more alternatives systems focusing on the whole life time cost includes investment cost, operation and maintenance, reinvestment cost and revenues. The test with the SPT has been done by defining the alternatives through field visit as well as interview with key persons in charge of water and sanitation and then running the SPT by entering in the model field data related to the different alternatives. For the two study sites, the cheapest alternatives have been selected and presented to the different actors of the project.

Introduction

In the framework of the implementation of the CLARA project, Water and Sanitation for Africa (WSA) was in charge of implementing the simplified planning tool developed in the field in partnership with two associations and the municipalities of which belongs the associations. Applying the CLARA Simplified Planning Tool (SPT) helped to compare water supply and sanitation system alternatives, if applied can helps to improve the water and sanitation sector of the targeted municipalities. Two municipalities were concerned with the application of the simplified planning tool and are in peri-urban areas: the “arrondissement 5” and “arrondissement 10”. The process of application of the simplified planning tool included a baseline study, a pre-planning and planning with the simplified planning tool. The result of the planning has been translated into an application document submitted to funding partners in the aims to get fund for application of the alternatives retained using the simplified planning tool.

The pilot community

The two pilot communities in sectors 27 and 30 of Ouagadougou include peri-urban areas of Ouagadougou in Burkina Faso. Sector 27 is located in the North-East of the city and sector 30 in the South-East (See Figure 1). The natural and social environment in the two pilot sites are virtually similar of these reported to Ouagadougou. The city is in the Mossi plateau, so its geography is almost flat. The city is bisected by a perennial stream in its northern part, which lead to canals and temporary ponds. Four dams are built on this stream. Aquifers are located on average more than 30 meters deep. Ouagadougou soils have low permeability toward the wastewater (10-40 l/d/m2), which is an advantage for the protection of the groundwater quality.

In Ouagadougou, an average rainfall of 750 mm of water is collected per year. The rainy season expand from May to October. The average temperature is about 30°C. The minimum temperature (December-January) is 19 °C while the maximum (April-May) is about 40°C.

Key messages:

- The implementation of the CLARA project in Burkina Faso gave opportunity to put together relevant actors working in ecological sanitation for improvement of the chain through the feedbacks of the baseline study undertaken
- The partners appreciated the CLARA SPT because it gives the opportunity to solve several environmental issues at one time through the combination of different technologies
- The implementation of CLARA gave opportunity to identify some issues in ecological sanitation for further research to improve the chain

