LOW-TECH SUSTAINABLE SANITATION OPTIONS FOR GHANA AND ETHIOPIA – ECONOMIC, SOCIAL AND TECHNICAL ASPECTS

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Sanitation is more important than political independence

Mahatma Gandhi (1869-1948)

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Abstract

With declining soil fertility and increasing water scarcity worldwide, the need to return nutrients back into agriculture and conserve water is gaining in importance more and more. Thus, an alternative approach to sanitation, referred to as ecological sanitation (ecosan) or sustainable sanitation, which is focused on closed-loop management of excreta and saving of other resources such as water, is becoming an integral part of the resource efficiency concept.

Despite the fact that sanitation is defined as a basic need and human right, many governments, in particular in developing countries, are facing financial challenges hindering the provision of basic services such as sanitation. Therefore, the private sector is becoming more and more involved in these services. This research was aimed at studying possible benefits of considering sanitation as a business. Therefore, the potential of the private sector involvement in sanitation was explored throughout the ecosan process chain, i.e. toilet manufacturing, urine collection, transportation, storage, marketing and application in agriculture.

Ecosan was analyzed from a holistic system's perspective on the example of two case studies, one from Ethiopia and the other one from Ghana. In the case study Ethiopia, a business idea revolving around the production of plastic toilets slabs applicable under the ecosan approach was drafted. A thorough analysis of different parameters, including technical aspects (e.g., coloration methods, manufacturing process, product features, production volume, raw material choice), logistics aspects (e.g., headcount planning, plant location and size, procurement of supplies), financial aspects (e.g., cost minimization options, demand estimation, sales planning) and aspects related to competition (e.g., current toilet prices, existing players on the market, potential substitute products) was performed. Furthermore, in the case study Ghana, an economic analysis of building or modifying toilets for the separate collection of urine and feces, transportation of urine to its storage locations, urine storage and subsequently selling it to farmers to be applied as liquid fertilizer in agriculture was performed. For this analysis, the local sanitary situation and agricultural practices were taken into account. In this way, the whole process chain was analyzed, including toilet manufacturing, toilet construction, management of ecosan products and marketing urine for its application in agriculture.

Based on the case studies analyzed, the following conclusions can be drawn:

- Production of plastic toilet slabs to be applied under the ecosan approach can be profitable in a country like Ethiopia as long as the demand for toilets is in place. It is, therefore, important for the manufacturing line to be designed in a flexible way, allowing for changes in production in case of failure or a decrease in demand for a particular product. Even though mass production results in lower operational costs, it requires a substantially higher investment, which may be difficult to secure in a country like Ethiopia.
- In the case of Ghana, the market value of human urine was calculated to be 0.014 GH¢/l (0.008 €/l). This value will generally change with global and local market prices of mineral fertilizers, the nutrient content of urine and the local demand for nutrients. The market value of urine is crucial for determining the profitability of urine transportation, which was identified as the highest cost in running of an ecosan system. In the case of a small to medium size ecosan system (7,000 l of urine collected daily), it would be economically feasible to

transport urine approximately 210 km (round trip). This distance will, however, depend on the local transportation costs (driver's salary, fuel price, the cost and lifespan of the truck and auxiliary equipment that influences depreciation costs, the type and cost of containers used for urine transportation and truck maintenance costs).

- The social acceptance for the application of human urine as fertilizer plays a critical role in marketing urine. Therefore, urine application options on non-food crops (e.g., oil palms for biodiesel and fast growing trees for fuel wood production) and food crops (e.g., maize plants) should be evaluated.
- Studying the local area for the design of a holistic ecosan system will allow exploring many options and coming up with the best arrangement for the local conditions. Designing projects that can interact with each other can help achieve savings on, e.g., transportation costs (truck can be used to collect and transport urine to its storage location and to transport other cargo on its return trip).
- Large scale implementation of ecosan systems will have a positive effect on the private sector involved in the manufacturing of toilets and the operation of systems due to, e.g., economies of scale, expertise as a result of experience and new skills and financial profits. It will also, however, benefit the users due to the product's and system's efficiency and possible lower costs, which correspond to lower prices. Also, the bigger the ecosan system, the larger the fertilization needs that can be satisfied. However, a utilization concept of ecosan products needs to be in place. Applying urine in agriculture can benefit farmers through a higher crop productivity, which would have a direct impact on farmers' income, and could make them, even if only partially, independent of mineral fertilizer.

Kurzfassung

Aufgrund der zurückgehenden Bodenfruchtbarkeit und der weltweit zunehmenden Wasserknappheit gewinnt die Notwendigkeit, dem Boden Nährstoffe zurückzuführen und gleichzeitig Wasser einzusparen immer mehr an Bedeutung. Aus diesem Grund entwickeln sich alternative Sanitärkonzepte (so genannte neuartige oder nachhaltige Sanitärsysteme), deren Schwerpunkt auf dem Kreislaufmanagement von Fäkalien und dabei auf der Schonung der Ressource Wasser liegt, zu einem festen Bestandteil des Ressourceneffizienzkonzeptes.

Obwohl die Sanitärversorgung als Grundbedarf und als Menschenrecht anerkannt ist, stehen viele Regierungen, besonders in Schwellenländern, vor finanziellen Herausforderungen diese grundlegenden Dienstleistungen bereitzustellen. Ziel dieser Forschungsarbeit ist es, das Potenzial für die Beteiligung des Privatsektors an der Sanitärversorgung zu untersuchen. Das Potenzial des Engagements von Privatinvestoren im Sanitärsektor wurde entlang der gesamten Wertschöpfungskette der Neuartigen Sanitärsysteme untersucht, d.h. von der Toilettenherstellung über die Urinsammlung, den Transport, die Lagerung und Vermarktung bis hin zur Verwertung in der Landwirtschaft.

Die Neuartigen Sanitärsysteme (NASS) wurden umfassend anhand von zwei Fallstudien (für Äthiopien und für Ghana) analysiert. Im Rahmen der Fallstudie Äthiopien wurde eine Geschäftsidee für die Herstellung der für NASS geeigneten Kunststofftoiletten erarbeitet. Eine umfassende Analyse verschiedener Parameter wie technischer Aspekte (u. a. Färbungsmethoden, Herstellungsprozess, Produktmerkmale, Produktionsmenge, Auswahlmöglichkeit der Rohstoffe), logistischer Aspekte (u. a. Personalbedarfsplanung, Fabrikstandort und -größe, Beschaffung von Betriebsstoffen), finanzieller Aspekte (u. a. Kostenminderungsoptionen, Nachfrageschätzung, Vertriebsplanung) und wettbewerblicher Aspekte (u. a. aktuelle Toilettenpreise, bestehende Akteure auf dem Markt, potenzielle Ersatzprodukte) wurde erstellt. Darüber hinaus wurde im Rahmen der Fallstudie Ghana eine ökonomische Analyse durchgeführt. Diese umfasste den Toilettenbau oder die Anpassung der bestehenden Toiletten, um eine separate Sammlung von Urin und Fäzes zu gewährleisten, ebenso den Urintransport zu seinem Lagerungsstandort, die Urinlagerung und eine spätere Vermarktung des Urins als Flüssigdünger zum Einsatz in der Landwirtschaft. Die lokale Situation hinsichtlich der Sanitärversorgung und des Potentials der landwirtschaftlichen Nutzung der Produkte wurde in diesem Fall speziell berücksichtigt. Auf diese Weise wurde die gesamte Wertschöpfungskette betrachtet.

Basierend auf den durchgeführten Fallstudien können folgende Schlussfolgerungen gezogen werden:

- Die Herstellung der für NASS geeigneten Kunststofftoiletten kann in einem Land wie Äthiopien profitabel durchgeführt werden, solange eine ausreichende Nachfrage besteht. Aus diesem Grund sollte die Fertigungslinie flexibel konzipiert werden, um auch kurzfristig Anpassungen an den vorhandenen Markt zu erlauben.
- In der Fallstudie Ghana wurde ein Marktwert von Urin von 0.014 GH¢/L (0.008 €/L) berechnet. Dieser Wert wird sich generell mit globalen und lokalen Mineraldüngerpreisen, dem Nährstoffgehalt des Urins sowie der lokalen Nachfrage nach Nährstoffen ändern. Der Urinmarktwert ist entscheidend, um die

Profitabilität des Urintransports, den Faktor der als höchster Kostenträger im Betrieb von NASS ermittelt wurde, zu bewerten. Im Fall eines kleinen bis mittelgroßen Systems (7.000 L von Urin gesammelt am Tag) würde es sich lohnen, den Urin bis zu 210 km (Fahrtstrecke hin und zurück) zu transportieren. Diese Distanz ist jedoch von den lokalen Transportkosten abhängig (Fahrerlohn, Treibstoffpreis, Preis und Lebensdauer des Fahrzeugs sowie des Zubehörs, die die Amortisationskosten beeinflussen, Preis sowie Art der für den Urintransport ausgewählten Behälter und Fahrzeugwartungskosten).

- Die soziale Akzeptanz für die Verwertung von menschlichem Urin als Dünger spielt eine wichtige Rolle in der Vermarktung von Urin. Deswegen sollte die Urinverwertung für Nicht-Nahrungsmittel-Anbau (z.B. Ölpalmen für die Biodieselproduktion und schnell wachsende Bäume für die Energieholzproduktion) und Lebensmittelanbau (z.B. Maispflanzen) differenziert ausgewertet werden.
- Eine gebietsspezifische Analyse zur Integration eines umfassenden Neuartigen Sanitärsystems beinhaltet immer die Betrachtung verschiedener Optionen mit dem Ziel, die am besten für die lokalen Bedingungen geeignete Lösung herauszufiltern. Die Arrangierung von ineinander fassenden Projekten kann zu beträchtlichen finanziellen Einsparungen führen (z.B. Senkung der Transportkosten durch die Benutzung des Fahrzeugs auf dem Hinweg für den Urintransport und auf dem Rückweg für den Transport von anderen Gütern).
- Die Einführung der NASS in großem Maßstab wird sich positiv auf die Beteiligung des Privatsektors in der Toilettenherstellung und im Betrieb von NASS auswirken (z.B. Nutzung von Skaleneffekten, Expertise als Resultat der Erfahrung sowie neue Kenntnisse und finanzieller Gewinn). Sie wird aber auch die Nutzung und damit den Absatz durch die Produkt- und Dienstleistungseffizienz, sowie die potenziell geringeren Kosten und die günstigen Preise fördern. Zusätzlich kann mittels größerer NASS eine höhere Düngemittelproduktion erreicht werden. Mittels der Urinverwertung in der Landwirtschaft können Bauern eine höhere Ernteproduktivität erzielen, die einen direkten Einfluss auf das Einkommen hat und gleichzeitig zumindest teilweise unabhängig vom Mineraldünger wirtschaften lässt.

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Abbreviations and symbols

AMA	Accra Metropolitan Area
ARM	Association of Rotational Molders
ARS	Agricultural Research Station of the University in Ghana
AS	Ammonium Sulfate
BOP	Bottom of the Pyramid (also Base of the Pyramid)
BOPP	Benso Oil Palm Plantation
CBD	Central Business District
CBO	Community-Based Organization
CLARA	Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas
CLTS	Community-Led Total Sanitation
cm	centimeter
CM	Contribution Margin
CNY (¥)	Chinese Yuan Renminbi (average exchange rate: OANDA, 2012) *(January 2012: 1 CNY = 2.71 ETB = 0.12 EUR = 0.10 GBP = 0.26 GHS = 13.45 KES = 0.16 USD)*
CONIWAS	Coalition of NGOs in Water and Sanitation
CRS	Catholic Relief Services
CSA	Central Statistical Agency of Ethiopia
CWSA	Community Water and Sanitation Agency
DALYs	Disability Adjusted Life Years
DANIDA	Danish International Development Assistance
DAP	Diammonium Phosphate
DMT	Dignified Mobile Toilets
DNCF	Discounted Net Cash Flow
ecosan	ecological sanitation
EFB	Empty Fruit Bunch
EHSD	Environmental Health and Sanitation Directorate
ESE	Ecological Sanitation Ethiopia
ESP	Environmental Sanitation Policy
ETB	Ethiopian Birr (average exchange rate: OANDA, 2012) *(January 2012: 1 ETB = 0.360 CNY = 0.044 EUR = 0.037 GBP = 0.096 GHS = 4.859 KES = 0.057 USD)*

EUR (€)	Euro (average exchange rate: OANDA, 2012) *(January 2012: 1 EUR = 8.1 CNY = 22.1 ETB = 0.8 GBP = 2.2 GHS = 109.7 KES = 1.3 USD)*
FAO	Food and Agriculture Organization of the United Nations
FC	Fecal Coliform
FFB	Fresh Fruit Bunch
FVI	Fuelwood Value Index
GAMA	Greater Accra Metropolitan Area
GBP (£)	British Pound (average exchange rate: OANDA, 2012) *(January 2012: 1 GBP = 9.8 CNY = 1.2 EUR = 26.5 ETB = 2.6 GHS = 131.9 KES = 1.6 USD)*
GDP	Gross Domestic Product
GHS (Gh¢)	Ghanaian New Cedi (average exchange rate: OANDA, 2012) *(January 2012: 1 GHS = 3.7 CNY = 0.5 EUR = 10.0 ETB = 0.4 GBP = 49.9 KES = 0.6 USD)*
GIZ	Deutsche Gesellschaft für Technische Zusammenarbeit (formerly GTZ)
GOPDC	Ghana Oil Palm Plantation Development Company
GPM	Gross Profit Margin
GPRS	Growth and Poverty Reduction Strategy
GWCL	Ghana Water Company Limited
GWSC	Ghana Water and Sewerage Corporation
HDI	Human Development Index
HDPE	High-Density Polyethylene
ICMSF	International Commission on Microbiological Specifications for Foods
IFAD	International Fund for Agricultural Development
IRR	Internal Rate of Return
JMP	Joint Monitoring Program
KES	Kenyan Shilling (average exchange rate: OANDA, 2012) *(January 2012: 1 KES = 0.072 CNY = 0.009 EUR = 0.196 ETB = 0.007 GBP = 0.019 GHS = 0.011 USD)*
kg	kilogram
km	kilometer
KVIP	Kumasi Ventilated Improved Pit latrine
kWh	kilowatt-hours
LLDPE	Linear Low-Density Polyethylene

LPG	Liquid Petroleum Gas
m	meter
MAP	Magnesium Ammonium Phosphate
MDG	Millennium Development Goal
MFI	Microfinance Institution
MOP	Muriate of Potash
MoWR	Ministry of Water Resources
MPa	Megapascal
MSF	Multi-Stakeholder Forum
Mt	metric ton
MWRWH	Ministry of Water Resources, Works and Housing
N	nitrogen
n.a.	not available; not applicable
NGO	Non-Governmental Organization
NO_x	Nitrogen Oxides
NPM	Net Profit Margin
NPV	Net Present Value
OECD	Organization for Economic Co-operation and Development
OFY	Operation Feed Yourself
OMFI	Omo Micro Finance Institution
p.a.	per annum
PCR	Post-Consumer Resin
P&L statement	Profit and Loss statement
PPP	Public-Private Partnership
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PBP	Payback Period
PRSP	Poverty Reduction Strategy Paper
RCA	Replacement Cost Approach
ROI	Return on Investment
ROSA	Resource-Oriented Sanitation concepts for peri-urban areas in Africa
sani-mart	sanitation market
SME	Small and Medium Enterprise
SNNP	Southern Nations, Nationalities and People’s (Region)
SPA	Sanitation in Peri-urban areas in Africa
SSP	Single Super Phosphate

SSPSS	Small-Scale Private Sanitation Sector
SUDEA	Society for Urban Development in East Africa
t	ton
TMA	Tema Municipal Area
TSP	Triple Super Phosphate
UDT	Urine Diverting Toilet
UDDT	Urine Diverting Dry Toilet
UN	United Nations
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
UPA	Urban and Peri-urban Agriculture
USD (US$)	U.S. Dollar (average exchange rate: OANDA, 2012) *(January 2012: 1 USD = 6.3 CNY = 0.8 EUR = 17.1 ETB = 1.7 GHS = 85.1 KES)*
VIP latrine	Ventilated Improved Pit latrine
VVU	Valley View University
WACM	Weighted Average Contribution Margin
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WSP	Water and Sanitation Program
WSSCC	Water Supply and Sanitation Collaborative Council

1 INTRODUCTION

The conventional approach to sanitation is based on systems that collect and store human excreta, so-called “drop and store systems”, or collect and transport excreta away from households, so-called “flush and discharge” systems (WHO and UNICEF, 2008). However, this conventional sanitation approach is not always applicable, particularly in developing countries. One important reason for this is the lack of necessary infrastructure for wastewater containment, treatment and safe disposal. Also, many developing countries suffer from water scarcity and “flush and discharge” systems use large amounts of water as a carrier for transportation of human excreta. Besides, the conventional approach does not include reuse of water. Furthermore, essential elements including nutrients and trace elements flow linearly from agriculture, through humans to receiving water bodies, resulting in their eutrophication and loss of soil fertility.

The conventional approach is not the only solution to sanitation (Otterpohl et al., 1997). With the growing need to save water and recycle nutrients, an alternative approach to sanitation has gained importance. This alternative approach to sanitation is commonly referred to as ecological sanitation (ecosan) or sustainable sanitation. By definition, a sustainable sanitation system needs to be “economically viable, socially acceptable, and technically and institutionally appropriate, it should also protect the environment and the natural resources” (SuSanA, 2008, p.1).

Ecosan encompasses a holistic sanitary concept and provides a lot of advantages over conventional sanitation. This alternative to conventional sanitation approach allows for the incorporation of the agricultural system into the sanitation system with almost full nutrient and water recovery (Otterpohl et al., 2004; Bahri, 2007). Human excreta is treated as a resource and the nutrients contained in excreta are recycled back into agriculture, after being treated when necessary (Winblad and Simpson-Hébert, 2004). Therefore, the implementation of ecosan contributes to the conservation of resources, preservation of soil fertility, long term food security and healthier environment (Panesar A.R. and Werner C., 2006).

Ecosan does not offer one particular technical solution. Instead, it recommends sanitary systems to fit the needs of social, economic and environmental sustainability in a given context (Panesar A.R. and Werner C., 2006). A variety of available technologies makes ecosan a very attractive solution, especially in the developing world, where the conventional approach to sanitation has often failed. Technologies under the ecosan approach range from simple low-tech (e.g., urine diverting dry toilets, composting toilets) to sophisticated high-tech solutions (e.g., vacuum toilets, membrane technology), with new approaches still evolving (e.g., Terra Preta Sanitation – a combination of sanitation, bio-waste management and agriculture) (Factura et al., 2010; Otterpohl R., 2011).

Sanitation is not only a basic need. It is also a human right as declared by the United Nations General Assembly in 2010 (UN, 2010a). In order to improve the situation of low access to sanitation facilities, sanitation needs to be made affordable to the population in low-income countries, where the coverage levels are still the lowest in the world (WHO and UNICEF, 2010). Nevertheless, many governments, in particular in developing countries, are facing a financial gap hindering the provision of basic services such as sanitation. Therefore, the private sector is becoming more and more involved in these services.

This research is aimed at showing possible benefits of considering sanitation as a business. Therefore, the potential of the private sector involvement in sanitation is explored throughout the process chain: toilet manufacturing, urine collection, transportation, storage, marketing and application in agriculture.

As many advantages as the ecosan approach brings along, it might also be faced with a number of challenges. Firstly, the cost and management of collection, transportation, storage and marketing of ecosan products can pose a challenge. In ecosan urine-separating systems, it is necessary to collect as well as treat urine and feces separately. Thus, an ecosan system requires appropriate logistics that allow for safe utilization of nutrients recycled from human excreta to agriculture. Furthermore, urine has a considerably low fertilizing value to volume ratio, which makes transportation costly. Marketing of excreta based fertilizers requires placing a value on nutrients contained in urine and feces, which depends on both global and local conditions, including mineral fertilizer prices, the nutrient content of urine and the local agricultural situation (e.g., the abundance of farmland, soil fertility, etc.).

Also, the acceptance of using excreta based fertilizers in agriculture might become a challenge. In some cultures it may not create any reservations, whereas in others, farmers, marketers and/or consumers may object to the application of human excreta in agriculture. It is, therefore, important to study the local attitude towards this issue. Depending on the local situation, it might be, for example, advisable to apply excreta based fertilizers on non-food crops instead of food crops in order to prevent social rejection.

All the above mentioned challenges of ecosan systems are put under close consideration in this study.

1.1 Objectives of the study

The main focus of this study is to analyze economic, social and technical aspects of low-tech sustainable sanitation.

The emphasis of the study is put on the economic aspects due to the fact that decision making mechanisms are very often based on a cost-benefit analysis. Furthermore, showing the financial benefits of the ecosan approach should attract the private sector’s attention. As a result, innovative products and suitable value and service chains can be created, which are crucial for a successful ecosan system. Thus, the economic feasibility of manufacturing toilets under the ecosan principle and of running ecosan systems, including toilet building, urine collection, transportation, storage and agricultural application is performed.

Technical aspects of sustainable sanitation are also an important part of this study due to the different options available and their appropriateness for a particular country, urban or rural setting and maintenance requirements. This study focuses on low-tech sustainable sanitation options due to their suitability for developing countries, in particular because of their lower cost, easiness of maintenance, spare parts availability and lower infrastructure demands.

Social aspects are also a part of this study due to the dependency between the acceptance and adoption of ecosan and social features such as religion and culture. Therefore, the study takes into account different facets of sanitation promotion in order to design a successful campaign to raise awareness and create demand for ecosan.

This research analyzed ecosan from a holistic system's perspective. Therefore, a business idea revolving around the production of toilets slabs suitable to be used under the ecosan approach was drafted. A thorough analysis of different parameters, including technical aspects (e.g., manufacturing process, raw material choice, coloration methods, production volumes, product features), logistics aspects (e.g., plant location and size, headcount planning, procurement of supplies), financial aspects (e.g., cost minimization options, sales planning, demand estimation) and aspects related to competition (e.g., current players on the market, current toilet prices, potential substitute products) was performed. Furthermore, an economic analysis of building or modifying toilets for separate collection of urine and feces, transportation of urine to its storage locations, urine storage and selling it to farmers to be applied as liquid fertilizer in agriculture was performed. For this analysis, the local sanitary situation and agricultural practices were taken into account. In this way, the whole process chain was analyzed, including toilet manufacturing, toilet building, management of ecosan products and marketing of urine for its application in agriculture.

The results of this study are expected to contribute to increased knowledge on the suitability of sustainable sanitation. By showing the economic benefits that it brings along, the interest of the private sector to become more involved in ecosan should be awaken, ideally leading to product innovation and successful business models that would benefit not only the private sector but also the users.

Two case studies were analyzed, one from Ethiopia and the other one from Ghana. Ethiopia was chosen as a representative of an East African country, whereas Ghana as an example of a West African country. Despite their different geographical location, these two countries have a lot in common, including the importance of agriculture to the country's economy, urban and peri-urban agriculture practices, wastewater irrigation practices, households being expected to meet the cost of sanitation hardware, lack of sufficient promotion, marketing and innovative microfinance arrangements for sanitation and decentralization of responsibilities in the water and sanitation public sector, to name just a few. However, it is also important to mention that Ethiopia and Ghana differ in some aspects, including, for example, country size, economic growth, education level, food security level, poverty level, sanitation coverage rates, slum population level, the size of urban population and available infrastructure.

In the case study Ethiopia, a business plan was created for an imaginary company to manufacture low-tech toilets that can be applied under the ecosan principle. This case study analyzes different manufacturing processes, machinery, raw material options and production volumes as well as cost minimization methods in order to define the best project framework under the local conditions. In this case study, toilet slabs are seen as a product that needs to be marketed. Thus, all the crucial market-related aspects are considered, including procurement and logistics, potential competitors and substitute products, product pricing, production and sales planning, operational costs, demand for products as well as investment requirements, project financing and returns.

In the case study Ghana, the idea of a supply chain is explored. It is based on a separate collection of urine from waterless urinals and urine diverting dry toilets, transportation of urine to storage locations, storage of urine and application of urine as liquid fertilizer on non-food and food crops. In order to market urine, its monetary value is calculated, taking into account its nutrient content as well as current world and local market fertilizer prices. The case study also analyzes the options for lowering or covering urine transportation costs together with reducing storage time and costs of urine.

The study was developed around a number of research questions with focus on African conditions, which mainly include the following:

- What factors determine the profitability of ecosan?
    - Toilet manufacturing costs
    - Demand for toilets
    - Toilet building costs
    - Urine transportation costs
    - Urine storage costs
    - Urine selling price
    - Demand for urine as fertilizer
- What are the possibilities of cost decrease for ecosan?
- Can urine be marketed in order to finance a sustainable sanitation system?
- How can one make storage and transportation of urine economically feasible?
- How much fertilizer can be offset when applying urine as liquid fertilizer?
- How to create demand for ecosan?
- What are the success factors for an effective ecosan promotion campaign?

1.2 Outline of the report

Chapter 2 presents background information on the private sector involvement in sanitation, highlighting its potential and limitations in the context of Ghana and Ethiopia.

Case study Ethiopia, which refers to the business idea of manufacturing low-tech plastic toilet slabs to be used under the ecosan approach, is presented in Chapter 3. Two scenarios were considered, depending on the production volumes that want to be achieved and the investment that needs to be made.

Chapter 4 presents the case study Ghana, with a supply chain for an ecosan system, including modification or building of sanitation facilities for separate urine and feces collection, collection, transportation, storage and agricultural application of urine. Chapter 4 studies three systems designed to interact with each other in two locations – the capital city of Ghana, Accra and a semi-urban settlement in the Eastern Region of Ghana, Kade.

Sanitation promotion is the topic of Chapter 5, where the social aspects of designing a promotion campaign are described, with emphasis on Ghana and Ethiopia. Thus, sanitation culture, access and popularity of different media as well as potential campaign partners are presented.

Conclusions of the study and recommendations for the future are summarized in Chapter 6.

2 INTRODUCTION TO PRIVATE SECTOR INVOLVEMENT IN SANITATION

This chapter discusses the potential and limitations for the private sector involvement in the sanitation sector. First, background information on Ghana and Ethiopia is presented, with emphasis on the agricultural situation to show the importance of nutrients reuse and the suitability of ecological sanitation (ecosan) in this context. Then, the global challenges of urbanization, growing food demand and depleting phosphorous resources are introduced. Next, the global sanitation challenge and benefits of access to improved sanitation facilities are described. Further, the enabling environment for private sector involvement in sanitation, existing challenges and potential solutions are discussed.

2.1 Ghana

This section presents background information about Ghana.

2.1.1 General information

Ghana is an English-speaking country located in West Africa with an estimated population of 24.4 million, of which over a half is urban (see Table 2.1) (World Bank, 2011a). The country has an area of 238,533 km^2 (Ghana Statistical Service, 2008a) and is divided into ten regions, i.e. Upper West, Upper East, Northern, Brong-Ahafo, Ashanti, Western, Central, Eastern, Greater Accra and Volta. Accra is the capital city of Ghana and is located in the Greater Accra Region. Background information about the country is summarized in Table 2.1.

Table 2.1: Summary of background information about Ghana (UN, 2011a; UNDP, 2011a; World Bank, 2011a)

Indicator	Year	Score
Population (million)	2010	24.4
Population growth (annual %)	2010	2.4
Urban population (% of total)	2010	52
Urban population growth (annual %)	2010	4
Slum population as percentage of urban (%)	2007	42.8
GDP (current, billion US$)	2010	31.3
GDP growth (annual %)	2010	6.6
GDP per capita (current, US$)	2010	1,283
Human Development Index	2011	135
Child mortality < 5 years (per 1,000 live births)	2010	74
Population < US$ 1 (PPP) per day (%)	2008	30
Poorest quintile's share in national income or consumption (%)	2006	5.2
Population below national poverty line (%)		
· national	2006	28.5
· urban	2006	10.8
· rural	2006	39.2
Population undernourished (%)	2007	5
Literacy rate, adult total (% of people aged 15 and above)	2009	67
Internet users per 100 population	2010	8.6
Mobile subscribers per 100 population	2010	71.5

In Ghana, the Gross Domestic Product (GDP) per capita is close to the GDP value for sub-Saharan Africa as a region (USD 1,302) (World Bank, 2011a). Ghana with a 2011 Human Development Index (HDI) of 0.541 was ranked 135 out of 187 countries with comparable data (UNDP, 2011a). The HDI 2011 of sub-Saharan Africa as a region was 0.463, placing Ghana above the regional average (UNDP, 2011a). Despite the positive developments, the country is still struggling with area-based differences, for example, poverty is ten times higher in Greater Accra than in Northern Ghana (UNDP, 2011b).

2.1.2 Sanitation coverage

Ghana's target to meet the Millennium Development Goal (MDG) for improved sanitation[1] is set at 54 % (base year: 1990) (Sanitation and Water for All, 2011b). The percentage of total population using improved sanitation facilities in Ghana grew from 7 % in 1990 and 9 % in 2000 to 13 % in 2008 (see Figure 2.1). Even so, in order to meet the MDG sanitation target, the improved sanitation coverage needs to increase about four times, i.e. over 1.6 million people need to get access to improved sanitation facilities annually (2008-2015) (Sanitation and Water for All, 2011b). Open defecation is still practiced by 20 % of the Ghanaian population. Shared sanitation facilities have become widely used in Ghana, especially in urban areas, where 70 % of the population used this kind of facilities in 2008 (see Figure 2.1). However, the WHO/UNICEF Joint Monitoring Program (JMP) does not classify shared sanitation facilities as improved. A considerable disparity between urban and rural sanitation coverage in Ghana can also be seen in Figure 2.1.

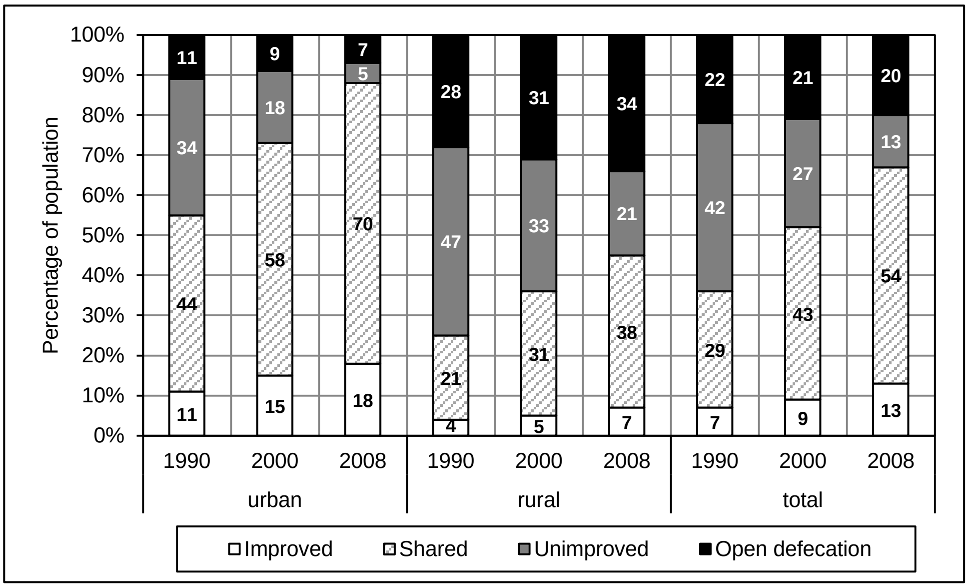


Figure 2.1: Urban, rural and total sanitation coverage in 1990, 2000 and 2008 in Ghana (based on WHO and UNICEF, 2010)

[1] According to the WHO/UNICEF Joint Monitoring Program (JMP), improved sanitation facilities ensure hygienic separation of human excreta from human contact. They include the use of the following facilities: flush/pour flush to piped sewer system, septic tank, pit latrine; ventilated improved pit latrine; pit latrine with slab; composting toilet (WHO and UNICEF, 2010).

2.1.3 Agriculture

Agricultural land area in Ghana comprises 57 % of the total land area (Ministry of Food and Agriculture, 2011). In 2010, almost 58 % of the agricultural land was under cultivation (Ministry of Food and Agriculture, 2011). The agricultural sector provides employment to 56 % of the Ghanaian population (CIA, 2005) and is responsible for over 73 % of the country's total exports (WTO, 2011). In 2010, the share of agriculture in the GDP was 30 % (World Bank, 2011a). This clearly demonstrates the importance of agriculture to Ghana's economy.

There are five main agro-ecological zones in Ghana and they are defined on the basis of climate, reflected by the natural vegetation and influenced by the soils (FAO, 2005a). The mean annual rainfall in these zones varies from 800 mm (Coastal Savannah) to 2,500 mm (Rain Forest) (FAO, 2005a).

The production of industrial crops (cocoa, coffee, rubber, shea nut and oil palm fresh fruit bunches) in Ghana amounted to over 2.9 million metric tons in 2010 (Ministry of Food and Agriculture, 2011). In 2010, 1,600,000 ha of land in Ghana was cultivated with cocoa and around 360,000 ha with oil palm (Ministry of Food and Agriculture, 2011). The most cultivated food crops in 2010 in Ghana (in descending order) included: cassava, yam, plantain, maize, cocoyam, rice (paddy), sorghum and millet (Ministry of Food and Agriculture, 2011).

Approximately 90 % of the farms in Ghana are smallholder farms of less than 2 ha in size (GNIB, 2008). Large-scale farms in Ghana are mainly for rubber, oil palm and coconut as well as for rice, maize and pineapples (Ministry of Food and Agriculture, 2010).

2.1.3.1 Fertilizer use

In general, Ghanaian soils have very low levels of organic carbon, nitrogen and available phosphorous (FAO, 2005a). Potassium is abundant in most soils in Ghana, whereas the levels of available calcium may vary between 14-470 mg/kg soil, depending on the region (FAO, 2005a; Ministry of Food and Agriculture, 2011). Soils with the highest nitrogen content can be found in the Ashanti Region, whereas soils with the highest phosphorous (P) content can be mainly found in the Greater Accra, Brong Ahafo, Upper East and Northern Regions (Ministry of Food and Agriculture, 2011). A large discrepancy can also be observed in the nutrient content of soils within one region, for example, soils in Greater Accra contain between 0.8-144 mg P/kg of soil (Ministry of Food and Agriculture, 2011).

Henao and Baanante (2006) reported the average levels of nutrient losses (nitrogen, phosphorus, potassium) in Ghana to be 58 kg per ha and year, which places Ghana in the medium nutrient depletion level group (30-60 kg/ha*year), but not far from the African countries with the highest depletion rates (60-90 kg/ha*year). Moreover, human induced soil degradation[2] affects approximately 11 % of the land in Ghana (FAO, 2005b).

[2] Soil degradation assessments by country based on the Global Assessment of Soil Degradation survey carried out during the 1980's by UNEP and International Soil Reference and Information Centre.

According to Lesschen et al. (2004), almost all crop balances in Ghana show a nutrient deficit[3]. Nutrient deficit represents a loss of potential yield and progressive soil deterioration (FAO, 2005a). Some crops in Ghana have almost neutral nutrient balances (e.g., fallow and groundnuts), whereas others have strongly negative balances (e.g., coconut and cassava) (Lesschen et al., 2004).

All fertilizers used in Ghana are imported and the major importers are private companies (FAO, 2005a). Fertilizer use in Ghana is primarily on cash crops (FAO, 2005a). Thus, major users of fertilizers include the oil palm sector, the tobacco sector, the cotton sector and large rice irrigation projects (FAO, 2005a). In the last years (2002-2008), the consumption of fertilizer in Ghana varied between 3.7 kg/ha of arable land in 2002, through 20.1 kg/ha in 2006 to 6.4 kg/ha in 2008 (World Bank, 2011a).

Users receive fertilizers either directly from importers or through wholesalers located in the main cities in Ghana, who supply fertilizers through a network of rural shops located in the districts (FAO, 2005a). Fertilizer dealers in all regions have to travel considerable distances to access their suppliers: in the Eastern Region, the average distance to the closest supplier is about 80 km, whereas in the Greater Accra Region it is 34 km (Krausova and Banful, 2010).

As it can be seen in Figure 2.2, fertilizers imported to Ghana in the years 2004-2009 included[4]: NPK, potassium and calcium nitrate, others, single super phosphate (SSP) and triple super phosphate (TSP), potassium sulfate, ammonium sulfate (AS), urea, cocoa fertilizer and muriate of potash (MOP) (Ministry of Food and Agriculture, 2010).

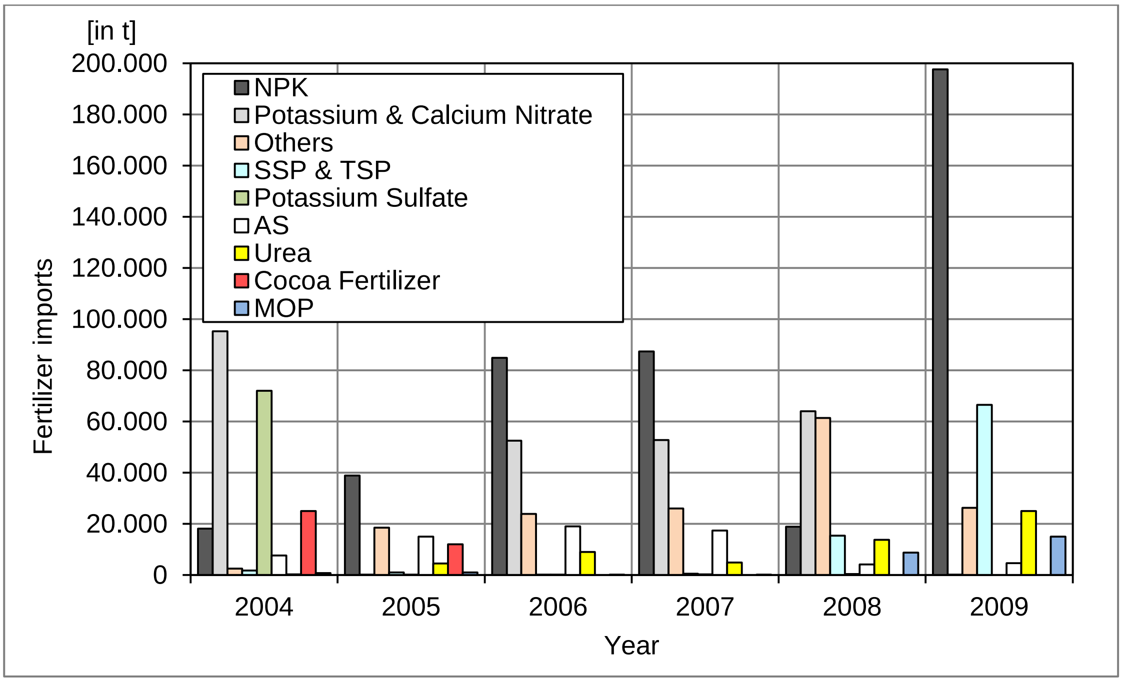


Figure 2.2: Fertilizer imports in Ghana, 2004-2009 (in tons) (based on Ministry of Food and Agriculture, 2010)

[3] Nutrient deficit translates to the difference between the quantities of plant nutrients applied and the quantities removed or lost.

[4] Fertilizers imported to Ghana are listed in a descending order, taking into account the cumulative tonnage for the years 2004-2009.

With declining soil fertility and crop yields, input subsidies are needed to restore growth in agricultural productivity. Therefore, in 2008 and 2009, the Government of Ghana instituted USD 15 million worth of subsidies on NPK 15:15:15, NPK 23:10:05, AS and urea nationwide due to increasing fertilizer prices (Banful, 2009). The subsidy was received in the form of vouchers distributed to farmers. As part of the subsidy program, the government and the private importers negotiated a price per 50-kilogram bag in each capital of a district (Krausova and Banful, 2010). The main findings regarding the subsidy program by Krausova and Banful (2010) can be summarized as follows:

- Only 40 % of the fertilizer retailers were able to participate in the 2008 voucher program.
- The voucher program required retailers to pass the vouchers received from farmers to one of three major fertilizer importers for reimbursement, based on the assumption that a good proportion of fertilizer retailers had relationships with fertilizer importers.
- In 2009, only 11 % of the fertilizer retailers had direct links to fertilizer importers from whom they could redeem the vouchers, and it is likely that a similar percentage had direct links in 2008.
- In 2008, 87 % of the fertilizer retailers who did not accept vouchers said it was because they had no way of redeeming them.

To conclude, up to 60 % of the fertilizer retailers were unable to participate in the 2008 and 2009 fertilizer subsidies programs, which can be mainly attributed to the fact that it was not taken into account that only a small proportion of fertilizer retailers had relationships with fertilizer importers (Krausova and Banful, 2010).

2.1.3.2 Urban and peri-urban agriculture[5]

Urban farming in Accra became particularly popular in the years 1972-1976 as a result of the government’s Operation Feed Yourself (OFY) program (Appeaning, 2010). The OFY program encouraged urban farming as a response to poor economic conditions and a resulting food scarcity. The importance of urban farming in Ghana is mirrored in the fact that 90 % of the lettuce and spring onions consumed in Kumasi and Accra are grown in and around urban areas (Cofie et al., 2004).

Cofie and Mainoo (2007) reported that the use of imported mineral fertilizers is beyond the economic means of poor urban farmers, which results in cropping without addition of adequate external nutrients. Animal manure (e.g., cow dung, poultry manure[6]) has been promoted by local and foreign partners but its availability in urban areas is scarce (Tettey-Lowor, 2008). Nevertheless, in particular due to its low cost, poultry manure is preferably used by urban farmers, e.g., in Accra and Kumasi (Amoah et al., 2007; Tettey-Lowor, 2008). Cofie et al. (2011) reported that in Accra,

[5] The definition of urban agriculture (UA) is as follows: "UA is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re-) using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area" (Mougeot, 2000, p.11).

[6] Poultry manure has the following average nutrient content (expressed as % by weight): N: 2.87; P_2O_5: 2.90; K_2O: 2.35 (Roy, 2006). It has the highest content of nutrients when compared to cattle and sheep dung (FAO, 2005a; Roy, 2006).

urban farmers mix poultry manure with chemical fertilizers. With regard to chemical fertilizers, urban farmers in Accra apply mainly NPK 15:15:15, ammonia sulfate, urea and muriate of potash (Cofie et al., 2011). According to a study by Agyarko and Adomako (2007), in vegetable farms in Ghana, organic manures were more frequently applied than inorganic fertilizers. Respondents stated low prices of organic manure as the reason for using them in place of inorganic fertilizers.

In urban areas in West Africa, subsistence farming[7] is performed as backyard or front yard farming, whereas in peri-urban areas, in home gardens or around homestead. In West Africa, approximately 20 million urban dwellers practice backyard gardening, mostly for subsistence (Drechsel et al., 2006). In Ghana, subsistence farmers are mainly located in the Northern, Upper East and Upper West Regions (Devereux, 2006). Almost two-thirds of households in the main urban centers of Ghana practice backyard farming (Cofie et al., 2004). Alone in Accra, there are about 80,000 small backyards, covering an area of only 50-70 ha and engaging 60 % of the households in Accra (Drechsel et al., 2006; Obuobie et al., 2006). Alongside subsistence farming, semi-subsistence farming[8] is also popular in Ghana.

According to Mainoo (2007), subsistence farmers in Ghana are more likely to use cheap internal inputs such as organic fertilizers produced locally (e.g., cow dung, poultry manure, organic waste) prior to purchasing expensive external inputs such as mineral fertilizers or organic fertilizers that need to be transported outside of the local region. Subsistence farmers tend to use easily available chemical fertilizers, which often contain banned and illegal substances that are harmful to the farmers, consumers and the environment (African Initiatives, n.d.).

2.1.3.3 Wastewater irrigation

Even though wastewater irrigation presents a major health risk, both to users and consumers, it is widely practiced, especially in developing countries. This practice is still expected to increase due to the need to provide food to growing urban population and lack of alternative water sources for this purpose in urban areas in developing and middle-income countries. A study of 53 cities in Africa, Asia and Latin America found out that only 15 % out of the cities surveyed reported to have little or no irrigated urban and peri-urban agriculture (UPA) (Raschid-Sally and Jayakody, 2008). According to Stedman (2008), approximately one tenth of the world's crops are irrigated with wastewater. Raschid-Sally and Jayakody (2008) estimate that 200 million farmers irrigate with wastewater worldwide, farming on at least 20 million ha.