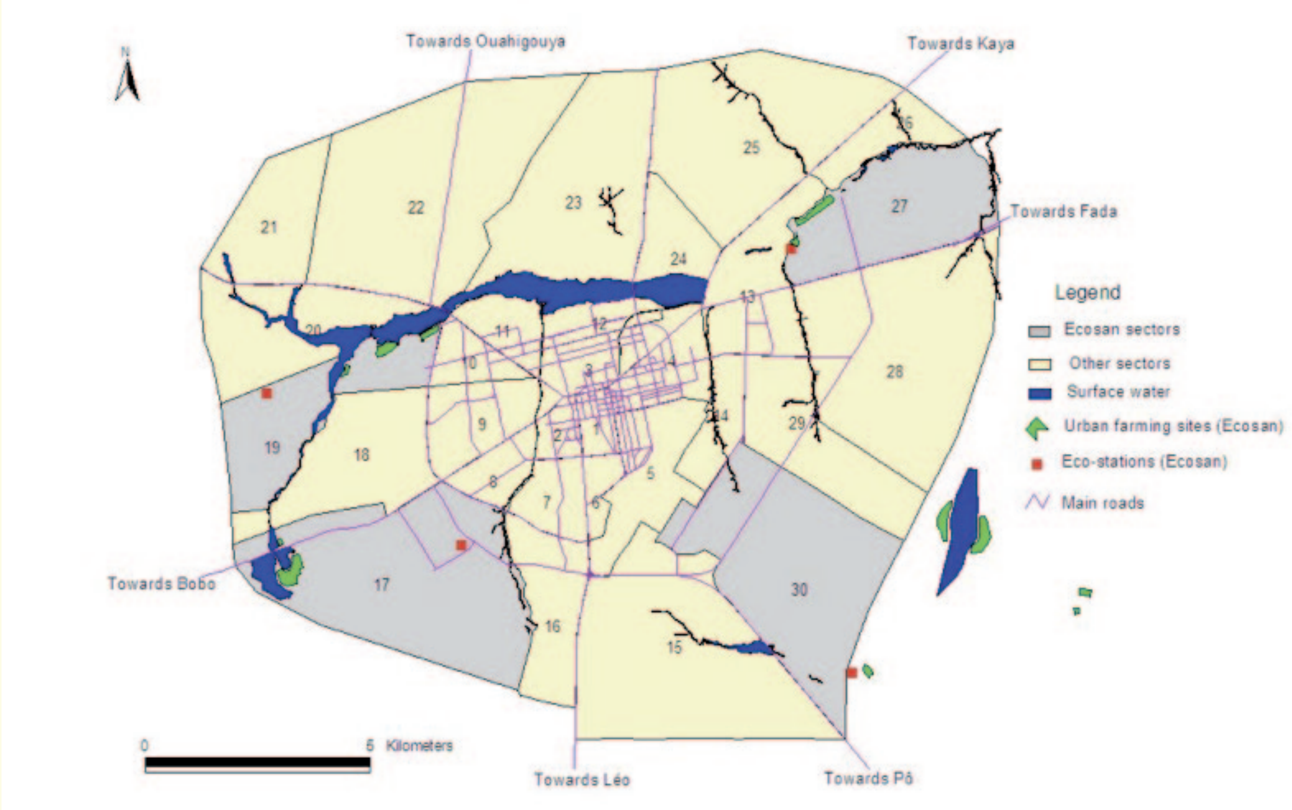


Figure 1: Location of the pilot communities in Ouagadougou.

The total population of the pilot communities is about 69525 inhabitants. The population in the two communities where the CLARA project is implemented increases very rapidly. However, more than half of houses are built with permanent materials. The average number of persons per household is seven). Most households have moderate incomes. In any household, spending priorities are essentially reserved for food, health care, education for children and drinking water. Often, sanitation does not fit in priority expenditures in households.
More than half of the population in each two pilot communities are Muslims, followed by Christians. To include religions in the distribution of populations may be important. Indeed, habits related to sanitation vary sometimes with religious affiliation, for instance the use of water for ablution or washing anal.

The baseline study

The baseline study in the pilot community consisted to establish a situation of reference in water and sanitation sector. To achieve this, a MoU has been signed between WSA and two associations working in the area of water and sanitation in the pilot communities. Then the two associations were involved at all the process of WSA activities in the framework of the CLARA project. The two associations working mainly in ecological sanitation, then the baseline study focused mainly in assessing the ecological sanitation chain so that at the end the results of the project can be applied by the associations. The baseline study also focused on the issue of access to safe water for communities. The main chains of ecological sanitation (collection, transport, storage, treatment and reuse) have been assessed through an application of questionnaire and focus group discussion.

The rate of access to drinking water is high in both areas where CLARA project is implemented. More than 33% of households are connected to the water distribution network led by a national society and about 55% of households get their water from public fountains. A small percentage of households (less than 5%) use water from traditional wells.

About the wastewater management, households usually use pit latrines and cesspools to dispose greywater (washing, shower). For some households, grey water is intentionally or not spilled into the street where they stagnate, because of the lack of sewer systems.

For solid waste management, most of households use anarchic systems to dispose their waste. There are wild dumps on free land or in holes. Some households are subscribed to a system of waste collection and others have joined an organized collection of household waste using bins for waste provided by the municipality.

More than 95% of households have latrines (including all types of latrines) to dispose excreta. Waste systems most commonly used for this purpose are improved traditional latrines, followed by VIPs, Flush Toilets with septic tank and UDDTs. Note that traditional latrines are still used in some households. Unfortunately, the use of this type of latrine (traditional one) presents risks due to the pollution of groundwater. In fact, the traditional latrine is unconventional in Burkina Faso, which is also why it is not included in the national program for the calculation of the coverage rate in terms of sanitation.