In Ghana, UPA develops wherever land is available and every accessible source of water is used for irrigation (Obuobie et al., 2006). In Accra, drains are the main source of irrigation water, which can be anything from raw wastewater to storm water diluted with wastewater (Obuobie et al., 2006). Obuobie et al. (2006) studied fecal coliform (FC) and total coliform levels in the Surbin River in Kumasi, which is used for domestic and irrigation purposes, and reported that they were very high (all above 10^6/100 ml), even as far as 32 km downstream of the city center. The situation is

[7] Subsistence farming is a form of urban and peri-urban farming, in which almost all of the produce is used to sustain the farmer and his family, with little, if any, surplus for sale.

[8] Semi-subsistence farming refers to a farm producing mainly for self-consumption, but also selling a certain part (surplus) of the produce.

similar in other main cities in Ghana, including Accra and Tamale. A microbiological analysis performed at six vegetable gardening sites within the Tamale metropolis in 2000/2001 showed FC levels of irrigation water higher than $2x10^6$/100 ml for all sites (Abdul-Ghaniyu et al., 2002). Wastewater irrigation results in crops being contaminated with pathogens. After testing samples of market vegetables from Accra, Kumasi and Tamale, it was reported that lettuce, cabbage and spring onions irrigated with wastewater carried FC populations ranging between $4.0x10^3$ to $9.3x10^8$ per gram (Amoah, 2008), far exceeding the International Commission on Microbiological Specifications for Foods (ICMSF) recommended level of 10^3 FC per gram fresh weight (ICMSF, 1974 cited in Amoah, 2008).

2.1.4 Water and sanitation sector development

The water and sanitation sector in Ghana "has a well-established institutional set-up with clear lines of responsibility" (WSP, 2011b, p.13). Even though the Growth and Poverty Reduction Strategy (GPRS 2006-2009) has not given sanitation much importance, there has been some recent developments in the sanitation sector in Ghana (refer to Figure 2.3).

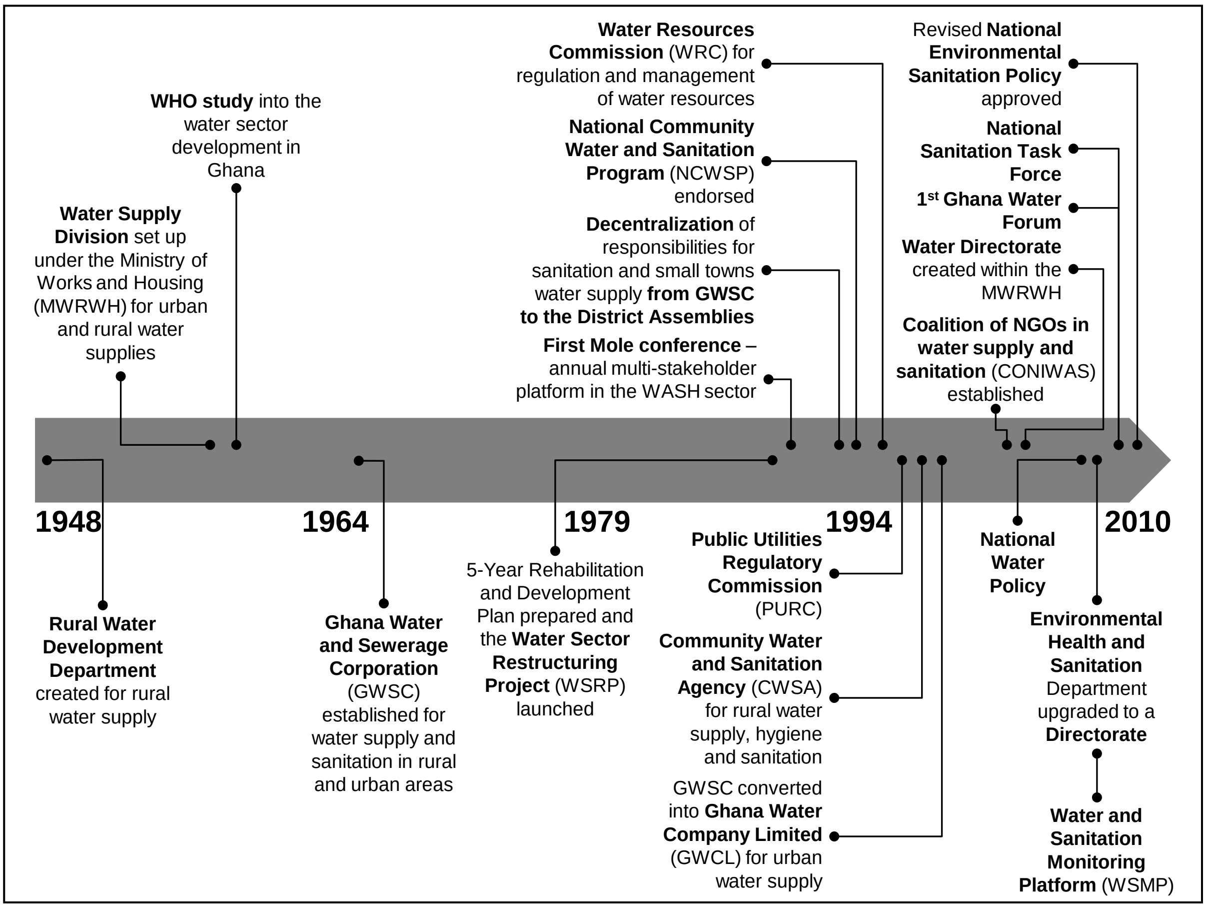


Figure 2.3: Important dates in the water and sanitation sector in Ghana (based on MWRWH, 2009 and WSP, 2011b)

A number of organizational reforms were initiated in the early 1990s within the Ghanaian water and sanitation sector. In 1993, responsibilities for sanitation and small towns water supply were decentralized from Ghana Water and Sewerage Corporation (GWSC) to the District Assemblies (MWRWH, 2009). In 1998, the

Community Water and Sanitation Agency (CWSA) was established to manage rural water supply systems, hygiene education and provision of sanitary facilities.

The formation of the Coalition of NGOs in Water and Sanitation (CONIWAS) in 2003 has contributed to a better sector coordination (MWRWH, 2009). CONIWAS also organizes the Mole Conference Series, which bring together sector practitioners such as non-governmental organizations (NGOs), government agencies, private sector and community-based organizations (CBOs) to discuss, learn and share knowledge on water, sanitation and hygiene (WASH) themes. In 2004, a Water Directorate was created within the Ministry of Water Resources, Works and Housing (MWRWH) to oversee sector policy formulation and review monitoring and evaluation of the activities of the agencies and co-ordination of the activities of donors (WSP, 2011b). An Environmental Health and Sanitation Division under the Ministry of Local Government and Rural Development was upgraded into a Directorate in 2008 (MWRWH, 2009). The Environmental Health and Sanitation Directorate (EHSD) is responsible for policy formulation and coordination and it is also the lead institution supporting processes for increasing access (Dabire, 2011).

A National Sanitation Task Force was formed in 2009 to monitor and document implementation challenges (Dabire, 2011). The draft Revised National Environmental Sanitation Policy has been recently approved and it will be published for dissemination soon (Smith-Asante, 2010). Regarding the efforts to meet the MDG sanitation target in Ghana, the EHSD has lately finalized the National Environmental Sanitation Action and Investment Plan, which aims at achieving minimum service options by 2015 (Dabire, 2011).

According to WSP (2011b), the total capital expenditure for sanitation hardware requirements to meet the MDG sanitation target in Ghana is estimated at USD 402 million per annum. With the community-led total sanitation (CLTS) accepted as a feasible approach, households are expected to meet the full costs of sanitation hardware (WSP, 2011b). However, the mechanisms and finance for promoting nationwide adoption of household sanitation are not fully clear yet (WSP, 2011b). Thus, sufficient promotion, marketing and innovative microfinance arrangements have to be introduced in Ghana in order to encourage households to invest in sanitation.

2.2 Ethiopia

This section presents background information about Ethiopia.

2.2.1 General information

Ethiopia is a landlocked country located in the Horn of Africa with an estimated population of nearly 83 million, of which approximately only 18 % is urban (see Table 2.2) (World Bank, 2011a). The country has an area of 100,000,000 km^2 (World Bank, 2011a) and is divided into nine regions, i.e. Afar, Amhara, Benishangul-Gumuz, Gambela, Harari, Oromia, Somali, Southern Nations, Nationalities, and People's Region and Tigray. Addis Ababa is Ethiopia’s capital city, which besides Dire Dawa is one of the two cities in the country that have a city and state status.

Background information about Ethiopia is summarized in Table 2.2. Even though the state of the Ethiopian economy has been improving, the country’s GDP per capita is one of the smallest in the world and far below the GDP value for sub-Saharan Africa as a region (World Bank, 2011a). Ethiopia with a 2011 Human Development Index (HDI) of 0.365 was ranked 174 out of 187 countries with comparable data and below the sub-Saharan Africa regional average of 0.463 (UNDP, 2011a). Ethiopia is suffering from poverty and food insecurity, which is mirrored in the high percentage of undernourished population and of population living below the national poverty line (see Table 2.2).

Table 2.2: Summary of background information about Ethiopia (World Bank, 2011a; UN, 2011a; UNDP, 2011a)

Indicator	**Year**	**Score**
Population (million)	2010	82.9
Population growth (annual %)	2010	2.1
Urban population (% of total)	2010	18
Urban population growth (annual %)	2010	4
Slum population as percentage of urban (%)	2007	79.1
GDP (current, billion US$)	2010	29.7
GDP growth (annual %)	2010	10.1
GDP per capita (current, US$)	2010	358
Human Development Index	2011	174
Child mortality < 5 years (per 1,000 live births)	2010	106
Population < US$ 1 (PPP) per day (%)	2005	39
Poorest quintile's share in national income or consumption (%)	2005	9.3
Population below national poverty line (%)		
· national	2004	38.9
· urban	2004	35.1
· rural	2004	39.3
Population undernourished (%)	2007	41
Literacy rate, adult total (% of people aged 15 and above)	2008	30
Internet users per 100 population	2010	0.8
Mobile subscribers per 100 population	2010	7.9

2.2.2 Sanitation coverage

The data provided by the Ethiopian government present higher sanitation coverage figures than the WHO/UNICEF Joint Monitoring Program (JMP) data. The government data show an increase to 39 % coverage by 2009 (30 % rural, 88 % urban) from a baseline of close to zero in 1990 (WSP, 2011a). JMP data, on the other hand, show a 12 % improved sanitation coverage in 2008 with the MDG sanitation target of 52 % by 2015 (see Figure 2.4) (WHO and UNICEF, 2010). Based on the JMP data, in order to meet the MDG sanitation target, 5.8 million Ethiopians need to get access to improved sanitation facilities annually (2008-2015) (Sanitation and Water for All, 2011a). There is also a huge disparity between urban and rural areas, with only 8 % of the rural population and 29 % of the urban population using improved sanitation facilities (see Figure 2.4). The percentage of population in Ethiopia that practices open defecation is still very high (60 %), even though it declined by 32 % since 1990 (see Figure 2.4).

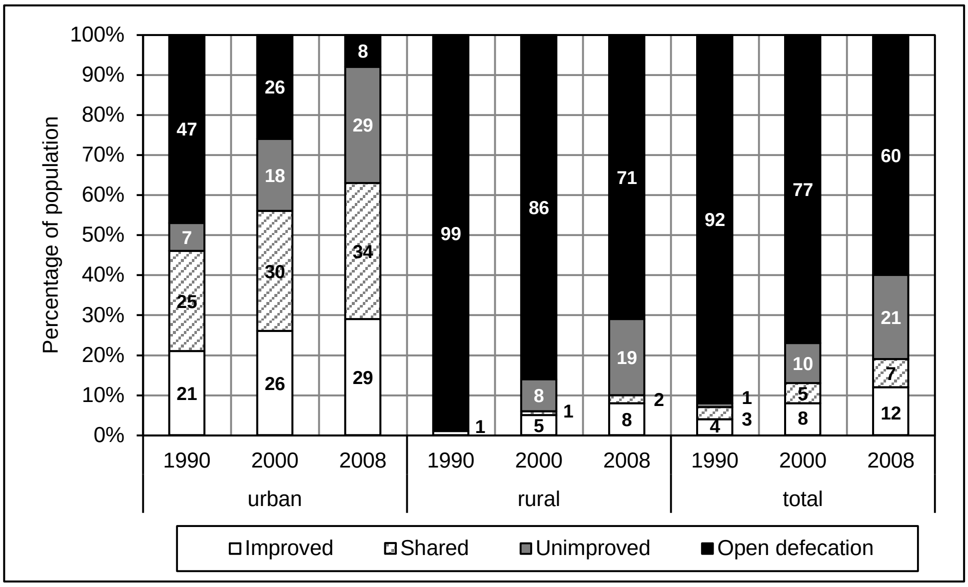


Figure 2.4: Urban, rural and total sanitation coverage in 1990, 2000 and 2008 in Ethiopia (based on WHO and UNICEF, 2010)

2.2.3 Agriculture

In 2008, agricultural land area in Ethiopia comprised almost 35 % of the total land area (World Bank, 2011a). In 2010, the share of agriculture in the GDP in Ethiopia was 48 % (World Bank, 2011a). The sector provides employment for 85 % of the Ethiopian population (Dejene, 2000 cited in Economic Commission for Africa, 2001) and is responsible for over 81 % of the country's total exports (WTO, 2011). This demonstrates the importance of agriculture to Ethiopia's economy, which is even higher than in the case of Ghana (see Section 2.1.3).

Ethiopia has five traditional agro-climatic zones that have different physical characteristics in terms of altitude, rainfall, length of the growing period and average temperature (Dejene, 2003). The annual rainfall in these zones varies from 200-800 mm (Kola – warm and semi arid zone) to 900-2,200 mm (Wurch – cold and moist zone) (Dejene, 2003).

The production of cash and industrial crops (sugar cane, pulses, vegetables, fruit, coffee, sesame, oil seeds, cotton, tea, tobacco, spices and sisal) in Ethiopia amounted to almost 7.4 million tons in 2009, of which the production of sugar cane amounted to 2.3 million tons, of pulses to 1.8 million tons, of vegetables to 1.6 million tons and of fruit to 0.8 million tons (FAO, 2012). In 2010, the most cultivated food crops in Ethiopia (in descending order) included: maize, teff, wheat, sorghum, barley, horse beans, potatoes and millet (FAO, 2011a). Thus, cereals and pulses are the most cultivated food crops in Ethiopia.

2.2.3.1 Fertilizer use

Soils in Ethiopia can be generally characterized as follows: soils with a low phosphorous content (found in most of the southern and southwestern Ethiopia), soils with a very low nitrogen content caused by water clogging (found in the highlands and some parts of the lowland), soils with a low nitrogen content caused by low organic content and with a relatively high phosphorous content (found in the central and northern highlands), soils with a high nitrogen but a low phosphorous content (found in the south and southwestern part) (Dejene, 2003).

Ethiopia is one of the countries in Africa with the most negative nitrogen, phosphorous and potassium balances because of a high ratio of cultivated to total arable land, relatively high crop yield and a high rate of soil erosion (Stoorvogel and Smaling, 1990 cited in Lesschen et al., 2004). The most visible form of land degradation in Ethiopia is soil erosion, which affects almost half of the agricultural land and results in soil loss of 1.5 to 2.0 billion tons per annum (Dejene, 2003).

Henao and Baanante (2006) reported the average levels of nutrient losses (nitrogen, phosphorus, potassium) in Ethiopia to be 49 kg per ha and year, which places Ethiopia in the medium nutrient depletion level group (30-60 kg/ha*year), but not far from the African countries with the highest depletion rates (60-90 kg/ha*year). Human induced soil degradation affects approximately 25 % of the land in Ethiopia, which is more than a double of that in Ghana (refer to Section 2.1.3.1) (FAO, 2005b).

In terms of the quantity of commercial fertilizer applied to crops in private holdings for the main cropping season in 2009/2010, the largest quantity of fertilizer was applied to cereals (almost 335,000 t), of which the most to teff, wheat and maize, pulses (over 41,000 t), oil seeds (almost 18,000 t), root crops (almost 10,000 t) and to vegetables (almost 8,000 t) (Central Statistical Agency of Ethiopia, 2011).

Fertilizer application rates grew in Ethiopia in the late 1990s, after farmers were allowed to buy fertilizer with 100 % credit (1995) and as a result of the Government's National Extension Package program that stressed the importance of using external inputs in order to accelerate production (Dejene, 2003). However, the current fertilizer prices make it often impossible for farmers to apply fertilizers. Thus, alternative options need to be explored. In the years 2002-2008, the consumption of fertilizer in Ethiopia varied between 16.9 kg/ha of arable land in 2002, through 5.6 kg/ha in 2004 to 7.7 kg/ha in 2008 (World Bank, 2011a).

Due to the fact that phosphorous and nitrogen are the most crucial limiting factors to plant growth in Ethiopia, a blanket recommendation of 100 kg DAP and 50 kg of urea was formulated for the country (Dejene, 2003). Thus, as it can be seen in Figure 2.5, fertilizers imported to Ethiopia in the years 2005-2009 included DAP and urea (FAO, 2011a). According to the Central Statistical Agency of Ethiopia (2011), in the main growing season of 2009/2010 in private holdings in Ethiopia, a total of almost 423,000 t of fertilizer was applied, of which 122,000 t of DAP, 21,000 t of urea and almost 280,000 t of DAP + urea.

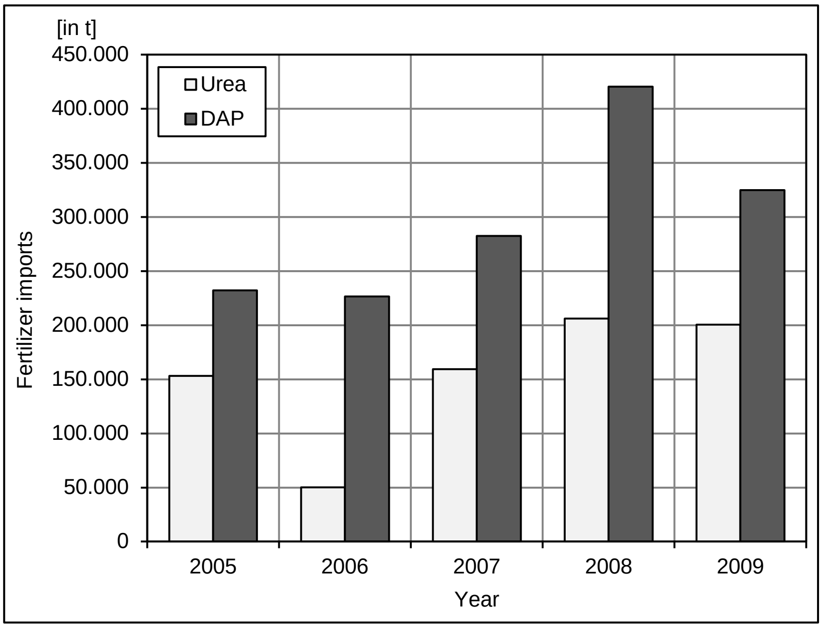


Figure 2.5: Fertilizer imports in Ethiopia, 2005-2009 (in tons) (based on FAO, 2011a)

2.2.3.2 Urban and peri-urban agriculture

Urban agriculture is a traditional practice in Ethiopia with the urban population producing mainly for household's own consumption, with a small proportion left for sale (Egziabher et al., 1994). Urban agriculture is practiced in Ethiopia as a response to food insecurity and due to the shortage of income and unemployment in urban areas (Lamba, 1993).

Addis Ababa houses about 23 % of the urban population in Ethiopia (Population Census Commission, 2008). There is a large number of households whose livelihoods are connected with farming in Addis Ababa, supporting directly more than 51,000 families (ORAAMP, 2000 cited in Tewodros, 2007).

Urban farming in Addis Ababa is practiced either as backyard farming in open spaces around houses and in low-lying areas that are located along a river or in peri-urban areas. Urban farming in the capital city encompasses crop production, livestock rearing and mixed farming (crop production and livestock rearing), the latter one being practiced by 40 % of the households in the city (Tewodros, 2007). Different sources state the extent of the area associated with urban agriculture in Addis Ababa. One source indicates that the total area dedicated to urban agricultural activities in the city extends over 9,380 ha (over 17 % of the city) of which about 490 ha is used for vegetable production (UAESCP, 2010 cited in Woldu, 2010). Another source reported that urban agriculture covers about 16,000 ha in Addis Ababa, of which almost 12,000 ha is cultivated (PSPC, 2003 cited in Girmai, 2007).

Crops cultivated in urban agriculture are mainly vegetables, which are in most cases sold and the revenue is used for buying food products to satisfy household's needs (Tewodros, 2007). The use of fertilizer and manure is common for urban farmers in Addis Ababa, with more than 80 % of the crop producers applying fertilizer and manure (Tewodros, 2007). Crop residues or animal manure (if they keep animals) is used by 42 % of the urban farmers producing crops and 27 % collects animal manure from livestock keepers located in the surrounding area.

2.2.3.3 Wastewater irrigation

Wastewater irrigation in urban and peri-urban farms for subsistence and market consumption has been practiced since 1940s in Addis Ababa and its surroundings (Weldesilassie et al., 2010). In Addis Ababa, approximately 49 million m^3 of wastewater is generated annually (Van-Rooijen et al., 2010) and most of it is disposed into rivers and streams flowing through the city (Bahri, 2007). One of these rivers – Akaki serves as irrigation water for vegetable farms (Van-Rooijen et al., 2010). The levels of total coliform count in the samples from the Little Akaki River[9] in 1997/1998 were between $2.9x10^6$/100 ml (dry season) and $3.8x10^4$/100 ml (upstream), i.e. higher than the local Environmental Protection Authority 2005 standard (400/100 ml) (Environmental Protection Authority, 2003 cited in Weldesilassie et al., 2010).

Urban agriculture in Addis provides approximately 60 % of the vegetables consumed in the city, which are mainly irrigated with wastewater (Bahri, 2007; Weldesilassie, 2008). Moreover, as many as 90 % of the leafy vegetables sold in the market in Addis originates from urban farms (Weldesilassie et al., 2010). In Addis Ababa, a "survey found about 1,260 farm households producing vegetables with wastewater irrigation on about 1,240 hectares" (Weldesilassie et al., 2010; p.30). Vegetable farmers in the capital of Ethiopia apply water to the soil (channel and furrow irrigation), which poses a lesser contamination risk than in case of sprinkling water over vegetables.

2.2.4 Water and sanitation sector development

Even though hygiene and sanitation had been marginalized for a long time in Ethiopia, the political commitment in the past few years resulted in important actions (refer to Figure 2.6).

Ethiopia went through a progressive decentralization process resulting in a significant transformation in the institutional arrangements for basic service provision. In the 1990s, the Regional Water Bureaus were provided with a large degree of autonomy to develop their water supply services (WSP, 2011a). Then, in 2004 a second wave of decentralization brought responsibilities over basic service delivery to the district or woreda[10] level (WSP, 2011a).

At the federal level, the Ministry of Water Resources (MoWR) has initiated many policies, strategies, sector development programs and implementation arrangements to reach the MDG water and sanitation target (WSP, 2011a). The National Hygiene and Sanitation Strategy (2005) expressed a shift towards low-cost sanitation solutions and large-scale investment in promotion (WSP, 2011a). This goes in line with the Health Extension Program (2004), within which a vast network of health extension workers were employed across the country to promote household sanitation. The political will to support the improvement of the sanitary situation in Ethiopia was particularly expressed in the Universal Access Plan (UAP) (2006), where a target of reaching 100 % sanitation coverage by the year 2012 (recently revised to 98.5 % and extended to 2015) was set (MoWR, 2006; WSP, 2011a). Even

[9] The Akaki River has two main catchments- the Little Akaki River and the Great Akaki River.

[10] Woredas are the basic units of government responsible for provision of public services in Ethiopia.

though the achievement of the UAP will be a challenge, setting such a bold target shows the importance of water supply and sanitation on the Ethiopian political agenda.

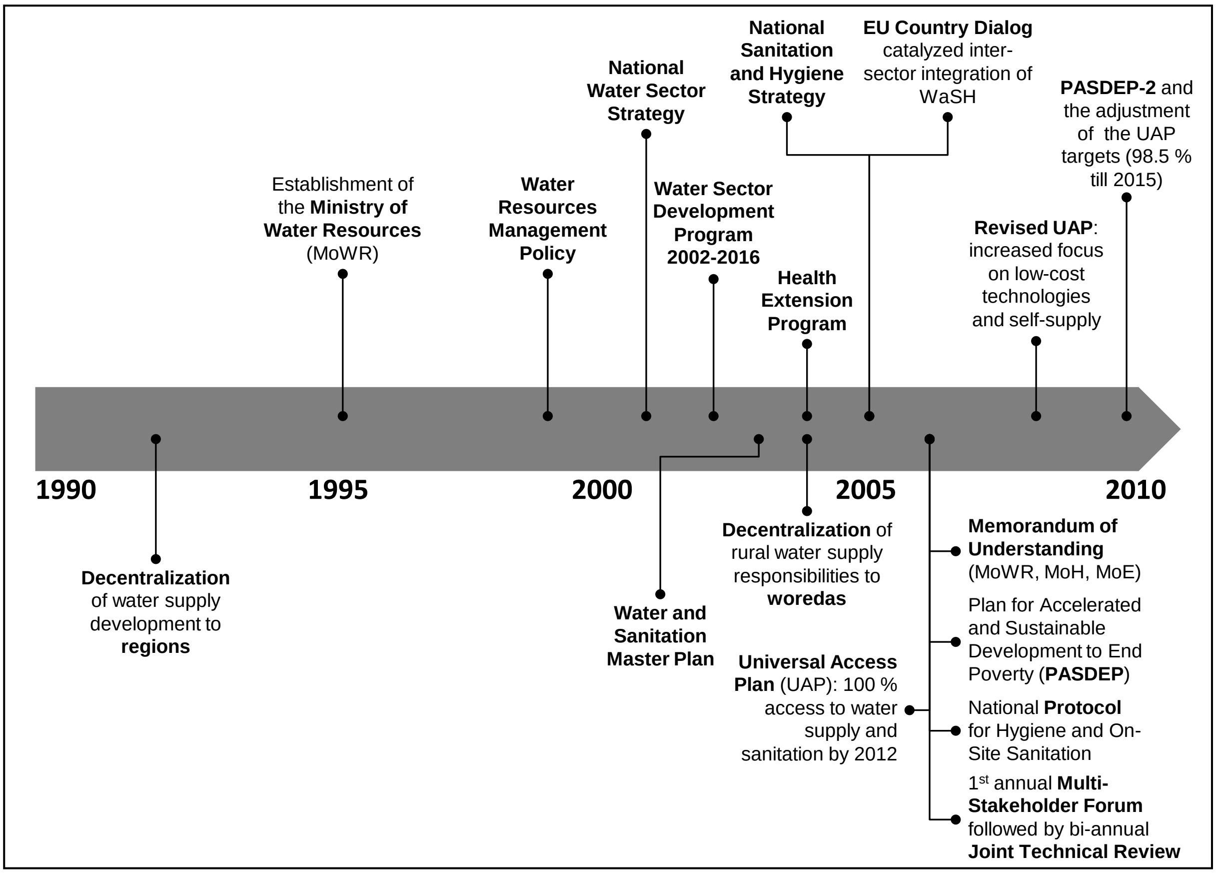


Figure 2.6: Important dates in the water and sanitation sector in Ethiopia (compiled from MoH, 2005; MoFED, 2006; MoH, 2006; MoWR, 2006; MoWR et al., 2006; Sengogo, 2009; WSP, 2011a)

The Poverty Reduction Strategy Paper (PRSP[11]) called Plan for Accelerated and Sustained Development to End Poverty (PASDEP) for the period between 2005/2006 and 2009/2010 planned a program to promote and support the use of toilets with a target of increasing rural and urban sanitation coverage (MoFED, 2006). In 2006, the Ministries of Water Resources, Health and Education signed a Memorandum of Understanding to integrate resources and to improve the coordination of water supply, sanitation and hygiene activities. In the same year (2006), the first WASH Multi-Stakeholder Forum (MSF) was held as a result of the EU Water Initiative Country Dialog. Both the annual MSF and bi-annual Joint Technical Review help to harmonize the fragmented donor finance (WSP, 2011a).

The Ministry of Water Resources estimated the minimum funding requirements to achieve universal household and institutional coverage of improved hygiene and sanitation by 2012 in Ethiopia (not taking into account water quality monitoring and solid waste) at USD 644 million (MoWR et al., 2007). The estimations by the WSP (2011a) are even higher as the total investment for sanitation hardware to meet the

[11] The PRSP approach, initiated by the International Monetary Fund and the World Bank in 1999, results in a comprehensive country-based strategy for poverty reduction.

government target was projected to be USD 795 million per annum, all of which is expected to be contributed by households due to the policy of users paying the full costs for sanitation hardware. The anticipated public investment for sanitation is at approximately USD 50 million per year, the majority of which is to be spent on promotion work, which is of crucial importance to convince households to finance and build their own facilities (WSP, 2011a). This investment is, however, likely to be insufficient. Furthermore, an institutional sanitation needs assessment in 2007 estimated the costs of sanitation for existing schools and health facilities to be an additional USD 50 million (WSP, 2011a). Also, with increasing coverage, rehabilitation costs also increase. According to the WSP (2011a), the annual operation and maintenance costs for sanitation in Ethiopia are estimated at USD 104 million.

2.3 Selected global challenges

Selected global challenges including urbanization, global food demand, depleting phosphorous resources and the global sanitation challenge are discussed in this section.

2.3.1 Urbanization

The rate of urbanization in African countries is growing at the highest pace in the world (UN, 2010b). In 2009, almost 40 % of the African population was urban, which will grow to 60 % by 2050 (UN-HABITAT, 2010). Ethiopia’s urban population is expected to grow from almost 17 % in 2009 to almost 38 % in 2050, whereas Ghana’s from almost 51 % in 2009 to almost 76 % in 2050 (UN, 2010b).

Another significant problem is the number of urban residents living in slum conditions, which grew from 657 million in 1990 to 767 million in 2000, with current estimates of approximately 828 million (UN, 2011b). In 2010, in sub-Saharan Africa, as much as 62 % of the urban population lived in slums (UN, 2011b). In Ghana, almost 43 % of the urban population and in Ethiopia, over 79 % of the urban population lived in slum conditions (UN, 2011a).

It is also important to highlight the fact that 70 % of all African urban population growth will take place in smaller cities, with populations of less than half a million (UN-HABITAT, 2010). Therefore, it is in particular the smaller African cities that will increasingly need public investment to cater for this growth (UN-HABITAT, 2010). Thus, the need for investment in water and sanitation, health care, education, transportation and housing is urgently needed in urban and peri-urban Africa.

2.3.2 Growing food demand

With the increasing global population[12], there is also a growing demand for food. At the same time, current practices of unsustainable wastewater disposal and agriculture systems are threatening the future global food supply. Not returning nutrients into the soil has caused an increasing demand for chemical fertilizers, for production of which large amounts of energy and mineral resources are used

[12] The world population will increase from almost 7 billion in 2011 to more than 8 billion by 2025, exceed 9 billion in 2043, and 10 billion by 2090 (UNDESA, 2011).

(Panesar A.R. and Werner C., 2006). It is also one of the reasons for degraded soils. Currently, approximately 25 % of the Earth's land is desertified[13] (IFAD, 2010). A map of degraded soils worldwide is presented in Figure 2.7. Very degraded soils are found, in particular in semi-arid areas (e.g., in sub-Saharan Africa), areas with high population growth (e.g., in China, Mexico, India) and regions undergoing deforestation (e.g., in Indonesia). In Africa alone, approximately 75 % to 80 % of the farmland is degraded and the continent loses about 30 kg to 60 kg of nutrients per hectare annually, which is the highest rate in the world (Rosemarin, 2010a).

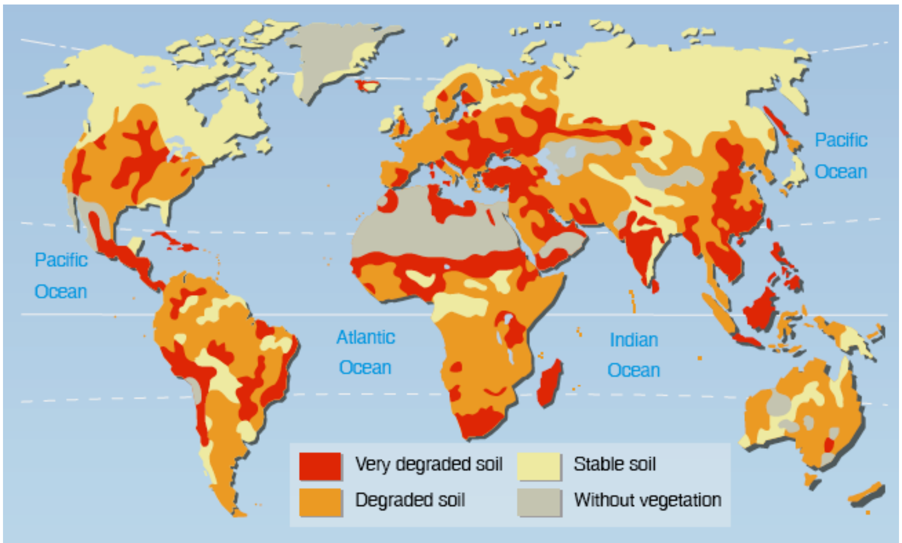


Figure 2.7: Global soil degradation (UNEP/GRID-Arendal Maps and Graphics Library, 2002)

Declining soil productivity reduces crop yields and sets in motion a vicious cycle of inadequate soil fertility causing low crop yields, which, in turn, produce limited farm revenue so that farmers lack funds to purchase mineral fertilizers (Faurès and Santini, 2010). As this cycle is repeated over time, soil fertility and crop yields continue to decline.

Urban and peri-urban agriculture can serve as one of the options for improving urban food supplies and for poverty reduction (Bahri, 2007; Raschid-Sally and Jayakody, 2008). For example, in Accra, approximately 200,000 urban residents benefit each day from vegetables produced in irrigated urban agriculture (Obuobie et al., 2006). Incorporating the agricultural system to the sanitation system is one of the methods to close the loop and recycle nutrients back to the agricultural system in urban, peri-urban and rural areas (Bahri, 2007). Also, the problem of waste disposal in cities may be reduced by encouraging urban agriculture, whereby waste is used as manure (Lamba, 1993).

2.3.3 Depleting phosphorous resources

Phosphorous, nitrogen and potassium are essential nutrients contained in fertilizers. Phosphorous as an element does not have any substitutes for plant or animal growth (Cordell et al., 2009). The dependence on phosphate rock to reach high crop yields

[13] Land desertification is defined as "persistent degradation of dryland ecosystems by human activities and climatic variations" (IFAD, 2010, p.1).

resulted in a growing concern about the depletion of global phosphate rock resources and the uncertainty about how long the existing deposits will last and whether further deposits can be found.

Phosphate fertilizer prices experienced a significant increase during 2007/2008 as a reaction to the severe increase in oil prices and the resulting production of ethanol as a liquid fuel from food crops (Rosemarin, 2010a). In the last couple of years, the price for phosphorous on global markets has been rising gradually. For example, the price for triple superphosphate in 2011 (Jan-Dec) increased by 41 % and the price for phosphate rock increased by about 50 % in comparison to the prices from 2010 (Jan-Dec) (World Bank, 2012a). According to FAO (2008), the annual demand for phosphorous fertilizer will grow by approximately 3 % until 2012. Especially in Africa, the demand for phosphorous fertilizers will continue to increase (Cordell et al., 2009).

Cordell (2010) estimates peak phosphorus to occur before 2035, after which demand for phosphorous will exceed its supply. Moreover, current sanitation and waste systems are not capable of easily recycling phosphorous (Rosemarin, 2010b). The demand for phosphorous could be met through a high recovery and reuse rate of all sources of phosphorous, including crop residues, food waste, manure, human excreta and virgin sources such as seaweed, algae and phosphate rock (Cordell et al., 2009; Cordell, 2010).

According to Dockhorn (2009), in the view of depleting phosphorous resources, the recovery of phosphorous from wastewater and sewage sludge will gain in importance. About 28 % of the global phosphorous fertilizer consumption could be offset with the phosphorous contained in human excreta (Dockhorn, 2009). The cost of phosphate removal from municipal water at a state-of-the-art wastewater treatment plant would amount to about EUR 9 billion per annum worldwide, which would be approximately 66 % of the actual market value of this phosphorous (Dockhorn, 2009). Therefore, separation of urine and feces at source (at the toilet) should be much more energy and cost efficient than removing phosphorous at a wastewater treatment plant (Cordell et al., 2009). Taking into account magnesium ammonium phosphate (MAP) as the phosphorous recovery product from wastewater, Dockhorn (2009) calculated the lowest MAP-production costs at 160 €/t MAP for MAP precipitation from urine with seawater used as a source of magnesium.

2.3.4 Global sanitation challenge

According to WHO and UNICEF (2010), in 2008, an estimated 2.6 billion people in the world did not have access to improved sanitation facilities. The greatest number of people without access to sanitation facilities are concentrated in Southern Asia, Eastern Asia and sub-Saharan Africa, as presented in Figure 2.8.

At the current rate of progress, the world will miss the MDG sanitation target and it will take until 2049 to provide 77 % of the global population with improved sanitation (WHO and UNICEF, 2010; UN, 2011b). Even if the world meets the MDG sanitation target, there will be still 1.7 billion people without access to basic sanitation (WHO and UNICEF, 2010). If the trend remains as currently projected, by 2015 there will be 2.7 billion people without access to basic sanitation (WHO and UNICEF, 2010).

There is also a big disparity between access to improved sanitation by poor and rich households. An analysis of trends over the period 1995-2008 for three countries in Southern Asia showed that sanitation improvements benefited the wealthier, while sanitation coverage for the poorest quintile of households barely increased (UN, 2011b).

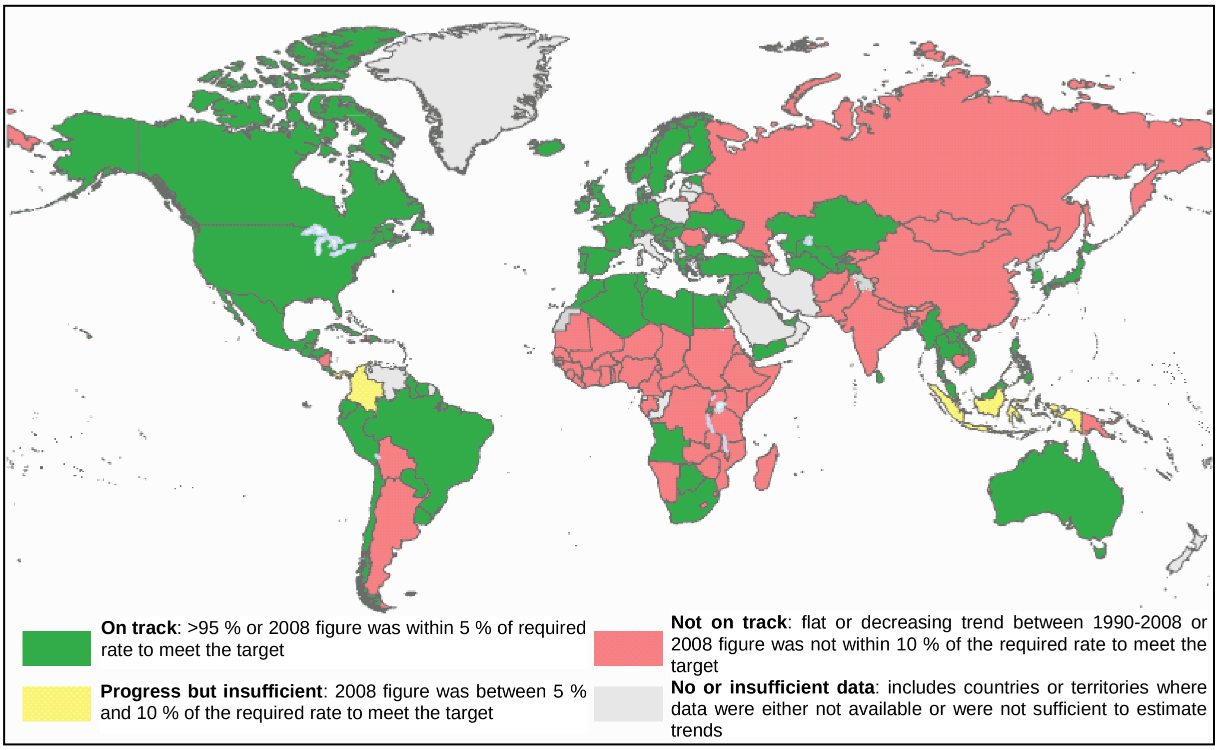


Figure 2.8: Sanitation progress towards the MDG target, 2008 (WHO and UNICEF, 2010)

The access to improved sanitation facilities is particularly low in sub-Saharan Africa, with little progress made – from 28 % coverage in 1990 to 31 % in 2008 (WHO and UNICEF, 2010). Open defecation is practiced by 27 % of the population living in sub-Saharan Africa, down from 36 % in 1990 (WHO and UNICEF, 2010). What makes matters worse is the striking disparity between urban and rural areas, as it was already presented on the examples of Ghana and Ethiopia (refer to Figure 2.1 and Figure 2.4). Access to improved sanitation in both countries is higher in urban areas, but it still accounts for less than 30 %, whereas in rural areas – for less than 10 %. Even though, in general, urban areas are better served than rural areas, they are struggling to keep up with the growth of the urban population (WHO and UNICEF, 2010). Also, the potential spread of diseases in highly populated areas like congested cities and slums poses a bigger health threat as it is much greater than in rural areas (Paterson et al., 2007).

2.3.4.1 Benefits of access to sanitation facilities

The importance of sanitation was proven in a pole carried out in 2007 for the British Medical Journal, where sanitation was voted the greatest medical milestone of the last 150 years (Ferriman, 2007). Also, recently, access to safe water and sanitation was listed among top global public health achievements in the first decade of the 21st century identified by the Centers for Disease Control and Prevention (Koppaka, 2011).

Hutton et al. (2007) distinguished between different benefits from gaining access to water and sanitation and these include the following:

- health benefits,
- direct economic benefits from avoiding diarrheal disease (the health care and non-health care costs avoided due to fewer cases of diarrhea),
- indirect economic benefits related to health improvement (gains related to lower morbidity and gains related to fewer deaths), and
- non-health benefits related to water and sanitation improvement (reduction in time expenditure or time savings associated with closer water and sanitation facilities).

In addition, improved sanitation increases primary school enrollment, productivity, provides security, especially for women, and reduces the pollution of the environment, in particular of water resources.

Health benefits

According to Stedman (2008), 15 % of the deaths in Ethiopia are attributable to water or wastewater. In Ghana, inadequate water supply and sanitation contribute to 70 % of the diseases (Public Citizen/ Water for All, 2002). Ghana has been experiencing cholera outbreaks almost every five years since the 1970s (Holland, 2011). Worldwide, almost 90 % of the diarrheal deaths are caused by unsafe water, sanitation or hygiene, with over 99 % of these deaths being in developing countries, of which about 84 % occur in children (WHO, 2009).

Fewtrell et al. (2005) reported that diarrheal morbidity can be reduced through investments in water and sanitation; a 45 % reduction of diarrheal cases from improved hygiene, a 39 % reduction from household water treatment and an average 32 % reduction from improved sanitation. According to WHO and UNICEF (2000), provision of adequate sanitation services, safe water supply and hygiene education reduces the mortality related to diarrheal disease by an average of 65 % and the related morbidity by 26 %.

If the MDG water supply and sanitation target is reached by 2015, potentially 546 million cases of diarrhea can be prevented annually (Hutton et al., 2007). Approximately 730,000 lives could be saved each year, of which roughly 33 % would be in Africa, if all the people in the world gain access to improved water supply and sanitation facilities (Hutton et al., 2007).

Under-five children mortality

Under-five children mortality is one of the indicators that measures the level of child health and overall development in countries. According to UNICEF, malnutrition and the lack of access to safe water and sanitation contribute to a half of child deaths every year. In 2009, under-five child mortality was the highest in sub-Saharan Africa, where 1 child in 8 died before their fifth birthday, which is nearly double the average in developing regions and almost 20 times the average in developed regions (UNICEF et al., 2010). In 2009, there were 31 countries with under-five mortality of at least 100 deaths per 1,000 live births and 30 of these countries were located in sub-Saharan Africa (UNICEF et al., 2010). In 2010, 74 out of 1,000 newborn children in Ghana and 106 out of 1,000 newborn children in Ethiopia was recorded as children mortality rate under five (World Bank, 2011a).