It is possible that open defecation is still practiced in each of two communities where the CLARA project is implemented, since there are about 5% of households do not have sanitation facilities. Moreover, in these areas the emptying of pit latrines and septic tanks is done manually or on using tank truck (mechanically). The cost for the service of mechanical emptying drain is around 15,000 FCFA, and between 5,000 and 7,000 FCFA, when done manually. The majority of households, He finds that the cost to empty the sludge is high. The sludge collected by trucks is often transported out of the city, to be discharged into the environment. Otherwise, the sludge manually emptied is buried in the ground close to the latrines.

In conclusion regarding the application of the SPT, the results of the baseline study revealed that the weakness of the sanitation chain were the collection and transport of urines and faeces. The baseline study also revealed that the issue of water is crucial because communities are still consuming water from wells even if some of them have access to safe water.

Alternative system solutions

The pre-planning consisted in defining different alternatives systems for water and sanitation for testing the CLARA SPT in the aims to select the appropriate one to solve the water supply and sanitation issue identified during the baseline study. In this paper we only show the sanitation alternatives in detail.

Table 1: Technology components for alternative 1 (OUN)

Functional group	Technologies	Input parameters
Waste Collection:	*Collection solid waste*	Type of transport : Donkey cart Number of locations : 6'455 Volume solid waste [m^3/d] : 54 Average distance to treatment site [km] : 3
	Collection faecal sludge	Type of transport : Vaccum truck Number of pick-up points : 9'435 Sludge collected per interval [m^3] : 5 Average distance to treatment site [km] : 20
	Collection urine	Type of transport : Vaccum truck Average distance to treatment site [km] : 4 PE : 6'952 Pick-up interval : 7 days
	UDDT chambers	Persons served : 6'952 Collection interval : 7 days
Waste Treatment	Urine storage	Amount of urine [m^3/d] : 0.4 Storage time [d] : 45
	Septic tank	PE (served) : 20'857 Number of septic tanks : 2979
	Composting	Faeces from UDDTs [m^3/d] : 0.016 Biowaste [m^3/d] : 2.7 Dewatered sludge [m^3/d] : 0
	Sludge dewatering	Sludge volume [m^3/d] : 1000 Sludge type : Unstabilised TS content [%] : 95
Reuse	Irrigation	Amount of irrigation water [m^3/d] : 2108 Market price irrigation water [EUR/m^3] : 0.80
	Compost use	Amount of compost [kg/d] : 1630 Market price compost [EUR/kg] : 0.07

Table 2: Cost distribution results in terms of life cycle costs

Functional group	Technologies	Input parameters
Waste Collection:	***Collection solid waste***	Type of transport : Small truck 1.2 tonnes Number of locations : 6455 Volume solid waste [m^3/d] : 54 Average distance to treatment site [km] : 10
	Collection faecal sludge	Type of transport : Vaccum truck Number of pick-up points : 8938 Sludge collected per interval [m^3] : 5 Average distance to treatment site [km] : 20
	Collection urine	Type of transport : Vaccum truck Average distance to treatment site [km] : 4 PE : 6'952 Pick-up interval : 7 days
	UDDT chambers	Persons served : 6'952 Collection interval : 7 days
Waste Treatment	**Urine storage**	Amount of urine [m^3/d] : 0.4 Storage time [d] : 45
	Septic tank	PE (served) : 17'381 Number of septic tanks : 2'483
	Composting	Faeces from UDDTs [m^3/d] : 0.016 Biowaste [m3/d] : 5.4 Dewatered sludge [m^3/d] : 0
	Sludge dewatering	Sludge volume [m3/d] : 1000 Sludge type : Unstabilised TS content [%] : 95
Reuse	**Irrigation**	Amount of irrigation water [m^3/d] : 2108 Market price irrigation water [EUR/m^3] : 0.80
	Compost use	Amount of compost [kg/d] : 3249 Market price compost [EUR/kg] : 0.07

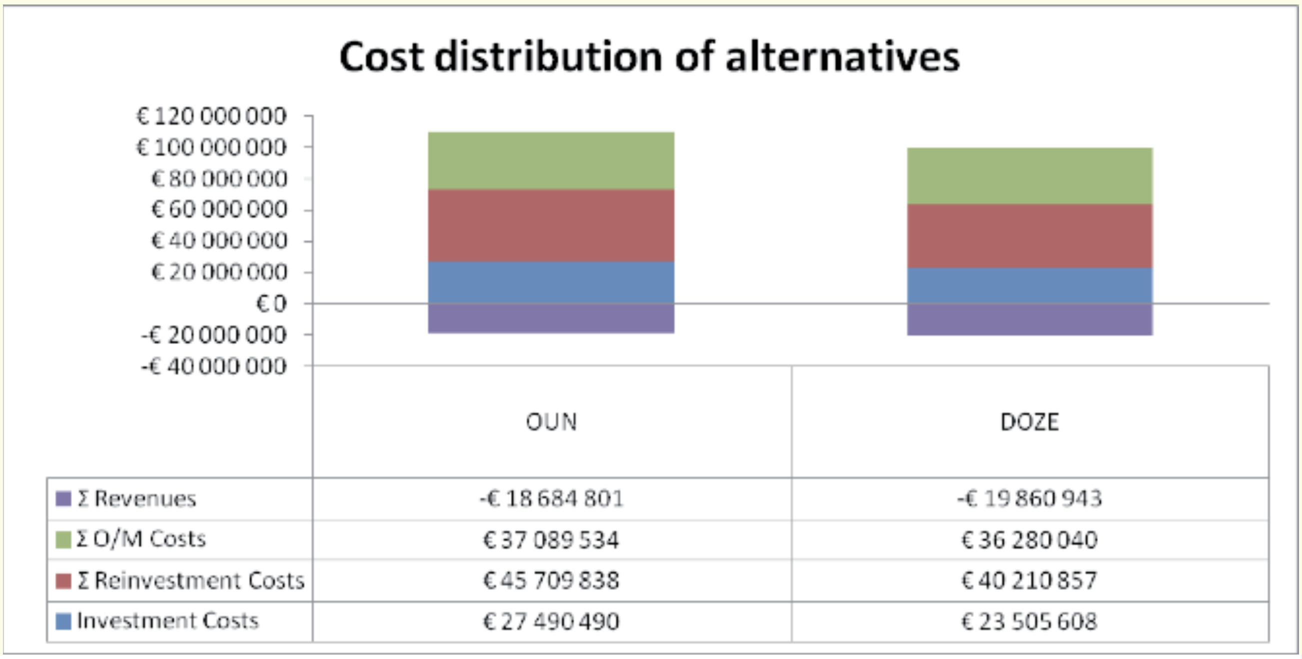
The two alternatives systems to solve the water issue in the pilot community were designed to solve the issue of safe water to be served to communities as following:

- The first water supply alternative uses groundwater and a spring as source of water while the second alternative used only the groundwater as source of water. The population considered is 69525 inhabitants
- The first alternative used disinfection as a water purification technology while the second alternative did not used any purification technology
- The second alternative used a network for water distribution while the first one did not used a network distribution but a surface water tank

The first alternative related to sanitation with type of transport with donkey chart and vacuum truck is called OUN and the second alternative with type of transport with small truck, donkey chart and tricycle is called DOZE. The set of technologies used for the first and second sanitation alternative are shown in Tables 1 and 2, respectively.

Results

The two compared alternatives showed to have the same cost behaviour, which can be explained by the fact that the difference between the two alternatives are at the level of type of transport and the sanitation coverage rate. However, we remark that the total cost of implementation of alternative 1 (OUN), is higher than the total cost of alternative 2 (DOZE).