Disability Adjusted Life Years

In 2004, over 4 % of the global burden of disease as measured in Disability Adjusted Life Years (DALYs) was attributed to unsafe water, sanitation and hygiene (WHO, 2009). Insufficient sanitation, hygiene and access to safe water increase the prevalence of diarrheal diseases. In 2004, these diseases were responsible for 1.9 million deaths, of which almost 0.9 million occurred in Africa (WHO, 2008). Diarrheal disease with 8.6 % of the total DALYs was among the leading causes of burden of disease in Africa (WHO, 2008).

Economic benefits

There is a clear economic benefit of gaining access to adequate sanitation facilities. The combined economic impact of inadequate sanitation in Cambodia, Indonesia, the Philippines and Vietnam was estimated to USD 9 billion per year (WSP, 2008a). Furthermore, ten countries in Africa, including Benin, Burkina Faso, Democratic Republic of Congo, Ghana, Kenya, Madagascar, Mozambique, Niger, Nigeria and Rwanda, are losing an average of 1 % of their GDP every year as a result of poor sanitation (WSP, 2011c). In some countries, the impact is higher than the average; about 2.4 % in Niger, 2.0 % in Burkina Faso, and 1.6 % in Ghana and in the Democratic Republic of Congo. According to UNDP (2006b), sub-Saharan Africa loses about 5 % of its GDP, in other words approximately USD 28.4 billion annually, due to the water and sanitation deficit. Therefore, providing access to adequate sanitation is a non-negotiable requirement for a country’s well-being and economic development.

A study proved that:

> “there is a strong economic case for investing in improved water supply and sanitation services, when the expected cost per capita of different combinations of water supply and sanitation improvement are compared with the expected economic benefits per capita“ (Hutton et al., 2007, p.499).

Hutton et al. (2007) estimated the potential annual health sector costs saved in developing regions for the MDG water and sanitation target at USD 1.7 billion per year. Furthermore, the global gain of 310 million working days can be reached for the total working population aged 15-59 for the MDG water and sanitation target (Hutton et al., 2007).

According to the UN, for every USD 1 spent on sanitation, the return on investment is approximately USD 9 (UN-Water, 2009). Hutton et al. (2007) estimated that in developing regions, the return on a USD 1 investment in water and sanitation improvements was in the range of USD 5 to USD 46, depending on the intervention. Even though the exact return is not easy to be estimated, the numbers suggest that there is a clear benefit of investing in water and sanitation facilities.

Economic benefits should be used as a driver for sanitation adoption. For example, in Ethiopia, an NGO called Vita (formerly known as Refugee Trust International) works with community-led total sanitation (CLTS). As part of Vita’s interventions, communities are told how much medical expenses they might face as a result of open defecation practices (pers. communication, A. Banjaw and B. Feseha, Arba Minch, 16.09.2008). In this way, the NGO shows the economic advantage of adopting sanitation. Not only do the communities start understanding the link between poor sanitation and health, but they also realize potential economic benefits of sanitation adoption. They recognize sanitation as an investment with future returns and do not consider it as an unnecessary expenditure that takes away their mostly valued resources. As a result of Vita's intervention, already nine villages declared to be open defection free.

Economic benefits are not only medical expenses, but also the time taken to find a place to relieve oneself, which is the time lost that could be spent on household tasks, domestic production, childcare, education or even paid work (Sijbesma et al., 2008).

2.4 The opportunity for private sector involvement in sanitation

According to Foster and Briceño-Garmendia (2010), countries need to spend approximately 0.9 % of the GDP per year, of which 0.7 % in investment and 0.2 % in operation and maintenance in order to meet the MDG sanitation target. Another publication suggests that "[e]stimated spending required in developing countries to provide new coverage to meet the MDG target is 42 billion United States dollars (US$) for water and US$ 142 billion for sanitation … " (Hutton and Bartram, 2008, p.iv). Maintaining existing services costs an additional USD 322 billion for water supply and USD 216 for sanitation (Hutton and Bartram, 2008).

Many countries in Africa, including Ghana and Ethiopia are struggling to provide adequate water supply and sanitation. Ghana and Ethiopia are among the signatories of the 2008 eThekwini Declaration, in which seventeen African governments pledged to allocate a minimum of 0.5 % of their GDP for sanitation and hygiene (WSP, 2008b). In Ghana, the 2008-2010 annual government spending on water and sanitation was 0.38 %, 0.28 % and 0.29 % of the GDP, respectively (WaterAid, 2011). In the years 2008-2010, the Ethiopian government allocated 0.60 % (2008), 0.56 % (2009) and 0.46 % (2010) of the GDP on water and sanitation (WaterAid, 2011).

2.4.1 Enabling environment for private sector involvement in sanitation

In order to help solve the problem of the low access to improved sanitation facilities (refer to Section 2.3.4), private sector involvement in sanitation should be given a closer consideration.

According to Davis (2005), private sector participation in water and sanitation is limited in sub-Saharan Africa; between 1990 and 1997, less than 0.2 % of all private sector investments in the developing world involved sub-Saharan Africa countries. Between 1990 and 2010, private sector investment in water and sewerage projects in sub-Saharan Africa amounted to approximately USD 2.7 billion spent on 26 projects, compared to about USD 29.6 billion spent on 402 projects in East Asia and Pacific (World Bank, 2011b). The investment in sub-Saharan Africa in water and sewerage projects was only about 0.2 % of the total investment in transportation, telecom and water and sewerage, compared to over 9 % in East Asia and Pacific.

Despite some reservations whether the private sector can meet the needs of the poorest citizens, the private sector is becoming more and more acknowledged as an important development partner in the water and sanitation sector (Howard, 2005). Arguments for the involvement of the private sector in water and sanitation provision include the fact that:

> "the private sector would introduce technical and managerial efficiency, expertise and new technologies; improve economic efficiency in operational performance and capital investment; inject large scale investment or gain access to private capital markets; reduce public subsidies or redirect them more directly to the poor; insulate basic services from short term political intervention and limit intervention by powerful interest groups; and make services more responsive to consumer needs and preferences through the introduction of business oriented principles" (Howard, 2005, p.2).

2.4.1.1 Situation in Ethiopia

In Ethiopia, the National Water Sector Strategy, which was adopted by the government in 2001, promotes the involvement of all stakeholders, including the private sector, and integrating water supply, sanitation and hygiene promotion activities (MoWR, 2001). Currently, the involvement of the private sector in hygiene and sanitation in Ethiopia is rather limited (WSSCC, 2009).

A number of NGOs, including Catholic Relief Services, Catholic Church of Gamo Gofa and South Omo, Oxfam and WaterAid, working in the Southern Nations, Nationalities and People's (SNNP) Region in Ethiopia were interviewed. The information collected showed that the local private sector has been contracted, in particular for consultancy, emptying of septic tanks and pit latrines, development of toilet molds, drilling work and for supply of materials and products. Local contractors have also launched cooperative activities with woredas, and these included, for example, training of artisans in slab production and toilet construction as well as provision of toilet molds. According to WSSCC (2009), construction of household sanitation facilities in towns in Ethiopia is performed by private masons and contractors.

Since 2004, the WASH movement has provided a panel for stakeholders such as governmental agencies, international and national NGOs, CBOs, media as well as the private sector, including bottle, soap and chemicals manufacturers as well as toilet and septic tank producers (e.g., AquaSan Ethiopia, Roto PLC) to work together. The activities of the WASH movement mainly focus on social mobilization and awareness raising. Within the framework of the movement, a global hand-washing campaign was conducted in 2004/2005 in order to improve the public-private sector partnership. Thus, the WASH movement, besides its main objectives, can be seen as a platform for exchanging information and fostering cooperation with the private sector.

As a result of the Memorandum of Understanding signed in 2006 between the Ministries of Water Resources, Health and Education (refer to Section 2.2.4), any water supply project is to be integrated with a hygiene and sanitation intervention, which has also drawn the attention of the private sector to the provision of services in the latter field.

Furthermore, since 2006, the annual WASH Multi-Stakeholder Forum (refer to Section 2.2.4) has been bringing all stakeholders at one table, including the private sector. The first Forum held in 2006 brought together participants from national and regional governments, UN agencies, NGOs, the private sector, academia and the donor community. One of the accomplishments agreed for the year ahead included the implementation of policy and regulatory measures to increase private sector participation for WASH services (Suominen et al., 2008). Even though the progress in terms of involving the private sector is still slow, setting the above-mentioned goal as one of the undertakings proves its importance in Ethiopia. Furthermore, one of the priorities for 2007/2008 agreed at the second MSF in 2007 involved establishing of models of sustainable service delivery, including the role of the private sector and effective supply chains (MoWR, 2007).

2.4.1.2 Situation in Ghana

One of the strategies of Ghana's national Environmental Sanitation Policy (ESP), which was developed in 1999 and recently revised, includes the privatization of environmental sanitation services (Thrift, 2007; WSP, 2011b). According to the ESP, services that are supposed to be provided by the private sector include, for example, the provision and management of septic tanks as well as the construction, rehabilitation and management of all public baths and toilets (Thrift, 2007). Also, the National Environmental Sanitation and Action Plan "puts forward the targets of 100 % privately operated desludging (…) and fully franchised management of all government-built treatment plants by 2015" (Murray et al., 2011).

In Ghana, the Mole Conference Series organized annually by the CONIWAS bring all stakeholders together to discuss WASH topics. This also helps to integrate the private sector into the WASH sector.

2.4.2 Challenges for private sector involvement in sanitation

There exist many barriers to general business growth in Africa and these may include[14]:

- access to and cost of financing,
- tax rates and tax administration,
- macroeconomic instability,
- corruption,
- economic and regulatory policy uncertainty,
- anti-competitive practices,
- customs and trade regulations,
- crime, theft and disorder,
- access to land,
- availability of skilled labor,
- availability of infrastructure (transportation, electricity, telecommunications),
- legal system,
- labor regulations, and
- business licensing and permits.

Doing business in the sanitation sector in countries like Ghana and Ethiopia can be generally translated into doing business with people living in poverty, because it is often the poor that need improved sanitation. For example, in Ethiopia, the bottom of the pyramid (BOP) share in total population is 95 %, with almost 86 % BOP share of total income (Hammond et al., 2007). This can be translated into a huge market potential. For companies, doing business with the poor creates a challenge of innovation, in particular with regard to product development, building markets and creating new spaces for growth (UNDP, 2008).

[14] Based on the World Bank Enterprise Surveys, expressing top concerns of firms in a particular country (World Bank, 2012).

There are many myths regarding doing business with the poor, one of them being that the poor do not have the financial capacity. In reality, it is the poor that often suffer from a “poverty penalty”, which means that they at times have to pay more than rich consumers for water and sanitation services due to the fact that they use informal vendors (UNDP, 2008; Sim et al., 2010).

The 4 billion people at the BOP have significant purchasing power: the BOP makes up a USD 5 trillion global consumer market (Hammond et al., 2007). There are different segments that the BOP customers spend their money on. The highest portion is spent on food (USD 2,895 billion), energy (USD 433 billion), housing (USD 332 billion), transportation (USD 179 billion), health (USD 158 billion), information and technology (USD 51 billion), and finally on water (USD 20 billion) (Hammond et al., 2007). The sanitation segment is much smaller than the water segment, as it is a fraction of it.

The poor need to become acknowledged as a potential consumer market. Also, sanitation should become a bigger concern to potential customers (Sim et al., 2010). One of the incentives of investing in sanitation should be presenting data on economic advantages of adopting sanitation, e.g., showing the medical expenses that may be faced with as a result of open defecation practices. This should have a better effect than only praising the health benefits resulting from access to improved water and sanitation. Health is a winning argument with governmental agencies, but for households that know the odor and discomfort of a pit latrine it is hard to link health benefits with sanitation.

2.4.3 General investment environment in Ghana and Ethiopia

The bottom line of doing business in the sanitation sector is the same like in any other business. Therefore, it is important to consider the overall investment environment in a particular country.

The general conditions for doing business in Ghana and Ethiopia have been improving, promoting Ghana to the fifth place and Ethiopia to the tenth place among countries in sub-Saharan Africa (World Bank, 2012b). In 2011, Ghana was ranked 63 and Ethiopia 111 out of 183 economies[15] for the ease of doing business (World Bank, 2012c).

Even though the investment climate in Ghana and Ethiopia has been improving, the countries are still faced with serious problems. Ethiopia’s corruption problem is mirrored in the 2011 Corruption Perceptions Index of Transparency International, which ranked Ethiopia at 120, whereas Ghana at 69 out of 183 economies (Transparency International, 2012). Furthermore, the annual inflation rate (consumer prices[16]) in Ethiopia in 2009 and 2010 was estimated at 8.5 % and 8.1 %, respectively (World Bank, 2011a). As a result, even though the per-capita income is growing, the purchasing power has been hindered due to the high inflation rate. In

[15] 183 economies: 46 in sub-Saharan Africa, 32 in Latin America and The Caribbean, 27 in Eastern Europe and Central Asia, 24 in East Asia and Pacific, 19 in the Middle East and North Africa and 8 in South Asia, and 27 OECD high-income economies as benchmarks.

[16] Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly (World Bank, 2011a).

Ghana, the annual rate of inflation (consumer prices) in 2009 and 2010 was estimated at 19.3 % and 10.7 %, respectively (World Bank, 2011a).

2.4.3.1 Infrastructure

Transportation costs are a serious bottleneck in many African countries. Ethiopia does not have a direct access to the sea and uses the port in Djibouti for the movement of goods. This makes imports of raw materials, machinery, etc. costly, in particular when taking into account the fact that the Ethiopian Shipping Lines are operating in an almost monopolistic manner and are able to demand elevated shipping costs (Germany Trade and Invest, 2009b). Furthermore, the road infrastructure in Ethiopia is underdeveloped. For example, for inland transportation and handling in Ethiopia, 7 days are required, whereas in Ghana, only 2 days (World Bank, 2012b).

The telecommunications infrastructure in Ethiopia is also underdeveloped. Both in Ghana and Ethiopia, a delay in obtaining a mainline telephone connection is longer than the sub-Saharan Africa average (World Bank, 2006; World Bank, 2007).

The development of the industrial economy in Ethiopia is hindered by the shortage of electricity and the resulting rationalization of power. With the electricity demand growing at an annual rate of 16 %, the electricity shortage is “solved” through so-called power shedding, i.e. since May 2009 all locations are withdrawn from the grid every second day for about 18 hours (Germany Trade and Invest, 2009a). It is therefore common to install power generators in order to continue industrial operation during this time. Also in Ghana, one of the main concerns of firms is the electricity infrastructure, with almost a half of firms identifying it as a problem (World Bank, 2007). Problems encountered include power outages and delays in obtaining electrical connection. In the category “getting electricity”, both countries did poorly, i.e. Ethiopia was ranked 93 and Ghana 68 out of 183 economies, which is mainly attributed to delays in getting a new connection (95 days in Ethiopia and 78 days in Ghana) (World Bank, 2012b).

2.4.3.2 Financing

The ease of starting a business in Ghana and Ethiopia, in terms of the number of procedures and time it takes, is much better than sub-Saharan Africa countries’ averages (World Bank, 2012c). At the same time, the minimum capital needed to start a business in Ethiopia (expressed in percentage of income per capita) is close to 334 %. Even though one needs to keep in mind that the average income in Ethiopia of 220 USD (2007) is one of the lowest in the world, it is still a big constraint (Germany Trade and Invest, 2009b). In Ghana, the minimum capital needed to start a business is close to 6 % of income per capita (World Bank, 2012c).

The cost of and access to financing is one of the major obstacles for firm growth in Africa. For example, for contractors and drillers, the absence of collateral is a major impediment to obtaining loans, both short and long term (Howard, 2005). As a result, start-up capital is often a challenge and it makes it one of the greatest priorities for credit schemes to become available to the private sector. In 2011, Ethiopia was ranked 150 and Ghana 48 out of 183 economies for the easiness of getting a credit (World Bank, 2012c).

2.4.3.3 Capacity development

Many developing countries suffer from lack of capacity, technical knowledge and expertise, in the government agencies, but also in the local private sector. According to Foster and Briceño-Garmendia (2010), low prevalence of improved sanitation facilities can be explained by poor knowledge in the construction sector about designs, lack of skilled workforce and shortage of materials.

In Ethiopia, the government is the dominant actor in the water and sanitation sector, but the division of roles and responsibilities between departments and bureaus is often ambiguous (Howard, 2005). Even though, in particular regional bureaus are often overstretched, they do not outsource work to the private sector, which would often make the implementation potentially quicker and cheaper (Howard, 2005). In order to develop capacity of the government agencies for monitoring and assessment, direct implementation of water and sanitation should be outsourced to the private sector.

Providing an enabling environment for the local market to develop facilitates innovation that can also lower the cost of improved sanitation facilities (Foster and Briceño-Garmendia, 2010). Technological innovation is needed in order to safeguard health benefits with cheaper alternatives, which are adapted to local conditions (Foster and Briceño-Garmendia, 2010).

2.4.3.4 Demand for sanitation

When a company has a product or service to sell, there needs to be demand in place, i.e. people willing to buy the particular product or service. Therefore, it is important to provide products and services that there is a demand for and to promote them in a suitable manner.

Sanitation adoption is mostly connected with a behavioral change, which needs to be prompted by a well-designed promotional campaign. During the interviews conducted in Ethiopia, representatives of many NGOs stated that a real challenge to adopting sanitation involves cultural issues and a lack of knowledge on the link between health and sanitation. It is particularly difficult to trigger a behavioral change in nomadic and pastoral communities and in regions with a high evaporation rate, availability of open spaces and low population density. In such regions, open defecation is not seen as a health threat but as a sanitation option. People living in these regions do not understand why sanitation should be fixed in one place and why they are expected to use their limited resources to built it. Thus, in communities, where financial resources are scarce and the level of knowledge is low, bringing about changes in behavior may present a serious challenge. It requires more effort on explaining the economic benefit of shifting from open defecation, in particular focusing on avoiding expenses on medication and working days lost due to illness.

2.4.4 Private sector involvement in water supply vs. sanitation

As already discussed, there are many challenges regarding the involvement of the private sector in sanitation in Africa. Nevertheless, some companies have managed to establish a market but the area of business of these companies is mainly related to the water supply sector.

According to Howard (2005), in the water and sanitation sector in Ethiopia, the private sector is mainly involved as contractors, consultants, suppliers, artisans and tap attendants. Private sector involvement in sanitation is even less common in Ethiopia and it is mainly limited to septic tank emptying or solid waste collection.

In Ghana, most small scale providers in urban areas such as tanker services and water vendors are involved in water supply services. In 1997, small scale independent providers were legalized in Accra and the main water supply utility (GWCL) entered into contract with water tanker associations (WELL, 2003). In 2005, a private operator called Aqua Vitens Rand was selected for a five-year management contract for urban water supply (WSP, 2011b). Informal providers in Ghana are also involved in sanitation services such as latrine construction, manual latrine cleaning, septic tank emptying and management of public latrines (WELL, 2003).

Even though the private sector involvement in water supply services is common in countries like Ethiopia and Ghana, in sanitation there are still not many partnerships involving the private sector. There are many reasons for that, including the fact that subsidies for water supply are allowed in Ethiopia, whereas it is not the case for household sanitation (MoH, 2005).

Also, compared to the water supply sector there is much less known about unit costs with regard to sanitation. This appears to be a clear disincentive for investors to move to this sector. Ghana is one of the countries where the WASHCost Project (2008-2012) is currently being implemented. The project researches the life-cycle costs of WASH services in rural and peri-urban areas, which will also help to study sanitation unit costs.

In Ethiopia, until recently, sanitation interventions had been mainly focused on rural areas and so had been the government. From the private sector's point of view, there is little potential profit from provision of sanitation in rural areas. Most toilets in rural areas are built with locally available materials and using self-help. Urban sanitation systems, on the other hand, offer a variety of processes representing potential business opportunities that may include small scale provision for construction of system components, collection, transportation, storage, processing or recovery of products, for example, biogas and fertilizer (Panesar et al., 2008).

2.4.5 Examples of private sector involvement in sanitation

Sustainable sanitation has potential for successful business opportunities, which has been proven by numerous projects and programs around the world., e.g., Ecoloove (India), Ecotact (Kenya), Gram Vikas (India), Sulabh International (India), Waste Concern Group (Bangladesh), Water for People's Sanitation as a Business Program (Malawi) (Sim et al., 2010; Gröber et al., 2011a). These business ventures show that sanitation not only generates profits but also provides jobs and improves the sanitary situation.

Private sector involvement in sanitation is not a new approach. Generally, one can differentiate between two types of sanitation entrepreneurs; those dealing with sanitation services (e.g., septic tank emptying, toilet building) and those making sanitation goods, such as manufacturing toilets or other hygienic products, for example, soap (Schaub-Jones, 2010). One can make an even more detailed division between sanitation entrepreneurs as sanitation provides a number of ways in which the private sector can become involved, including the following (adapted from Gröber et al., 2011a):

(a) manufacturing of sanitation products (e.g., toilet slabs, septic tanks),
(b) installation of sanitation systems (e.g., pit digging, superstructure installation),
(c) operation and maintenance (e.g., of community or public toilets),
(d) promotion and advertising (e.g., sanitation adoption promotion),
(e) collection, storage and safe disposal (e.g., pit latrine emptying, storage of collected urine from UDDTs),
(f) training (e.g., in application of urine as fertilizer, toilet building, hygienic behavior),
(g) nutrients reuse (e.g., selling of urine after required storage for use as fertilizer or sanitized feces as soil conditioner), and
(h) consulting (e.g., technology or site selection, preparation of baseline studies).

There are many examples of entrepreneurs that have established successful companies in the sanitation sector and three of them are presented below.

Ecotact[17] – an example of (b), (c) and (d)

In 2006, David Kuria, who was elected an Ashoka[18] fellow in 2007, founded a social business venture in Kenya called Ecotact. Ecotact builds Icotoilets malls, customers of which can take advantage of toilets and a variety of services available alongside, including a water kiosk, a baby-changing station, shoe shine, barber booths, food stalls, phone, newspaper stands or showers. In Kibera, one of the largest slums of Sub-Saharan Africa (UNDP, 2006a) that is located in Kenya, around 30,000 customers use Icotoilet facilities on a daily basis. As of June 2011, 30 Ikotoilets have been built, and the number of Ikotoilet customers is expected to reach 10 million in 2011, compared to 6.2 million in 2010 (Gröber et al., 2011a). The operation and maintenance of toilet malls is guaranteed by a trained workforce.

Through social marketing campaigns with celebrities, for example, the vice-president of Kenya and Miss Kenya, weekly tournaments and a reality TV show, Ecotact is trying to reduce the shame and taboos linked with toilets and hygiene in order to make sanitation “fashionable”.

Ecotact is also embarking on an enterprise franchise model, where the company invests in construction of toilet facilities, develops a management guide and quality matrix, and franchises the management of facilities to local entrepreneurs within their respective municipalities. Further plans include converting human waste into biogas, as well as collecting urine separately for fertilizing crops and as a means of saving flush water. Expanding the facilities countrywide and to other countries in Africa are also on the company’s agenda.

[17] Information on Ecotact is based on Schwab Foundation for Social Entrepreneurship (n.d.), unless indicated otherwise.

[18] Ashoka network is a global association of social entrepreneurs who work on social innovation worldwide in a variety of sectors, for example, health, energy, housing, water and sanitation, etc.

Dignified Mobile Toilets – an example of (c), (d) and (e)

Another example of turning sanitation into a business venture was accomplished by Isaac Durojaiye, who is also an Ashoka fellow. He started the first mobile toilet initiative in Nigeria as a response to the lack of adequate public toilet facilities in the country. His company – Dignified Mobile Toilets (DMT) supplies plastic toilets for lease and handles their emptying.

Toilets are leased to unemployed youth. They are placed in public places and are used by approximately 100 people per day (DMT Toilets, 2010). The franchisees collect a fee for the toilet use, pay back 40 % to DMT and stay with the rest as their income (DMT Toilets, 2010). In this way, the system is able to provide jobs and assures cleanliness and proper functioning of toilets. Toilets can also be rented or sold to other companies.

Businesses can also buy advertising space on the toilet doors. The DMT business generates approximately 25 % of its annual revenues from selling of advertising spaces (Drewko, 2007).

DMT is also planning to establish a biogas plant designed to process and convert sanitation waste into cooking gas (Akinpelu, 2008). The company is also involved in social projects in Nigeria, for example, it runs the Basic Toilet for Schools Scheme, through which schools are offered mobile toilets at special discounts (Akinpelu, 2008).

Sulabh International – an example of (b) and (c)

Sulabh International is an NGO working in India that addresses the sanitation challenge. Sulabh operates a variety of services, including construction of two-pit pour-flush toilets for individual households, construction and maintenance of community toilets on a pay-and-use basis and community toilets in slums. Pay-and-use community toilets catering to the urban poor living in slums and squatter settlements and the low-income floating population in the served areas are located at public places. The community toilets managed by Sulabh are normally located in low-income settlements, serving the residents where household toilets are not available (Chary et al., 2003).

In the pay-and-use approach, the municipal corporations provide land, and cover utility and construction costs as well as the service charge, which is 20 % of the project cost paid to Sulabh to meet its overhead, monitoring and supervision costs (Chary et al., 2003). In the pay-and-use approach, Sulabh charges an equivalent of USD 0.02 per use of a toilet or bath and the use of urinals is free of charge (Chary et al., 2003). Thus, Sulabh covers all its operational costs from user’s fees and does not depend on foreign donors. For the construction, operation and maintenance of community toilet complexes Sulabh plays a role of a catalyst and a partner between the official agencies and the users of the toilet complexes (Chary et al., 2003). The municipal corporations are the key public partners. They enter into a lease agreement with Sulabh for the construction and maintenance of community toilets. As far as community toilets are concerned, the corporations have to provide a block grant to the private operator in the view of maintenance costs, and so the toilets are provided free of charge to the users (Chary et al., 2003).

2.4.6 Methods to address challenges for private sector involvement in sanitation

Methods to tackle the challenges for private sector involvement in sanitation as described in Section 2.4.2 are discussed further.

2.4.6.1 Infrastructure

As already discussed, one of the biggest problems in Africa includes issues related to transportation and supply, which are directly linked to bad road infrastructure. In order to reduce transportation costs, factories should be open close to where the demand is located. Also, considering product design that allows arranging goods on one another enables more products to be transported at the same time and reduces transportation costs of finished products. Also, moving from cement to plastic raw material makes products easier and cheaper to transport, which results in plastic sanitary product manufacturers showing interest in the urban sanitation market.

2.4.6.2 Financing

One idea to overcome the financial constraints faced by the private sector is to change the requirements for obtaining a loan, for example, insurance or advance payment bonds instead of collateral (Howard, 2005). In order to reach remote rural areas and poor urban areas, it is necessary to encourage the microfinance sector to grow. Micro-credit schemes for sanitation provision “should be based upon market research of locally based demand, appropriate financial and accounting systems, thorough understanding of the borrower and intermediary capabilities” (Fonseca, 2006). When microfinance products are aimed at small scale private providers, it is important that a company provides an appropriate and affordable technology and different sanitation options so that diverse customer needs can be met.

As a result of promotional efforts of the Government of Ethiopia, the number of institutions providing micro-credits in Ethiopia has expanded. As of June 2007, there were 26 operational microfinance institutions (MFIs), which collectively serviced about 1.7 million borrowing clients (Amha, 2008). Mehta (2008) classified Ghana and Ethiopia as countries with a medium supply side potential for scaling up through the microfinance sector, i.e. water supply and sanitation loans make up 5-15 % of the microfinance gross loan portfolio. Therefore, the microfinance sector can meet a part of the potential water supply and sanitation demand in Ghana and Ethiopia. Furthermore, Ethiopia is among the countries with high financial sector potential, i.e. financial deposits of more than 30 % of the GDP (Mehta, 2008).

Potential clients of microfinance for sanitation are CBOs, small scale private providers and households. Mehta and Virjee (2003) reported that some donor programs are using MFIs in Ethiopia to provide financial services to CBOs in the implementation of rural water supply and sanitation projects. For example, in Amhara, saving with MFIs allows access to funds for repairs and maintenance. The advantages of using MFIs in micro-credit schemes include sustainable management of loans, existing skills and capacities and legal provision to manage the microfinance activity (Mahider and Demie, 2005). On the other hand, a guarantee requirement, high interest rates and down payment are major limitations for the poor (Mahider and Demie, 2005).

Grants could be used to set up a microfinance scheme for sanitation related investments with funds channeled from the central or local government or donor and charity allocations (Sijbesma et al., 2008).

In Ethiopia, "friends/relatives, suppliers credit[19], and Iqub (rotating saving and credit associations) are the most important sources of finance in that order, and moneylenders are used very rarely" (Ageba and Amha, 2006, p.63).

A membership in one of CBOs is very common in Ethiopia, with many CBOs playing an active part in the lives of Ethiopians. One of them is the above mentioned equb (also called iqub), in which members collect money and distribute it among themselves following set rules. If equbs started providing short term loans, also to non-members, they could offer competitive interest rates compared to that of banks and MFIs. Another advantage of using equbs for micro-credit schemes is the fact that they already have skills and experience in managing loans (Mahider and Demie, 2005).

It is also possible to involve water and sanitation committees and other CBOs in micro-credit schemes. For example, in Ethiopia, idirs are CBOs whose original purpose is to organize funerals for their members, but their activities may also include organizing awareness campaigns on HIV or family planning. Incorporating idirs into micro-credit schemes would mean less bureaucracy during loan appraisal and customer selection, however, other potential problems such as credit repayment and a lack of skills of credit management should be addressed (Mahider and Demie, 2005). Companies working in the sanitation field should partner with savings groups, for example, equbs or local micro-credit institutions to facilitate payment in installments.

According to Sijbesma et al. (2008), it is not the cost of sanitation or the willingness to pay that is a challenge for poor households, but the upfront lump sum investment. While wealthier households can make use of conventional loans, poor households are more inclined to borrow money through solidarity group loans. Revolving funds, which do not require collateral, but money is saved and borrowed on a rotational basis with no interest rate, could help households get financial resources for buying sanitary products and building sanitation facilities. According to WSSCC (2009), micro-credit or revolving funds for financing household sanitation facilities has not been practiced in Ethiopia. In Ghana, the Association of Water and Sanitation Development Boards adopted a strategy similar to a revolving fund and established a reserve fund that they allocated in short term investments of low risk (Sijbesma et al., 2008). The interest they earn on these investments is used by member boards to fund water supply and sanitation interventions.

It is worth looking at the iconic example of the Grameen Bank, which charges commercial interest rates, but has a high repayment rate. In Bangladesh, the bank lends money mostly to poor women, who are organized in cells of five and are collectively responsible for each other's loans (Hulme, 2008). The bank also requires clients to make compulsory small savings each week. It does not ask for collateral, but a guarantee from a relative or a group to which the client belongs and allows repayment at intervals that work best for the borrower (Sijbesma et al., 2008).

[19] Supplier's credit refers to a financing arrangement, whereby an exporter extends credit to the buyer.

In Kenya, small and medium enterprises (SMEs) offer complete packages for water and sanitation, which are bought on credit, mainly by institutions (Rowe, 2007). These loans are partly supported by the government. A similar approach could also be adopted by companies in Ghana and Ethiopia. Ageba and Amha (2006) reported that credit could become a potential instrument for banks to channel finance to SMEs in Ethiopia in order to improve access, e.g., to modern machinery, equipment or tools.

Kentainers, a company located in Kenya that manufactures plastic water and sanitation products, encourage individuals to either form or join a CBO in order to be able to buy water and sanitation products in bulk and to take advantage of any credit facilities that a CBO may offer (Rowe, 2007). For manufacturers of sanitary products, selling products in bulk to associations is practiced in order to overcome the financial issues related to expensive local dealers (pers. communication, A. Knapp, World Bank's Water and Sanitation Program, Addis Ababa, Ethiopia, 09.09.2008).

Sanitation should be considered as a public good, thus some tax exemptions should be allowed. There are many examples where it could be applicable, including artisan associations or local companies manufacturing toilets. In this way, these actors could become capable of technology, skills and expertise development, which could, in turn, encourage the growth and efficiency of the small scale private sector.

So far, tax incentives in Ethiopia include duty-free import of machinery and spare parts and a time limited duty-free import of raw materials that are not available in Ethiopia (pers. communication, A. Woldemariam, Director of Investment, Promotion and Public Relation, Ethiopian Investment Agency, Addis Ababa, 15.05.2009). In Ghana, the standard value added tax (VAT) rate is at 12.5 %, in Ethiopia: 15.0 %, whereas, in Uganda, a zero VAT rate on sanitation products has been introduced as a government's initiative to increase sanitation coverage levels (Rowe, 2007).

2.4.6.3 Capacity development

Training needs to be provided, for example, to local artisans, consultants, toilet manufacturers, in order to develop their capacities and help them provide efficient services. Local small scale providers often do not have the resources to develop new skills and to make use of new technologies (Foster and Briceño-Garmendia, 2010). In order for the private sector to develop new skills, large scale implementation is required. This would provide necessary resources to develop new technologies and achieve economies of scale. In order for this to happen, governmental support and regulation is required, for example, through an establishment of a new institution with adequate experience in the water and sanitation sector (Howard, 2005).

In order for the private sector to go to scale, a social franchising concept could be considered. Social franchising is:

> "[a]n adaptation of a commercial franchise in which the developer of a successfully tested social concept (franchisor) enables others (franchisees) to replicate the model using the tested system and brand name to achieve a social benefit" (WHO, 2007, p.5).

Through a franchise system, economies of scale can be reached relatively fast. Thus, products or services can be made available at a much lower cost than commercial solutions. As already mentioned, Ecotact in Kenya is launching a franchise network. Also, the World Toilet Organization is developing a social franchise model called SaniShop, in which a franchisor is going to provide fast replication training modules to local entrepreneurs (Sim et al., 2010). Devine (2010) reported that the Global Scaling Up Project in East Java is taking into consideration applying the social franchising approach. Within this approach, selected entrepreneurs will be identified for capacity building in various areas, e.g., stock management, post-sales servicing or financing.

Subsidies for sanitation hardware may have downsides, for example, reducing the demand of households that are able to pay (Foster and Briceño-Garmendia, 2010). Also, subsidies often lead to poorly managed sanitation facilities. Therefore, indirect subsidies for the development of the private sector could be provided instead. In this way, undeveloped sanitation supply chains and an immature sanitation market could take advantage of the government’s start-up support. This could be provided at the product development stage, for quality assurance or marketing and promotion. This would encourage technological innovations and allow adapting existing sanitary options to local conditions. It is also advisable to provide a range of sanitation options in order to meet specific requirements. Companies need to experiment with their product development. In order to keep the manufacturing costs down, over-engineering of products should be avoided. However, the durability and desired longevity needs to be assured. Governmental support could also be used for training of local sanitation providers.

2.4.6.4 Demand for sanitation

Marketing of sanitation is an important aspect as it ensures that the customers choose what they want and what they are willing to pay for. Kentainers came up with a simple method of drafting a theoretical demand for nutrients reuse in order to plan a marketing strategy for their sanitary products that are applicable in the ecosan approach. They considered the following aspects and marked them on different layers on a map: need for sanitation facilities, ethnic groups (which influences the acceptance of excreta based fertilizers to be applied in agriculture), agricultural practices, so that they could clearly see where they should start promoting their products (pers. communication, A. Knapp, World Bank’s Water and Sanitation Program, Addis Ababa, Ethiopia, 09.09.2008).

Sanitation marketing is an important approach for creating demand for sanitation. Sanitation marketing is a part of social marketing, which “is a systematic strategy in which acceptable concepts, behaviours, or products, and how to promote, distribute and price them for the market, are defined” (Simpson-Hébert and Wood, 1998, p.51).

Like traditional marketing, social marketing also has four components: product, price, place and promotion. It is important to offer a range of products that can match the demand of different customers. Product might be referred to as a physical product such as a toilet slab or a service such as toilet installation. Products need to be offered at an affordable price. Affordable means that the price needs to match the willingness to pay and the spending capacity of the target customers. At the same time, the price needs to allow the business to generate sufficient revenues in order to make it profitable. The place component of social marketing means that the product needs to be made available to the customer, i.e. it refers to the distribution channels of the product. The promotion component aims at getting the customer’s attention through a variety of channels, e.g., advertising in media, special offers or theatre plays organized at a community level.

Heierli and Frias (2007) introduced “people” as the fifth component of the sanitation marketing mix, referring to a people-centered approach to sanitation. A publication by USAID HIP (2010) introduced “policy” and “partners” as further components of the sanitation marketing mix. The understanding of the policy is required in order to assess whether it is supportive of sanitation marketing or imposes a constraint. In this aspect, the policy is not strictly related to laws and regulations but also considers local cultural norms and customs. Due to the fact that sanitation marketing is based on partnerships, involving other stakeholders and informing them about the benefits of their involvement is essential. It is also important to be informed about the on-going sanitation interventions (e.g., by NGOs or CBOs) to determine their potential to contribute to the development of sanitation marketing.

A study in Peru reported by Baskovich (2010) showed that not health but enhancing the social status was the top trigger to invest in sanitation. Thus, toilets should be sold “as an object of desire and a symbol for a healthy, sustainable and modern lifestyle” (Sim et al., 2010, p.26). One example of seeing the disparity between buying something considered as a status symbol and investing in sanitation comes from India, where 563.7 million people own cell phones, whereas only 366 million have access to modern sanitation (Cohen, 2010). There are examples of successful sanitation promotion campaigns, where, for example, sports stars were used as role models in order to raise awareness for WASH improvements (Gröber et al., 2011b).

Product branding in sanitation is another emerging approach that aims at winning customers. For example, in the Global Scaling Up Sanitation Project in East Java, a “WC Sehat Murad Sumadi” is sold to rural households (Devine, 2010). The business selling the branded product also offers post-sales service and warranties.

A recent study performed in Amhara, Ethiopia suggested that sanitation marketing should become an integral part of a sanitation promotion program. It was substantiated by the reasons argued by households that did not adopt sanitation and were still practicing open defecation. The reasons for not constructing a toilet included the following: 33 % stated no land owned or no space available to construct a toilet, 17 % stated absence of someone in the household to construct a toilet, 10 % stated other priorities, 9 % stated no skills to build, and only 4 % stated the cost (USAID, 2011).

2.4.6.5 Example from the SNNP Region, Ethiopia

Even though the involvement of the private sector in sanitation interventions in Ethiopia has been neglected, it offers a great opportunity that should be explored (Drewko and Otterpohl, 2009; Drewko and Otterpohl, 2010). According to N. Asaro (tel. interview, Head of Drinking Water Resources Department at the Regional Water Bureau, Awassa, 19.09.2008), there are many suppliers of sanitation products operating in the SNNP Region. Unfortunately, they are facing a number of problems. One of the biggest challenges is connected with maintenance, in particular the provision of spare parts. Furthermore, the local private sector has not succeeded in creating a well-functioning marketing system, nor there is an information-sharing system in place that would allow the private sector to get informed on planned or on-going sanitation projects in the region. The local private sector also lacks training.

According to the interviewee, spare part centers (also called sani-marts) are planned to be established in four cities in the SNNP Region[20]. Through sani-marts the problem of spare parts provision could be solved, and training together with technical expertise could be provided there. Spare part centers could also serve as product information centers, where access to experts and even financial opportunities could be offered. In this way, customers would be attracted to one single location, where purchase of sanitation products would be made easy for them. Furthermore, promotional efforts could be concentrated around sani-marts, so a variety of demonstration toilets and related literature could be made available.

In order to mitigate the problem of low private sector involvement level in the sanitation sector, the potential market opportunities should be communicated to the private sector. In order to encourage cooperation, foster experience and ideas sharing as well as to obtain a better overview of stakeholders operating in the sanitation sector, a regional multi-stakeholder forum is planned to be established in the SNNP Region (tel. interview, N. Asaro, Head of Drinking Water Resources Department at the Regional Water Bureau, Awassa, 19.09.2008).

Members of the regional multi-stakeholder forum would include representatives of local government offices, NGOs, CBOs and the private sector. Each of the forum members has big assignments on their own agenda. Thus, the objective of the forum would not involve dealing with each and every technical aspect, but to share experience and ideas with different stakeholders operating in the region. The multi-stakeholder forum meeting could be held every three or six months, depending on the demand. The private sector could use NGOs' inside local knowledge in order to better estimate the demand for their products and services. This could result in creating a sanitation partnership between local government agencies, NGOs, CBOs and the private sector in order to reach sustainable solutions.

The example from the SNNP Region in Ethiopia shows that the identification of problems that the local private sector is facing is crucial. It is necessary for the potential solutions to be backed by the regional or local government, due to its credibility and required public resources.

[20] It is an intervention proposed in the "Needs assessment to achieve universal access", with two sani-marts set up at each woreda to introduce different available sanitation options to the community and a market for sanitation material supply (WSSCC, 2009). However, as of 2009, no finance has been allocated for sani-marts.

3 CASE STUDY ETHIOPIA

As discussed in Chapter 2, many governments in developing countries, including Ethiopia, are facing a significant financial gap hindering the provision of basic services such as sanitation. Therefore, the private sector is becoming more and more involved in these services. This chapter presents a business idea of manufacturing and selling plastic toilet slabs (to be used under the ecological sanitation (ecosan) approach) in Ethiopia. First, technical and economic background is presented. Then, competitors and prices of toilets in Ethiopia are discussed. Next, procurement and logistics as well as market and sales are introduced. Finally, investment requirements, project financing and returns as well as government support and regulations are described.

3.1 Technical outline for toilet manufacturing in Ethiopia

Technical aspects for the business idea of manufacturing plastic toilet slabs in Ethiopia are discussed in this section. First, the business idea is introduced. Further, a comprehensive product and process description follows, including a selection of available manufacturing processes as well as technical parameters considering aspects such as coloring techniques, material preparation, machine types, molds and moldable materials.

3.1.1 Business idea

The project considers a private company founded in Arba Minch, Ethiopia for the manufacturing and sales of four selected types of plastic toilet slabs to be used under the ecosan principle. The business idea assumes that manufactured products will be sold in Arba Minch and other cities in the Southern Nations, Nationalities and People's (SNNP) Region. Toilet slabs will be produced with the rotational molding process. Manufacturing machinery and raw materials are not available in Ethiopia, thus will be imported. Land for the manufacturing plant, warehouse and office buildings will be leased in a designated industrial zone in Arba Minch. Depending on the production and sales volume, transportation of finished products will be performed by a third party or a car will be purchased for own distribution. The company will employ engineers, production staff, plant maintenance staff, security and office staff as well as drivers.

The business idea assumes that the investment will be primarily focused on serving the local household and institutional sanitation market in Arba Minch and its vicinity with a high prospect of the regional market penetration in the SNNP Region in Ethiopia. The speed of the market expansion from local to regional reach will be mainly dependent on the sufficient demand creation, available physical infrastructure, manpower and the capacity of the production plant to meet respectively higher production volumes.

3.1.2 Product description

Products manufactured by the company will be a selection of toilet slabs that will satisfy various customer needs. All dimensions of products are presented in Table 3.1. Product schemes are presented in Figure 3.5 to Figure 3.8. A urine diverting sitting slab will be further referred to as Product 1, a urine diverting squatting slab as Product 2, an Arborloo slab as Product 3 and a Fossa Alterna slab as Product 4.

Table 3.1: Dimensions of manufactured products

Product no.	Product name	Size (cm)
1	Urine diverting sitting slab	50 x 60 x 24
2	Urine diverting squatting slab	55 x 30 x 18
3	Arborloo slab	80 (diameter) x 4
4	Fossa Alterna slab	120 x 90 x 4

The design of Product 1 and Product 2 allows urine and feces to be collected separately, i.e. urine is diverted from feces and does not mix with feces. Urine diverting toilets are built for separate collection and resulting treatment of urine and feces and their use in agriculture as a source of nutrients. Users decide whether they prefer a sitting (Product 1) or a squatting (Product 2) urine diversion toilet.

Product 3 is suitable as an Arborloo slab. Arborloos are similar to pit latrines, however, all parts of an Arborloo are portable and they are moved at about 6-12 monthly intervals (Morgan, 2004). Arborloo pits are shallow (up to 1 m deep) and soil, wood ash and leaves are added regularly to the pit in addition to excreta to aid the composting process (Morgan, 2004). After moving an Arborloo toilet to a new site, a layer of leaves and fertile topsoil is added to the contents of the pit and a young tree is planted (Morgan, 2004).