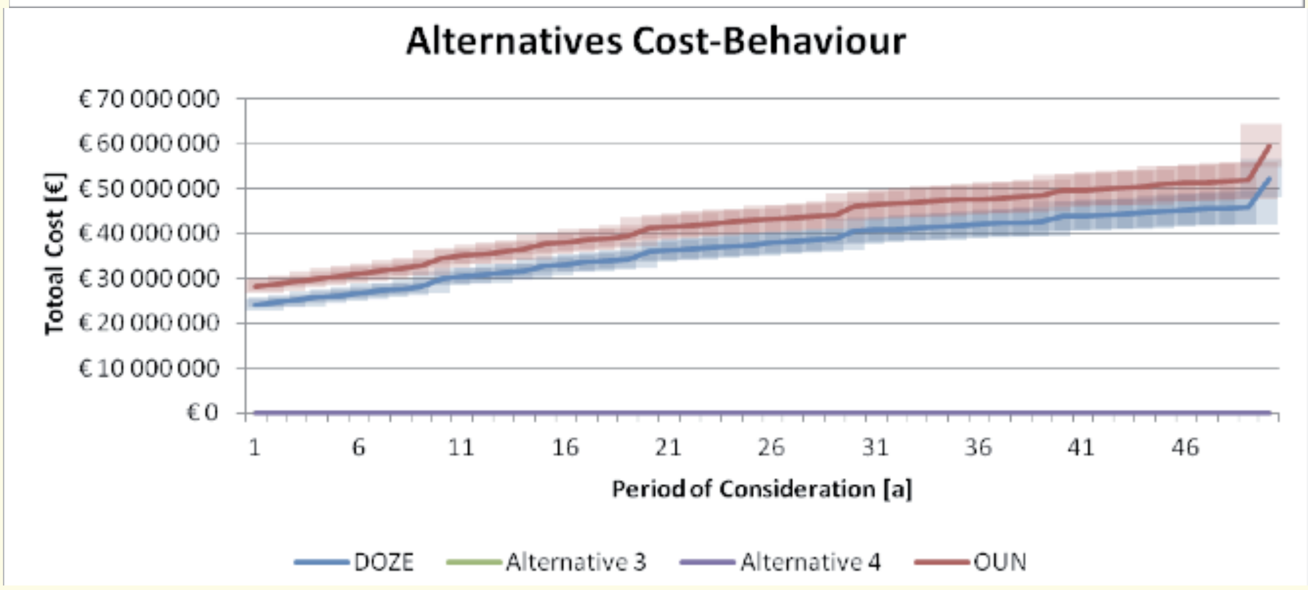


Figure 2: Results from using the CLARA SPT for sanitation alternatives in Ouagadougou

Conclusion, perspectives and recommendations

The CLARA SPT has been successfully tested in Burkina Faso. The presentation of the results of the test with the SPT to the partners during a stakeholder event showed and interest about the tool. A training session for local stakeholders in the use of the SPT as well as the presentation of the results by applying the SPT to the pilot communities was organised. The stakeholders agreed with the selected alternatives and they requested to put in place a core team who will be following the submission of the application document to the funding partner. They also requested a continuous assistance even after the project in the use of the tool to test specific alternatives.

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Summary and outlook

In this paper summarises the main findings and achievements of the CLARA project and the future work planned.

Authors: Günter Langergraber and Norbert Weissenbacher

Abstract

During the last 3 years (1.3.2011 - 28.2.2014) the CLARA project promoted resources-oriented sanitation concepts as a route to sustainable sanitation. The development of the CLARA Simplified Planning Tool (SPT) is for sure the main achievement of the project. However, also during the planning process and testing of the SPT the awareness of stakeholders on sustainable implementation of water supply and sanitation systems could be raised. During our field research we focussed on mainly on soft factors such as operation and maintenance and the incorporation of local entrepreneurs in the sanitation service provision. In this paper the CLARA main findings and achievements that have not been presented in the previous contributions are summarised and an outlook on future activities is given.