Figure 3.1: Urine diverting sitting slab

Figure 3.2: Urine diverting squatting slab

Figure 3.3: Arborloo with a cement slab

Figure 3.4: Fossa Alterna (Photo: P. Morgan)

Product 4 is suitable as a Fossa Alterna slab. Fossa Alterna is a simple alternating pit toilet system designed specifically to make humus suitable for agriculture. There are two permanently sited shallow pits and the toilet is managed so that the conversion of human excreta to humus takes 12 months (Morgan, 2004). Humus is then excavated every year, which makes an empty pit available (Morgan, 2004).

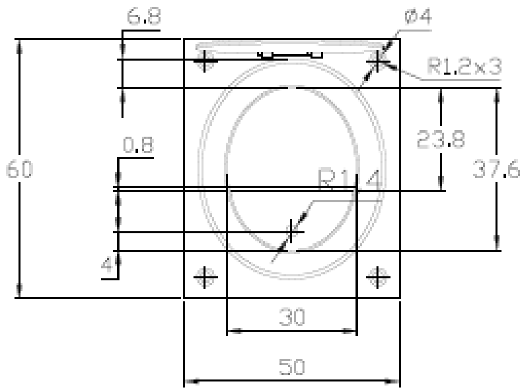


Figure 3.5: Urine diverting sitting slab scheme

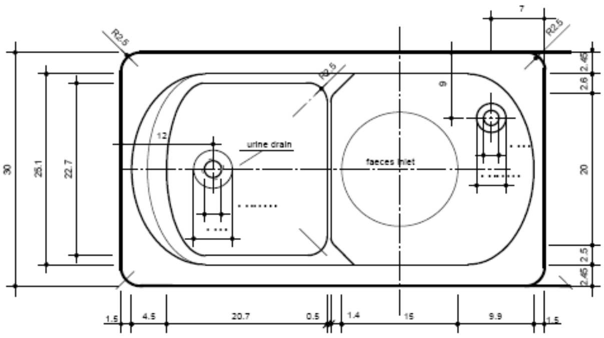


Figure 3.6: Urine diverting squatting slab scheme

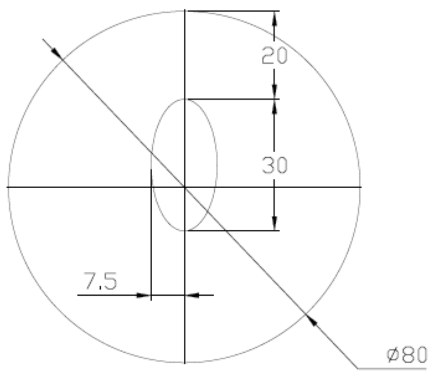


Figure 3.7: Arborloo slab scheme

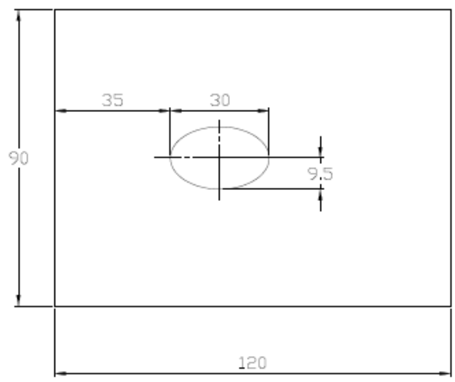


Figure 3.8: Fossa Alterna slab scheme[21]

3.1.3 Process description

This section describes different processes applicable for manufacturing of plastic products. It focuses on process considerations regarding molds, moldable materials, machine types and other crucial technical aspects.

3.1.3.1 Rotational molding

Plastic toilet slabs, referred to as Product 1, 2, 3 and 4 (refer to Table 3.1), can be produced with rotational molding. Rotational molding is a process that produces hollow parts by adding plastic powder to a shell-like mold and rotating the mold about two axes, at the same time, heating it and the powder (Crawford and Throne, 2002). It is typically applied in production of small or large parts of unusual shape that cannot be produced as one piece by other processes.

[21] Figure 3.5 to Figure 3.8 was prepared by T. Cakici (student assistant, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany).

The rotational molding process is split into the following four operations (based on British Plastics Federation, n.d.; Crawford and Throne, 2002):

(a) **Charging:** A pre-determined amount of plastic in powder, granular or viscous liquid form is placed in the mold, the mold is then closed, locked and loaded into the oven.

(b) **Heating:** Once in the oven, the mold is slowly rotated around two axes. As the mold is heated, the plastic enclosed in the mold adheres to and forms a monolithic layer against the mold surface.

(c) **Cooling:** When the melt has been consolidated to the desired level, the mold is cooled by air or water or a combination of both and the polymer solidifies to the desired shape.

(d) **Demolding:** When the polymer has cooled, the mold is open and the product removed, then the powder can once again be placed in the mold and the cycle repeated.

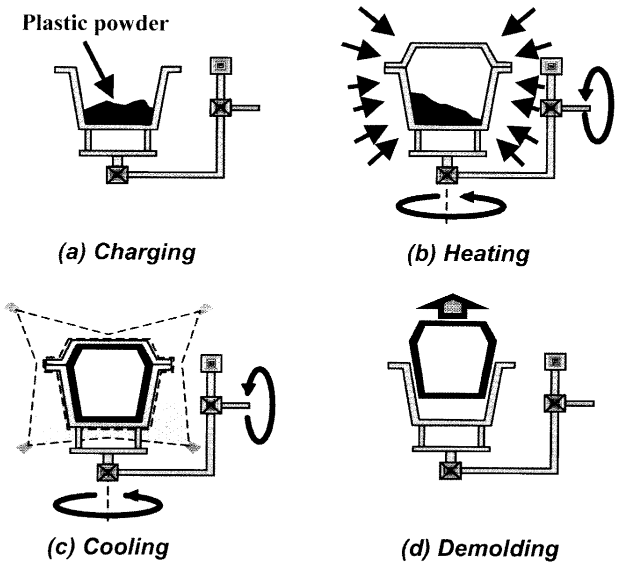


Figure 3.9: Principle of rotational molding (Crawford and Throne, 2002)

The advantages and disadvantages of the rotomolding process are discussed further.

Cost advantages

Rotational molding has a number of cost advantages. For example, with a proper design, parts that are assembled from several pieces can be molded as one part without weld lines or joints, saving on expensive fabrication costs (ARM, 2000). In addition, rotational molding can produce both large and small parts in a cost effective manner, with short production runs also being economically viable. Furthermore, with no internal core to manufacture, tooling is less expensive and minor changes can be easily made to an existing mold (ARM, 2000). Rotational molding also allows producing large or complex parts on short notice using low-cost molds.

Technical advantages

The process requires minimum design constraints. Designers can choose the best material for their selection and additives to make the parts weather resistant, flame retardant or static free (ARM, 2000). Also, the surface color and finish can be easily tailored to suit the product's requirements (ARM, n.d.).

The process has a number of design strengths, including consistent wall thickness and the end product being essentially stress free (ARM, 2000; Crawford and Throne, 2002). Modern, multi-armed machines allow multiple molds of different size and shape to run simultaneously (Crawford and Throne, 2002).

Rotational molding differs from other plastics processing methods in that the heating, melting, shaping, and cooling stages occur after the polymer is placed in the mold, thus no external pressure is applied during forming (British Plastics Federation, n.d.). It results in the ability to produce parts which are relatively stress free (ARM, n.d.). This aspect is important when considering large, load-bearing parts which must provide corrosion or stress-crack resistance (ARM, n.d.).

The lead time for the manufacture of a mold is relatively short and there is almost no material wastage as the full charge of material is normally consumed in making the part (Crawford and Throne, 2002).

Cost and technical disadvantages

The rotational molding process also has some limitations, including limited choice of suitable molding materials (Crawford and Throne, 2002). This is mainly due to the severe time-temperature demand placed on the polymer. Where special resins are available, the material prices are high due to the development costs passed on to the user and small scale grinding of the granules to powder. Other disadvantages include: long manufacturing times and difficulty in molding some geometrical features (Crawford and Throne, 2002).

Molds

All rotational molding molds are relatively low in cost when compared to the ones for, e.g., blow or injection molding. The selection of a mold material needs to consider thermal stress executed on the molds during the process as well as design, production, and economic factors (ARM, 2000).

Rotational molding molds are normally shell-type molds (ARM, 2000). They do not have internal cores and the inside surface of the part is formed by the outside shape of the part and the thickness of the nominal wall (ARM, 2000).

There are many types of molds but the most common ones include (Crawford and Throne, 2002):

(a) cast aluminum molds

(b) sheet metal molds fabricated from steel, aluminum or stainless steel sheets.

The usage of sheet metal molds is common when the size of the parts is large and when only one cavity is required. Sheet metal molds are lightweight and have uniformly thin cavity wall thickness. They also provide the lowest cost approach to the production of large molds of a simple shape.

Lineal low-density polyethylene as a suitable moldable material

Theoretically, any plastic material can be rotationally molded. Commonly, thermoplastics which melt and soften when heated and harden when cooled are rotationally molded. The rotationally molded material must flow adequately to coat the cavity evenly while the mold is rotated and it must be thermally stable at the oven temperature and for the oven cycle time required (ARM, 2000).

Polyethylene, in its many forms, is currently the most widely rotationally molded polymer (approximately 85-90 % of all polymers that are rotationally molded) (Crawford and Throne, 2002). Polyvinylchloride, nylon, polycarbonate and polypropylene are among other materials applied in rotational molding.

The key physical properties of moldable materials include melt index, molecular weight distribution and density. With increasing melt index, gloss improves, whereas heat resistance, breaking tensile strength and low temperature impact decreases (ARM, 2000). With increasing density, the stiffness, heat-deflection temperature, warpage and shrinkage will generally increase (ARM, 2000).

Linear low-density polyethylene (LLDPE) is one of the most widely used materials for rotational molding (Crawford and Throne, 2002). The density of LLDPE ranges from 0.91 to 0.94 g/cm^3 and its melt index range is quite large, from fractional to 20 and more (Crawford and Throne, 2002). It has better mechanical properties than low-density polyethylene (LDPE). It has flexible to medium stiffness, excellent high-temperature strength of about 100°C, an excellent chemical and environmental stress crack resistance and it is easy to process. LLDPE is often applied in the production of water tanks, containers and industrial parts.

Other types of polyethylene used in rotational molding include high-density polyethylene (HDPE), cross-linked and ethylene-vinyl acetate (EVA) copolymer (ARM, 2000).

Material preparation

A polyethylene material used for rotational molding is in the form of powder or micro-pellets (Crawford and Throne, 2002). Powder is produced by pulverization, also called grinding. The majority of polymers are ground between rotating metal plates. The basic stages of the grinding process are illustrated in Figure 3.10.

Molders can purchase materials either in a form of pellets or powder. The decision whether it is better to buy the material in a powder form or to set up an in-house grinding facility is not straightforward (Crawford and Throne, 2002). If the latter is chosen, the following costs need to be taken into account: depreciation costs of the grinding and auxiliary equipment, quality control costs, power supply costs, housing costs, maintenance costs, warehousing costs, insurance costs, dedicated manpower, administrative costs, supervision costs, health and safety costs, overhead and environmental costs (Crawford and Throne, 2002).

In-house grinding allows more control over costs and it makes sense if economies of scale can be achieved, i.e. large quantities of a particular grade and color are required.

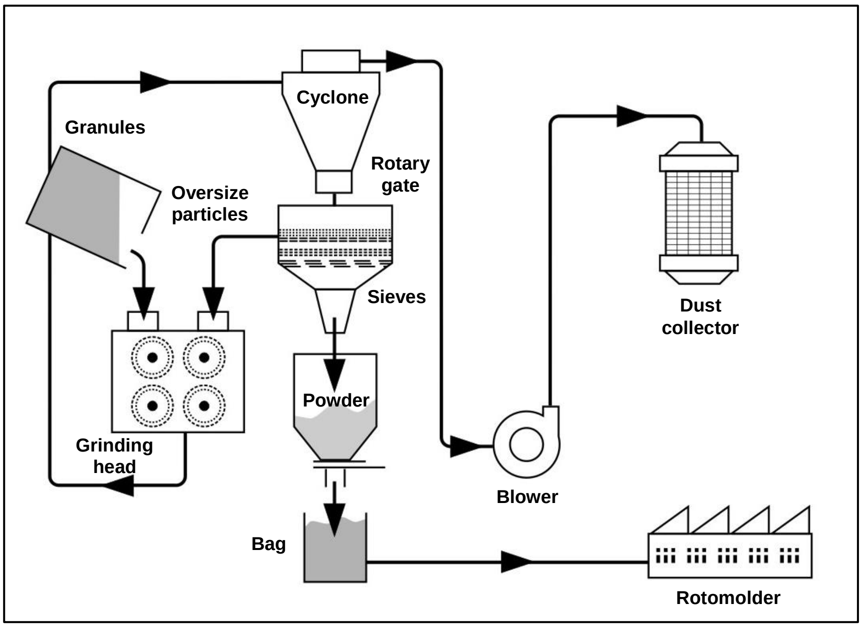


Figure 3.10: Stages in the grinding of powders for rotational molding (redrawn from McDaid, 1998)

Machine types

There are many types of rotational molding machines and the most common are discussed further.

Carousel machines

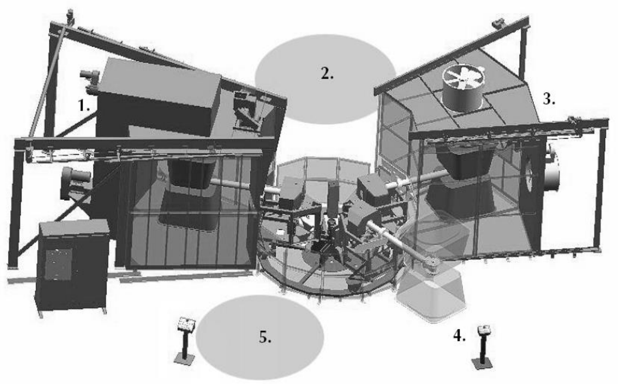
Carousel, also called turret machines have a center pivot with three to six arms and each arm has a mold attached to its end (ARM, 2000). They are best for long production runs of medium to moderately large parts (Crawford and Kearns, 2003). One arm is at each of the three stations (heating, cooling, servicing) at all times and different molds can be run on each arm (Crawford and Throne, 2002). The combinations of molds on one arm or on the other arms can be changed at regular intervals, allowing for versatility in production schedules (Crawford and Kearns, 2003). On the other hand, with fixed-arm carousel machines, all arms index at the same time, which requires heating, cooling and servicing times to be accomplished within the same time allotment for optimum use (Crawford and Kearns, 2003).

The limitation of fixed-arm carousel machines has been partly overcome with independent-arm carousel machines which can have five designated stations (refer to Figure 3.11), and between two and four arms that sequence independently of one another (Crawford and Throne, 2002; Crawford and Kearns, 2003). Even though the arms cannot move past each other, if the heating stage is finished the arm can move out of the oven and continue the mold rotation in ambient air, whilst waiting for the arm in front to complete the cooling stage (Crawford and Kearns, 2003). It also allows one arm to index while the other arms may remain stationary, providing more process flexibility. Even though they are more expensive than other machines, they are designated for custom rotational molding operations (Crawford and Throne, 2002).

Shuttle machines

Shuttle machines move the mold along an oval or straight arm that indexes from the load/unload station, to the oven, and to the cooling station (ARM, 2000). They are low in cost for the size of product manufactured and they conserve floor space (Crawford and Throne, 2002). The efficiency of the shuttle machine is improved by using a dual-carriage design (refer to Figure 3.12), where the oven is always occupied by the heating of a mold whilst the mold on the other carriage is being cooled or serviced (Crawford and Throne, 2002). If the cooling/servicing time is the same as the heating time, then optimum output rates can be achieved on this machine (Crawford and Kearns, 2003).

Carousel and shuttle machines can reach a life span of more than forty years (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, USA, 14.10.2009).



1. Oven
2. Pre-cool
3. Cooling
4. Unload
5. Load

Figure 3.11: Independent-arm rotational molding machine general arrangement (courtesy of FERRY INDUSTRIES, INC., Stow, Ohio, USA)

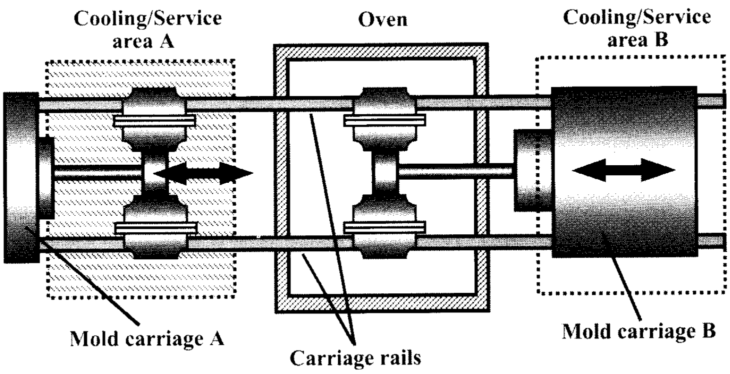


Figure 3.12: Shuttle rotational molding machine (Crawford and Throne, 2002)

Other machine types

A clamshell machine is a single station machine, where the mold rotation arm can swing into and out of the open oven (ARM, 2000). The cover and front panel are opened for part cooling, part removal and reloading of the mold (ARM, 2000). More than one mold can be attached to the single arm. Clamshell machines have a shorter life expectancy (8-10 years) than carousel and shuttle machines since they heat and cool in the same chamber (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, USA, 14.10.2009).

Swing machines have one or more pivot units with a single arm that indexes from the load/unload station to the oven and to the cooling station (ARM, 2000).

In vertical machines, molds, mounted on cradles, are indexed simultaneously from station to station, with the load/unload station at the bottom of the wheel (ARM, 2000).

Rock and roll machines are best suited for parts with very long length to diameter ratios (ARM, 2000). The mold, mounted on a cradle, is rocked back and forth on a stationary, horizontal axis and at the same time it is rotated about a moving axis, which is perpendicular to the rotating axis (ARM, 2000).

Other technical considerations

The information in this section is based on ARM (2000), unless indicated otherwise.

The nominal wall thickness of the part can be explained as its basic frame that defines its shape. Thus, it is the single most important element in the design and it must be handed correctly. The type of plastic material used and the thickness of the nominal wall will establish the strength and load bearing capability of the finished part.

The nominal wall will directly affect the cost of the finished part, taking into account the added cost of the material used in a thicker wall, the cycle time and energy required to heat and cool the plastic that is related to the wall thickness.

Polyethylene wall thicknesses are ideally in the range of 1.5-12.7 mm (Beall, 1998). The ideal wall thickness is the thinnest wall, which will provide for the functional and the processing requirements of the product (Beall, 1998).

In order to determine resin weight for molding any type of a plastic part, one needs to calculate part weight, assuming a given wall thickness as indicated in Equation 3.1.

Equation 3.1: Resin weight determination (ARM, n.d.)

$$Part\ weight = Area\ (cm^2)\ \times Thickness\ (cm)\ \times Desity\ (\frac{g}{cm^3})$$

Where: Area – surface area of part,
Thickness – estimated or desired wall thickness,
Density – resin density.

3.1.3.2 Other manufacturing processes in comparison to rotational molding

Other manufacturing processes that can also be applied for manufacturing of plastic products are presented and compared to rotational molding in this section.

Injection molding

Injection molding is another suitable process for manufacturing of plastic parts. The equipment required for injection molding consists of an injection molding machine and an injection mold (Pötsch and Michaeli, 2008). A variety of polymers can be used for injection molding, including all thermoplastics, some thermosets and some elastomers.

Injection molding cycle starts when the mold closes, then the polymer is injected into the mold cavity (Osswald, 1998). When the cavity is filled, a holding pressure is maintained to compensate for material shrinkage. Then, the screw turns feeding the next shot to the front of the screw, which causes the screw to retract once the next shot is prepared. When the part is cooled, the mold opens and the part is ejected.

Injection molding makes sense when high production rates of mass produced parts of complex shapes and precise dimensions are desirable (Osswald, 1998). Molds for injection molding are much more expensive than for rotational molding due to the high internal pressure that they have to withstand.

Rotational molding, on the other hand, is a low-pressure process and the strength required from the molds is minimal, which results in the production of large or complex parts on short notice, using low-cost molds. Rotational molding requires less time for design and tooling than injection molding. Due to less expensive tooling, rotational molding makes smaller runs on production economical. Table 3.2 presents a comparison of injection and rotational molding.

Table 3.2: Comparison of injection and rotational molding (based on Crawford and Kearns, 2003)

Factor	Injection Molding	Rotational Molding
Plastics available	broad	limited
Feedstock	granule/pellet/powder	liquid/powder
Mold materials	steel/aluminum/beryllium-copper alloy	steel/aluminum
Mold pressure	high	<0.1 MPa
Mold cost	high	moderate
Wall thickness uniformity	uniformity	uniformity possible
Inserts	yes	yes
Residual stress	high	low
Part detailing	very good	adequate
In-mold graphics	yes	yes
Cycle time	fast	slow
Labor intensive	no	moderate

Deep drawing

Deep drawing is another manufacturing process suitable for plastic products. Materials that can be deep drawn include polycarbonate, polyethylene, polyvinylchloride, polypropylene and polystyrene. Drawing takes place in thermoform machines.

The process can occur in many ways. One way is to warm up the plastic sheet so that it becomes soft and elastic. By applying pressure, a form is press-formed in the plastic sheet so that it assumes the outer form of a model. After cooling, it has the contours of the model and can be formed further. Another option is to press a warmed-up plastic sheet onto a model until it reaches a desired form. Another way is to combine pressure and vacuum, whereby a model is pressed onto a warm plastic sheet and the air that was between the sheet and the model is sucked up. This method is called the vacuum forming process. Molds for deep drawing are made of wood or aluminum, which makes their price even lower than for rotational molding.

This manufacturing process would make sense at the beginning of a company’s operation. This method is sensible with production volumes up to 5,000 pieces per year (pers. communication, W. Berger, Berger Biotechnik, Hamburg, Germany, 04.06.2010). Deep drawing requires a skilled and experienced employee for temperature control and adjustment as well as for subsequent finishing of parts, which is much more intensive than with rotational and injection molding.

3.1.3.3 Methods used to color plastics

Two product lines can be chosen to color plastics: mass colored plastic material or in-house coloring. A comparison of both is summarized in Table 3.3.

Table 3.3: Comparison of methods for plastics coloring (adapted from Crawford and Throne, 2002; Müller, 2003)

Massed colored	Self-coloration
· Longer delivery times	· Short term delivery of natural colored plastics · Fast service and supply of new color preparations by the manufacturer of color preparations · Easy and fast change of color during production on the processing machine
· Only standard colors available	· High degree of flexibility in color matching
· Minimum quantity set for customer matched colors	· Supply and storage in container or in bulk
· Remaining rather expensive stock	· Low stock · Small quantities of leftovers of color preparations
· Optimum in color distribution	· Possible effects on the structural properties of the finished product, e.g., embrittlement of the molded part
· No additional equipment required	· Need for additional equipment (expensive)
· Guaranteed properties	· Greater requirements for quality assurance

Two different methods of coloring raw material, i.e. compounding and dry blending are discussed further.

Compounding

There are a number of ways to impart color to the end product in rotational molding, with pigmenting the molding being the main method of coloring rotomolded parts (Crawford and Throne, 2002).

The pigment can be added as granules or pellets are produced by the extruder so that the resulting powder will be of the desired color (Crawford and Throne, 2002). This method is called compounding and it usually produces the best results as it provides the best blending and homogenization of the pigment and the plastic. The resulting properties of the molded parts will be better than those produced by other coloring methods.

If the pigment concentration needs to be in the excess of 0.2 % (wt), it must be melt-blended with the polymer (Crawford and Kearns, 2003). Pigments should be compounded with the polymer prior to grinding as it gives the best mechanical properties in the molded part. However, such colored powder is expensive to produce (Crawford and Throne, 2002).

Dry blending

Another option to color raw material is to dry blend the pigment with the powder. The pigment will not be as well homogenized with polymer as in compounding using an extruder. However, dry blending may be attractive due to cost savings that can be made by purchasing bulk quantities of natural material and coloring this as required prior to molding (Crawford and Throne, 2002).

To improve dry blending of pigments into polymers, high-speed mixers or turbo blenders can be used (Crawford and Throne, 2002). Adhesion of pigment to the inner mold surface can be a problem with dry blended pigments (Crawford and Kearns, 2003). One way of mitigating this problem is the application of permanent or semi-permanent mold release, e.g., fluorinated ethylene propylene, fluoropolymer or siloxane.

3.1.3.4 Comments on special technical complexities, know-how and skills

The design of the toilet slabs (as described in Section 3.1.2) requires skilled product designers, where considerations such as meeting all required and specified design criteria of the finished part, producing the part at the minimum cost for the projected market size and the consequences of the part failing to meet minimum requirements need to be taken into account (Crawford and Throne, 2002).

Labor costs with rotational molding can be kept low as long as unskilled labor is used alongside skilled engineers, who are needed for the proper process planning, design and operation and maintenance of the manufacturing plant. In Ethiopia, salaries of engineers are over seven times higher than that of unskilled workers (Ethiopian Investment Agency, 2008b). Unskilled labor can be employed for the maintenance of the plant and most of the stages of the manufacturing process.

3.1.3.5 Potential environmental issues

The operation of the manufacturing plant and auxiliary activities should not negatively influence the environment.

The rotational molding process has a low material loss rate, but depending on the equipment used, the operators of the machine and the fluctuation in the ambient temperature, one can have scrap parts. One can recycle the scrap oneself or send it to a processor who will buy it, compound it and resell it. If one recycles oneself, a granulator needs to be purchased to cut the parts to a size that will allow one to put it into a pulverizer, which will grind it. If a product can be rotomolded with reprocessed materials so that it will not affect its integrity, one can use 100 % regrind. In other cases a certain percentage of reprocessed materials can be added to virgin material. It normally reprocesses to black so it needs to be dry blended or compounded to black.

There is a possibility of incorporating post-consumer resins (PCR) into rotomolded products. Most available PCRs are made from high-density polyethylene (HDPE) blow molded containers, and they have much lower melt indexes than of typical rotational molding resins (ARM, 2000). Therefore, an HDPE PCR is blended with a virgin resin and these blends can range from 10-25 %. Blends are made by melt compounding or dry blending PCR and virgin blends, the latter method results in worse physical features.

The color of parts molded from mixed blends will be influenced by the type of HDPE PCR in the blend (ARM, 2000). HDPE PCR/virgin resin blends have lower toughness than the virgin LLDPE resin and lower environmental stress crack resistance than of the virgin polyolefin resin.

3.2 Economic outline

This chapter presents essential economic theory. Firstly, various measures of costs are defined. Next, different evaluation criteria for investment are presented. Then, the basics of a break-even analysis are discussed. Finally, financial statements and key financial indicators are explained.

3.2.1 Various measures of cost

There are various measures of cost but one can generally divide costs into fixed and variable costs.

Fixed costs are the ones that do not vary with the quantity of output produced (Mankiw, 2004). In other words, fixed costs (e.g., rent) are incurred even if a company does not produce anything at all. Fixed costs, however, can alter in the long term, for example, as a result of investment in production capacity (e.g., higher costs of insurance). Examples of fixed costs include advertising costs (non-revenue related), depreciation costs, insurance costs, interest paid on loan, non-production related personnel and associated social expenses, start-up costs (e.g., on plant machinery, office equipment) and telecommunication costs (e.g., telephone, fax, Internet).

Variable costs are the ones that vary with the quantity of output produced (Mankiw, 2004). Examples of variable costs include electricity costs, production related personnel and associated social expenses, cost of raw materials and transportation costs of finished products.

3.2.2 Evaluation criteria for an investment

Different methods of evaluation criteria for an investment, including non-discounted and discounted cash flow methods are discussed further.

3.2.2.1 Non-discounted cash flow method

Payback period (PBP) is a simple measure of the return from an investment. It shows the length of time required for an investment to recover its initial cost. PBP is calculated as indicated in Equation 3.2.

Equation 3.2: Payback period (Rogers, 2001)

$$PBP = \frac{C_0}{NCF}$$

Where: C_0 – the initial cost of the project,
NCF – net cash flow that will recover the investment after the payback period.

Even though PBP is easy to calculate and interpret, it should not be considered alone as it ignores any benefits that occur after the PBP and does not measure the profitability. It also ignores the time value for money. It should be presented together with other indicators such as the Net Present Value (NPV) and the Internal Rate of Return (IRR), which are discussed further.

3.2.2.2 Discounted cash flow method

The Net Present Value (NPV) is the sum of discounted annual net cash flows (from non-financial operations) during the lifetime of the project (Romijn and Balkema, 2009). The NPV is calculated according to Equation 3.3.

Equation 3.3: Net Present Value (Crundwell, 2008)

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+i)^t}$$

Where: CF_t – net cash flow in year t,
i – discount rate,
n – lifetime of the project.

The selected discount rate (i) reflects the costs of financing the project. Thus, it generally represents the interest rate on a commercial loan.

If the NPV is greater than zero, it is expected that the value will be created for the investor, i.e. the project is expected to yield more than the prevailing market interest rate (Romijn and Balkema, 2009). On the other hand, if the NPV is less than zero, the project should not be approved as the net project earnings are estimated to be lower than the cost of financing the project.

The Internal Rate of Return (IRR) is the discount rate that makes the NPV equal to zero (Crundwell, 2008). One of the easiest methods to calculate the IRR of a project is to use the built-in MS Excel function, which forces the NPV to turn zero and finds the associated IRR. One should compare the IRR of the project with the market interest rate. If the IRR is higher than the market interest rate (i), the project is expected to yield more than the cost of financing it, whereas if it is lower than the market interest rate, it is not advisable to implement the project as it will be less profitable than the cost of financing it (Romijn and Balkema, 2009).

The influence of inflation

Current prices (actual market prices) are prices that are expected to occur in the future during the lifetime of a project (Romijn and Balkema, 2009). However, if a country experiences inflation, using current prices is troublesome due to the problem of estimation of the prices in a reliable manner. Therefore, it is necessary to re-calculate the project cash flows in constant prices, i.e. prices that prevail in the project base year and the real discount factor, which is also called an “inflation-free” discount rate. The real discount factor is calculated according to Equation 3.4.

Equation 3.4: Real discount factor (Romijn and Balkema, 2009)

$$r = \frac{(1+i)}{(1+p)} - 1$$

Where: p – average expected annual rate of inflation,
i – nominal discount rate.

The NPV from constant and current prices should always be the same (Romijn and Balkema, 2009). The real IRR is calculated using the cash flows in constant prices. The real IRR does not include an inflation effect, just like the real discount rate. To determine the profitability of the project, the real IRR should be compared to the real discount factor (*r*), whereas the nominal IRR to the nominal discount factor (*i*).

3.2.3 Break-even analysis

In order to determine the point at which company's costs exactly match the sales volume, a break-even analysis needs to be performed. The business objective, however, is not to break even but to earn a profit. The break-even point can be determined by mathematical calculation as presented in Equation 3.5.

Equation 3.5: Breakeven point (sales) (Pinson, 2008)

$$Breakeven\ Point\ (Sales) = Fixed\ costs + \frac{Variable\ Costs}{Estimated\ Revenues} \times Sales$$

The break-even point can also be determined by computing a graph. In a graph, revenue, total cost and fixed cost is plotted on the vertical axis and volume is plotted on the horizontal axis. The break-even point is where the revenue line intersects the total cost line (Shim and Siegel, 2007).

An important term used in a break-even analysis is contribution margin (CM), which is the marginal profit per unit sale. It is a useful indicator of the profit potential of a business. CM is the excess of sales over variable costs, as presented in Equation 3.6 (Shim and Siegel, 2007).

Equation 3.6: Contribution margin (Shim and Siegel, 2007)

$$Contribution\ Margin = Selling\ Price - Variable\ Costs$$

Break-even analysis with more than one product sold requires more computations. (Shim and Siegel, 2007). As different selling prices and variable costs can result in different contribution margins, break-even points change depending on the proportions of the products sold, i.e. sales mix.

In order to calculate a break-even point for more than one product sold, the sales mix needs to be predetermined and a weighted-average contribution margin (WACM) needs to be calculated (Shim and Siegel, 2007). A WACM is calculated by multiplying each product's unit CM by its proportion of total sales. In a break-even analysis for a multiproduct business, an assumption that the sales mix will not change has to be made.

3.2.4 Financial statements

Three main financial statements, i.e. a profit and loss statement, a cash flow statement and a balance sheet are explained further.

3.2.4.1 Profit and loss statement

Profit and loss (P&L) statement shows a business's financial activity over a period of time (Pinson, 2008). In order to develop a P&L statement, information presented in Table 3.4 is required.

Table 3.4: Profit and loss statement (Handelsgesetzbuch, 2003)

Revenues
+/- Increase or decrease in work in progress and finished goods
+ Other company-produced additions to plant and equipment
+ Other operating income
- Cost of goods sold (raw materials and supplies, received services)

= Gross Profit
- Personnel expenses (salaries, wages, social benefits)
- Depreciation (of fixed and current assets)
- Other operating expenses
+ Dividends from associated companies
+ Income from financial assets and marketable securities
+ Interest income
- Write-down of financial assets
- Interest expenditures

= Profit or loss from operation
+ Extraordinary income
- Extraordinary expenses
- Income tax
- Other taxes

= Profit or loss after tax

Fixed assets, over time, lose ability to provide services. The periodic recording of the cost of a fixed asset as an expense is referred to as depreciation (Warren et al., 2009). Depreciation is not a cash spending. It allocates the capital expenditure over the lifetime of the investment.

There are many ways of calculating the depreciated value. For the purpose of this thesis, the straight-line method is used. This method provides for the same amount of depreciation expense for each year of the asset's useful life and it is calculated according to Equation 3.7.

Equation 3.7: Straight-line depreciation calculation (Warren et al., 2009)

$$Annual\ depreciation = \frac{Cost}{Useful\ life}$$

3.2.4.2 Cash flow statement

Cash flow statement, in general, identifies when cash is expected to be collected and when it must be allocated to pay bills, debts, etc. (Pinson, 2008). A cash flow statement can be computed as presented in Table 3.5.

Table 3.5: Cash flow statement

Profit/loss after tax
+/- Non-cash expenses:
Depreciation
= Operating cash flow
+/- Changes in working capital
- Loan payback
- Capital expenditures
= Cash flow
Source of funds
+ Bank debt
+ Shareholders loan
= Total source of funds
Financing balance
+ Balance of last year
= Financing balance

3.2.4.3 Balance sheet

A balance sheet is another financial statement, which shows the financial situation of the business as of a fixed date (Pinson, 2008). Projected balance sheets are computed in order to present them to lenders or investors and they measure the growth of the business over a particular period of time, usually one year. Balance sheets present assets against liabilities.

Assets are grouped into (*Handelsgesetzbuch,* 2003):

(a) Liability of shareholders for uncalled capital
(b) Fixed assets:
- Intangible assets (e.g., intellectual property rights)
- Tangible assets (e.g., land, buildings, equipment, furniture)
- Financial assets (e.g., shareholdings)

(c) Current assets:
- Inventory (e.g., raw materials, work in progress, finished goods)
- Receivables and other current assets (e.g., accounts receivable, which is money owed to the business for selling goods or services)
- Securities
- Liquid assets (cash)

(d) Accruals

Liabilities are grouped into (*Handelsgesetzbuch,* 2003):

(a) Equity:
- Subscribed capital
- Capital reserve
- Revenue reserve
- Profit or loss carried forward
- Annual profit or loss

(b) Accrued liabilities (e.g., pension reserves, provision for taxation)
(c) Debts (e.g., bonds, bank debts, accounts payables – obligations payable within one operating cycle)
(d) Accruals

3.2.5 Key financial indicators

There are many financial indicators that can be used to analyze financial statements. Three selected indicators (return on investment, gross profit margin and net profit margin) are discussed further.

3.2.5.1 Return on investment

Return on investment (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of investments. It measures the effectiveness of a business to generate profits from the available assets (Pinson, 2008). ROI is calculated according to Equation 3.8.

Equation 3.8: Return on investment (Shim and Siegel, 2008)

$$Return\ on\ investment = \frac{Net\ profit\ after\ taxes}{Total\ assets}$$

ROI is presented in a form of a percent, whereby a positive number represents a financial gain and a negative one a financial loss. A higher ROI indicates a better financial result of a business.

3.2.5.2 Gross profit margin

Gross profit margin (GPM) is a profitability indicator, which shows the percentage of each sales remaining after a business has paid for its goods (Pinson, 2008). The GPM represents the actual markup a company has on the good sold. GPM is calculated according to Equation 3.9. A high GPM suggests that a company can realize a reasonable profit as long as it manages to keep overhead costs in control (Webster, 2003).

Equation 3.9: Gross profit margin (Pinson, 2008)

$$Gross\ profit\ margin = \frac{Gross\ profit}{Sales}$$

3.2.5.3 Net profit margin

Net profit margin (NPM) is a profitability indicator, which is the measure of a business success with respect to earning on sales (Pinson, 2008). It indicates how well the business is generating enough sales volume to cover minimum fixed costs and still leave an acceptable profit. The NPM is calculated according to Equation 3.10. A higher NPM means that a company is more profitable.

Equation 3.10: Net profit margin (Shim and Siegel, 2008)

$$Net\ profit\ margin = \frac{Net\ profit\ after\ taxes}{Sales}$$

3.3 Competitors and prices

This section discusses potential competitors currently present on the plastic products market, the future role of the company on the market and current prices of toilet slabs in Ethiopia.

3.3.1 Potential competitors

There are manufacturers of plastic toilet slabs in Ethiopia that currently play a significant role on the market. Two of them – AquaSan Manufacturing Ethiopia PLC and Roto PLC – were interviewed due to their leading role on the market. The interviews were conducted in order to study the potential for founding a company in the plastic toilet slabs business. Follow-up information was gathered through personal correspondence with representatives of both companies. A description of the manufacturers, their key products and an overview of main findings from the interviews is given below.

3.3.1.1 AquaSan Manufacturing Ethiopia PLC

Company's Profile

AquaSan Manufacturing Ethiopia PLC is a subsidiary of AquaSanTec with seven subsidiaries in East Africa and six manufacturing plants (AquaSanTec, 2007). The Ethiopian subsidiary is located in Addis Ababa.

Products

The company's product portfolio is spread over three areas: water, sanitation and energy.

In the dry sanitation products section, they offer the following products:

- Eko-loo, which comprises of a toilet slab[22] and a superstructure;
- Mobilet, which is a mobile toilet designed for pit latrines;
- Wonderloo®, which is urine diversion pedestal for in-house installation.

The range of the company's dry sanitation products is presented in Appendix A.

The company sells dry sanitation products to businesses, individuals, institutions and wholesalers. Main customers of products that can be applied under the ecosan approach include NGOs and local government agencies.

All products are made of LLDPE and manufactured by rotational molding, with the exception of an eco-plate for sitting, which is produced with injection molding. Products are manufactured in a plant that belongs to Kentainers (a subsidiary of AquaSanTech in Kenya). The plant encompasses an area of about 5,000 m^2 and it has a rotomolding production capacity of approximately 30 tons per month (pers. communication, S. Ganapathy, Kentainers Factory Manager, Addis Ababa, Ethiopia, 15.05.2009). As of May 2009, a production plant was being put into operation in Ethiopia to avoid transportation expenses (from Kenya).

[22] A slab can be either an eco-slab for urine diversion, eco-plate for sitting or eco-plate for squatting.

Costs

Capital costs for the Kentainers' manufacturing plant were not high (pers. communication, S. Ganapathy, Kentainers Factory Manager, Addis Ababa, Ethiopia, 15.05.2009). These costs comprised mainly of the machinery (e.g., rotational molding machine, extruder, pulverizer, etc.) and cold rolled sheet steel molds, which were imported from India.

Product costs are mainly related to the cost of raw materials, which are imported from Saudi Arabia. The company also bears transportation costs of raw materials to the factory and of finished products to the customer or wholesaler. Labor costs make up a small fraction of overall costs as unskilled labor is used alongside a few skilled engineers. The electricity consumption is approximately 120,000 kWh per month. Liquid petroleum gas (LPG) is used to heat the molds during the rotational molding process. Marketing costs are not high. Marketing activities include advertisements in newspapers, awareness-creating campaigns, brochures, direct marketing with clients, field presentations to end-users and partnering with NGOs and the government to educate people on the advantages of using the company's products.

3.3.1.2 Roto PLC

Company's profile

Roto PLC is located in Addis Ababa and it is a part of Flame Tree Group of companies (Nairobi, Kenya) with factories in over seven countries in Africa (Roto PLC, 2012).

Products

The company has a wide range of products, focusing mainly on plastic tanks for water, but also offers a selection of sanitation-related products. Their details are presented in Appendix A. The Roto toilet hut (superstructure) with different slabs available is similar to Mobilet produced by AquaSan/Kentainers discussed above. The hut is suited for, for example, a dry pit latrine slab, which is available in round and square forms. Roto sanitary plastic products are mainly manufactured with HDPE.

Costs

Costs incurred by Roto PLC are similar to the costs described for AquaSan/Kentainers in Section 3.3.1.1. Raw material is imported from Europe, India and Saudi Arabia. Part cooling is performed with high speed fans, whereas water is used for cooling of the rotational molding machine. Electricity consumption is around 120,000 kWh per month. Roto PLC employs three skilled engineers and has the production capacity of 8.5 tons per day (pers. communication, J. Mathews, Country Manager at Roto PLC, Addis Ababa, Ethiopia, 15.05.2009). The production and storage area is set on 7,500 m^2 of land.

3.3.1.3 Other companies

There is another company located in Addis Ababa that manufactured a small number of sitting and squatting urine diverting toilets made of fiberglass. The company is called EthioFibre Glass Ethiopia. The production was supported by a public-private partnership (PPP) project scheme Ecological Sanitation Ethiopia (ESE) funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). GIZ sponsored the production of the mold, which is made of fiberglass (von Münch and Winker, 2011). The product is manufactured manually, requires skilled labor and yields one product per 3-5 hours (pers. correspondence, A. Bahubeshi, EthioFibre Glass Ethiopia, 16.04.2009).

Another company called Tabor ceramics and located in Awassa produced ceramic urine diverting squatting pans, also as a part of the same PPP project scheme. GIZ sponsored raw material for their production (von Münch and Winker, 2011). Due to the small number of the ecosan products manufactured by these two companies their details will not be discussed further, but their products are presented in Appendix A.

3.3.2 Role of the company on the market

The market of plastic sanitation-related products in Addis Ababa is penetrated by two biggest players discussed in Section 3.3.1 – AquaSan and Roto PLC. Both companies claim to be the leaders on the rotational molding market in Ethiopia. Their product portfolio is not limited to sanitation products as they also manufacture water tanks, septic tanks and other plastic products. The market presence of AquaSan and Roto PLC in Addis Ababa is well assured, which is a good reason for opening a company in a different city, i.e. Arba Minch, where the market of plastic products is not saturated yet.

Establishing a company with a specialization on toilets to be used under the ecosan approach should be an effective strategy. It would allow the company to become recognizable as a unique manufacturer of this kind of products, to reach economies of scale faster and increase efficiency due to the focus on a particular product portfolio. Due to specialization, product and process design advantages, e.g., time savings and efficient production runs can be reached.

3.3.3 Prices of toilets in Ethiopia

Price quotes for products comparable to the products considered for this business plan (as described in Section 3.1.2) were investigated in Ethiopia. Information was gathered in September 2008 and May 2009 in Ethiopia by personal communication and correspondence with representatives of companies operating in Ethiopia and Kenya as well as from Catholic Relief Services (CRS) – an NGO operating in Ethiopia. These prices are presented in Table 3.6.

Table 3.6: Prices of toilets in Ethiopia

Similar to product[a]	Size (cm)	Material	Price (ETB)[b]	Producer	Comment
1	60x60	LLDPE	600	Kentainers/ AquaSan	· Eco-plate for sitting · Produced with injection molding
1	654x600x816[c]	fiberglass	1,530	EthioFibre Glass Ethiopia	· UD[d] pedestal toilet · Fitted with a box
2	45x30	LLDPE	150	Kentainers/ AquaSan	· Eco-plate for squatting · Applicable for a single vault UDDT
2	1060x32	fiberglass	375	EthioFibre Glass Ethiopia	· UD squatting toilet · Applicable for a double vault UDDT
2	60x50	ceramic	310	Tabor Ceramics	· UD squatting toilet
3	80x60	LLDPE	*360*	Kentainers/ AquaSan	· Pit latrine slab
4	n.a.	concrete	*60-140*	n.a.	· Extremely cheap option · Hardly comparable with plastic toilet slabs
4	100x100	LLDPE	*840*	Kentainers/ AquaSan	· Pit latrine slab

a) For the list of products, refer to Table 3.1.

b) The prices in italics were converted from USD or KES to ETB using an average exchange rate as of 2009 from OANDA (2012).

c) The dimensions include the box that the toilet is fitted with.

d) UD refers to urine diverting.

3.4 Procurement and logistics

This chapter presents specific aspects behind the business plan of producing plastic toilet slabs to be used under the ecosan approach, including possible suppliers of equipment and raw materials, parameter selection for the manufacturing process, the location and size of the manufacturing plant as well as the availability of required infrastructure.

3.4.1 Possible suppliers of equipment

The manufacturing line requires machinery that is summarized in Table 3.7, where its application, price and possible suppliers of equipment are listed.

Table 3.7: Possible suppliers of equipment

No.	Equipment	Application/ Comment	Price, including shipping (ETB)[a]	Supplier
1	Rotational molding machine	Manufacturing of toilet slabs	Machine 1: 2,677,500 Machine 2: 4,100,000	Ferry Industries Inc., USA, (www.ferryindustries.com)
2	Burner	Burner for the rotomolding machine due to LPG composition in Ethiopia	76,600	Ferry Industries Inc., USA, (www.ferryindustries.com)
3	Pulverizer	Grinding of LLDPE granules to powder	254,500	Zhangjiagang Lanma Machinery Co., Ltd., China, (www.yfplasticmachinery.com)
4	High-speed Mixer	Color dry blending	948,000	Plasmec S.R.L., Italy, (www.plasmec.it)
5	Router	Secondary operations on finished products	462,000	Tongxing Technology Development Co., Ltd., China, (www.txgm.com)
6	Band saw with extra blades	Cutting of back-to-back molded products	200	Local hardware store in Arba Minch
7	Trimmers	Manual deflashing of parts	200	Ferry Industries Inc., USA, (www.ferryindustries.com)
8	Generator	For electrical power supply in the event of a power outage	460,000[b]	Local supplier in Arba Minch
9	Color compounding line	Color compounding	13,035,500[c]	KraussMaffei Berstorff GmbH, Germany (www.kraussmaffei.com)
10	Granulator	Recycling of scrap plastic	243,000	Zhejiang Qunli Plastics Machine Co., Ltd., China, (www.circularloom.cn)

a) Prices were obtained in CNY, EUR and USD and converted to ETB using average exchange rates as of October 2009 and February 2010 from OANDA (2012). Shipping costs to Addis Ababa were obtained from Ethiopian Investment Agency (2008b). Installation costs were considered for complex equipment (for no. 1, 3, 4, 5, and 10) and calculated as 15 % of the price of equipment.

b) The price includes installation costs.

c) The price includes all the necessary equipment, shipping, installation and commissioning costs.

3.4.2 Possible suppliers of raw materials

This section defines potential suppliers of LLDPE and different options for coloring of raw material, including compounded color and dry pigment.

3.4.2.1 Linear low-density polyethylene

LLDPE market prices were studied through personal correspondence with companies supplying these types of materials worldwide. For LLDPE price quotes, the information as presented in Table 3.8 was used (pers. correspondence, R. Entner, Vice President at Uhde GmbH, Dortmund, Germany, 22.10.2009). Additional 40 % of the price of raw material was added to the average spot price to compensate for shipping costs (including marine freight transportation, cargo insurance, unloading, processing fee and import duty) from Europe to Addis Ababa, Ethiopia. The prices presented in Table 3.8 do not consider transportation costs of raw material from Addis Ababa to Arba Minch.

Table 3.8: LLDPE market prices including shipment to Addis Ababa

LLDPE	Average spot price[a] (ETB/kg)[b]
Butene-based	21.2
Hexene-based	23.1
Octene-based	25.0

a) Spot price is a market price at which a product is sold at a particular point in time.

b) The price was converted from USD to ETB using average exchange rate from October 2009 from OANDA (2012).

For the manufacturing of toilet slabs, the average spot price for butene-based LLDPE was chosen. This price seemed the most reasonable, in particular after taking into account the information obtained in Ethiopia: LLDPE delivery price to Addis Ababa of 14.0-18.9 ETB/kg (pers. communication, J. Mathews, Country Manager at Roto PLC, Addis Ababa, Ethiopia, 15.05.2009).

Part weight for each manufactured product was calculated according to Equation 3.1 and it is shown in Table 3.9. Detailed calculations of part weight for Products 1, 2, 3 and 4 are presented in Appendix B.2.

Table 3.9: Calculated part weight for manufactured products

Product	Product 1	Product 2	Product 3	Product 4
Part weight (kg)	3.74	2.53	4.40	9.65

Knowing the part weight, the required amount and resulting costs of LLDPE per product were determined. Table 3.10 shows these costs, which also include delivery costs to Arba Minch.

Table 3.10: Calculated costs of raw material (LLDPE) for manufactured products

LLDPE costs	Product 1 (ETB/unit)	Product 2 (ETB/unit)	Product 3 (ETB/unit)	Product 4 (ETB/unit)
Year 1	95.3	64.6	112.1	246.2
Year 2-5	84.2	57.1	99.1	217.5

The additional cost of purchasing raw material in a powder form has also been included. Based on the information provided (pers. correspondence, P. Chassin, Sales Director at Ter Hell Plastic GmbH, Herne, Germany, 29.10.2009), the price difference between granular and powder LLDPE can be estimated to approximately 20 % more for powder form. Starting from the second year of operation, costs will decrease due to the installation of an in-house pulverizer, whereby raw material is processed from granules to powder directly at the plant. After the first year of duty free imports of LLDPE, a customs duty tax of 5 % is levied, which is also included in the price of raw material.

3.4.2.2 Compounded color vs. dry pigment

As already discussed, compounded color can be either processed in house or bought from a third party. The important advantage of internal color compounding is being able to control production lead times. However, the costs of installing an extruder and a grinder are high, and instead, e.g., another rotational molding machine could be purchased in order to expand the production.

According to the information gathered, large volumes of colored compound should not be significantly more expensive than uncolored material (pers. correspondence, C. Hampton, Manager at Hamptons Colours Limited, Gloucestershire, UK, 26.02.2010). However, smaller quantities will be more expensive than uncolored, making dry color more viable. The value of the colorants in compound is negligible compared to the processing costs. Furthermore, compounded color is likely to be more expensive for small lots than dry color, but the structural integrity will be better.

Different companies were consulted for compounded color quotes. The price of compound material is based on the cost of raw material in a particular month, pigment costs, and transportation costs. The price quotes obtained can be summarized as follows:

(a) approximately 43 ETB/kg[23] (pers. correspondence, F. Ramezani, Business Development Manager at Matrix Polymers Ltd, Northampton, UK, 04.03.2010). The price includes raw material, compounding, pigments, grinding, packaging and shipping to Ethiopia.

(b) approximately 31 ETB/kg[24] (for 1,000 kg lots) to 857 ETB/kg (for 5 kg lots) (pers. correspondence, C. Hampton, Manager at Hamptons Colours Limited, Gloucestershire, UK, 26.02.2010). The price does not include pigments, grinding and shipping costs to Ethiopia.

[23] The price was converted from EUR to ETB using an average exchange rate as of March 2010 from OANDA (2012).

[24] The price was converted from GBP to ETB using an average exchange rate as of February 2010 from OANDA (2012).

The price quote (a) is about the double of the price of not colored raw material (refer to Table 3.8). After adding pigments, shipping and grinding costs to the price quote (b), it should be comparable to the price quote (a).

Different price quotes for dry pigment in various colors were studied. The price quote of 151 ETB/kg[25] of dry pigment in white was chosen as the most cost efficient (pers. correspondence, C. Hampton, Manager at Hamptons Colours Limited, Gloucestershire, UK, 19.02.2010).

The prices for manufactured products (for the list of products refer to Table 3.1) using dry pigment in white (addition rate: 0.5 % wt.) and compounded color are summarized in Figure 3.13. It is clear that using compounded color is much more expensive than using dry pigment. All costs include shipping costs of raw materials to Addis Ababa and transportation by road to Arba Minch. In both cases, starting from the second year of operation, the price includes 5 % of customs duty levied on plastic raw materials. In the case of using LLDPE with dry pigment, in the first year, approximately 20 % of the price of raw material (in granules) is included on top of the price of raw material as the material needs to be purchased in a powder form. In the second year of operation, a pulverizer is installed to produce powder from granules in house so the costs decrease. For compounded color, the price quote of 43 ETB/kg was used (see the discussion above). Costs presented in Figure 3.13 include a 5 % error indicator.

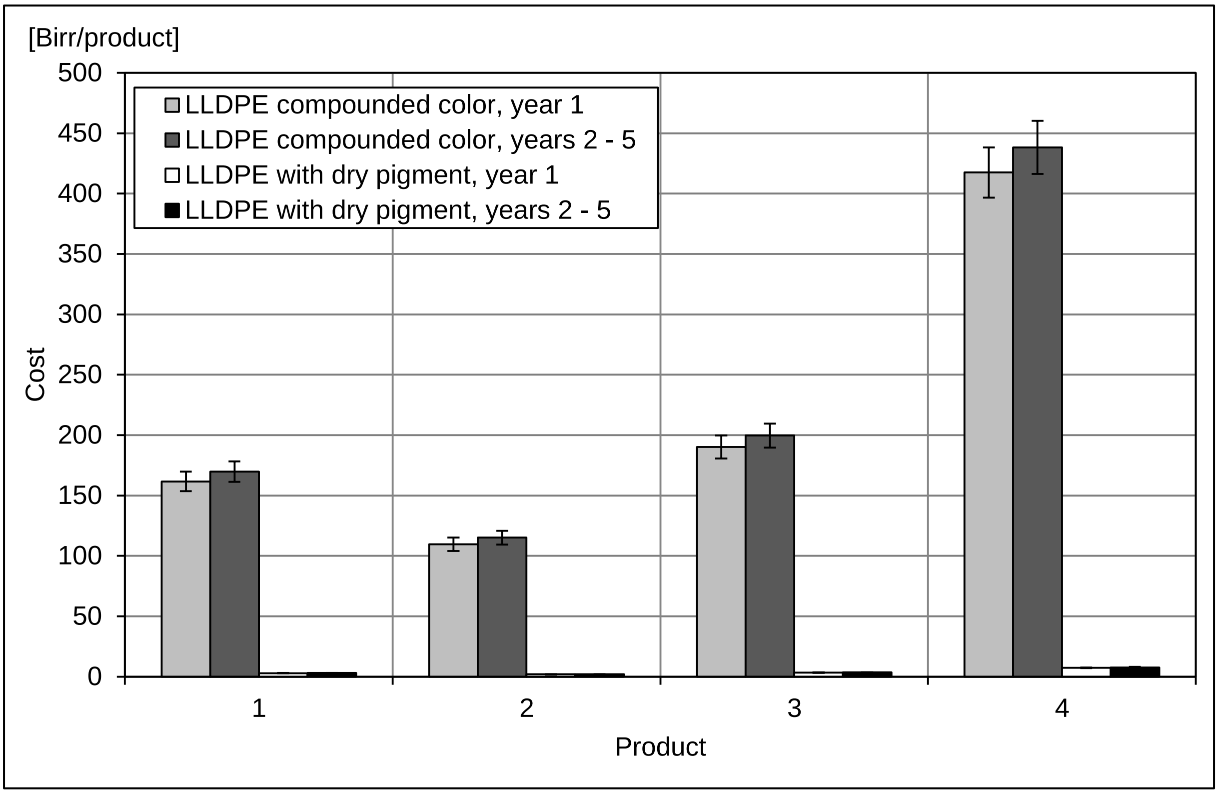


Figure 3.13: Cost comparison of using LLDPE with compounded color and dry pigment

[25] The price includes shipping costs to Addis Ababa and it was converted from GBP to ETB using an exchange rate as of 19.02.2010 from OANDA (2012).

Even though color compounding is superior to dry blending it, after taking into account the nature of the products to be manufactured and the fact that they are not high appearance products, dry blending with pigment should be a more appropriate choice, mainly due to its cost efficiency (refer to Figure 3.13).

A further advantage of internal dry blending is stocking uncolored LLDPE and coloring just enough that one needs each time. By choosing a high-intensity mixer over a paddle blender, a superior color mix can be achieved due to more frictional heating and better mixing of the pigment and the plastic powder (Crawford and Throne, 2002). Especially with the maximum throughput of approximately 1 ton at a time, dry blending makes sense cost wise. The disadvantages, on the other hand, are that working with the pigment can be untidy, and there could be effects on the structural properties of the finished product, e.g., embrittlement of the molded part (Crawford and Throne, 2002). For more information on coloring methods refer to Section 3.1.3.3.

3.4.3 Selection of parameters for the manufacturing process

After having considered the information presented in Section 3.1.3, technical parameters for the planned business were selected and they are presented further.

3.4.3.1 Manufacturing process

Plastic toilet slabs (Products 1, 2, 3 and 4, refer to Table 3.1) should be produced with the rotational molding process. This decision was based on the cost and operational advantages of this process vis-à-vis injection molding and deep drawing.

Injection molding was not chosen for the planned manufacturing line as it makes sense with higher production volumes than assumed for this business idea. It is also associated with higher capital investment and operating costs. Furthermore, it is more appropriate for more complex part designs.

Deep drawing, on the other hand, makes sense with lower production volumes than assumed for this business idea. Furthermore, it requires an experienced operator to control and adjust temperature and finish the parts.

3.4.3.2 Molds

Steel molds were chosen for the manufacturing process due to their low cost and availability. They can be imported from India and their price depends on the complexity of the design. Their life span is for approximately 20,000-30,000 parts (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, 14.10.2009). Based on the information gathered, a mold similar to the one required for the manufacturing of Product 2 costs approximately 10,000 ETB (pers. communication, S. Ganapathy, Kentainers Factory Manager, Addis Ababa, Ethiopia, 15.05.2009). As Product 1 requires a slightly more complicated mold than Product 2, the mold for Product 1 is assumed to cost 15,000 ETB, whereas for Products 3 and 4, which are less complicated in design – 6,000 ETB each. They will be imported from India so shipping costs of 14,500 ETB[26] have to be covered additionally (Ethiopian Investment Agency, 2008b).

3.4.3.3 Moldable material

For the manufacturing process, LLDPE was selected as a suitable raw material. This decision was based on its properties (for details refer to Section 3.1.3.1) and the experience of other companies in Ethiopia that use it as a raw material for the production of plastic toilet slabs with the rotational molding process.

3.4.3.4 Material preparation

In order to reduce the cost of raw material, the company should purchase a pulverizer to grind raw material from pellets to powder. It was assumed that this investment would be made in the second year of operation.

3.4.3.5 Coloring of raw material

It was decided that dry pigments would be dry blended with a plastic raw material (LLDPE) in a high-speed mixer. The decision was based on the cost comparison for producing colored parts by using compounded color against dry pigment (refer to Figure 3.13).

3.4.3.6 Machine

Shuttle and independent-arm carousel machines were chosen as two alternatives for the manufacturing process of plastic toilet slabs. Scenario 1 will consider manufacturing with a shuttle machine (Machine 1), whereas Scenario 2 will consider manufacturing with an independent-arm carousel machine (Machine 2). For information on rotomolding machines refer to Section 3.1.3.1.

Machine 1 stands for FERRY RotoSpeed Model M1-2600 (M1-2600) rotational molding shuttle machine type with a single arm. It was assumed that this machine would be expanded to have two arms and carts (M2-2600) in the third year of operation in order to increase the production capacity. Machine 2 stands for FERRY RotoSpeed Model R3-2600 (R3-2600) independent-arm carousel machine type with three arms. The price quotes and technical specifications for both machines were obtained by pers. correspondence with A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, USA, October 2009-February 2010.

In both scenarios (with Machine 1 and with Machine 2), it was assumed that two parts would be molded per cavity. Machine 1 has four cavities before the extension and afterwards eight cavities, arranged so that they fit two side by side on the straight arm.

The higher productivity of Machine 2 is attributed to the fact that each part of the process (loading, oven, cooling/unloading) occurs simultaneously. For more information on shuttle and carousel machines refer to Section 3.1.3.1.

[26] Price was converted from USD to ETB using the average exchange rate as of May 2009 from OANDA (2012).

The rotational molding machines (Machine 1 and Machine 2) can also be used for production of other plastic products, e.g., other toilet slabs, water tanks, septic tanks, etc. Furthermore, molds for rotational molding are not as expensive as in the case of injection molding, therefore, the production line is more flexible and easier to be adapted to the demand for new products, once required.

3.4.3.7 Other technical parameters

A part wall thickness of approximately 5 mm was chosen (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, USA, 14.10.2009). The density of butane-based LLDPE of 0.9185 g/cm^3 was consulted in the literature (NCDEX, 2010).

3.4.4 Plant location

The location of the plant is suggested for the town of Arba Minch. Information regarding Arba Minch and the reasons for its attractiveness for plant location are discussed further.

3.4.4.1 Introduction to Arba Minch

Arba Minch is located in the Southern Nations, Nationalities and People's (SNNP) Region, about 500 km south of Addis Ababa (the capital of the country) and 275 km south of Awassa (the capital of the region) (refer to Figure 3.14). Arba Minch is the capital of the Gamo Gofa Zone.

Figure 3.14: Location of Arba Minch, Ethiopia (based on Google Maps)

In the years 1994-2007, the annual population growth in the SNNP Region (2.9 %) was one of the highest in Ethiopia (Population Census Commission, 2008). Arba Minch is also experiencing a rapid growth. The population of the town has been projected to grow from almost 60,700 inhabitants in the year 2002 to almost 121,000 inhabitants in the year 2015 and to over 181,000 inhabitants in the year 2025, which corresponds to the overall growth rate would of 4.5 % p.a (DHV Consultants, 2002).

In 2007, the population of Arba Minch town was already estimated to almost 75,000 inhabitants (CSA, 2007), whereas a local survey conducted in 2006/2007 estimated the population to almost 79,000 inhabitants (AMU and ARB, 2007). In residential areas of the town, the population density is at 154 persons/ha, and it is expected to grow to 250 persons/ha in 2025 (DHV Consultants, 2002).

The city is located between the Lakes Chamo and Abaya. The climate of Arba Minch is characterized by two rainy seasons, occurring from April till May and from September till October. The mean annual rainfall is approximately 806 mm p.a. and the average air temperature is 20°C (DHV Consultants, 2002). The River Kulfo flows through Arba Minch and it serves many purposes, including irrigation, domestic water use and as an open defecation area (AMU and ARB, 2007).

Arba Minch does not have a sewer system. Only the Arba Minch University that houses approximately 7,000 people is connected to waste stabilization ponds (AMU and ARB, 2007). Sanitation facilities in Arba Minch mainly constitute of private (31 % of the housing units) and shared pit latrines (44 % of the housing units) (CSA, 2007). Shared ventilated improved pit (VIP) latrines are used by 4 % of the housing units, whereas private VIP latrines by 2 % of the housing units in the town (CSA, 2007). Pit latrines in Arba Minch are often of low quality, susceptible to flooding and collapse (AMU and ARB, 2007). Most of the pit latrines in the town have squatting floors made of wooden logs with no or very poor superstructures and privacy covers. When the pit gets full, it is usually covered with soil and used for solid waste disposal and a new pit is dug for a new latrine. Other households employ someone to empty the pit manually, which costs approximately 50 to 100 Birr and there are no official sites for sludge disposal (AMU and ARB, 2007). Most pits are dug shallow due to the poor soil quality and high costs of pit digging (ca. 15-50 Birr/meter) (AMU and ARB, 2007).

As many as 16 % of the housing units in Arba Minch do not have any toilet facilities (CSA, 2007). Open defecation sites in the town include gorges, jungle sites, riverside, university campus and the vicinity of the marketplace (AMU and ARB, 2007).

Only a few housing units (approximately 3 %) have private or shared flush toilets connected to a septic tank. These households and institutions (e.g., hotels) are responsible for handling their emptying. Thus, they need to order a vacuum truck, which travels from distant towns, i.e. it is connected with a considerable expense.

According to the information gathered in Arba Minch, a lot of development is taking place in the town (pers. communication, D. Dibeta, Urban Planning Department, Arba Minch, 25.05.2009). It mainly involves new settlements and condominium housing, which increases the need for adequate sanitation solutions. Furthermore, aside from demographic change, the city is experiencing migration from rural to urban areas.

3.4.4.2 Attractiveness of Arba Minch for plant location

Arba Minch has lower prices of land lease than Addis Ababa or Awassa[27] (Ethiopian Investment Agency, 2008b). Other costs, including building costs, insurance, and personnel costs are also cheaper in Arba Minch.

[27] A land lease in Addis Ababa for a traditional business zone is 427-796 ETB/m^2, in Awassa for an industrial zone: 0.80 ETB/m^2, and in Arba Minch: 0.70 ETB/m^2 (Ethiopian Investment Agency, 2008b).

Transportation costs of raw materials to Arba Minch are not much higher than to Addis Ababa, as the price for transporting any material from Addis Ababa to Arba Minch is low. Additional transportation costs of machinery and auxiliary equipment for the manufacturing process can be considered as an obstacle, however, a price for delivery from Addis Ababa to Arba Minch of heavy-duty equipment can be negotiated with a third party.

The market of plastic producers in Addis Ababa is becoming saturated (refer to Section 3.3.2). In Arba Minch and its vicinity, the activities of the Resource-Oriented Sanitation for peri-urban areas in Africa (ROSA) project (1 October 2006 – 31 March 2010) made people familiar with the ecosan approach. Another project called Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas (CLARA) was launched in March 2011. The field research of the project is also based in Arba Minch and its overall objective is to strengthen the local capacity in the water supply and sanitation sector (CLARA, 2011). The CLARA project builds on the experience of the ROSA project and aims at developing a planning tool for water supply and sanitation systems that will be field tested in different African locations.

In addition, there are numerous NGOs working in Arba Minch and its surrounding areas. Their work is also focused on the improvement of the sanitary situation in the town and its vicinity.

As a result of the above considerations, it was assumed that the demand for sanitary products would be in place in Arba Minch and other woredas in the Gamo Gofa Zone. Furthermore, current facilities which are mostly unsheltered pits with wooden logs[28] do not provide comfort nor dignity. Therefore, it is expected that the demand for plastic toilet slabs would be in place. The potential customer groups include households, public institutions and organizations (e.g., NGOs and CBOs). For detailed information on the estimated demand for plastic toilet slabs in Arba Minch and other woredas in the Gamo Gofa Zone refer to Section 3.5.6.

3.4.5 Plant size

As already indicated in Section 3.3.1, two manufacturing companies of plastic sanitary products – Roto PLC and AquaSan Manufacturing Ethiopia PLC – were consulted for the estimation of the plant size.

Roto PLC has an area of 7,500 m^2 designated for production (capacity: 8.5 t/day) and storage. Until May 2009, AquaSan Ethiopia was manufacturing their products in Kenya (Kentainers – subsidiary of AquaSanTech) and having them shipped to Ethiopia. In Kenya, the area available for production (capacity: 30 t/month) with rotational molding is 4,000 m^2 and the same area is available for loading and offloading operations.

For the planned business idea, the final production capacity (year 5 of operation) with Machine 1 is estimated to 18 t/month, whereas with Machine 2 to 22 t/month. Therefore, Scenario 1 assumes leasing 7,200 m^2 of land, of which 2,400 m^2 would be assigned for the production and processing plant, the same for storage, 70 m^2 for the office building and the rest for the yard (loading and offloading operations). Scenario

[28] According to AMU and ARB (2007), over 64 % of households from a transect walk survey in Arba Minch had pit toilets with a floor made wooden logs.

2 assumes leasing 9,000 m^2 of land, of which 3,000 m^2 would be for the production and processing plant, the same for storage, 70 m^2 for the office building and the rest for the yard.

3.4.6 Availability of manpower and infrastructure facilities

This section discusses the availability of manpower and infrastructure in Arba Minch and related costs.

3.4.6.1 Manpower

Skilled and unskilled manpower is available in Arba Minch. Specialized training opportunities also exist, e.g., at Selam Vocational and Training College in Addis Ababa. Monthly salaries of potential employees are summarized in Appendix B.3.

3.4.6.2 Electricity and telecommunication infrastructure

The information about the electricity and telecommunication infrastructure in Ethiopia was discussed in Section 2.4.3.1. Due to the fact that power outages are likely to occur, it is common to install power generators in order to continue industrial operation during this time[29].

Telecommunications infrastructure is also available, including phone lines, cellular phone network and the Internet. However, its quality in Ethiopia is often not satisfactory and during power cuts its use is limited.

3.4.6.3 Transportation

As indicated in Section 2.4.3.1, Ethiopia does not have a direct access to the sea and uses the port in Djibouti for the movement of goods. Shipping costs of raw materials to Addis Ababa represent 35 to 45 % of the raw materials costs (pers. communication, J. Mathews, Country Manager at Roto PLC, Addis Ababa, Ethiopia, 15.05.2009). Therefore, when considering the cost of raw materials (LLDPE and dry pigment), 40 % of the cost of goods was assumed in order to compensate for shipping costs to Addis Ababa.

Transportation of raw materials from Addis Ababa to Arba Minch is possible and the distance is about 500 km. The trip can take between 10-12 hours, depending on the weather conditions. Transportation costs are at 0.55 ETB/km*t of transported good (pers. correspondence, W. Ayele, Project Coordinator at ROSA office, Arba Minch, Ethiopia, 17.03.2009).

Transportation of finished products within and in the vicinity of Arba Minch is possible. With a third party, it costs 0.75 ETB/km*t (pers. correspondence, W. Ayele, Project Coordinator at ROSA office, Arba Minch, Ethiopia, 17.03.2009). If the company purchases own truck, the overall transportation costs of finished products include fuel cost, car maintenance, insurance, driver’s salary and car depreciation costs.

[29] Therefore, power generators are also considered in the investment costs in the business plan (refer to Table 3.25).

3.5 Market and sales

In this section, projected production volumes, unit prices, sales planning and operating costs are discussed. Then, experience with ecosan in Ethiopia is presented. It is followed by defining potential users of manufactured products as well as cooperation and financing opportunities. Next, present sources of supply, future competition, substitute products and critical factors determining the market are discussed.

3.5.1 Production volume

Depending on which machine is used for the manufacturing process, the estimated production volumes will vary (refer to Table 3.11). Variables for calculating estimated production volumes for both machines are presented in Table 3.12.

In the case of Machine 1, with four molds mounted per straight arm[30], one will realize eight parts per each cycle. Thus, in eight cycles completed per day and twelve workdays per month, one will yield 768 parts, less 10 % for scrap, inefficiencies and preventative maintenance (refer to Table 3.12). Therefore, one can count with 2,064 parts of each of four products per year and, in total, 8,256 parts per year (refer to Table 3.11).

In the case of Machine 2, with four molds mounted per straight arm, one will also realize eight parts per each of the three arms and cycle. Thus, in twenty-one cycles completed per day and twelve workdays per month, one will yield 2,016 parts, less 10 % for scrap (refer to Table 3.12). Thus, one can count with 5,436 parts of each of four products per year and, in total, 21,744 parts per year (refer to Table 3.11).

RotoCycle Simulation Reports (refer to Appendix B.1) for Machine 1 before and after the extension and for Machine 2 show all data required for the calculation of the estimated production volumes.

Table 3.11: Estimated production volumes for Machine 1 and Machine 2

	Machine 1=Scenario 1					Machine 2=Scenario 2				
	Production volume (parts/year)					Production volume (parts/year)				
Year	**Pr.[a] 1**	**Pr. 2**	**Pr. 3**	**Pr. 4**	**Total**	**Pr. 1**	**Pr. 2**	**Pr. 3**	**Pr. 4**	**Total**
1	2,064	2,064	2,064	2,064	8,256	5,436	5,436	5,436	5,436	21,744
2	3,456	3,456	3,456	3,456	13,824	5,436	5,436	5,436	5,436	21,744
3	6,912	6,912	6,912	6,912	27,648	9,072	9,072	9,072	9,072	36,288
4	10,368	10,368	10,368	10,368	41,472	9,072	9,072	9,072	9,072	36,288
5	10,368	10,368	10,368	10,368	41,472	12,432	12,432	12,432	12,432	49,728

[a)] Pr. stands for Product.

[30] Two parts molded per cavity and four cavities per straight arm, arranged so they can fit two side by side on the straight arm.

Table 3.12: Assumed variables for calculating estimated production volumes of Machine 1 and Machine 2

Machine 1=Scenario 1					
Variables	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Workdays/month	12	20	20	20	20
Parts produced/cycle, arm	8	8	8	8	8
Cycles completed/day (for all arms)	8	8	16	24	24
Parts produced/month (including scrap)	768	1,280	2,560	3,840	3,840
Parts produced/month (minus 10 % scrap)	691	1,152	2,304	3,456	3,456
Parts produced/year[a]	8,292	13,824	27,648	41,472	41,472
Machine 2=Scenario 2					
Variables	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Workdays/month	12	12	20	20	18[b]
Parts produced/cycle, arm	8	8	8	8	8
Cycles completed/day (for all arms)	21	21	21	21	32
Parts produced/month (including scrap)	2,016	2,016	3,360	3,360	4,608
Parts produced/month (minus 10 % scrap)	1,814	1,814	3,024	3,024	4,147
Parts produced/year[a]	21,768	21,768	36,288	36,288	49,764

a) Small differences in the number of parts produced per year as presented in Table 3.11 are due to the rounding of numbers, which was required in order to assume production of an equal number of parts of all four products per cycle.

b) Less working days than in the previous year due to the higher number of cycles per day.

3.5.2 Unit prices

Unit prices of Products 1, 2, 3 and 4 were estimated based on the prices of similar products in Ethiopia and Kenya (refer to Table 3.6). The unit costs for all four products for Scenario 1 and Scenario 2 in the first year of operation are presented in Table 3.13 and Table 3.14. The unit costs in further years of operation change due to the different conditions previously discussed, e.g., purchase of in-house grinding equipment, customs duty tax levied on raw material, etc.

Table 3.13: Unit costs per product for Scenario 1, year 1

	Product 1 (ETB/unit)	**Product 2 (ETB/unit)**	**Product 3 (ETB/unit)**	**Product 4 (ETB/unit)**
Direct costs				
Raw material	98.2	66.6	115.5	253.5
Liquid petroleum gas	17.5	17.5	17.5	17.5
Electricity	8.4	8.4	8.4	8.4
Production personnel (skilled)	5.1	5.1	5.1	5.1
Production personnel (unskilled)	1.4	1.4	1.4	1.4
Transportation of finished products	0.4	0.4	0.4	0.4
Social expenses for production personnel	0.1	0.1	0.1	0.1
Indirect costs				
Advertising costs	4.0	4.0	4.0	4.0
Telecommunication costs	2.9	2.9	2.9	2.9
Indirect personnel costs	7.5	7.5	7.5	7.5
Other administrative costs	3.6	3.6	3.6	3.6
Sum	**149.1**	**117.5**	**166.4**	**304.5**

Table 3.14: Unit costs per product for Scenario 2, year 1

	Product 1 (Birr/unit)	Product 2 (Birr/unit)	Product 3 (Birr/unit)	Product 4 (Birr/unit)
Direct costs				
Raw material	98.2	66.6	115.5	253.5
Liquid petroleum gas	17.6	17.6	17.6	17.6
Electricity	6.3	6.3	6.3	6.3
Production personnel (skilled)	3.9	3.9	3.9	3.9
Production personnel (unskilled)	0.8	0.8	0.8	0.8
Transportation of finished products	0.6	0.6	0.6	0.6
Social expenses for production personnel	0.1	0.1	0.1	0.1
Indirect costs				
Advertising	1.5	1.5	1.5	1.5
Telecommunication costs	1.1	1.1	1.1	1.1
Indirect personnel costs	3.2	3.2	3.2	3.2
Other administrative costs	2.0	2.0	2.0	2.0
Sum	**135.3**	**103.7**	**152.6**	**290.6**

Current prices of similar products sold in Ethiopia (refer to Table 3.6) and the unit costs shown above served to establish the selling prices of manufactured products as presented in Table 3.15.

Table 3.15: Unit prices of manufactured products

	Product 1	Product 2	Product 3	Product 4
Selling price (ETB)	600	180	400	900

Despite the fact that the unit prices presented in Table 3.13 and Table 3.14 suggest that the price for manufactured products could be set lower than presented in Table 3.15, one needs to account for other costs such as start-up investment, investment required in the following years (e.g., tooling expenses), interest rate on loan, etc. Therefore, the prices were set higher, taking the prices of similar products sold in Ethiopia (refer to Table 3.6) as a reference.

3.5.3 Sales planning

A sales plan for the production with Machine 1 and Machine 2 is summarized in Table 3.16 and Table 3.17, respectively. Sales volumes projected in both cases represent approximately 80 % of the projected production volume (compare with Table 3.11), which will be further referred to as normal case scenario. The production volume of 80 % takes into account the risk of not facing enough demand to respond to 100 % of the production volume, which might be likely to happen, in particular in the first years of the company’s presence on the market. The sales plans take into account the supply of the toilets, whereas the demand for toilets is discussed in Section 3.5.6.

Table 3.16: Projected sales planning for production with Machine 1

Year		1		2		3		4		5	
Product	**Price (ETB)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**
1	600	1,620	972,000	2,700	1,620,000	5,424	3,254,400	8,136	4,881,600	8,136	4,881,600
2	180	1,620	291,600	2,700	486,000	5,424	976,320	8,136	1,464,480	8,136	1,464,480
3	400	1,620	648,000	2,700	1,080,000	5,424	2,169,600	8,136	3,254,400	8,136	3,254,400
4	900	1,620	1,458,000	2,700	2,430,000	5,424	4,881,600	8,136	7,322,400	8,136	7,322,400
Total		6,480	**3,369,600**	10,800	**5,616,000**	21,696	**11,281,920**	32,544	**16,922,880**	32,544	**16,922,880**

Table 3.17: Projected sales planning for production with Machine 2

Year		1		2		3		4		5	
Product	**Price (ETB)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**	**Volume (units/p.a.)**	**Sales (ETB/p.a.)**
1	600	4,284	2,570,400	4,284	2,570,400	7,140	4,284,000	7,140	4,284,000	9,852	5,911,200
2	180	4,284	771,120	4,284	771,120	7,140	1,285,200	7,140	1,285,200	9,852	1,773,360
3	400	4,284	1,713,600	4,284	1,713,600	7,140	2,856,000	7,140	2,856,000	9,852	3,940,800
4	900	4,284	3,855,600	4,284	3,855,600	7,140	6,426,000	7,140	6,426,000	9,852	8,866,800
Total		17,136	**8,910,720**	17,136	**8,910,720**	28,560	**14,851,200**	28,560	**14,851,200**	39,408	**20,492,160**

3.5.4 Breakdown of projected operating costs

As discussed in Section 3.2.1, operating costs are grouped according to fixed and variable costs. These costs are presented further for both business scenarios (Scenario 1 for Machine 1 and Scenario 2 for Machine 2).

3.5.4.1 Fixed costs

Fixed costs for Scenario 1 are presented in Figure 3.15 and for Scenario 2 in Figure 3.16. Fixed costs presented in both figures include a 5 % estimation error. Fixed costs were grouped according to the following categories: advertising, insurance, land lease, other costs, personnel (non-production related) and telecommunication.

Advertising

Advertising costs are based on the costs of advertising on the SNNP Region radio station (FM 100.9) and in Debub Nigat newspaper (refer to Appendix B.4), which is one of the most widely read in Arba Minch (pers. communication, Information and Culture Department, Arba Minch, 25.05.2009). It is assumed that in both scenarios, the company will start with two prime time[31] radio advertisements per month and one quarter page advertisement in newspaper. Starting from the second year, the company will increase to four prime time radio and four quarter page advertisements per month to better promote the manufactured products. Leaflets with information on the products and the company will be printed[32].

Insurance

Insurance in Arba Minch can be provided by the Ethiopian Insurance Corporation. The Arba Minch subsidiary of the insurance company does not provide coverage against burglary. Thus, the calculated insurance covers buildings, machinery, equipment and stock (unfinished goods and spare parts) against fire and lightning. The cost of insurance was provided by the Ethiopian Insurance Corporation in Arba Minch. The calculation is based on the example of 400,000 ETB/year of premium payment for an insured value of 200 million ETB. The insured value was calculated per each year of operation for each scenario, and then a required equivalent of premium payment was extrapolated.

Land lease

Land lease in Arba Minch is calculated for 80 years and the lease rate is at 0.7 ETB/m^2 (Ethiopian Investment Agency, 2008a). For details on the required plots of land for both scenarios refer to Section 3.4.5 and Section 3.6.1.1

[31] Prime time refers to Monday till Friday, before and after news.

[32] The price quote of 2 ETB/leaflet for 2,000 pieces was obtained from Lion Advertising and Public Relations (pers. communication, M. Aytenfesu, Addis Ababa, Ethiopia, 18.05.2009). The more leaflets are printed, the lower the price. For example, with 4,000 pieces, the price goes down to 1.7 ETB/piece.

Other costs

Other costs refer to stationary, postage, banking charges, extra production costs, inspection and marking fee. Water is not used in the manufacturing process and the water consumption of the office building is included in other costs. Other costs are estimated to 6,000 ETB/year for both scenarios.

Personnel (non-production related)

Non-production personnel expenses (manager, office staff, facility guards and drivers) are considered as fixed costs. The headcount plan for Scenario 1 and Scenario 2 is presented in Appendix B.3. Insurance of non-production related personnel, which comprises 1.5 % of a workman's annual salary, is also included in personnel costs projections (Ethiopian Investment Agency, 2008a).

Telecommunication

Projected telecommunication expenses are based on costs provided by the Ethiopian Investment Agency (2008a) and they amount to approximately 24,000 ETB per year. Telecommunication expenses are summarized in Appendix B.5.

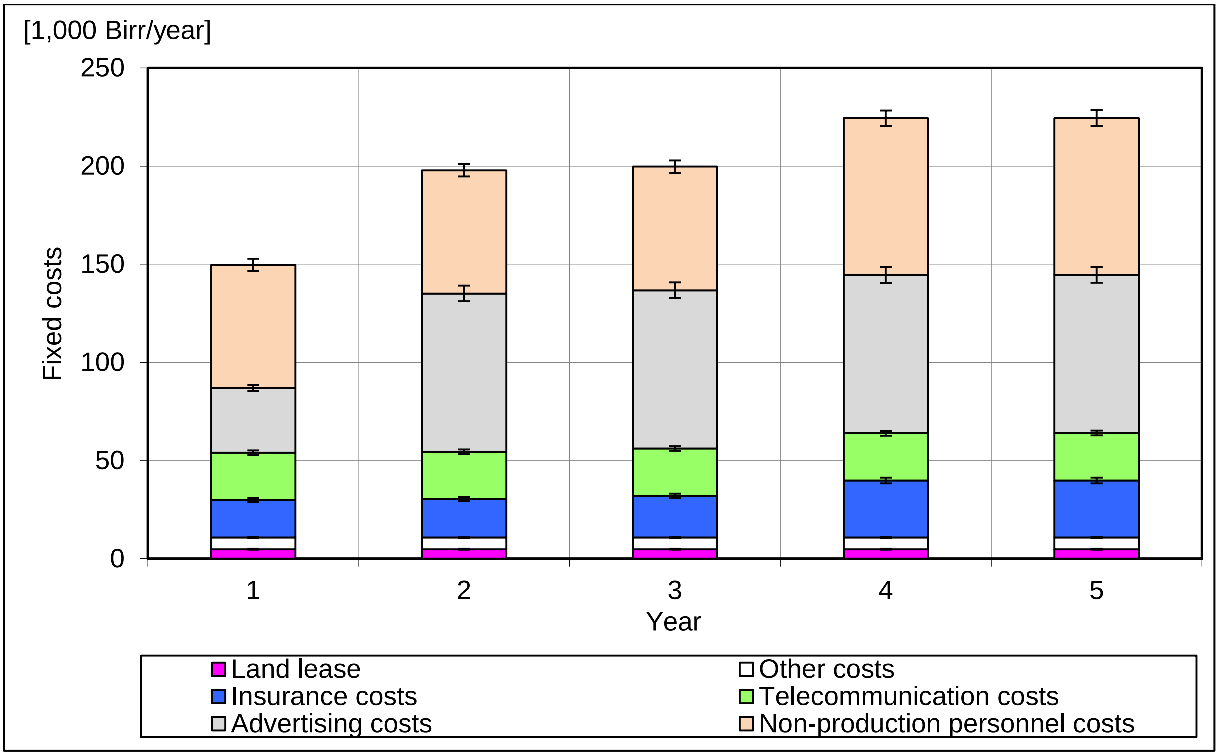


Figure 3.15: Fixed costs for Scenario 1

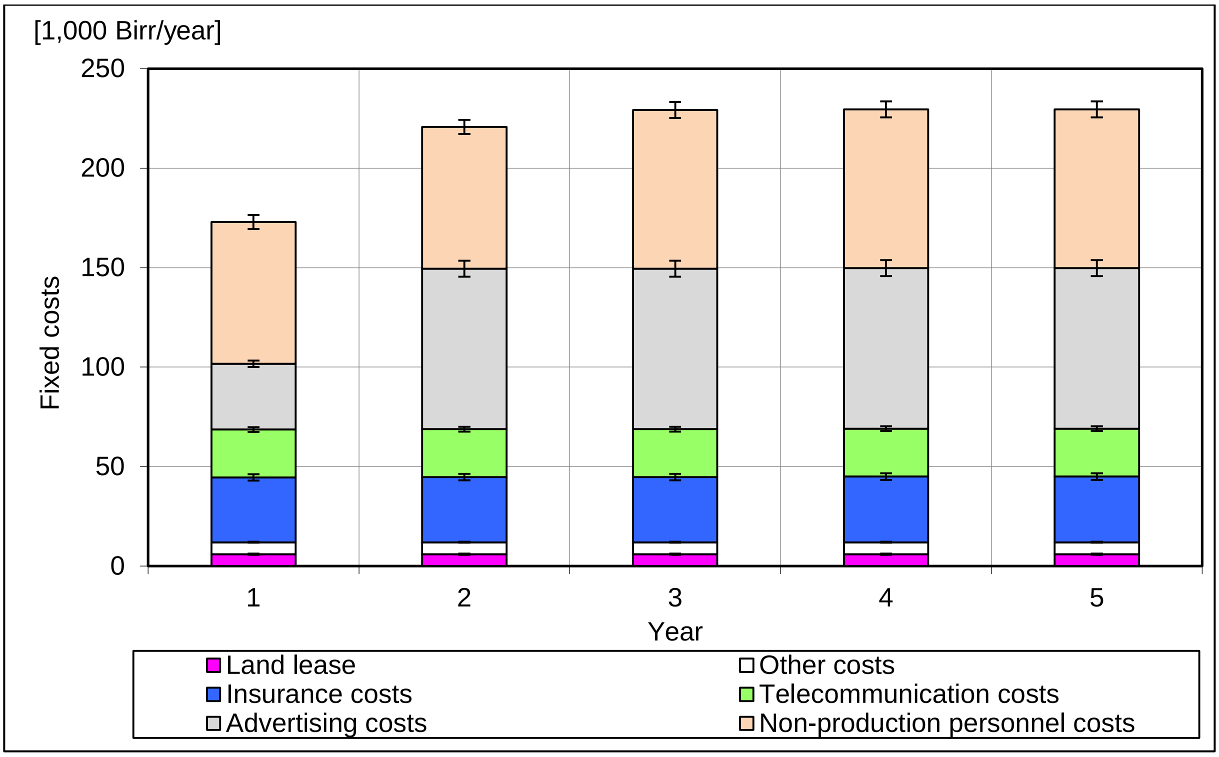


Figure 3.16: Fixed costs for Scenario 2

Looking at Figure 3.15 and Figure 3.16 there are no significant differences between fixed costs in both scenarios. Land lease payment is a bit higher for Scenario 2 as the plot size is also bigger in order to accommodate higher production volumes. Property and car insurance is slightly more expensive due to the fact that the value of the machinery with Scenario 2 is higher than with Scenario 1. Non-production related staff expenses are almost same for both scenarios and the small differences are due to the employment of drivers earlier in Scenario 2 than in Scenario 1. In Scenario 1, a car is purchased in the fourth year of operation, whereas in Scenario 2, in the first year. In both scenarios non-production related personnel and advertising expenses constitute the highest outlay among fixed costs.