Summary of main findings

The results of the field research in Arba Minch can be summarised as follows:

- Small enterprises active in the sanitation sector can make profit. However, to compare these enterprises with „normal" business is not fair. It is crucial that municipalities recognise that these enterprises provide services that are actually a duty of the municipality and also support these enterprises to make the business profitable. Public-private-partnership can serve as model for the collaboration between private sector and municipalities.
- Producing struvite from source-separated urine in Arba Minch has been shown to be not economically feasible. This is mainly due to the fact that artificial fertilizers are heavily subsidised in Ethiopia and thus much cheaper than struvite.
- When using flush toilets in areas with limited public water supply (e.g. for the condominium houses in Arba Minch) it is essential that alternative water sources are considered during planning. This is important to guarantee the functioning of the flush toilets and thus preventing health hazards.

The development of the CLARA Simplified Planning Tool (SPT) was for sure one of the main achievements of the project. After testing the tool and presenting it to various stakeholders that feedback that we received showed that:

Main results:

- The CLARA Simplified Planning Tool (SPT) was developed and made available for download from http://clara.boku.ac.at/ free of charge. The SPT was also made available via the SSWM Toolbox and promoted in the SuSanA Forum.
- A key element of CLARA was that the local teams had to prepare applications documents so that the pilot communities can ask for funding from donors for implementation.
  - The follow-up project in Arba Minch funded by the African Water Facility is already on track and shall start in July 2014.
  - Implementation of solutions suggested by CLARA has been guaranteed for Frasers community in South Africa (by eThekwini municipality) and for Ait Idir in Morocco (due to the cooperation with the SWIM project).
- Municipalities have to recognize that small enterprises active in sanitation service provision are actually providing services that are a duty of the municipality. Municipalities thus should support these enterprises to make their businesses profitable.
- The documentation „Agriculture, food and water technologies" was produced and is available on youtube.

- The value of the CLARA SPT is apparent when investigating alternative water supply and sanitation solutions and evaluating the differences between the alternatives. Adjustments can be made at various cost or input data levels to compare different perspectives within the same actual scenario.
- The SPT has the potential to inform planners, engineers and municipal management of the longer term cost implications and thus the viability of various system options for a municipality and thus, contribute to the promotion of sustainable long term plans for communities.

Dissemination activities

A strong focus in the CLARA work was on disseminating the results and experiences gained in the project. The main activities and results in this respect are summarised below.

The CLARA website http://clara.boku.ac.at

The CLARA website has been online since CLARA started. Besides the CLARA SPT also the main documents produced (e.g. the final reports from field research) are available for download from the CLARA website.

Additionally, the CLARA SPT was made available at the SSWM (Sustainable Sanitation and Water Management) Toolbox and promoted in the SuSanA (Sustainable Sanitation Alliance) Forum.

General publications

In CLARA we produced 2 general publications:

- International Innovation 2012: The 3 page paper „Simplifying solutions for sanitation and water supply“ was published in October 2012 and distributed to 30‘000 stakeholder (including 6‘000 in Africa, ministries, NGOs, etc.)
- Pan European Network (http://www.paneuropeannetworks.com/): In 2013 CLARA was featured in 4 issues of the publication „Pan European Network – Science & Technology“. The main aim of these short contributions was to introduce the CLARA SPT.

The general publications on CLARA are available for download from the CLARA website

Collaboration with other water-related Africa-2010-call projects

Besides CLARA 9 other water-related projects have been funded within the FP7-Africa-2010-call (besides water the other topics of the call have been health and food). The main objective of the collaboration was to look for possibilities to disseminate project results to relevant high-level African decision makers. The discussions have not been finalised yet and are on-going. Several joint activities have been carried out during the last years, e.g. the organization of a session of the water-related Africa-2010-call projects at the 1st WATERBIOTECH conference in October 2012 in Cairo, Egypt.

Throughout its lifetime, CLARA collaborated more intensively with the WASHTech and WATERBIOTECH projects. Additionally, in September 2012 CLARA and WHaTeR hold a joint stakeholder event in Arba Minch as Arba Minch University was partner in both projects.