3.5.4.2 Variable costs

Projected variable costs for Scenario 1 are presented in Figure 3.17 and for Scenario 2 in Figure 3.18. Variable costs were grouped according to the following categories: electricity, liquid petroleum gas, personnel (production related, referred to as direct personnel costs), raw material and transportation of finished products.

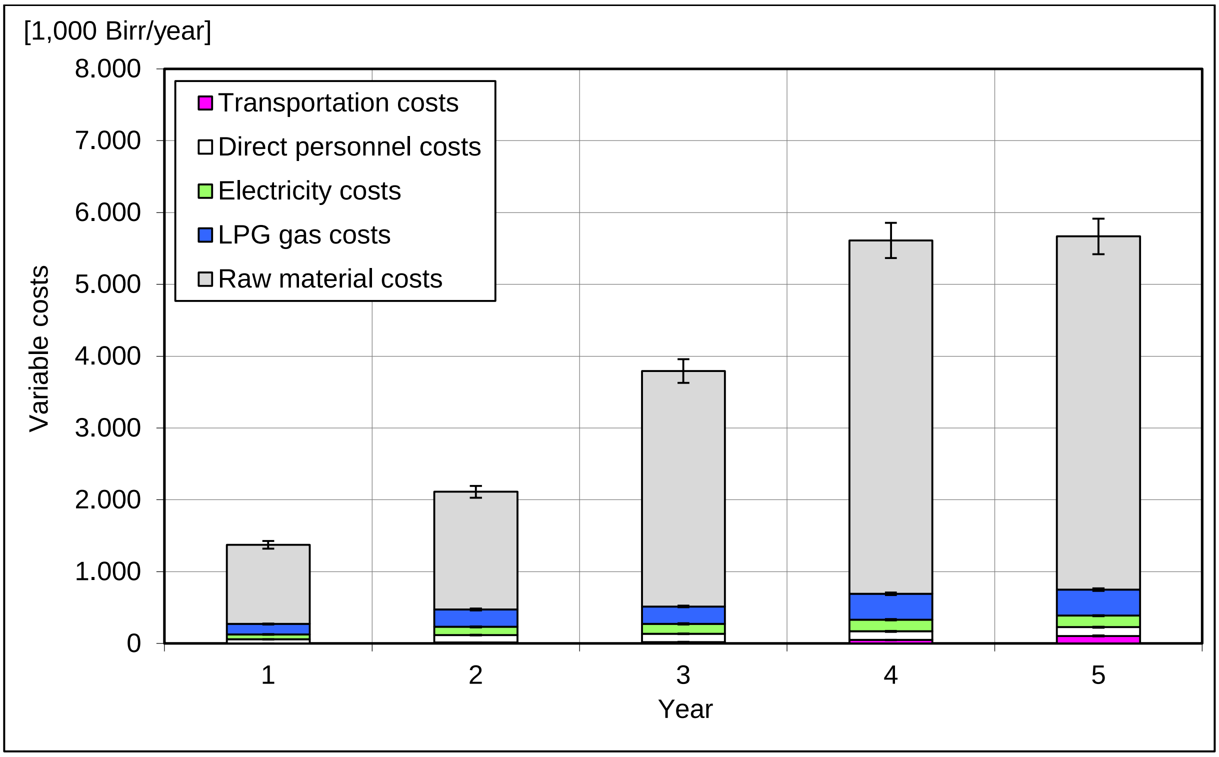


Figure 3.17: Variable costs for Scenario 1

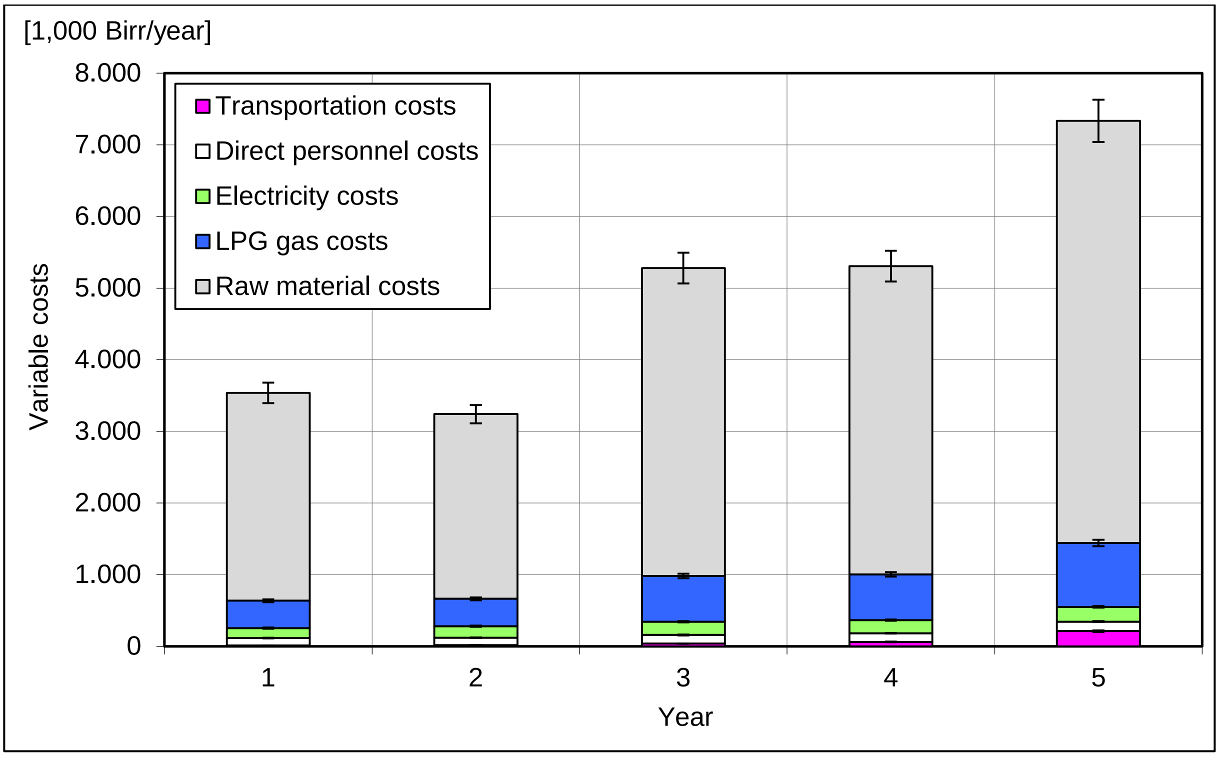


Figure 3.18: Variable costs for Scenario 2

Electricity

Electricity consumption increases with growing production volumes. Electricity is mainly used by fans (for cooling of molds), a router, a high-speed mixer and a pulverizer. The electricity consumption is lower when raw material is supplied pulverized or pre-colored.

Electricity consumption and resulting costs are summarized in Table 3.18. Electricity costs consist of a service fee (approx. 650 ETB/year) and a consumption cost of approximately 0.4 ETB/kWh (Ethiopian Investment Agency, 2008a). Electricity consumption grows with increasing production volumes, resulting in more extensive use of auxiliary equipment. Electricity consumption is higher for Machine 2 due to the higher production volumes.

Table 3.18: Electricity consumption and related costs for Scenario 1 and Scenario 2

Scenario	Year	1	2	3	4	5
1	**Projected electricity consumption (kWh/year)**	180,000	300,000	360,000	420,000	420,000
	Cost (ETB/year)	69,150	114,800	137,650	160,500	160,500
2	**Projected electricity consumption (kWh/year)**	360,000	420,000	480,000	480,000	540,000
	Cost (ETB/year)	137,650	160,500	183,300	183,300	206,150

Liquid petroleum gas

Liquid petroleum gas (LPG) is used during the manufacturing process to heat the molds. The maximum LPG consumption for either rotational molding machine is 99 L/h and an average consumption is 50 % of that, i.e. 44.5 L/h (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, 25.11.2009). One needs to calculate how many minutes per hour the oven is used in each machine. The information is provided in the RotoCycle Simulation Report (refer to Appendix B.1). The density of LPG in Ethiopia is 0.534 kg/l and the price is 14.7 ETB/kg (pers. correspondence, A. A. Lisanework Baheru, ESE Project Coordinator, Addis Ababa, Ethiopia, 08.12.2009).

If eight parts are produced per cycle, in the first year of operation with Machine M1-2600, each product requires 1.2 kg of LPG, resulting in the cost of LPG for each manufactured product of approximately 17.5 ETB. This cost will change with the oven utilization (different for Machine M2-2600 and Machine R3-2600[33]), the number of parts produced per hour and production volumes. The differences for LPG costs for Machine 1 and Machine 2 are presented in Figure 3.19, which includes a 5 % indication error.

[33] The oven utilization value presented in the simulation report in the Appendix B.1 shows 36 % for M1-2600, 72 % for M2-2600 and 95 % for R3-2600.

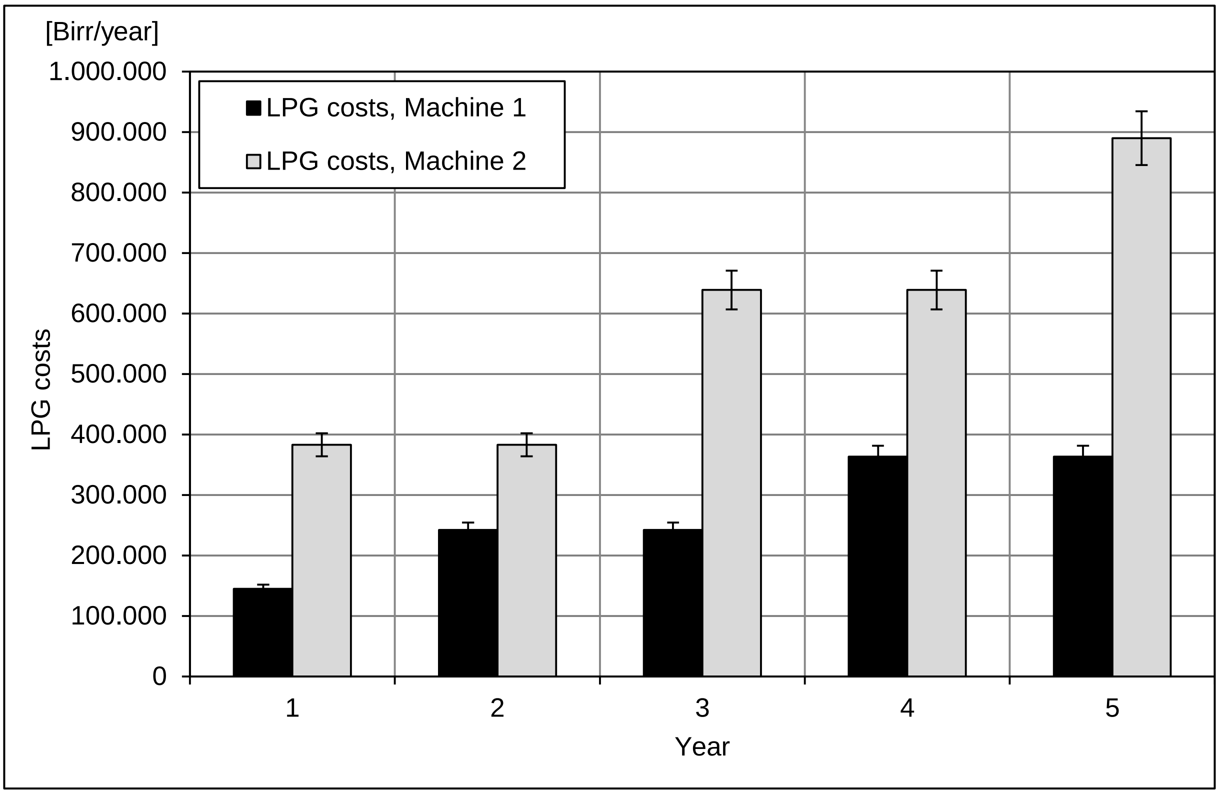


Figure 3.19: Comparison of LPG costs for Machine 1 and Machine 2

Personnel (production related)

Production related (direct) personnel expenses include the salaries of plant maintenance staff as well as skilled (engineers) and unskilled production staff. Insurance of direct personnel is also included in production related personnel expenses. The headcount plan for Scenario 1 and Scenario 2 is presented in Appendix B.3.

Raw material

When it comes to variable costs, the highest expenditure in both scenarios is incurred through the purchase of raw materials (see Figure 3.17 and Figure 3.18). The notion “raw material” refers to both LLDPE and dry pigment for coloring. The latter is a minor expenditure as the addition rate is only at 0.5 % (wt) for white pigment. For prices of LLDPE refer to Section 3.4.2.1 and for dry pigment refer to Section 3.4.2.2.

In Figure 3.18, the costs of raw materials go down in the second year of operation due to the fact that the production volumes stay the same as in the first year, but a pulverizer is installed. This allows for the purchase of raw material in granules, which is approximately 20 % cheaper than powder.

LLDPE prices are susceptible to price fluctuations, which, in turn, are dependent on the global supply-demand relationship. The more products are being manufactured, the more raw materials need to be purchased. Raw materials are purchased in bulk in order to negotiate prices with suppliers and save on the shipping costs. Enough cash has to be secured to pay for semi-annual or quarterly deliveries of raw materials. Shipping costs to Addis Ababa and transportation costs to Arba Minch are included in the price of raw materials presented in Figure 3.17 and Figure 3.18. As a savings measure, one should buy raw material in bulk once the price is on the down-turn and, if possible, find a reliable shipping company, where a long term contract price could be negotiated.

Transportation

Transportation of finished products makes up a very small part of variable costs, as the transportation costs within and in the vicinity of Arba Minch are low (refer to Section 3.4.6.3) and the purchase of own truck makes it even less expensive, once the production volume is high enough for the margin to cover car maintenance, driver's salary, fuel costs and car's depreciation costs.

In the calculations of transportation costs for Scenario 1, it was assumed that a third party would transport finished products over 100 km/month (1^{st} year), 250 km/month (2^{nd} year) and 500 km/month (3^{rd} year). In the following years, the car (owned by the company) would drive approximately 1,200 km/month (4^{th} year) and 2,600 km (5^{th} year) within the Gamo Gofa Zone. In the calculations for Scenario 2, it was assumed that the car would drive 300 km/month (1^{st} year), 400 km/month (2^{nd} year), 900 km/month (3^{rd} year), 1,500 km/month (4^{th} year) and 5,200 km/month (5^{th} year) within the Gamo Gofa Zone and to Awassa. Detailed parameters for the calculation of transportation costs are presented in Appendix B.6.

3.5.5 Examples of experience with ecological sanitation in Ethiopia

In order to understand the selection of products to be manufactured, it is important to consider the experience of other sanitation projects implemented in Ethiopia. In this section, four examples of experience with ecosan in Ethiopia are discussed.

3.5.5.1 Resource-Oriented Sanitation for peri-urban areas in Africa

Project description

The Resource-Oriented Sanitation for peri-urban areas in Africa (ROSA) project (10.2006-03.2010) promoted resource-oriented sanitation concepts as a way of achieving sustainable and ecologically sound sanitation. The ROSA implementation status of sanitation systems is presented in Table 3.19 (pers. correspondence with W. Ayele, ROSA Project Coordinator, Arba Minch, Ethiopia, 12.03.2010).

Table 3.19: Implementation status of sanitation systems in Arba Minch, Ethiopia

Toilet type	**Number of toilets installed**	**Number of users**
Urine diverting dry toilet (UDDT)	15	447
Arborloo	9	33
Fossa Alterna	30	177
Total	**54**	**657**

First toilet units were always built for demonstration purposes and their construction costs were covered by the ROSA project. Further units were built with a cost-sharing scheme, where about 75 % of the total construction costs was covered by the implementing households and the remaining 25 % was covered by the ROSA project.

Successful toilet designs

Within the ROSA project, among the different toilet types listed in Table 3.19, a Fossa Alterna was identified as the most favorite option among the inhabitants of

Arba Minch. It is mainly due to the fact that it resembles a traditional pit latrine and does not require any handling of urine and feces. Fossa Alternas have a permanent location and the contents of the toilet look harmless and do not smell. Fossa Alternas, on contrary to UDDTs, are not sensitive to inexperienced users, yet they still require some education and demonstration.

A UDDT was identified as the second most favorite option, especially when it is possible to generate income from selling of excreta as fertilizer and soil conditioner. A UDDT has a permanent location and it can be installed inside a house. It also overcomes the problems of rocky and sandy soil and of areas susceptible to flooding as it can be built above ground.

The third most favorite toilet among the inhabitants of Arba Minch was an Arborloo, mainly due to the fact that it requires more space, which is seldom available in urban areas. Nevertheless, it is greatly valued in areas where soil fertility is poor. It is also acceptable in cultures where excreta management is a taboo.

3.5.5.2 Catholic Relief Services

Project description

Catholic Relief Services (CRS) Ethiopia is an NGO that works with sanitation projects. The information that follows was gathered through personal communication with B. Abaire (Program Manager Water and Sanitation at CRS) and C. Tolessa (Water and Sanitation Project Officer at CRS) on 25.09.2008 in Addis Ababa, Ethiopia.

CRS' sanitation projects are being currently implemented in Amhara, Oromia, Somali, SNNP and Tigray Region.

Successful toilet designs

Initially, CRS promoted ventilated improved (VIP) and conventional pit latrines, which did not provide good results due to a relatively high cost of hardware. Communities could not see the impact of sanitation on health improvement. In response to little progress achieved through this approach, CRS started piloting the concept of ecosan in order to reduce costs, minimize labor requirements for construction, supply fertilizer from human manure for food security and prevent deforestation[34].

In 2005, Arborloo and Fossa Alterna toilets were tried out by a group of farmers from food insecure communities while CRS project partners started crop trials with human urine (Simpson-Hébert and Abaire, 2009). The cost of an Arborloo and Fossa Alterna is mainly in the slab, in 2005-2008 being about 5-12 USD/slab[35] (Simpson-Hébert and Abaire, 2009). Slabs are made of cement, sand and gravel. After the completion of pilot trials, by the end of 2005, 30 demonstration units of Arborloos had multiplied to nearly 3,500 units and crop trials were giving good results (Simpson-Hébert and Abaire, 2009). As a result, in total, 40,000 Arborloos were constructed between 2005 and 2008 (Simpson-Hébert and Abaire, 2009). Latest information (as of December 2011) quotes 72,000 Arboloos installed within the project (pers. correspondence, B.

[34] Wooden logs are used for the construction of pit latrines.

[35] Cement slabs are less expensive than plastic slabs, however, the transportation of plastic slabs is easier and cheaper due to their lower weight.

Abaire, Program Manager Water and Sanitation at CRS, 06.03.2012). Farmers started digging even more shallow pits in order to be able to plant more tree seedlings. Families started instructing children not to practice open defecation but to use the constructed Arborloo. Farmers understood that vegetable production improved as a result of using Arborloos.

In the CRS project, Fossa Alterna trials did not prove to be as popular as Arborloo trials. This might be attributed to the fact that with a Fossa Alterna it takes about 1-2 years to get humus, which can then be applied to soil, so only about 30 Fossa Alternas were constructed (Simpson-Hébert and Abaire, 2009). CRS is currently planning to scale up Fossa Alterna implementation in the Tigray Region (pers. correspondence, B. Abaire, Program Manager Water and Sanitation at CRS, 24.02.2012).

3.5.5.3 Society for Urban Development in East Africa

Project description

The Society for Urban Development in East Africa (SUDEA) is actually the main promoter of ecosan in Ethiopia (WSP, 2005). Since 1996, a number of pilot projects have been undertaken in partnerships with local NGOs in Addis Ababa, Jimma, Bahir Dar, Hamusit and Harar (WSP, 2005; Terrefe and Edstrom, 2007).

Successful toilet designs

One of the most successful toilet designs during the pilot projects in Ethiopia was a UDDT as a sitting option for household use and a squatting option for public toilets. The first assessment of the pilot project conducted by SUDEA in Ethiopia demonstrated that the system of urine diversion is affordable, safe and acceptable (Terrefe and Edstrom, 2007). Technical problems reported were mainly with regard to low-quality plastic products available in Ethiopia (e.g., toilet seats, pipes) (Terrefe and Edstrom, 1999). According to SUDEA, most families in Ethiopia chose a UDDT with a sitting option over a squatting one due to comfort, dignity, child-friendliness, pregnancy-friendliness and aged- and disabled-friendliness (Terrefe and Edstrom, 2007).

3.5.5.4 Sanitation in peri-urban areas in Africa

Project description

The Sanitation in peri-urban areas in Africa (SPA) project aims at improving the sanitary situation in peri-urban areas of five cities in different countries in Africa, one of them being Arba Minch. The initiative of the SPA project was triggered by the ROSA project. The main goal of SPA is to provide good toilet facilities at the household level or in public places in peri-urban areas, together with a service to empty, collect, transport and dispose of excreta (Plan Nederland, WASTE, SNS REAAL Water Fund, 2007).

In each city, a relevant utility will have to bear responsibility for dealing with the sanitation problem in peri-urban areas (Plan Nederland, WASTE, SNS REAAL Water Fund, 2007). They will receive and manage the investment funds and hire the small scale private sanitation sector (SSPSS) for toilet construction and service delivery. System users will pay a monthly fee for services to a respective utility. The amount that users will pay will cover the operation and management costs of services, the costs borne by utilities and SSPSS and the investment and the interest rate. Omo Micro Finance Institution (OMFI), which is the main local financing partner of the SPA project, operates the credit disbursement and repayment from households at a 10 % interest rate (*Sustainable sanitation service delivery Arba Minch Town,* 2010). The municipality will receive funds from the SPA consortium to create a revolving sanitation financing fund, which is operated by OMFI in the form of micro-loans provided to various sanitation service providers at a 10 % interest rate (*Sustainable sanitation service delivery Arba Minch Town,* 2010; pers. correspondence, E. Olto, SPA project coordinator, Arba Minch, 29.08.2011).

Toilet designs

The project's idea is to construct both conventional toilets and toilets to be used under the ecosan principle (urine diverting dry toilets, Fossa Alternas, Arborloos). The SPA plan for household sanitation in Arba Minch assumes the following toilets to be constructed (2009-2013): 1,000 UDDTs, 2,200 Fossa Alternas, 100 Arborloos, 1,200 pit latrines, 650 VIPs, 10 pour flush toilets with septic tanks, 15 flush toilets with septic tanks, and 5 community pour flush toilets with septic tanks (*Sustainable sanitation service delivery Arba Minch Town,* 2010). First toilet installations began in mid-2010 and, during the first year, 45 toilets have been constructed (pers. correspondence, E. Olto, SPA project coordinator, Arba Minch, 29.08.2011).

3.5.6 Potential users of products

Potential users of the manufactured products are individuals (households), institutions and businesses (when toilets will be installed at work places and as public toilets) and NGOs implementing sanitation projects with a focus on resource-oriented sanitation. The project concentrates on the Gamo Gofa Zone, where Arba Minch is located and other cities and rural areas in the SNNP Region. The number of households by toilet type is listed in Table 3.20.

In order to estimate the number of potential customers to help define the market potential, one can assume the number of households that do not have any toilet facilities. In Arba Minch alone, 16 % of the housing units (3,016 households[36]) (see Table 3.20) in 2007 did not have any toilet facility (CSA, 2007). In the Gamo Gofa Zone, approximately 42 % of the housing units (142,534 households[37]) in 2007 did not have sanitation facilities (CSA, 2007). Furthermore, in Awassa, the number of housing units without a toilet facility in 2007 was estimated to approximately 23 %. Thus, it corresponds to 14,035 households[38] (see Table 3.20) that definitely need to get access to sanitation facilities in Awassa. There is also a significant proportion of the population in Awassa that might be considered as unsatisfied with their current sanitation facilities and may be willing to switch to toilets to be used under the ecosan principle. In 2007, 45 % of the housing units in Awassa (corresponding to 27,310

[36] Calculation based on the number of households per housing unit in Arba Minch being 1.045 (CSA, 2007).

[37] Calculation based on the number of households per housing unit in the Gamo Gofa Zone being 1.033 (CSA, 2007).

[38] Calculation based on the number of households per housing unit in Awassa being 1.046 (CSA, 2007).

households) and 44 % of the housing units in Arba Minch (corresponding to 8,328 households) were using shared pit latrine facilities (see Table 3.20) (CSA, 2007).

Additionally, households that have problems with currently available sanitation options (e.g., pit collapsing, lack of space for pit latrines, areas that are prone to flooding) may be willing to test new sanitation solutions. In Arba Minch, a survey performed in 2007 revealed that 64 % of the surveyed households had a pit latrine with a squatting wooden floor (AMU and ARB, 2007). Furthermore, communities in areas where new sanitation options had already been implemented, e.g., through the activities of the ROSA project, are aware of ecosan and its advantages and may be willing to adopt it.

The number of households without toilet facilities and the number of households that might be considered as unsatisfied with their current facilities (using shared pit latrines) in the Gamo Gofa Zone amounts to over 177,500 households. When looking at the whole SNNP Region, the number of households without a toilet facility in 2007 was reported to be almost 1,492,300 and the number of households using a shared pit latrine to be almost 336,900 (see Table 3.20) (CSA, 2007). This clearly shows the need for improved sanitation facilities in the SNNP Region.

Table 3.20: Number of households[a] by type of toilet facility in the SNNP Region, Arba Minch and Awassa (adapted from CSA, 2007)

Geographical area	**No. of households by type of toilet facility**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**1 + 7**
	No toilet	**Flush private**	**Flush shared**	**VIP private**	**VIP shared**	**Pit latrine private**	**Pit latrine shared**	
SNNP Region	1,492,273	15,994	7,136	26,728	15,651	1,205,441	336,888	1,829,161
Awassa City Administration Zone	14,035	1,169	1,225	2,127	4,189	10,078	27,310	41,345
Gamo Gofa Zone	142,534	1,475	591	4,422	1,555	150,066	34,984	177,519
Selected woredas in the Gamo Gofa Zone								
Arba Minch Woreda/Town	3,016	395	242	379	700	5,827	8,328	11,345
Bonke Woreda	9,428	33	5	697	49	19,070	1,228	10,656
Chencha Woreda	10,886	118	26	414	52	11,032	990	11,876
Dita Woreda	12,657	27	10	59	32	3,729	547	13,204
Geze Gofa Woreda	7,998	21	53	64	5	5,726	1,094	9,092
Kemba Woreda	15,618	189	59	184	44	13,357	1,539	17,157
Kucha Woreda	9,178	172	27	521	102	17,371	3,509	12,686
Melekoza Woreda	11,373	122	32	599	32	14,799	1,501	12,874
Mirab Abaya Woreda	3,867	17	0	217	142	7,335	2,774	6,641
Uba Debretsehay Woreda	10,457	0	5	80	37	3,580	1,356	11,813

[a)] CSA (2007) provides the number of housing units by type of toilet facility, which was translated into the number of households, based on the number of households per housing unit.

Based on sales planning as presented in Table 3.16 for Scenario 1 and in Table 3.17 for Scenario 2 and the information presented above, the projected demand and the time it will take to satisfy it was estimated for both scenarios and it is presented in Table 3.21 and Table 3.22.

In Scenario 1, it was assumed that the company will sell toilet pans within the Gamo Gofa Zone due to the shorter distances from Arba Minch to selected woredas located in this zone (max. distance to Geze Gofa Woreda: 480 km, round trip from Arba Minch) than to Awassa (550 km, round trip from Arba Minch). In Scenario 2, due to higher production volume and projected sales (refer to Table 3.17), it was assumed that the company will sell its products not only within the Gamo Gofa Zone but also in Awassa. The selection of woredas from the Gamo Gofa Zone to be supplied with products was based on the projected demand (refer to Table 3.20) and their distance from Arba Minch, where the production plant would be located.

Table 3.21: Projected demand coverage for Scenario 1

Geographical location	Assumed demand	Accumulated demand	Year of demand coverage	Distance from Arba Minch, round trip (km)
Arba Minch Woreda	11,345	11,345	1 and 2	35
Mirab Abaya Woreda	6,641	17,986	2	100
Chencha Woreda	11,876	29,862	3	75
Kucha Woreda	12,686	42,548	3 and 4	100
Bonke Woreda	10,656	53,204	4	100
Dita Woreda	13,204	66,409	4	150
Kemba woreda	17,157	83,566	4 and 5	170
Melekoza Woreda	12,874	96,440	5	250
Geze Gofa Woreda	9,092	105,532	5	480

Table 3.22: Projected demand coverage for Scenario 2

Geographical location	Assumed demand	Accumulated demand	Year of demand coverage	Distance from Arba Minch, round trip (km)
Arba Minch Woreda	11,345	11,345	1	35
Mirab Abaya Woreda	6,641	17,986	1	100
Chencha Woreda	11,876	29,862	2	75
Kucha Woreda	12,686	42,548	2 and 3	100
Bonke Woreda	10,656	53,204	3	100
Dita Woreda	13,204	66,409	3 and 4	150
Kemba Woreda	17,157	83,566	4	170
Melekoza Woreda	12,874	96,440	4 and 5	250
Geze Gofa Woreda	9,092	105,532	5	480
Awassa City Administration Zone	41,345	146,877	5	550

3.5.7 Present sources of supply for products

The products related to the ecosan approach implemented within the framework of the ROSA project were either ordered from the companies described in Section 3.3.1 or produced by the project employees themselves. UDDT slabs were ordered from AquaSan Manufacturing Ethiopia PLC, EthioFibre Glass Ethiopia in Addis Ababa and Tabor Ceramics in Awassa. Some UDDT slabs were made of reinforced concrete and were cast in the ROSA office compound in Arba Minch. Fossa Alterna and Arborloo slabs were also cast using concrete in the ROSA office compound in Arba Minch.

3.5.8 Substitute products

Due to the economic development of the country, households might be willing to demand more luxurious products than the ones offered by the company. Fortunately, the rotational molding technology is flexible about changing the product portfolio. Merely new molds need to be ordered for the production to switch from one product to another. Molds do not take as much time to be produced and are not as expensive as with injection molding. Therefore, the company would be able to change or extend its product assortment, depending on the demand.

Companies manufacturing plastic products, which have bigger production volumes, have an advantage of reaching economies of scale faster and, consequently, of reducing their prices. Therefore, it is important to create a good image of the company on the local and regional market and constantly expand its customer's base.

3.5.9 Critical factors determining potential market

Critical factors that determine the potential market are directly connected with the aspects regarding the adoption of ecosan. The determining factors with this respect include privacy, convenience and status that the new toilets bring along. The cultural and social influence also plays a significant role. These factors have a great impact on the design of and the demand for sanitation facilities (Meier, 2008). Consequently, knowledge and understanding of the cultural background is essential for the promotion of ecosan.

Culture may influence the acceptance and implementation of ecosan facilities. Religion can have a great impact on the exposure to human excrements and on people's sanitary behavior. Ethnicity refers to beliefs and norms which can influence people's sanitary behavior. Role allocation and responsibilities of men, women and children within the household or being scared of bad spirits if using the toilet at night are just a few possible examples (Meier, 2008). These factors are described in more detail in Section 5.4.1.

3.6 Investment requirements, project financing and returns

This chapter deals with investment requirements and project financing of the business. First, start-up costs of the business are introduced. Then, the proposed financial structure and projected financial plan is presented, including an evaluation of two scenarios, a break-even analysis, financial statements for the first five years of company's operation and key financial indicators. In addition, critical factors determining profitability are analyzed and possibilities of cost decrease are described.

3.6.1 Start-up project costs

This section considers the initial investment required for Scenario 1 and Scenario 2 in order to estimate the start-up capital.

3.6.1.1 Land

In Ethiopia, the land belongs to the state and it can only be leased for a certain period of time. In many cities in Ethiopia, there are designated industrial zones for planned industrial activities, where land can be leased. The lease holding price for industrial zones in Arba Minch is 0.7 ETB/m^2 per year (Ethiopian Investment Agency, 2008b)[39]. Table 3.23 summarizes land lease payments for both scenarios with regard to land requirements as discussed in Section 3.4.5.

Table 3.23: Primary and annual lease payments for Scenario 1 and 2

Cost item	**Scenario 1**	**Scenario 2**
Plot size (m^2)	7,200	9,000
Primary payment (ETB)	20,200	25,200
Annual lease payment (ETB/year)	4,800	6,000

3.6.1.2 Construction

The construction of a simple building in Addis Ababa costs 1,500-2,500 ETB/m^2 (Ethiopian Investment Agency, 2008b). Due to the fact that this cost quote refers to Addis Ababa, the cost of 1,000 ETB/m^2 is assumed for Arba Minch, including the cost of labor, construction materials and foundation. Taking into account the size of the plant, warehouse and office building (discussed in Section 3.4.5), the resulting construction costs for Scenario 1 and Scenario 2 are presented in Table 3.24.

Table 3.24: Construction costs for Scenario 1 and 2

Cost item (ETB)	**Scenario 1**	**Scenario 2**
Plant building	2,400,000	3,000,000
Warehouse building	2,400,000	3,000,000
Office building	70,000	70,000
Total	**4,870,000**	**6,070,000**

3.6.1.3 Installed equipment for production

Table 3.25 presents equipment for Scenario 1 and Scenario 2 listed according to the year of operation in which it would be installed. Prices for the equipment were taken from Table 3.7 and they include shipping costs to Ethiopia. Installation costs were included for complex equipment, for which external help for installation and commissioning would be required.

In Scenario 2, the cost of steel molds is higher due to the higher volume of production and, consequently, larger number of molds required. In Scenario 1, the first set of molds needs to be replaced after four years of operation, and in Scenario 2, after three years of operation. This estimation is based on the projected lifespan of 25,000 parts per mold. The difference in the cost of saw bands and trimmers is due to the different number of products manufactured per rotational molding cycle (refer to Table 3.11). New trimmers and saw bands are purchased every year due to wear.

It was assumed that in-house grinding equipment (pulverizer) would be installed in the second year of operation in both scenarios. It was decided to purchase a pulverizer and transform LLDPE from granules to powder as soon as the volume of production and the related volume of raw materials increase. In the third year of operation, an extra arm for the rotational molding machine would be purchased in

[39] A payment of 5 % out of the total lease payment needs to be made in advance, and then a lease payment needs to be made annually (Ethiopian Investment Agency, 2008b).

Scenario 1 in order to increase the volume of production. As a result, more steel molds would need to be purchased.

Table 3.25: Type and cost of installed plant equipment for Scenario 1 and Scenario 2

Year	Equipment (ETB)	Scenario 1	Scenario 2
1	Rotational molding machine	2,677,500	4,100,000
	High-intensity mixer	948,000	948,000
	Generator	460,000	460,000
	Burner	76,600	76,600
	Router	462,000	462,000
	Steel molds	51,500	125,500
	Saw band + blades	800	2,000
	Trimmers	1,600	4,200
	Total	***4,678,000***	***6,178,300***
2	Pulverizer	254,500	254,500
	Extra saw band + blades	800	2,000
	Extra trimmers	1,600	4,200
	Total	***256,900***	***260,700***
3	Extra arm for rotational molding machine	770,000	0
	Extra steel molds	51,500	0
	Extra saw band + blades	800	2,000
	Extra trimmers	1,600	4,200
	Total	***823,900***	***6,200***
4	Extra saw band blades	1,200	2,000
	Extra trimmers	2,400	4,200
	Steel molds	0	125,500
	Total	***3,600***	***131,700***
5	Extra saw band + blades	1,200	3,200
	Extra trimmers	2,400	6,400
	Steel molds	51,500	0
	Total	***55,100***	***9,600***

3.6.1.4 Other investment

It was assumed that in Scenario 1 a car would be purchased in the fourth year of operation. The decision was based on the comparison of the costs of transportation of finished products with a third party and by using own means of transportation. The costs of the latter option include car's depreciation, insurance and maintenance costs, driver's salary and fuel costs. In the fourth year, operation and maintenance of own means of transportation is cheaper than third party services for the delivery of finished products to distribution centers and end customers. In Scenario 2, it was decided that a car would be purchased in the first year of operation. The cost of a car in both scenarios is 770,000 ETB (pers. communication with A. Woldemariam, Director of Investment Promotion and Public Relation at Ethiopian Investment Agency, Addis Ababa, Ethiopia, 15.05.2009). The purchase of a car is mirrored in insurance costs (refer to Figure 3.15 and Figure 3.16).

Other expenses include administrative investment for telephone, fax and Internet services, which in both scenarios are estimated to 2,500 ETB. Another investment is needed for business documents, including an investment permit, trade registration certificate, trade name registration and a business license, which sums up to 900 ETB for each scenario. An investment permit is valid for a year and it needs to be renewed annually, which costs 200 ETB.

3.6.1.5 Summary of start-up costs

Start-up costs for Scenario 1 and Scenario 2 are presented in Figure 3.20, including an error indicator, which was set at 5 %. The costs were grouped according to the following categories: land, building, plant, office, administration and raw materials. Finishing equipment refers to band saws and blades as well as trimmers. The first supply of raw materials corresponds to the supply of LLDPE and dry pigment (for coloration) required for the first quarter of the annual production. Total start-up costs for Scenario 1 amount to almost 10 million ETB and for Scenario 2 to almost 14 million ETB.

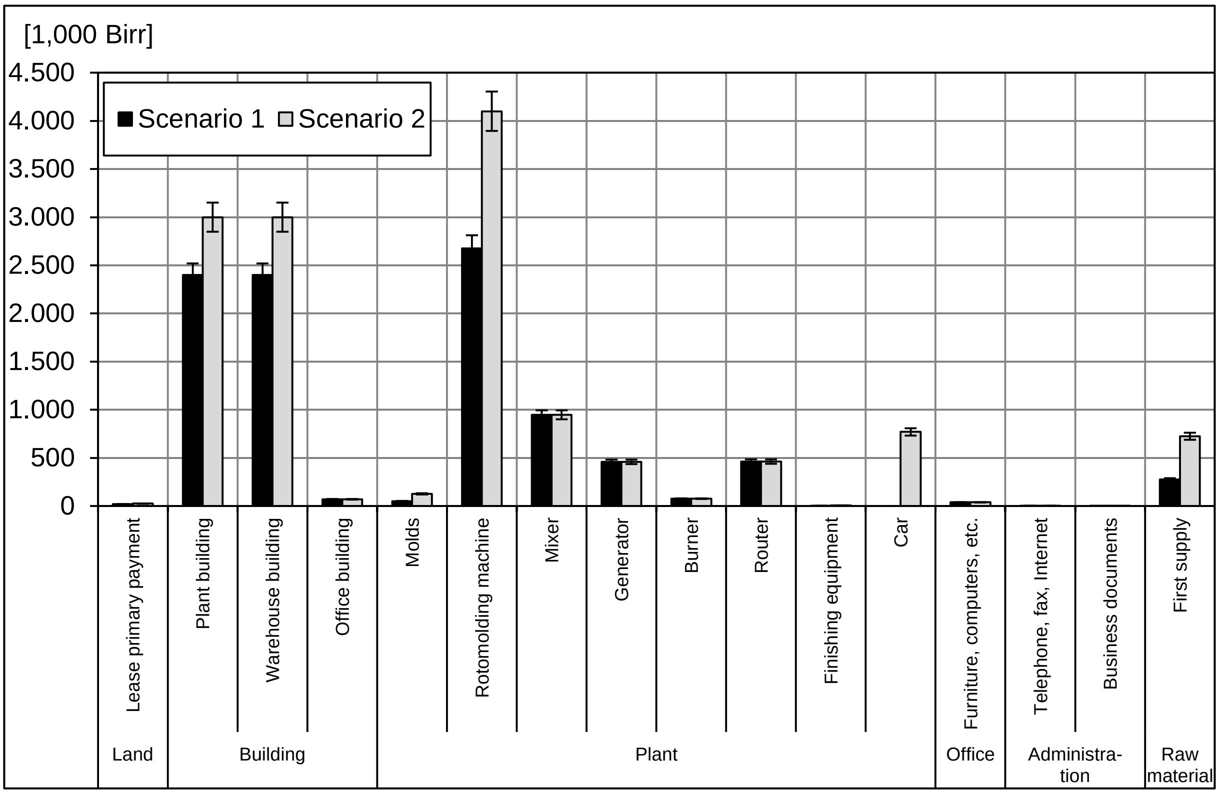


Figure 3.20: Start-up costs for Scenario 1 and Scenario 2

3.6.2 Proposed financial structure of the business

It was assumed that the company's legal structure would be sole proprietorship with one owner (no board or advisors required). A sole proprietor would own all assets and would be responsible for all debts.

The loan would be requested from an Ethiopian bank. If not enough money was secured, organizations dealing with international funding programs for sanitation projects would be contacted.

3.6.3 Projected financial plan

This section explains the financial plan of the business venture for Scenario 1 and Scenario 2.

3.6.3.1 Start-up costs

Start-up costs are different for Scenario 1 and Scenario 2, as already indicated in Section 3.6.1. Scenario 1 requires an initial investment of approximately 10.5 million ETB, whereas Scenario 2: approximately 14.5 million ETB[40]. It was assumed that the loan would be obtained from a bank in Ethiopia with an interest rate of 10 % (Ethiopian Investment Agency, 2008b). Other sources of loan with a similar interest rate can also be considered, e.g., a microfinance institution or a foreign investor.

3.6.3.2 Evaluation of Scenario 1 and Scenario 2

In order to evaluate both scenarios, the following indicators were used: the net present value (NPV), the internal rate of return (IRR) and the payback period (PBP).

The interest rate on loan of 10 % was used as the nominal discount rate (i). The PBP was calculated according to Equation 3.2. The NPV was calculated according to Equation 3.3 based on the cash flows as presented in Appendix B.7 and Appendix B.8. The real interest rate (r) was calculated according to Equation 3.4. The projected inflation rate[41] (p) of 8 % was assumed in Ethiopia (World Bank, 2011a). The nominal and real IRR was calculated using a built-in MS Excel function, which was described in Section 3.2.2.2. The calculation of the real and nominal IRR was based on the cash flows as presented in Appendix B.7 and Appendix B.8.

Table 3.26: Net Present Value, Internal Rate of Return and Payback Period for Scenario 1 and Scenario 2

	Scenario 1			Scenario 2		
Sales	**60 %**	**80 %**	**100 %**	**60 %**	**80 %**	**100 %**
NPV (ETB)	7,754,312	20,859,692	34,314,293	10,158,490	26,596,259	43,240,990
real IRR	20%	42%	60%	21%	46%	67%
nominal IRR	29%	53%	72%	31%	57%	81%
PBP (years)	3.6	2.7	2.2	3.3	2.3	1.7

The comparison of NPV, IRR and PBP for Scenario 1 and Scenario 2 presented in Table 3.26 shows results for three sales scenarios; assuming that about 60 % (worst case scenario), 80 % (normal case scenario) and 100 % (best case scenario) of the manufactured products would be sold (for the numbers on the volume of production refer to Table 3.11).

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[40] Additional 5 %, which represents the assumed error indicator, was added to the initial investment as presented in Section 3.6.1.5.

[41] Source: the average annual inflation rate (consumer prices) for the years 2009-2010 (World Bank, 2011a).

Worst case scenario

In the event that only 60 % of the volume of products manufactured is sold, both Scenario 1 and Scenario 2 will have a rather low NPV. The worst case scenario NPV for both Scenario 1 and Scenario 2 is approximately 40 % of the normal case NPV. Also, about 3.6 and 3.3 years will be needed, respectively to recover the investment. In the worst case scenario, the real IRR is higher than the real interest rate (2 %) and the nominal IRR is higher than the discount rate (10 %) in both Scenario 1 and Scenario 2. Nevertheless, comparing the real and nominal IRR of the worst case and normal case scenarios, the difference is quite significant (over 20 % for both Scenario 1 and Scenario 2).

Normal case and best case scenario

In the normal case and best case scenario, Scenario 2 scores better in terms of the NPV. With 80 % and 100 % of the volume of products manufactured sold, the nominal IRR in both Scenario 1 and Scenario 2 is higher than the nominal discount rate. However, it is higher in Scenario 2 than in Scenario 1. In the normal case and best case scenario, Scenario 2 requires less time than Scenario 1 to recover the investment made. This is due to the higher volume of production (and resulting sales) projected for Scenario 2 in comparison to Scenario 1 (refer to Section 3.5.1).

If not enough demand is in place to meet the estimated sales, both scenarios will not be as financially profitable as in the normal case and best case scenario. Nevertheless, Scenario 2 scores better in terms of the NPV, IRR and PBP in all cases.

3.6.3.3 Break-even analysis

Break-even points for Scenario 1 and Scenario 2 are presented in Figure 3.21 and Figure 3.22, respectively.

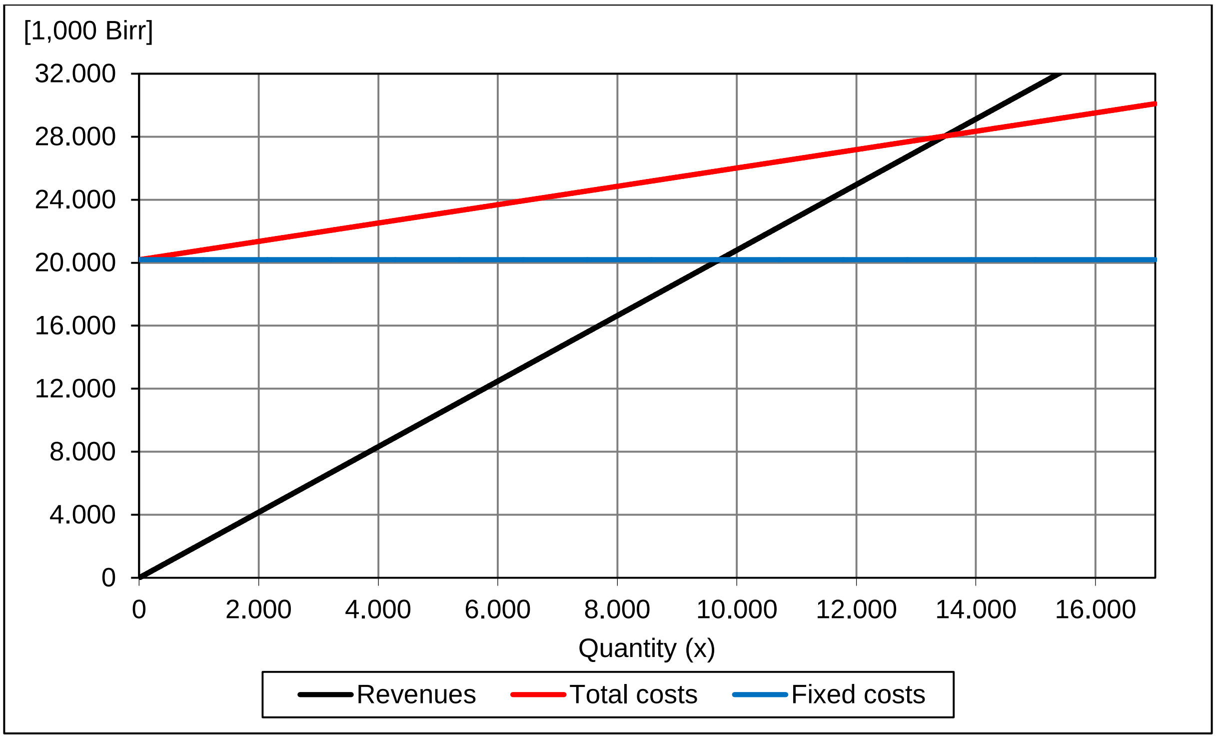

Figure 3.21: Break-even point for Scenario 1

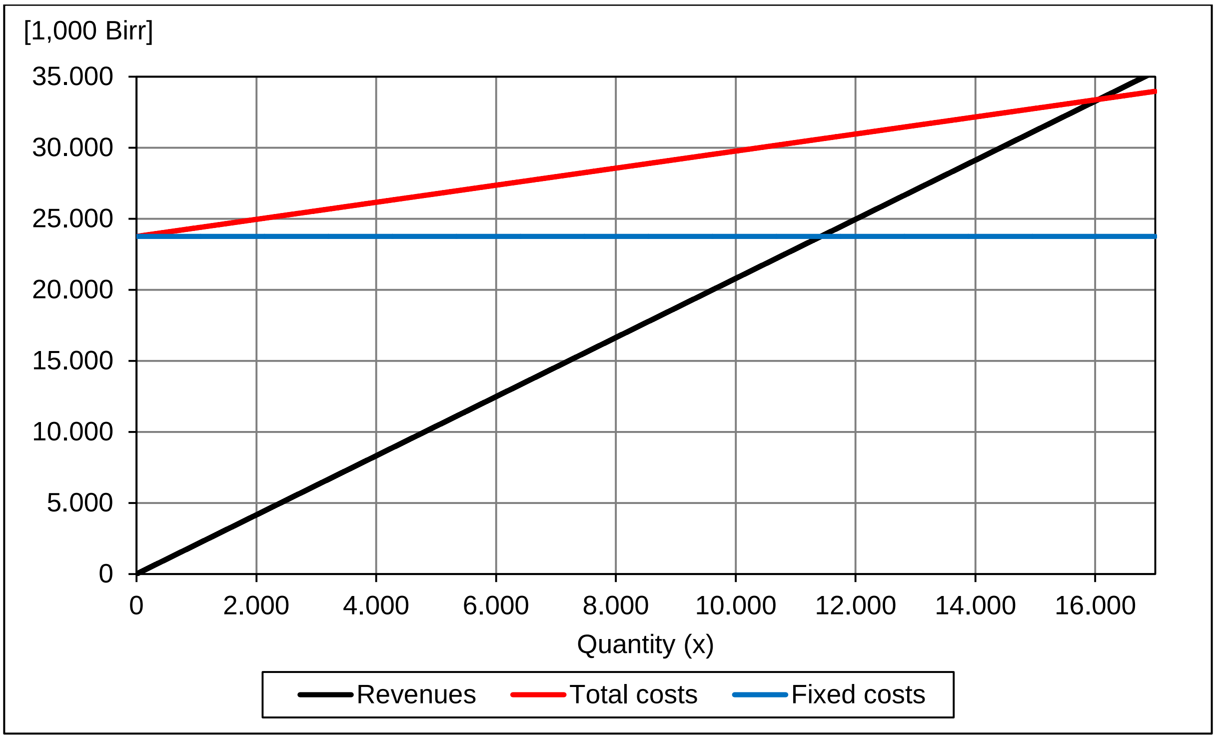

Figure 3.22: Break-even point for Scenario 2

Break-even points were computed as described in Section 3.2.3. All the required variables for performing the break-even analysis are presented in Table 3.27 and Table 3.28. Break-even point for Scenario 1 was determined at 13,483 units of each product, which corresponds to 53,930 units of all four products. For Scenario 2, the break-even point was determined at 16,059 units of each product, which corresponds to 64,235 units of all four products. The difference in break-even points for both scenarios is due to the fact that Scenario 2 requires more expenditure, in particular on start-up investment.

Table 3.27: Break-even analysis for Scenario 1

	Product 1	**Product 2**	**Product 3**	**Product 4**	**Total**
Units sold	26,016	26,016	26,016	26,016	104,064
Sales price/unit	600	180	400	900	
Variable cost/unit	114	85	129	255	
Sales (A)	15,609,600	4,682,880	10,406,400	23,414,400	54,113,280
Variable cost (B)	2,953,752	2,204,643	3,363,794	6,634,023	15,156,212
Contr. Margin (CM) (A-B)	12,655,848	2,478,237	7,042,606	16,780,377	38,957,068
Less: Fixed cost					20,189,150
Net income					18,767,918
Weighted average CM					374
Weighted average CM %	23.4%	4.6%	13.0%	31.0%	71.99%
Break-even Point (units)	13,483	13,483	13,483	13,483	53,930
Break-even Sales (ETB)	8,089,535	2,426,860	5,393,023	12,134,302	28,043,721
Break-even Sales share	28.8%	8.7%	19.2%	43.3%	100%

Table 3.28: Break-even analysis for Scenario 2

	Product 1	**Product 2**	**Product 3**	**Product 4**	**Total**
Units/year	32,700	32,700	32,700	32,700	130,800
Sales price/unit	600	180	400	900	
Variable cost/unit	118	89	134	260	
Sales (A)	19,620,000	5,886,000	13,080,000	29,430,000	68,016,000
Variable cost (B)	3,861,355	2,919,784	4,376,743	8,487,156	19,645,037
Contr. Margin (CM) (A-B)	15,758,645	2,966,216	8,703,257	20,942,844	48,370,963
Less: Fixed cost					23,754,520
Net income					24,616,443
Weighted average CM					370
Weighted average CM %	23.2%	4.4%	12.8%	30.8%	71.1%
Break-even Point (units)	16,059	16,059	16,059	16,059	64,235
Break-even Sales (ETB)	9,635,195	2,890,559	6,423,464	14,452,793	33,402,011
Break-even Sales share	28.8%	8.7%	19.2%	43.3%	100%

The numbers presented above refer to five years of operation for each scenario. Variable cost per unit represents average variable cost per part[42]. Fixed costs include primary investment (building costs, plant and office equipment, primary lease payment, administrative investment and investment documents, car and molds), investment required in the following years (tooling and plant equipment), interest payment on the loan, depreciation, land lease, non-production related personnel expenses, advertising, insurance, telecommunication and other costs.

Sales, variable costs and contribution margin is higher in Scenario 2 due to the economies of scale that can be reached faster with higher production volumes. Break-even sales are higher in Scenario 2 but the share of break-even sales is the same in both scenarios due to the fact that the same sales mix was considered in both cases. For background information on break-even analysis refer to Section 3.2.3.

3.6.3.4 Projected Profit and Loss

For background information on financial statements refer to Section 3.2.4.

Financial statements were computed for both Scenario 1 and Scenario 2 for the first five years of the company's operation. Table 3.29 and Table 3.30 shows the Profit and Loss (P&L) statement for Scenario 1 and Scenario 2, respectively. The volume of production as presented in Table 3.11 and the normal case scenario (80 % of the volume of products manufactured sold) was considered.

[42] Variable costs per unit as presented in Table 3.13 and Table 3.14 are not the same as in Table 3.27 and Table 3.28 due to the fact that for the calculation of the break-even point, average variable costs per unit for all five years of operation were used.

Table 3.29: Profit and loss statement for Scenario 1

PROFIT & LOSS STATEMENT – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Revenues	3,369,600	5,616,000	11,281,900	16,922,900	16,922,900
minus Cost of service sold					
Raw material and supplies	864,650	1,280,250	2,571,900	3,857,850	3,857,850
Received services	217,050	370,450	400,400	572,900	629,900
Gross Profit	2,287,900	3,965,300	8,309,600	12,492,150	12,435,150
minus Personnel expenses					
Salaries and wages	115,600	163,300	175,100	197,500	197,500
Social benefits	1,750	2,450	2,750	3,000	3,000
minus Depreciation	524,000	549,450	581,600	658,600	658,600
minus Lease payment	25,000	4,800	4,800	4,800	4,800
minus Other operating expenses	85,600	130,500	132,150	139,900	140,000
minus Interest rate	1,050,000	1,050,000	1,000,000	950,000	650,000
Profit or loss from operation	**485,950**	**2,064,800**	**6,413,200**	**10,538,350**	**10,781,250**
minus Income tax	145,785	619,440	1,923,960	3,161,505	3,234,375
Profit/Loss after tax	**340,165**	**1,445,360**	**4,489,240**	**7,376,845**	**7,546,875**

Table 3.30: Profit and loss statement for Scenario 2

PROFIT & LOSS STATEMENT – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Revenues	8,910,700	8,910,700	14,851,200	14,851,200	20,494,150
minus Cost of service sold					
Raw material and supplies	2,286,500	2,031,350	3,385,600	3,385,600	4,671,550
Received services	532,850	559,800	859,100	883,500	1,307,800
Gross Profit	**6,091,350**	**6,319,550**	**10,606,500**	**10,582,100**	**14,514,800**
minus Personnel expenses					
Salaries and wages	171,700	171,700	197,500	197,500	208,800
Social benefits	2,550	2,550	3,000	3,000	3,150
minus Depreciation	743,300	771,150	771,150	771,150	771,150
minus Lease payment	31,200	6,000	6,000	6,000	6,000
minus Other operating expenses	99,050	143,600	143,600	143,900	143,900
minus Interest rate	1,450,000	1,450,000	1,200,000	900,000	350,000
Profit or loss from operation	**3,593,550**	**3,774,550**	**8,285,250**	**8,560,550**	**13,031,800**
minus Income tax	1,078,065	1,132,365	2,485,575	2,568,165	3,909,540
Profit/Loss after tax	**2,515,485**	**2,642,185**	**5,799,675**	**5,992,385**	**9,122,260**

Revenues refer to the revenues of the normal case scenario (80 % of the volume of products manufactured sold). For the projected sales planning for Scenario 1 and Scenario 2 refer to Table 3.16 and Table 3.17, respectively[43]. In Scenario 2, the revenues are higher than in Scenario 1 due to the higher volume of production.

The financial statements above assume the volume of production as presented in Table 3.11 and the resulting expenditure on the raw materials.

Received services refer to the costs of third party services, i.e. transportation of finished products to end customers and distribution centers, electricity and LPG.

For the discussion on the personnel expenses and social benefits refer to Section 3.5.4.1 and Section 3.5.4.2.

[43] Small differences in the revenues as presented in Table 3.29 and Table 3.30 to the revenues as presented in Table 3.16 and Table 3.17 are due to the rounding of numbers.

Depreciation was calculated according to the straight-line method (refer to Equation 3.7). The assumed useful life for the calculation of depreciation is summarized in Appendix B.9.

Refer to Table 3.23 for the details on the land lease payment.

Other operating expenses refer to the costs of advertising, property insurance and administrative costs (telecommunication, investment documents, stationery, postage, banking costs, etc.). In the first year of operation, other operating expenses also include the administrative investment (telephone, fax, Internet connection, etc.).

The interest rate of 10 % on the bank loan was included in the P&L statement.

The corporate tax in Ethiopia is set at 30 % (Ethiopian Investment Agency, 2008b). Despite the possibility of some tax exemption in the first years of operation, it was assumed that the tax would be levied.

The profits[44] are higher in Scenario 2, as expected, due to the higher volume of production and respective sales. It needs to be highlighted that far-reaching promotional campaigns for the adaptation of the ecosan approach need to be performed in order to generate enough demand, not only in Arba Minch but in the whole SNNP Region. Refer to Chapter 5 for more information on promotion of ecosan.

3.6.3.5 Projected Cash Flow

Cash flow statements for Scenario 1 and Scenario 2 for the normal case are presented in Table 3.31 and Table 3.32, respectively.

Profit/loss after tax was taken from the P&L statement for the respective year.

Depreciation represents non-cash expenses so it had to be added in the cash flow statement.

Changes in working capital refer to the ones which were not yet included in the P&L statement (e.g., difference in finished goods, raw material, accounts receivable and accounts payable).

In Scenario 1, the first installment of the loan repayment was assumed to be made in the second year of operation and the loan would be paid back within the first 5 years of operation. In Scenario 2, the loan repayment would also start in the second year of operation and result in a full payback within the first 5 years of operation. In Scenario 1, the first installments of the loan repayment would be much smaller than in Scenario 2.

Capital expenditures include the investment in buildings, manufacturing machinery (including molds) and office equipment.

In Scenario 1, the project would require a loan of 10.5 million ETB, whereas in Scenario 2: 14.5 million ETB (refer to Section 3.6.3.1), which was indicated as debt in the cash flow statements.

[44] Profit after tax (presented in Table 3.29 and Table 3.30) takes into account the difference between revenues and operational costs (variable and fixed costs) and income tax. Net profit (presented in Table 3.27 and Table 3.28) does not take income tax into account.

Table 3.31: Cash flow statement for Scenario 1

CASH FLOW STATEMENT – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Profit/loss after tax	340,165	1,445,360	4,489,240	7,376,845	7,546,875
plus/minus Non-cash expenses					
Depreciation	524,000	549,450	581,600	658,600	658,600
Operating cash flow	**864,165**	**1,994,810**	**5,070,840**	**8,035,445**	**8,205,475**
plus/minus Changes in working capital	425,950	263,988	682,650	686,321	0
minus Loan payback	0	500,000	500,000	3,000,000	6,500,000
minus Capital expenditures	9,587,000	256,900	823,900	773,600	55,100
Cash flow	**-9,148,785**	**973,923**	**3,064,290**	**3,575,524**	**1,650,375**
Source of funds					
plus debt	10,500,000	0	0	0	0
Total source of funds	**10,500,000**	**0**	**0**	**0**	**0**
Financing balance	1,351,215	973,923	3,064,290	3,575,524	1,650,375
plus Balance of last year	0	1,351,215	2,325,138	5,389,428	8,964,952
Financing balance	**1,351,215**	**2,325,138**	**5,389,428**	**8,964,952**	**10,615,327**

Table 3.32: Cash flow statement for Scenario 2

CASH FLOW STATEMENT – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Profit/loss after tax	2,515,485	2,642,185	5,799,675	5,992,385	9,122,260
plus/minus Non-cash expenses					
Depreciation	743,300	771,150	771,150	771,150	771,150
Operating cash flow	**3,258,785**	**3,413,335**	**6,570,825**	**6,763,535**	**9,893,410**
plus/minus Changes in working capital	1,115,629	-41,621	721,217	0	644,729
minus Loan payback	0	2,500,000	3,000,000	5,500,000	3,500,000
minus Capital expenditures	13,057,300	260,700	6,200	131,700	9,600
Cash flow	**-10,914,144**	**694,256**	**2,843,408**	**1,131,835**	**5,739,081**
Source of funds					
plus debt	14,500,000	0	0	0	0
Total source of funds	**14,500,000**	**0**	**0**	**0**	**0**
Financing balance	3,585,856	694,256	2,843,408	1,131,835	5,739,081
plus Balance of last year	0	3,585,856	4,280,112	7,123,520	8,255,355
Financing balance	**3,585,856**	**4,280,112**	**7,123,520**	**8,255,355**	**13,994,436**

3.6.3.6 Projected Balance Sheet

Projected year-end balance sheets for Scenario 1 and Scenario 2 for the normal case are presented in Table 3.33 and Table 3.34, respectively.

Buildings represent the investment in the office, plant and warehouse building.

Plant and office equipment refers to the accumulated investment in manufacturing machinery (including molds), office equipment (e.g., computer, printer, telephone, fax, office furniture, etc.) and a car. Plant equipment for both scenarios is summarized in Table 3.25. Office equipment costs 39,000 ETB, and a car costs 770,000 ETB, as indicated in Section 3.6.1.4.

Accumulated depreciation refers to the depreciation of the current and previous years.

Cash and cash in bank represents the financing balance taken from the cash flow statement for the respective year.

Inventory was assumed to be one twelfth of the raw material supplies. In order to keep it simple, finished products that were listed as inventory were valued according to the amount of raw materials used for their production. It was assumed that the majority of finished products would be sold to distributors, which would allow selling in bulk, thus, moving the inventory to the distributors.

Accounts receivable was assumed to be due after one month, which corresponds to one twelfth of the total revenues.

Profit/loss carry forward refers to the accumulated profit/loss after tax taken from the P&L statements from the previous years.

The annual result was taken from the P&L statement for the respective year.

Loan refers to the amount of the loan that would still be left to repay. It was assumed that the loan would be paid back in installments, which were estimated based on the company's annual financial result.

Accounts payable refers to the supplier's credit granted for the supply of raw materials, which was assumed to be due after two months.

Table 3.33: Year-end balance sheet for Scenario 1

YEAR-END BALANCE SHEET – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
ASSETS					
Fixed assets					
Buildings	4,870,000	4,870,000	4,870,000	4,870,000	4,870,000
Plant and office equipment	4,717,000	4,973,900	5,797,800	6,571,400	6,626,500
Accumulated depreciation	524,000	1,073,450	1,655,050	2,313,650	2,972,250
Total fixed assets	**9,063,000**	**8,770,450**	**9,012,750**	**9,127,750**	**8,524,250**
Current assets					
Cash and cash in bank	1,351,215	2,325,138	5,389,428	8,964,952	10,615,327
Inventory					
raw materials and supplies	91,800	136,563	273,121	409,683	409,683
finished products	236,950	358,500	705,550	1,058,350	1,058,350
Accounts receivable	280,800	468,000	940,158	1,410,242	1,410,242
Total current assets	**1,960,765**	**3,288,200**	**7,308,257**	**11,843,227**	**13,493,602**
Total assets	**11,023,765**	**12,058,650**	**16,321,007**	**20,970,977**	**22,017,852**
LIABILITIES					
Equity					
Profit/loss carry forward	0	340,165	1,785,525	6,274,765	13,651,610
Annual result	340,165	1,445,360	4,489,240	7,376,845	7,546,875
Income of the period	0	0	0	0	0
Loan	10,500,000	10,000,000	9,500,000	6,500,000	0
Total equity and returned earning	**10,840,165**	**11,785,525**	**15,774,765**	**20,151,610**	**21,198,485**
Short term debt					
Other liabilities	0	0	0	0	0
Accounts payable	183,600	273,125	546,242	819,367	819,367
Total short term debt	**183,600**	**273,125**	**546,242**	**819,367**	**819,367**
Total liabilities	**11,023,765**	**12,058,650**	**16,321,007**	**20,970,977**	**22,017,852**

Table 3.34: Year-end balance sheet for Scenario 2

YEAR-END BALANCE SHEET – Normal case					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
ASSETS					
Fixed assets	6,070,000	6,070,000	6,070,000	6,070,000	6,070,000
Buildings	6,987,300	7,248,000	7,254,200	7,385,900	7,395,500
Plant and office equipment	743,300	1,514,450	2,285,600	3,056,750	3,827,900
Accumulated depreciation	**12,314,000**	**11,803,550**	**11,038,600**	**10,399,150**	**9,637,600**
Total fixed assets					
Current assets	3,585,856	4,280,112	7,123,520	8,255,355	13,994,436
Cash and cash in bank					
Inventory	241,779	214,800	358,475	358,475	491,242
raw materials and supplies	614,850	546,250	916,100	916,100	1,223,350
finished products	742,558	742,558	1,237,600	1,237,600	1,707,846
Accounts receivable	**5,185,043**	**5,783,720**	**9,635,695**	**10,767,530**	**17,416,873**
Total current assets					
	17,499,043	**17,587,270**	**20,674,295**	**21,166,680**	**27,054,473**
Total assets					
LIABILITIES					
Equity	0	2,515,485	5,157,670	10,957,345	16,949,730
Profit/loss carry forward	2,515,485	2,642,185	5,799,675	5,992,385	9,122,260
Annual result	0	0	0	0	0
Income of the period	14,500,000	12,000,000	9,000,000	3,500,000	0
Loan	**17,015,485**	**17,157,670**	**19,957,345**	**20,449,730**	**26,071,990**
Total equity and returned earning					
Short term debt	0	0	0	0	0
Other liabilities	483,558	429,600	716,950	716,950	982,483
Accounts payable	**483,558**	**429,600**	**716,950**	**716,950**	**982,483**
Total short term debt					
	17,499,043	**17,587,270**	**20,674,295**	**21,166,680**	**27,054,473**
Total liabilities					

The financial statements for Scenario 1 and Scenario 2 presented above show that less profit is expected in Scenario 1 than in Scenario 2. This is directly connected with lower revenues. In Scenario 2, the higher revenues and financial liquidity allow for the loan to be repaid in higher installments. On the other hand, the higher revenues in Scenario 2 are mirrored in the higher expenses on raw materials and supplies, costs of received services (e.g., electricity), personnel expenses and other operating expenses. The higher production capacity of Scenario 2 requires higher capital investment, which influences the loan that needs to be taken out. The decision on which scenario should be chosen is not straightforward and further analysis of the financial statements will be performed by analyzing the key financial indicators.

3.6.3.7 Key financial indicators

As discussed in Section 3.2.5, commonly used financial indicators for the evaluation of financial statements include return on investment (ROI), gross profit margin (GPM) and net profit margin (NPM).

Table 3.35 presents ROI for Scenario 1 and Scenario 2 for each year of operation. Scenario 2 has a significantly better result in the first year due to the higher number of products manufactured and sold (refer to Table 3.11), which has a direct effect on the company's profit. In the first year, the projected sales of Scenario 2 are 2.6 times the projected sales of Scenario 1 (refer to Table 3.29 and Table 3.30). In the second and third year, Scenario 2 has a slightly higher ROI as a result of the higher production and, consequently, higher sales in Scenario 2. In the fourth year of operation, more products are manufactured and sold in Scenario 1, which is the reason for this scenario's better score in terms of ROI. In the fifth year of operation, the volume of production is again higher in Scenario 2 and the difference in ROI between both scenarios is again minimal.

Table 3.35: Return on investment for Scenario 1 and Scenario 2

Year	ROI (%)	
	Scenario 1	Scenario 2
1	3.1	14.4
2	12.0	15.0
3	27.5	28.1
4	35.2	28.3
5	34.3	33.7

Table 3.36 shows Gross Profit Margin (GPM) ratios for both scenarios. Scenario 2 has slightly better results in the first two years due to the higher revenues (refer to Table 3.29 and Table 3.30). In the following years, the GPM of Scenario 1 becomes higher due to the lower gross profit ratio of Scenario 2 to Scenario 1 than the revenues ratio of Scenario 2 to Scenario 1 (refer to Table 3.29 and Table 3.30).

Table 3.36: Gross profit margin for Scenario 1 and Scenario 2

Year	GPM (%)	
	Scenario 1	Scenario 2
1	67.9	68.4
2	70.6	70.9
3	73.7	71.4
4	73.8	71.3
5	73.5	70.8

Net Profit Margin (NPM) for Scenario 1 and Scenario 2 is summarized in Table 3.37. In the first year, the NPM for Scenario 2 is almost three times the NPM for Scenario 1. This is due to the revenues and profit after tax that are much higher than in Scenario 1 (refer to Table 3.29 and Table 3.30). In the second year, Scenario 2 has a bit higher NPM than Scenario 1, due to the revenues and profit after tax being slightly higher in Scenario 2. In following years, the NPM generally remains higher in Scenario 1 due to the lower profit after tax ratio of Scenario 2 to Scenario 1 than the revenues ratio of Scenario 2 to Scenario 1. For both scenarios, a margin of more than 40 % (in the fourth and fifth year) is a very good result. The discussed NPM results prove that if more products are manufactured and sold, economies of scale can be reached and make the business more profitable.

Table 3.37: Net profit margin for Scenario 1 and Scenario 2

Year	NPM (%)	
	Scenario 1	Scenario 2
1	10.1	28.2
2	25.7	29.7
3	39.8	39.1
4	43.6	40.3
5	44.6	44.5

The only considerable difference between both scenarios in the analyzed financial indicators can be seen for ROI and NPM for the first year (Scenario 2 scored significantly better) and for ROI for the fourth year (Scenario 1 scored significantly better). Scenario 2 had a better ROI in the first year due to the much higher profit after tax in Scenario 2 (the profit after tax in Scenario 2 was approximately 7.4 times the profit after tax in Scenario 1) (refer to Table 3.29 and Table 3.30). Scenario 2 had a better NPM in the first year due to the higher revenues in Scenario 2 (the revenues in Scenario 2 were approximately 2.6 times the revenues in Scenario 1) (refer to Table 3.29 and Table 3.30) and due to the already mentioned higher profit after tax achieved in Scenario 2 as compared to Scenario 1. Scenario 1 scored better in terms of ROI in the fourth year due to the higher profit after tax in Scenario 1 (refer to Table 3.29 and Table 3.30) and much higher assets in Scenario 2 (refer to Table 3.33 and Table 3.34).

Despite the good financial results of Scenario 2, it has to be accounted for the fact that Scenario 2 requires a considerably higher start-up investment and loan than Scenario 1 (refer to Section 3.6.3.1), which might be difficult to realize in Ethiopia.

3.6.4 Critical factors determining profitability

Critical factors that determine the project's profitability were examined through a sensitivity analysis.

3.6.4.1 Influence of sales volume

The most important factor influencing the profitability of the project is related to the demand, which is reflected in the volume of products sold and revenues. The differences in the NPV, real and nominal IRR as well as PBP between best (100 % of the manufactured products sold), normal (80 % of the manufactured products sold) and worst (60 % of the manufactured products sold) scenarios were presented in Section 3.6.3.2. Nevertheless, a sensitivity analysis of decreasing revenues was performed, taking the normal case scenario (refer to the financial statements in Sections 3.6.3.4, 3.6.3.5 and 3.6.3.6) as a starting point. The difference in Net Profit Margin for Scenario 1 and Scenario 2 with decreasing revenues is presented in Figure 3.23 and Figure 3.24, respectively.

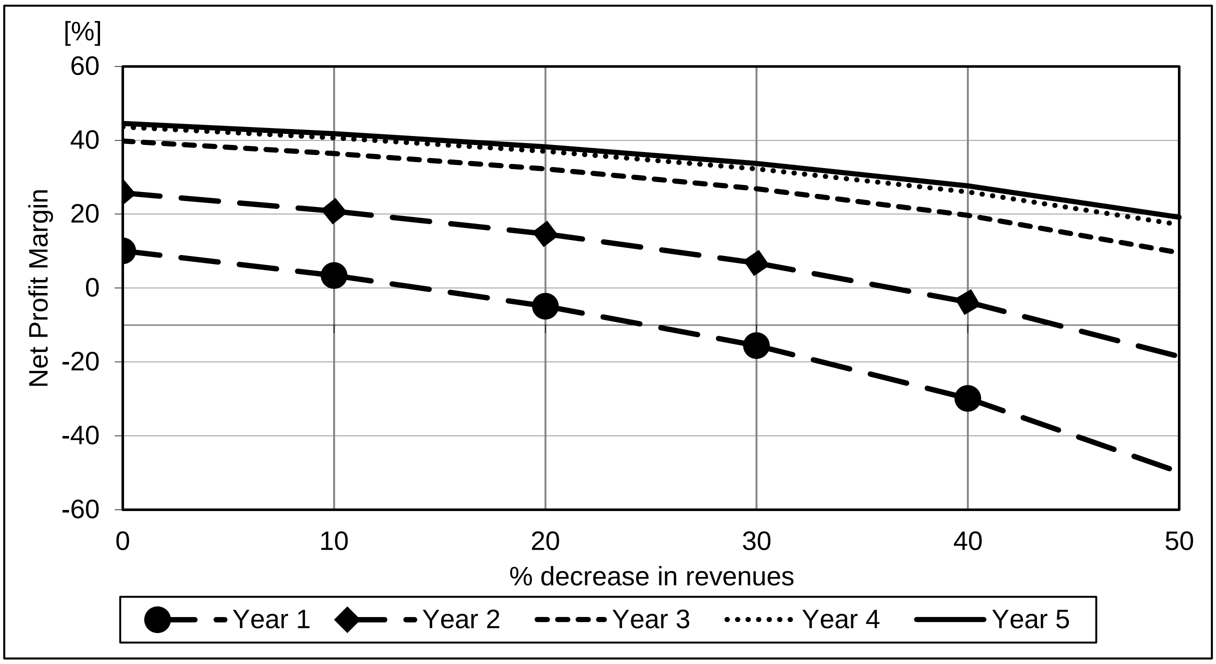

Figure 3.23: Net Profit Margin vs. decreasing revenues for Scenario 1

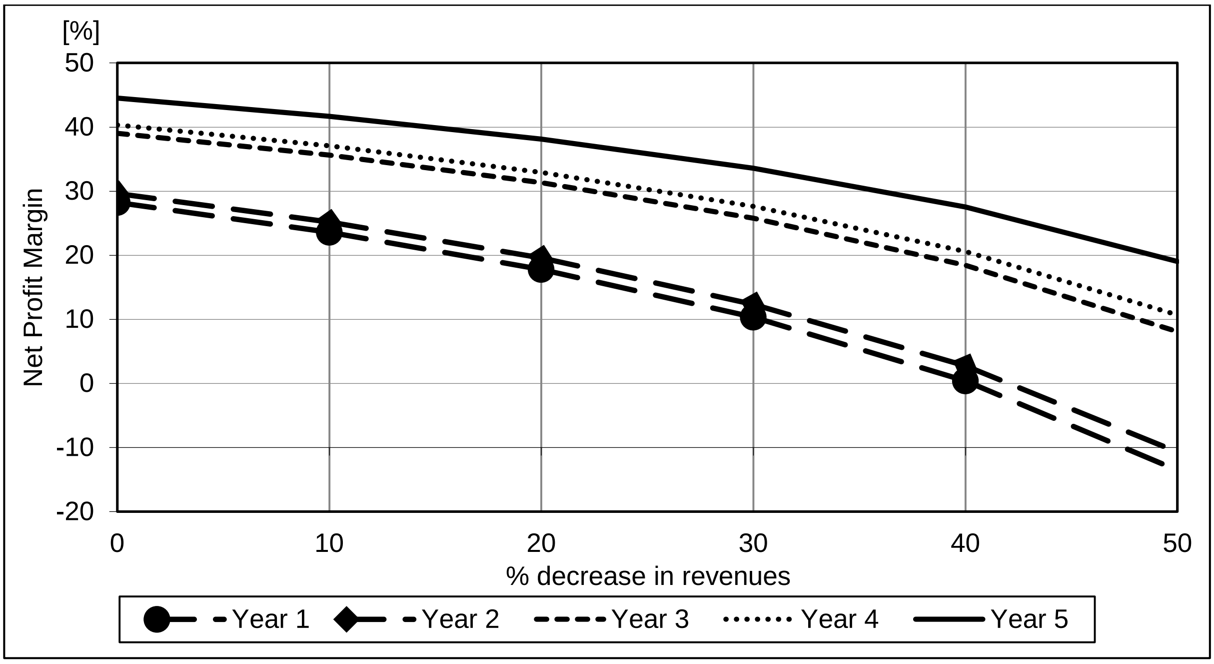

Figure 3.24: Net Profit Margin vs. decreasing revenues for Scenario 2

Switching value[45] represents a decrease in revenues by approximately 42 % for both Scenario 1 and Scenario 2. Even though the switching value is the same for both scenarios, the effect of the potentially decreasing revenues on the NPM is much stronger in Scenario 1 than in Scenario 2 (refer to Figure 3.23 and Figure 3.24). It becomes clear than a significant drop in revenues will create serious financial effects and hinder profitability. This emphasizes the fact that an adequate demand needs to be in place for the business to be financially successful. Therefore, marketing and sanitation promotion activities need to be performed.

[45] Switching value refers to the change in a cash flow item that is required for the NPV to turn to zero.

It was assumed that the company would manufacture four products, of which a Fossa Alterna slab (Product 4) would have the highest contribution margin, followed by a urine diverting sitting slab (Product 1) (refer to Table 3.27 and Table 3.28). Due to the fact that these two products are decisive for the profit, the company should focus on creating demand for them. The marketing of Fossa Alternas should be directed at rural households, where more space is available and it is generally preferable to build a toilet outside. On the other hand, urine diverting sitting slabs are more appropriate for higher-income households or institutions, where toilets are built inside and more emphasis is put on comfort and status. If the company faces problems with the demand resulting in lower sales, the production mix should be reconsidered, e.g., more Fossa Alterna (Product 4) and UD sitting slabs (Product 1) could be produced in order to generate enough profits. Refer to Chapter 5 for more information on the promotion of ecosan in Ethiopia.

3.6.4.2 Influence of the price of raw materials

Another decisive parameter for the project's profitability is the price of raw materials (LLDPE and dry pigment) as it constitutes the highest variable cost (see Figure 3.17 and Figure 3.18). A sensitivity analysis of potentially increasing prices of raw materials showed, as expected, that the profitability of the company would be endangered in the event that the prices of raw materials increase significantly.

The Net Profit Margin changing with the increasing raw material prices for Scenario 1 and Scenario 2 is presented in Figure 3.25 and Figure 3.26.

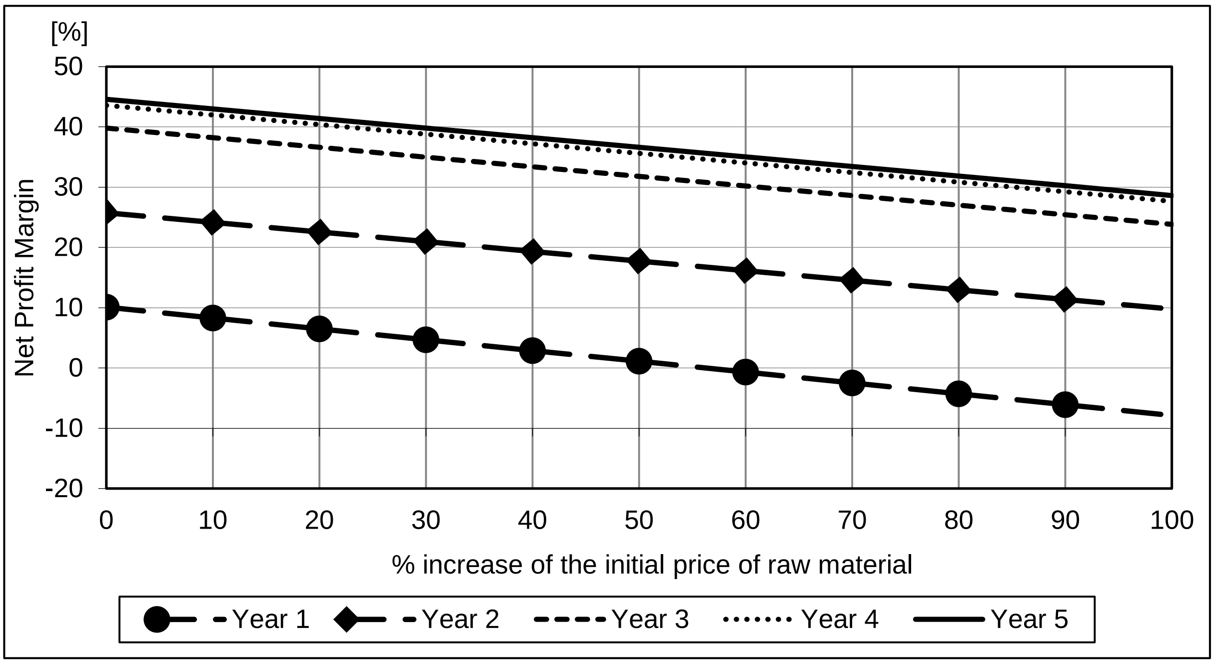

Figure 3.25: Net Profit Margin vs. increasing prices of raw material for Scenario 1

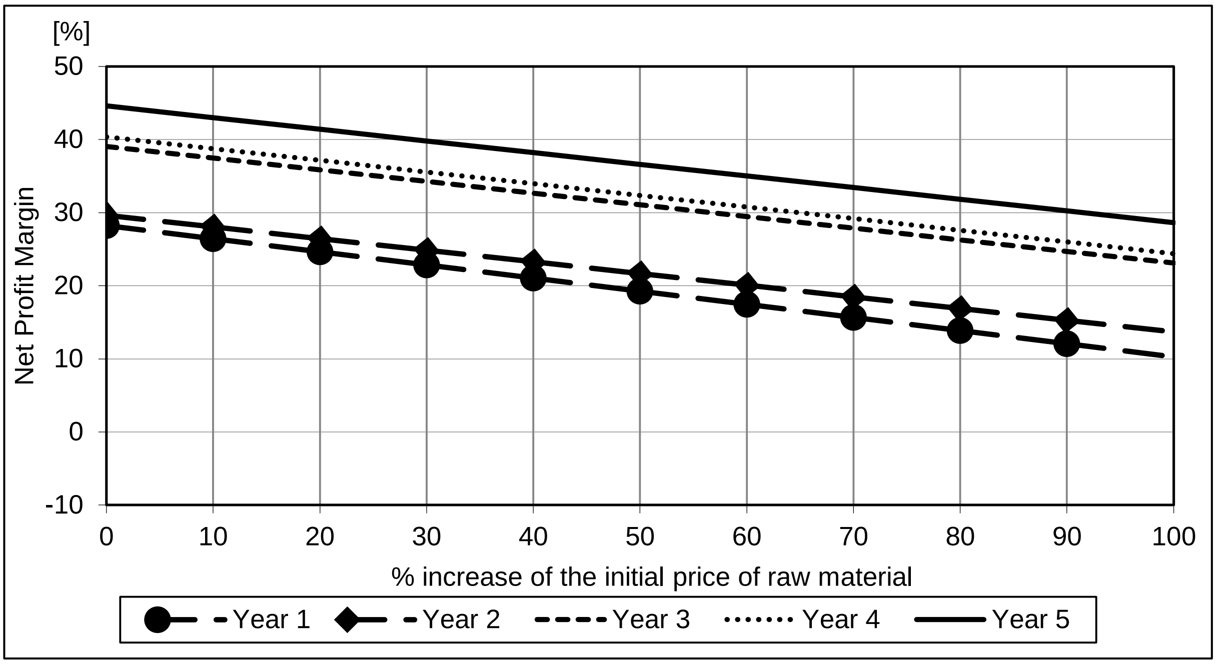

Figure 3.26: Net Profit Margin vs. increasing prices of raw material for Scenario 2

If prices of raw materials increased by approximately 140 % of the initial price, the NPV in Scenario 1 and Scenario 2 would drop to zero, which represents the switching value. Therefore, a long term contract should be sought with suppliers of raw materials so that a contract price could be negotiated and the company's profitability would not suffer from fluctuating raw material prices. If no long term contract is possible, new suppliers should be sought in order to ensure the lowest available price.

3.6.4.3 Influence of personnel expenses

Another important parameter that was included in the sensitivity analysis refers to production related (direct) personnel expenses listed under variable costs (refer to Figure 3.17 and Figure 3.18). For both scenarios, the project is not sensitive to potentially increasing personnel costs. In the event that direct personnel expenses grew even by 100 % the change in the NPV (-2.3 % for Scenario 1 and -2.1 % for Scenario 2) is not considerable. The same applies to the difference in the nominal IRR (-1.7 % for Scenario 1 and -1.6 for Scenario 2) and PBP, which is negligible (less than 1 month) for both scenarios.

3.6.4.4 Influence of advertising costs

Advertising costs are one of the most important parameters among fixed costs (refer to Figure 3.15 and Figure 3.16). Therefore, a sensitivity analysis of potentially increasing advertising costs was performed. The results for both scenarios show that the project is not sensitive to this particular parameter. The influence of the increase in advertising costs even by 100 % does not have any significant influence on the NPV (-1.6 % for Scenario 1 and -0.4 % for Scenario 2) nor the PBP (less than 1 month for both scenarios).

3.6.4.5 Influence of transportation costs

Transportation costs of finished products belong to variable costs (refer to Figure 3.17 and Figure 3.18). The results of the sensitivity analysis of potentially increasing transportation costs show that the project is not sensitive to this variable. If the transportation costs increased by 100 %, the change in the NPV (-0.8 % for Scenario 1 and -1.2 % for Scenario 2), the nominal IRR (-0.4 % for Scenario 1 and -0.6 % for Scenario 2) and the PBP (not even 1 month for both scenarios) would be negligible.

3.6.4.6 Influence of start-up costs

Another parameter that was put under examination considered start-up costs, which include primary payment for land lease, building costs, cost of the manufacturing machinery and equipment as well as of the office equipment. The switching value for the start-up costs in Scenario 1 is an increase by approximately 220 % in the start-up costs, and in Scenario 2, by approximately 200 %. The result is similar for both scenarios. It indicates that there is a certain room for error in the assumptions that were made.

3.6.4.7 Summary of the sensitivity analysis

A summary of results of the sensitivity analysis for Scenario 1 and Scenario 2 is shown in Table 3.38 and Table 3.39, respectively.