Video on CLARA

Together with the projects AGRICAB, EAU4Food and WHaTeR, CLARA produced the video *„Agriculture, food and water technologies“.* The CLARA part of the video was shot in Arba Minch. The video is available at:

http://www.youtube.com/watch?v=Vp8coUMPlJg&app=desktop

Presentation of CLARA results at conferences and publications

The results of CLARA‘s work have been presented at several conferences. The main events where CLARA results have been presented were:

- The Faecal Sludge Management 2 (FSM2) conference, 29-31 October 2012, Durban, South Africa: 3 papers on CLARA have been presented, one general, one on struvite production and one on composting. The papers, presentations and videos from the presentations are available at the SuSanA website.
- The 3rd IWA Development Congress and Exhibition, 14-17 October 2013, Nairobi, Kenya: We defined this event toward the end of CLARA‘s duration as our main dissemination event. The CLARA team in total had 5 presentations (3 oral and 2 poster presentations). Additionally, the CLARA SPT was launched at the workshop „Methods and tools for assessing and planning sanitation in developing countries“ that was organized by the IWA Specialist Group on „Resources-Oriented Sanitation“. About 80 persons participated in in the workshop.

Although the main aim of CLARA was to produce public accessible material we also could produce a publication in the Desalination and Water Treatment journal. In this paper Feki et al. (2014) report the findings on investigating rain water harvesting as potential additional water source for multi-storey buildings.

Further presentations at conferences and publications on CLARA‘s results in general and on the CLARA SPT in particular are planned for 2014.

Outlook

Towards implementation in the CLARA pilot communities

A key element of CLARA was that at the end of the project the local teams had to prepare applications documents. With these documents the pilot communities should be able to ask for funding from donors for implementation of the best water supply and sanitation solutions.

<u>Frasers community, South Africa</u>

For Frasers community is likely that one of the options presented for Sarasvathi School (not shown in this special issue) and Frasers informal settlement will be fully implemented by eThekwini as part of their water and sanitation activities. The Municipality of eThekwini was informed through the project of the options suggested in the pre-assessment phase and after the testing with the tool. They did see the value of the options as presented by the tool and will consult further especially the consideration of the longer term costs.

<u>Arba Minch, Ethiopia</u>

In Arba Minch the proposal for continuation of the work with the CLARA SPT was included in the project „Sani-Poor“ which is funded by the African Water Facility (AWF). The project is aiming to supporting the municipality to implement sustainable sanitation services in Arba Minch. Within the project the application of the CLARA SPT is planned as part of developing a master plan for Arba Minch. Key partners of CLARA, i.e. BOKU and EcoSan Club are involved in „Sani-Poor“ as well.

<u>Njoro Township, Kenya</u>

The Kenyan CLARA team together with NARUWASSCO (Nakuru Rural Water and Sanitation Company) has prepared a draft application document for being submitted to the AWF. The aim of this project is the development of a master plan for water supply and sanitation of Njoro Township.

<u>Ait Ider, Morocco</u>

The implementation of the proposed solutions in Ait Ider was already secured from the beginning of the project as the Moroccan CLARA team teamed up with the SWIM project (as described in Mahi and Jaait, 2014).

<u>Ouagadougou, Burkina Faso</u>

For continuing the work in Ouagadougou, the WSA team got in contact with the local office of the African Development Bank (AfDB) to discuss funding possibilities. A concept note on how to improve water supply and sanitation for the two pilot communities in Ouagadougou was prepared for submission to the AfDB.

Further developments of the CLARA SPT

Several activities are planned for further developing the CLARA SPT:

- In the follow-up project in Arba Minch (see above) the CLARA SPT shall be further developed.
- EcoSan Club and BOKU got awarded a project funded by the Ugandan Ministry of Water in which the SPT shall be adapted for Uganda and applied to several case studies in Uganda.
- BOKU is partner in a project funded by the ACP-EU Water Facility in which a sanitation and waste plan for Iringa Municipality, Tanzania, will be developed. It is planned that the CLARA SPT is used and (if resources allow) should be adapted for Tanzania.
- Other project applications are planned in which the SPT should be used and further developed.

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