Table 3.38: Summary of the results of the sensitivity analysis for Scenario 1

Parameter	Assume	Effect on NPV	Effect on nominal IRR	Switching value
Revenues	10 % decrease	24.2 % decrease	15.9 % decrease	approx. 42 % decrease
Cost of raw materials	10 % increase	7.1 % decrease	4.6 % decrease	approx. 140 % increase
Personnel expenses	100 % increase	2.3 % decrease	1.7 % decrease	Negligible
Advertising costs	100 % increase	1.6 % decrease	1.3 % decrease	Negligible
Transportation costs	100 % increase	0.8 % decrease	0.4 % decrease	Negligible
Start-up costs	10 % increase	4.6 % decrease	8.3 % decrease	approx. 220 % increase

Table 3.39: Summary of the results of the sensitivity analysis for Scenario 2

Parameter	Assume	Effect on NPV	Effect on nominal IRR	Switching value
Revenues	10 % decrease	24.0 % decrease	17.0 % decrease	approx. 42 % decrease
Cost of raw materials	10 % increase	7.1 % decrease	5.0 % decrease	approx. 140 % increase
Personnel expenses	100 % increase	2.1 % decrease	1.6 % decrease	Negligible
Advertising costs	100 % increase	0.4 % decrease	0.5 % decrease	Negligible
Transportation costs	100 % increase	1.2 % decrease	0.6 % decrease	Negligible
Start-up costs	10 % increase	4.9 % decrease	9.3 % decrease	approx. 200 % increase

The sensitivity analysis proved that both scenarios are sensitive to the generated revenues. Therefore, it is necessary to perform an adequate sanitation campaign in order to create the necessary demand and raise people's awareness on the advantages of using ecosan. A proposal for a promotional campaign in Arba Minch will be presented in detail in Chapter 5 (refer to Section 5.6).

Due to the fact that the cost raw materials constitutes the highest variable cost, the project is also sensitive to this particular parameter. Nevertheless, the switching value of approximately 140 % for both scenarios shows that low price fluctuations that are kept within reasonable limits will not greatly affect the profitability of the project. The project is not sensitive to changes in advertising costs, personnel expenses nor transportation costs of finished products. It is due to the fact that these costs are low in a country like Ethiopia. Start-up costs would have to increase by approximately 220 % in Scenario 1, and by approximately 200 % in Scenario 2 for the project to become endangered. This is unlikely to happen as the costs were inquired from existing suppliers and the Ethiopian Investment Agency.

3.6.5 Possibilities of cost decrease

This section explores the possibilities of cost decrease, focusing on the machinery (rotomolding machine) as the highest cost constituent among start-up costs and on raw materials (LLDPE) as the highest constituent of variable costs.

Machinery

Due to the fact that the investment for a rotational molding machine constitutes the highest start-up cost, purchasing used machinery for the planned manufacturing line was considered. Ferry Industries Inc. was consulted for used equipment price quotes (pers. correspondence, A. Rowland, International Sales Manager at Ferry Industries Inc., Stow, Ohio, 17.02.2010).

The problem with used machines is that they are sold as is, where is, i.e. the buyer is responsible for dismantling, removing, packing and shipping them from their current locations to Ethiopia. These machines do not have any warranty. The following machines were available for sale: FERRY RS-200 fixed arm turret model with three straight arms built in 1997 (140,000 USD or 1.9 million ETB[46] excluding dismantling and shipping costs) and FSP M-80 ATI turret machine with three straight arms built in 1991, which is not made anymore, so spare parts availability could create a problem. This is also the reason for its low price (78,000 USD or 1.1 million ETB[47] excluding dismantling and shipping costs). Compared to the prices for new machinery (refer to Table 3.7), these machines are cheaper, but the cost of dismantling and shipping is not considered, which might make the price non-competitive. Nevertheless, the possibility of buying used equipment in order to cut down start-up costs can be considered.

Raw material

Another option to decrease costs would be using recycled raw material obtained from own manufacturing scrap material or purchased from suppliers. For details on using post-consumer resins, refer to Section 3.1.3.5. A company in China (Laizhou Wenfeng Electric Equipment Co. Ltd) was consulted for recycled LLDPE and HDPE price quotes. The average price of both recycled LLDPE granules and HDPE granules is approximately 17.3 ETB/kg[48], with a minimum order of 16 tons. The price includes additional 40 % of the raw material costs added to compensate for shipping costs (including marine freight costs, insurance and unloading) from China to Addis Ababa. The exemplary price of recycled LLDPE in granules (17.3 ETB/kg) is approximately 82 % of the price of virgin material in granules (21.2 ETB/kg as presented in Section 3.4.2.1), so one could save on raw material costs by using blends of virgin and recycled material. More potential suppliers would have to be consulted in order to negotiate the price and to find the best suitable recycled raw material that could be used to manufacture toilet slabs. The price given above serves to give a general idea of how much one could save by using blends of post-consumer resins over virgin raw material.

3.7 Government support and regulations

This section describes the possibilities of the Ethiopian government support for the project as well as regulations that need to be taken into account. First, the government’s economic development and investment program is introduced. Then, potential government incentives are discussed. In addition, expected contribution of the project to the economic development of the country is presented.

3.7.1 Project in context of government economic development and investment program

Since the draught in 2002/2003 that resulted in a decline in the GDP by 3.3 %, the economic development in Ethiopia has been taking place in all sectors (Germany Trade and Invest, 2009b). In 2009/2010, Ethiopia experienced an increase in real GDP by 8.0 % and it was estimated that in 2010/2011 the real GDP would increase by 7.5 % (Germany Trade and Invest, 2011).

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[46] Price was converted from USD to ETB using exchange rate from OANDA (2012).

[47] Price was converted from USD to ETB using exchange rate from OANDA (2012).

[48] Price was converted from CNY to ETB using exchange rate from OANDA (2012).

3.7.2 Specific government incentives and support available to the project

The Ethiopian Investment Agency in Addis Ababa and the Gamo Gofa Trade, Industry and Tourism Main Department in Arba Minch were consulted for the information on incentives that may be available for the project.

In the first year of operation, plastic raw materials can be imported duty free. The manufacturing machinery and spare parts constituting up to 15 % of the total value of the imported equipment can also be imported duty free. These two incentives were considered in the business plan presented in Section 3.6.

There is also a possibility of income tax exemption for 2-7 years for investments in the area of manufacturing, agro-processing and agriculture (pers. communication, A. Woldemariam, Director of Investment Promotion and Public Relation, Ethiopian Investment Agency, Addis Ababa, 15.05.2009). In order to be granted this incentive, the project needs to offer a special value for the society. The presented project offers such a value due to the possibility of applying urine as fertilizer in agriculture (collected from urine diverting dry toilets) or of agricultural production due to the planting of tree seedlings in place of former Arborloo toilets.

It is also possible to use land freely (without leasing it) for 2-3 years in Arba Minch, if it is proven that the investment provides a certain advantage to the society as a whole.

The incentive of corporate tax exemption and free use of land was not considered in the business plan due to the fact that it could not be granted that they would be available for the considered business. However, if received, they would result in lower fixed costs (land lease) and an increase in profit by 30 % (corporate tax exemption). The difference between the net profit margin (NPM) of the project with no incentive and the project with the discussed incentives is presented in Figure 3.27. The presented NPM includes a 5 % error indicator.

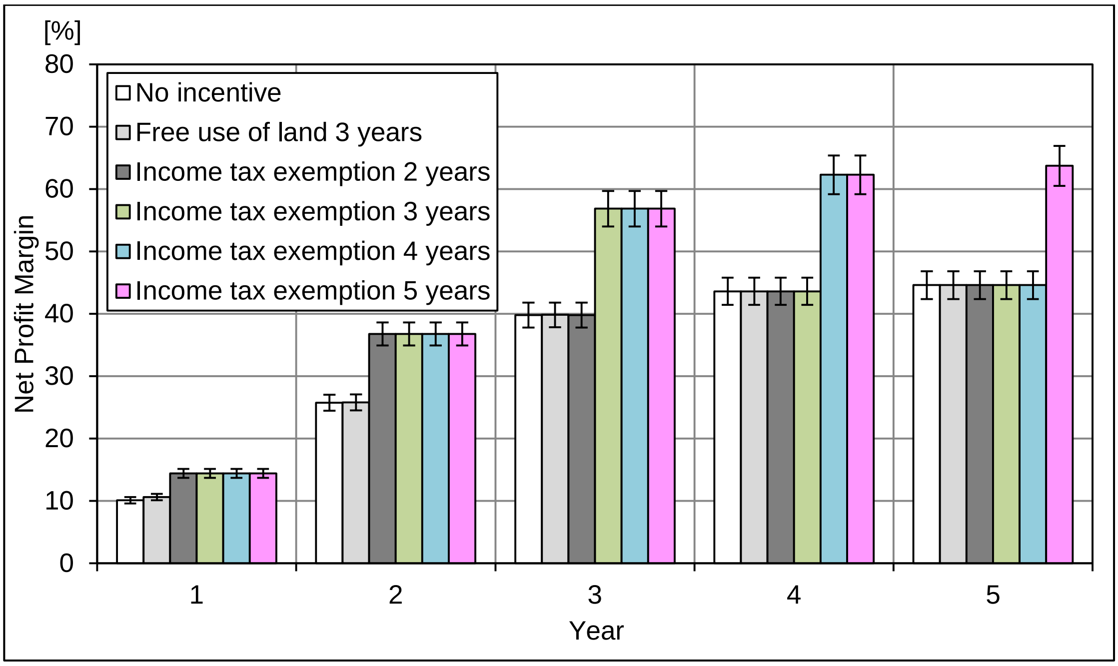

Figure 3.27: Influence of government incentives on the Net Profit Margin of the project for Scenario 1

The incentive of the free use of land for the period of 3 years would not have almost any impact on the NPM of the project due to the low cost of the land lease in Arba Minch (refer to Table 3.23). On the other hand, the incentive of tax exemption would have a significant impact (refer to Figure 3.27).

3.7.3 Expected contribution of the project to the economic development

The project would contribute to the economic development through creating employment possibilities. Skilled and unskilled staff would be taken on and employees would be provided industrial training, which would increase their value on the work market.

Economic development of a country is not possible without solving the problem of the provision of sanitation services. Even though health is not a common driving force for sanitation adoption, it is often the most important driver for public authorities. A company manufacturing durable toilet slabs that can be applied under the ecosan approach can contribute to eliminating the sanitation challenge. Both hygienic aspects that these toilets bring along and the potential of agricultural reuse of sanitized excreta contribute to the economic development of the communities involved.

It can be expected that households in Arba Minch will be willing to improve their sanitary facilities, mainly due to the privacy, comfort and status that they offer. The population in Arba Minch is growing, the migration from rural to urban areas as well as infrastructural development is taking place (refer to Section 3.4.4). Thus, sanitation facilities need to serve the growing population and adapt to the on-going developments accordingly.

It is also possible to involve SMEs in Arba Minch to operate urine and feces collection from public, shared or individual UDDTs, storage of urine as well as composting of feces and further sale as liquid fertilizer and soil conditioner for application in agriculture. In this manner, SMEs could become business partners or operate independently and a new business opportunity would be created.

3.8 Further discussion

The business idea presented in this chapter encompasses a production line for plastic toilet slabs to be used under the ecosan approach. The analysis of different manufacturing methods suitable for plastic products led to a conclusion that for the local conditions and planned volume of production it would be best to chose the rotational molding process. This process has a much less expensive equipment and tooling than other manufacturing processes, e.g., injection molding. Due to simpler mold designs, production lead times are also shorter than for injection molding. Also, thanks to the relative simplicity of the tooling, small alterations can be made to an existing mold to respond to changing production needs, which makes it more flexible than injection molding. Furthermore, rotomolding is suitable for both low-volume prototypes and high-volume production runs.

Even though rotomolding has many advantages vis-à-vis other processes, it also has a few disadvantages. Despite the high investment needed for injection molding, part costs may be lower than with rotomolding process due to the longer cycle times. Therefore, if higher production runs are required, injection molding could be taken into consideration in place of rotomolding. It is important to analyze the local situation, including the demand for products, production lead times, potential need for alternations in part design, part design requirements (e.g., uniform wall thickness is a clear advantage of rotational molding, which also affects the durability of a product), etc. Only then a choice between different manufacturing techniques available can be made.

Observing global and local market trends is of crucial importance to the business. Moving from cement to plastic products, also in sanitary hardware, is becoming a trend in many countries, especially in urban areas. As a result, the private sector is drawn to enter the area of sanitation business, mainly due to the transportation of plastic products being easier and cheaper in comparison to cement products. Nevertheless, sanitary products made of other materials than plastic, e.g., porcelain toilet bowls, might be requested by customers. In this case, the production line would be different than for plastic toilet pans. Porcelain toilets require longer production times than rotomolding (e.g., greenware castings dry in open air for several days). Even though material costs would be lower than with rotomolding, other costs would be much higher, including the transportation costs of finished parts (porcelain products are heavier than plastic products) and fuel costs for the firing process performed in kilns.

The proposed project was presented for two scenarios: Scenario 1 with a lower capacity of production and a lower investment and Scenario 2 with a higher capacity of production and a respectively higher investment. The loan for Scenario 2 is higher by almost 40 % in comparison to Scenario 1. According to the financial analysis performed, Scenario 2 is expected to bring more profits as expressed in terms of the NPV, IRR and PBP (refer to Section 3.6.3.2). Nevertheless, enough demand would have to be in place in order to sell the manufactured parts. This was particularly proven by the sensitivity analysis performed for both scenarios. The normal case scenario, for which the financial analysis was performed, assumed that 80 % of the manufactured products would be sold. This assumption was made as it could not be taken for granted that enough demand would be in place, in particular at the beginning of the company's operation, to meet the production capacity. A drop in sales (from the normal case scenario) by approximately 42 % (for Scenario 1 and Scenario 2) would make both scenarios unprofitable. In the cases studied, it would be necessary to sell over 53,900 of products in Scenario 1 and over 64,200 products in Scenario 2 (refer to Section 3.6.3.3 for the details on the break-even analysis) to break even. In general, Scenario 1 is slightly less sensitive to potential changes in start-up costs and both scenarios would be negatively influenced in the event of potentially increasing raw material prices (refer to Table 3.38 and Table 3.39).

Alone in the first year of operation, Scenario 2 projects approximately 2.6 times sales volume of Scenario 1. In Arba Minch alone, almost 11,350 households might be willing to adopt the type of toilet slabs offered by the company (refer to Section 3.5.6). These are households without access to sanitation facilities, experiencing problems or being unsatisfied with current sanitation options. Scenario 2 would meet this demand already by the end of the first year of operation (within 8 months), whereas Scenario 1 would need approximately 1.3 years. Therefore, the company needs to expand its area of reach already at the beginning of its operation. Marketing and promotion of products needs to be performed also in other areas in the SNNP Region, in particular in the Gamo Gofa Zone. For example, in rural areas, the adoption of Arborloos and Fossa Alternas should prove successful, looking at the experience of the Catholic Relief Services (refer to Section 3.5.5.2) and the fact that there is enough space available in rural areas for this type of toilets. Also, the activities of the completed ROSA project and the CLARA as well as SPA projects, which are still running in Arba Minch, help to raise awareness on the ecosan approach. Therefore, the SNNP Region, with emphasis on the Gamo Gofa Zone, should be a good potential market for this type of toilets.

Despite the better financial projections for Scenario 2, Scenario 1 seems a more rational alternative for the presented business idea due to the much lower investment required and smaller capacity of production. In this way, during the first two years of the company's presence on the market, it would be possible to promote the company's products effectively. The company would aim to become famous in the region as a manufacturer and promoter of toilets used in the ecosan approach with an adequate production capacity to meet the demand for products in Arba Minch and other urban and rural areas in the Gamo Gofa Zone. Furthermore, the planned purchase of an extra arm for the machine in Scenario 1 (in order to increase the capacity of production) can be postponed if not enough demand is in place.

Another idea would be to place the production plant in another city, e.g., in Djibouti that has a direct access to the sea, where export of toilet slabs would be possible. Such a plant would have to reach a much higher volume of production than proposed in this project as it would aim at a larger market, primarily in East Africa, but also in other countries. This plant could specialize in toilet slabs to be applied under the ecosan approach but also manufacture a different set of products, e.g., septic tanks or rainwater tanks. The advantage of the rotational molding process is that molds are not as expensive as in injection molding. The production line can be changed in a short period of time as the molds are not complicated in fabrication, thus, not much time is needed to adjust or extend the production to other products. A big manufacturing plant that would satisfy the demand for products not only in Africa but products could also be exported to other continents, would not have to fear the intrusion of competitors and a sudden fall in prices as a result of a price war. Such a company would be able to gain a certain status and its production volumes might even allow it to become a leader on the African market.

The presented business idea, apart from the obvious advantage of job creation in the region and the contribution to the economic development of the region, also has a number of further advantages. The promotion of the ecosan approach that involves recycling of nutrients could make Ethiopian farmers, even if only partially, independent of mineral fertilizers. Local farmers very often cannot afford mineral fertilizers, so returning nutrients from human excreta into agriculture would help their farmlands become more fertile. Furthermore, a large scale adoption of the ecosan approach requires a system for the collection, transportation, storage and sanitization as well as marketing of ecosan products. Local small and medium enterprises could become involved in these services, which offers further business opportunities.

4 CASE STUDY GHANA

Common challenges regarding the implementation of the ecological sanitation (ecosan) are the acceptance of using excreta based fertilizers in agriculture and the cost and management of collection, transportation, storage and marketing of ecosan products (Drewko et al., 2010). This chapter proposes the idea of a supply chain, based on fertilizing non-food (oil palms and fast growing trees) and food crops (maize) with urine for biodiesel, fuel wood and maize production. It also proposes running trucks on biodiesel for urine transportation and exploiting trucks in a multi-tasked transportation service. As a result of the proposed supply chain, lowering or even covering urine transportation costs, as well as, reducing storage time and costs of urine can be achieved.

4.1 Technical outline for closed-loop nutrient management in Ghana

This chapter provides background information and a technical outline for the case study Ghana. First, a method for calculating the value of nutrients contained in urine in Ghana is introduced. Next, sanitation facilities, urine storage and transportation options are discussed. Furthermore, the process of biodiesel processing is explained, with special focus on the biodiesel production potential in Ghana and palm oil used as a feedstock for biodiesel production.

4.1.1 Value-to-volume ratio of urine

If income is to be generated through marketing of sanitized, liquid fertilizer, i.e. human urine, a price for this fertilizer has to be determined. For estimation of nutrients contained in human urine, the Replacement Cost Approach (RCA) method described in Drechsel et al. (2004) was used. This method is the most common one used in developing countries for the economic assessment of soil nutrients. It is used to assign monetary values to depleted soil nutrients. One of the advantages of the RCA methodology is that market prices are usually available for the most common nutrients.

Data on market prices for fertilizer raw materials such as urea, diammonium phosphate (DAP) and muriate of potash (MOP) is given for June-September 2010. The calculation takes advantage of the more or less fixed price ratio between main nutrients (nitrogen (N), phosphorous (P) and potassium (K)) (Drechsel et al., 2004). Based on world market prices for products and the average nutrient content in raw material, the macro-unit prices and standardized nutrient ratios were determined (refer to Table 4.1). Based on these price ratios, the nutrient cost in nitrogen equivalents was determined (refer to Table 4.2). Multiplying the price ratio of the raw materials for phosphorous and potassium per nitrogen unit (refer to Table 4.1), the nutrient costs were calculated for P_2O_5 and K_2O (refer to Table 4.3).

Table 4.1: World market prices of fertilizer raw materials

Costs	Fertilizer raw material		
	Urea	**DAP**	**MOP**
Raw material (US$/kg)[a]	0.28	0.48	0.34
Nutrient in raw material	N	P_2O_5	K_2O
Nutrient (%) in raw material	46 %	46 %	60 %
Price of nutrient (US$/kg)	0.60	1.04	0.56
Price ratio/N unit[b]	1.00	1.74	0.94

[a)] Source: www.africafertilizer.org (international monthly average prices, June-September 2010).

[b)] Any other nutrient than N could also be used. The price ratio between the main macro-nutrients (N, P and K) is used.

Table 4.2: Cost per unit of nutrient in N price equivalent in Ghana

Fertilizer product (N:P:K)	N (g N/ g fertilizer)	P[a] (g P/ g fertilizer)	K[b] (g K/ g fertilizer)	All three nutrients	Price in Ghana (US$/kg)[c]	Cost/ N eq.[d] (US$/kg)
NPK 15:15:15	0.15	0.11	0.12	0.38	0.449	1.176
Urea 46:0:0	0.46	0.00	0.00	0.46	0.397	0.862
NPK 23:10:5+4MgO+2Zn	0.23	0.08	0.04	0.35	0.452	1.308
Ammonium sulfate 21:0:0	0.21	0.00	0.00	0.21	0.301	1.433
Mean value						**1.195**

[a)] P is available as P_2O_5 in NPK fertilizer, which contains 44 % of elemental P.

[b)] K is available as K_2O in NPK fertilizer, which contains 83 % of elemental K.

[c)] Source: www.africafertilizer.org (monthly average local prices in Ghana, June-September 2010).

[d)] N eq. stands for nitrogen equivalent.

Table 4.3: Average nutrient costs on the Ghanaian market

Nutrient	Nitrogen	Phosphorous	Potassium
Price (US$/kg)	1.19	2.08	1.12
Price (GH¢/kg)[a]	1.72	2.98	1.61

[a)] Prices were converted from US$ to GH¢ using the average exchange rate from June-September 2010 from OANDA (2012).

Table 4.4: Nutrient content in urine and feces in Ghana (Cofie and Mainoo, 2007; Germer and Sauerborn, 2008)

Excreta type	Nitrogen	Phosphorous	Potassium
Urine (g/l)	5.0	0.7	2.3
Feces (g/kg)	4.4	1.0	0.9

Combining the information from Table 4.2, Table 4.3 and Table 4.4, the value of the fertilizer content in urine and feces in Ghana was calculated (see Table 4.5).

Table 4.5: Market value of nutrients contained in urine and feces in Ghana

Excreta type	Nitrogen	Phosphorous	Potassium	Total
Urine (GH¢//l)	8.62×10^{-3}	2.05×10^{-3}	3.68×10^{-3}	14.35×10^{-3}
Feces (GH¢//kg)	7.53×10^{-3}	2.98×10^{-3}	1.43×10^{-3}	11.95×10^{-3}

The market value of nutrients in human urine in Ghana adds up to approximately 0.014 GH¢/l (0.008 €/l). It appears to be a reasonable result, especially after comparing it to a study made in Uganda, where the price for urine of 0.01 €/l was calculated, following the same method (Schröder, 2010).

4.1.2 Urine diverting sanitation facilities in Ghana

In order to market urine as fertilizer, sanitation facilities that allow separate urine and feces collection need to be installed.

4.1.2.1 Technical aspects

An example of a urine diverting dry toilet (UDDT) block that consists of six urine diverting squatting pans, two urinals and two sinks for hand washing is presented in Figure 4.1. This UDDT complex is based on the one built at the Valley View University (VVU) in Ghana and can be used by up to 500 people daily (see Figure 4.2). Detailed information about the ecosan project at the VVU can be found in Geller et al. (2006) and Berger (2010).

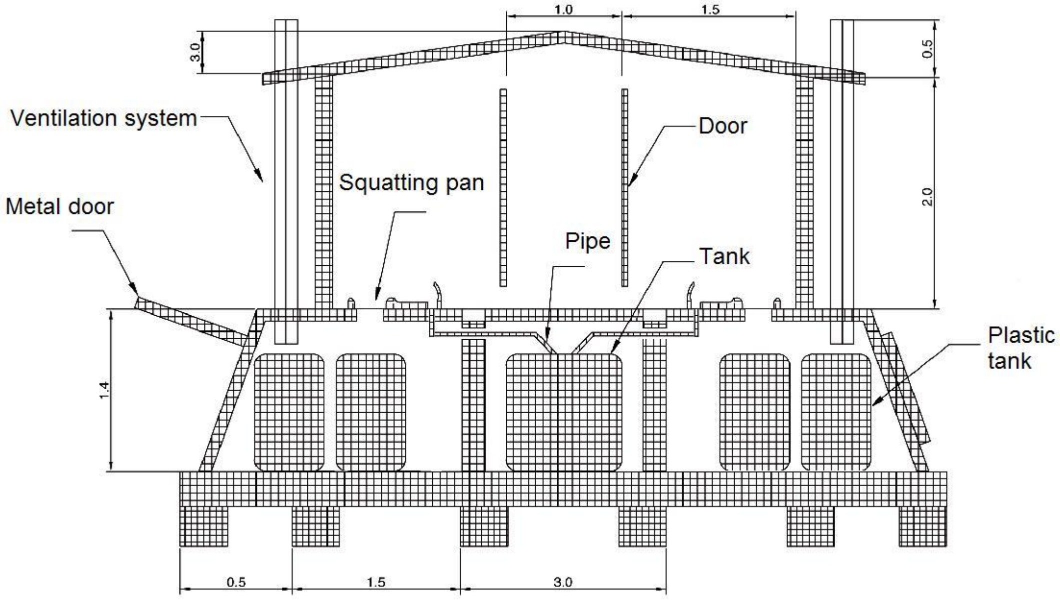

Figure 4.1: Side view of the proposed urine diverting dry toilet complex (measures in meters) (Martinez Neri, 2009)

Feces drop into a plastic container located in the basement. When the container is full, it is replaced by the adjacent one. Metal doors located on the side are used to remove plastic containers after the dehydration has been completed and transport dehydrated feces to the location where they will be treated further in a subsequent composting process. It is important to add ashes or sawdust to feces after each use in order to facilitate the dehydration process, reduce odor and eliminate pathogens by elevating the pH-value. A ventilation system helps to prevent odor. Urine is transported through a pipe into a collecting plastic tank, which when full is emptied and urine is transported to its storage location.

Figure 4.2: UDDT complex at the Valley View University in Ghana (Berger, 2010)

4.1.2.2 Costs

The urine diverting dry toilet (UDDT) block presented in Figure 4.1 costs approximately GH¢ 5,500. The price for the UDDT block presented in Figure 4.1 includes material costs (approx. GH¢ 3,100), labor costs (GH¢ 900), the cost of two sinks (approx. GH¢ 100), two urinals (GH¢ 120), six squatting pans (GH¢ 210), twelve plastic containers for feces collection (GH¢ 500) and a 3,000 l plastic tank for urine collection (GH¢ 600) (Martinez Neri, 2009). Urine diverting squatting pans made of porcelain are estimated to cost approximately GH¢ 35[49].

Ordinary public urinals located in Accra can also be modified for urine collection. The costs for modifying one urinal are approximately 770 GH¢, which includes material costs (approx. GH¢ 130), labor costs (GH¢ 250) and the cost of a plastic tank for urine collection (GH¢ 390) (Martinez Neri, 2009).

4.1.3 Storage of urine

Technical and hygienic aspects as well as costs of urine storage are discussed further.

4.1.3.1 Technical and hygienic aspects

In order for urine to be safely used as fertilizer, it needs to be stored first. Storage of urine is performed for hygienic reasons. In a Swedish study, 22 % of the tested samples of source-diverted urine were contaminated with feces, on average by about 9 mg feces per liter of urine (Höglund et al., 2002). In the event that urine was contaminated with feces, storage ensures pathogen die-off. The risk for transmission of infectious diseases is dependent on the storage temperature and duration of storage of urine before used as fertilizer (Höglund, 2001). In general, the higher the storage temperature, the less probable it is for pathogens to survive in urine (Höglund, 2001).

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[49] Prices were converted from ETB to GHS using the average exchange rate of September 2009 from OANDA (2012).

The final application of urine determines its storage time and storage costs. As presented in Table 4.6, when fertilizing food crops that will be processed, urine requires a minimum of one month of storage, whereas for all other crops (not to be processed) – six months or more at 20°C (WHO, 2006). “Later studies suggest two months (of recommended storage) at >20°C when the ammonia content is approximately 50 mM NH_3 and less than 10 days at 34°C at 50 mM NH_3, considering *Ascaris suum*, bacteria and viruses” (Vinnerås et al., 2008; Nordin et al., 2009 cited in Niwagaba, 2009). A study by Vinnerås et al. (2008) “indicated that the current recommended storage time for urine of 6 months at 20°C or higher is safe for unrestricted use and could probably be shortened, especially for undiluted urine”. For further considerations in this thesis, 1 month of storage for non-food crops to be processed and 6 months of storage for unrestricted use will be applied.

Table 4.6: Relationship between storage conditions, pathogen content[a] of the urine mixture[b] and recommended crop for larger systems[c] (WHO, 2006)

Storage temperature	Storage time	Possible pathogens in the urine mixture	Recommended crops
4°C	≥1 month	viruses, protozoa	food and fodder crops that are to be processed
4°C	≥6 months	viruses	food crops that are to be processed, fodder crops[d]
20°C	≥1 month	viruses	food crops that are to be processed, fodder crops[d]
20°C	≥6 months	probably none	all crops[e]

a) Gram-positive bacteria and spore-forming bacteria are not included in the underlying risk assessment, but are not normally recognized as causing any of the infections of concern.

b) Urine or urine and water. When diluted, it is assumed that the urine mixture has at least pH 8.8 and a nitrogen concentration of at least 1 g/l.

c) A larger system in this case is a system where the urine mixture is used to fertilize crops that will be consumed by individuals other than members of the household from which the urine was collected.

d) Not grasslands for production of fodder.

e) For food crops that are consumed raw, it is recommended that the urine be applied at least one month before harvesting and that it be incorporated into the ground if the edible parts grow above the soil surface.

There are different opinions on urine storage among ecosan practitioners. One important aspect is related to pharmaceutical residues possibly present in urine and their potential take-up by plants when urine is applied as liquid fertilizer. Winker (2010) reported that if pharmaceutical residues are polar and hardly biodegradable they can probably enter the human food chain after being taken up by plants. The main problem lies in the fact that a full toxicological evaluation of pharmaceuticals ingested by humans through consumption of crops fertilized with urine has not been performed yet. Nevertheless, “research carried out so far shows that the expected concentrations of pharmaceutical residues in average urine do not reach concentration levels which affect plant growth and development” (Winker, 2010, p.23). New methods of urine hygienization include, for example, urine composting with wood chips addition (pers. communication, R. Otterpohl, Head of Wastewater Management and Water Protection Institute, Hamburg University of Technology, Hamburg, 16.12.2011).

Urine can be used pure or diluted and it should be applied close to the soil or incorporated into the soil in order to avoid odor, aerosol formation, foliar burns and the loss of ammonia (Jönsson et al., 2004; Schönning and Stenström T. A., 2004; Kvarnström et al., 2006; WHO, 2006). A period of at least one month between application and harvest is recommended (WHO, 2006).

Ideally, urine storage facilities should be located next to the place of urine application. If possible, farmers can store urine on their farmlands in order to avoid the necessity of purchasing or leasing land required for urine storage.

4.1.3.2 Costs

Costs of urine storage depend on the type of container used. Urine can be stored in plastic tanks or plastic bladders. Plastic bladders are commonly applied to store large volumes of liquids, for example, water, chemicals, fuel, liquid fertilizers, slurry, etc. Monthly costs of urine storage are presented in Table 4.7. A plastic bladder with a life span of 8 years costs GH¢ 600, whereas a plastic tank of the same volume, with a life span of 15 years, costs almost GH¢ 4,000. Even though plastic bladders have a shorter life span than tanks, as presented in Table 4.7, plastic bladders offer a competitive price for urine storage (approx. 30 % of the cost of storage in a plastic tank).

Table 4.7: Cost of urine storage

Type of container	Capacity (liters)	Life span (years)	Price (GH¢)[a]	Cost of storage (GH¢/l*month)[b]
Plastic tank	30,000	15	3,970	0.735×10^{-3}
Plastic bladder	30,000	8	600	0.208×10^{-3}

[a)] Source: Weifang Kracivi Trade Co. Ltd., China cited in Martinez Neri, 2009.

[b)] Cost of storage includes depreciation costs of storage equipment.

Using plastic bladders in place of plastic tanks offers a price advantage, which makes a significant difference, especially with a 6-month storage period (4.4×10^{-3} GH¢/l instead of 1.3×10^{-3} GH¢/l of stored urine, respectively).

4.1.4 Transportation of urine

Transportation of urine might not be cost effective if urine is to be transported over long distances. Due to the low value-to-volume ratio of urine, the transportation distance allowed to achieve economic balance of an ecosan project is limited.

Previous studies in Ghana suggested using suction trucks or tank trucks (trucks mounted with a tank) to collect urine from public toilets in Accra (Cofie et al., 2005; Tettey-Lowor, 2008). However, these options have considerable disadvantages: a high cost in the case of a suction truck, limited use (only transporting urine) in the case of a tank truck and the fact that they are often not able to reach many remote areas. Using a suction truck is necessary with fecal sludge and since urine is liquid it does not require such an expensive piece of equipment.

Instead of using a tank truck fitted with one large plastic tank, a truck equipped with a number of smaller plastic containers would make transportation, loading and offloading easier to handle for the operators. Such a truck can be equipped with a different number of containers, i.e. different volumes of urine can be transported. Also, a truck used to transport urine should be equipped in such a way that it allows other transportation activities to be performed. A used heavy duty truck can be imported, for example, from the USA and then fitted with plastic containers and a diesel-powered water pump to pump the urine into the containers (see Table 4.8).

Table 4.8: Costs and variables for transportation of urine

Variable	Value	Unit
Truck costs (including shipping costs)[a]	26,550	GH¢/truck
Plastic container costs[b]	75	GH¢/container
Diesel-powered water pump costs[c]	1,200	GH¢/pump
Container volume	300	liters
Truck payload	7	tons
Truck lifespan	10	years
Diesel-powered pump lifespan	5	years
Fuel consumption	4	km/l
Average fuel price[d]	1.27	GH¢/l
Truck maintenance[e]	200	GH¢/5,000 km
Driver's salary	8.0	GH¢/day

[a)] Source: Kelley Blue Book Co., Inc.; Carex International Shipping Company; Ghana Free Zones Board, Accra; [b)] Source: Poly Tanks Ghana Ltd., Accra; [c)] Source: Cemix Ltd., Accra; [d)] Source: ARS, average price 09.2008-09.2009; [e)] Source: Africa Motors, Accra. All sources cited in Martinez Neri, 2009.

4.1.5 Biodiesel

As presented in the introduction (see Section 4), the supply chain discussed in this chapter proposes running trucks on biodiesel for urine transportation. Therefore, this section discusses the most important issues with regard to biodiesel[50].

4.1.5.1 Biodiesel properties

Biodiesel obtained from vegetable oils has similar characteristics as fossil diesel fuel. The significant differences include: a 10 % lower calorific value of biodiesel, which means that more biodiesel is required to give the same power output as standard diesel; approximately 10 % higher density of biodiesel, which results in higher brake specific fuel consumption and a higher flash point, making transportation and handling of biodiesel safer (Elsbett and Bialkowsky, 2003). For a detailed list of the differences in properties of biodiesel compared to standard diesel refer to Appendix C.

Despite some technical challenges (e.g., reduction of NO_x exhaust emissions), biodiesel shows significant advantages compared to standard diesel: reduction of most exhaust emissions (with the exception of NO_x), improved biodegradability and domestic origin (Knothe and Steidley, 2005).

Direct use of vegetable oils and their blends has been generally considered problematic for direct and indirect injection diesel engines (Elsbett and Bialkowsky, 2003). Some research results have proven successful engine performance under short term vegetable oil usage, but have faced degraded engine performance for

[50] Biodiesel is a term used for renewable fuel obtained from plant or animal material and used in diesel engines. The term biofuel is commonly applied to liquid fuels used for transportation, with the two most common biofuels produced today being bioethanol (produced from, e.g., corn or sugar cane) and biodiesel (produced from vegetable oils, e.g., palm or soy oil) (Kleiner, 2007).

prolonged operation time (Elsbett and Bialkowsky, 2003). Even though, for example, the Elsbett-Engine enables combustion of natural vegetable oils, in general, vegetable oils have to undergo chemical reactions prior to their use as biodiesel in diesel engines.

4.1.5.2 Biodiesel processing

In order to produce biodiesel from raw vegetable oil, alcohol, catalyst and vegetable oil need to be mixed in a container and heated to a required reaction temperature.

According to Demirbas (2008), the most desirable vegetable oil sources are soybean, canola, palm and rape. The choice normally depends on local availability, affordability and government incentives (Caminiti et al., 2007). The oils mostly used for biodiesel production are rapeseed (European Union countries), soybean (Argentina, USA), palm (Asian and Central American countries) and sunflower, but other oils are also used (peanut, linseed, safflower, used vegetable oils and animal fats) (Romano and Sorichetti, 2011).

Methanol is the most common primary alcohol used for biodiesel production, but ethanol, isopropanol and butyl can also be used (Demirbas, 2008). Potassium hydroxide, sodium hydroxide and sodium methoxide are common reaction catalysts (Demirbas, 2008).

The respective ratio of the mixture, temperature and reaction time is defined for each oil type. The mixture is left aside for approximately 8 hours during which separation takes place and glycerides fall to the bottom of the container. Biodiesel is removed from the top and washed by mixing with pure water and left to separate. Biodiesel is then again recovered from the top and left for a few days to dehydrate and to become clear. It can then be used to power diesel engines.

4.1.5.3 Critical view on biodiesel

Despite the many advantages of biodiesel, the emissions released by fossil fuels, e.g., for the production of fertilizers to grow crops, during manufacturing and distribution process of biodiesel have to be considered (Mastny, 2008; UNEP, 2009; Nersesian, 2010). Also, biodiesel usually costs more than standard diesel. There is also the concern of using food crops as a feedstock for biodiesel, especially in developing countries. A related concern is the fact that land that could have been used to grow food will be used for growing crops for fuel (Kleiner, 2007). Thus, factors such as available feedstock, market conditions, environmental impact and trade balance need to be taken into account while accessing biodiesel as an alternative to standard diesel (Demirbas, 2008).

4.1.5.4 Biodiesel market potential in Ghana

The biodiesel market is constantly growing and is undergoing fragmentation, which allows new players to enter the industry. According to Johnston and Holloway (2007), Ghana holds the fifth place (after Malaysia, Thailand, Colombia and Uruguay) among developing countries with profitable biodiesel export potential. This can be mainly attributed to its geographical location, relative safety, stability and lack of debt (Johnston and Holloway, 2007).

The fuel industry in Ghana is run by the state. There are some measures that the Ghanaian government is considering to promote the use of biofuels. According to

Caminiti et al. (2007), there is a particular interest in the creation of a domestic biodiesel industry in Ghana, with primary reasons including the desire for economic growth, fuel security, a potential increase in employment and climate change mitigation. When it comes to feedstock for biodiesel, the government is interested in promoting jatropha and palm oil (Caminiti et al., 2007). This thesis will focus on the latter due to the abundance of oil palm fields in the case study area.

The draft policy “Bioenergy policy for Ghana” mandates to substitute national petroleum fuels consumption with biofuel in the amount of 10 % by 2020 and 20 % by 2030 (Energy Commission, 2010). It has to be noted that this policy is currently a draft and is subject to change before its final approval as legislation (Caminiti et al., 2007). Another objective of the policy is to remove institutional barriers in order to promote private sector participation in the biofuel industry (Energy Commission, 2010). The policy also discusses zero corporate tax for 10 years for companies involved in feedstock production with labor-intensive methods. Furthermore, the policy considers fiscal and tax incentives for the biofuel industry such as zero import duty and value added tax for 10 years on equipment for biofuel processing and income tax reliefs for 10 years of operation for biofuel companies (Energy Commission, 2010).

The goals presented in the draft policy are uncertain as there is no large scale production of biodiesel currently being undertaken anywhere in Ghana. Also, in spite of continuously increasing interests in organized biofuel production in Ghana, appropriate consultation across the whole supply chain for all stakeholders is not yet in place (Caminiti et al., 2007).

4.1.5.5 Palm oil as a feedstock for biodiesel

Palm oil is extracted from fruits of an oil palm tree. A palm bears its fruit in bunches, varying in weight from 10-40 kg (Poku, 2002). An individual fruit (6-20 g), is made up of an outer skin called exocarp, a pulp (mesocarp) and a kernel, which contains an oil different from palm oil, resembling coconut oil (Poku, 2002). Thus, two types of oil can be produced from an oil palm tree: palm oil and palm kernel oil.

The palm oil-winning process involves reception of fresh fruit bunches (FFB) from plantations, sterilizing and threshing of bunches in order to free palm fruits, mashing fruits and pressing out crude palm oil (Poku, 2002). Crude oil is then further treated, i.e. purified and dried for storage and export.

Oil palms are grown in many agricultural regions in Africa. Parameters for growing oil palms include: temperature of min. 20°C and max. 35°C; annual rainfall of min. 1,500 mm and max. 3,000 mm and soil pH of min. 4.5 and max. 6.0 (FAO, 2011b).

The energy balance expressed by the ratio of energy output to input is wider for oil palm than other commercially grown oil crops (Wood and Corley, 1993). In addition, oil palm has a competitive oil yield per hectare compared to other vegetable oil crops.

Oil palm in Ghana

Oil palm is one of the most important industrial crops in Ghana. The production trend for oil palm in Ghana has been increasing for the past years (Ministry of Food and Agriculture, 2010). In 2009, Ghana, with the production of 130,000 metric tons of palm oil, was among the top twenty palm oil producing countries (FAO, 2009a)[51]. Climatic conditions in the country allow producing up to 2,500 liters of vegetable oil per ha annually (Adamtey, 2005). However, such a good yield can only be reached with proper fertilization methods and good management of oil palm plantations. Most of the small scale plantations in Ghana have a current annual yield of about 1,000 liters of oil per hectare (Adamtey, 2005). In order to improve the yields, sustainable soil fertility has to be reached. However, many farmers do not apply mineral fertilizers due to economic hardships (Cofie and Mainoo, 2007). Thus, applying urine as fertilizer can help to solve this problem. Fertilization of oil palm with urine for biodiesel production will not face the risk of rejection by society as is probable in the case of fertilization of land used to cultivate edible crops.

Fertilization needs of oil palm trees

In order to estimate how much urine should be applied to satisfy the fertilization needs of oil palms, it is required to study their fertilization needs. The estimated fertilization needs of an oil palm tree, as indicated by Dr. Ofosu-Budu[52] and cited in Martinez Neri (2009), are presented in Table 4.9. Based on the data in Table 4.9, the amount of nitrogen, phosphorous and potassium required to meet the fertilization needs of each palm tree was calculated (see Table 4.10).

Table 4.9: Fertilization needs of one oil palm tree

Year	NPK 16-16-16 (kg/tree)	Organic NPK 3-2-13 (kg/tree)	NPK 12-17-2 (kg/tree)
1st	0.75	3.0	-
2nd	1.00	6.0	-
3rd	1.50	6.0	-
4th and above	-	6.0	1.5

Table 4.10: Amount of nutrients required to meet fertilization needs of one oil palm tree

Year	Nitrogen (kg/tree)	Phosphorous (kg/tree)	Potassium (kg/tree)
1st	0.21[a]	0.18	0.51
2nd	0.34	0.28	0.94
3rd	0.42	0.36	1.02
4th and above	0.36	0.38	0.81

a) Calculation example: 0.75 kg N/tree×0.16 kg N + 3 kg N/tree×0.03 kg N = 0.21 kg N/tree

Considering nutrients contained in urine in Ghana (see Table 4.4), the equivalent amount of urine necessary to meet the nutritional requirements of each oil palm tree was calculated (see Table 4.11).

51 The biggest producers of palm oil in 2009 were Indonesia (20.6 million Mt), Malaysia (17.6 million Mt), Nigeria (1.4 million Mt), Thailand (1.3 million Mt) and Colombia (0.8 million Mt) (FAO, 2009a).

52 Senior researcher at the Agricultural Research Station (ARS) of the University of Ghana in Kade, Kwaebibirem District.

Table 4.11: Amount of urine required to meet nutritional requirements of one oil palm tree

Year	Nitrogen (l/tree)	Phosphorous (l/tree)	Potassium (l/tree)
1st	42	263	223
2nd	68	409	412
3rd	84	525	447
4th and above	72	547	355

If urine (after required storage) is to be used to satisfy phosphorus and potassium needs, nitrogen requirements of an oil palm tree will be exceeded. If urine is applied to satisfy nitrogen nutritional requirements of oil palm trees, only 13 % of the phosphorous and 20 % of the potassium nutritional requirements will be met (see Table 4.11). Poultry manure, which is rich in phosphorous (2.90 % P_2O_5) and potassium (2.35 % K_2O) (Roy, 2006) can complement the fertilization of oil palms in order to avoid potential waste of nitrogen. Also, composted urban material is rich in phosphorous (1.0 % P_2O_5) and potassium (1.5 % K_2O) (Roy, 2006). Oil palm empty fruit bunches (EFB) rich in potassium (Corley and Tinker, 2003) can also be used to complement the fertilization of oil palms. The mean content of EFB is as follows (dry matter basis): 0.8 % N, 0.22 % P_2O_5, 2.90 % K_2O (Gurmit et al., 1999 cited in Corley and Tinker, 2003).

4.1.5.6 Biodiesel production costs

The estimated costs of producing biodiesel from crude palm oil, following the method proposed by Alkabbashi et al. (2009), are presented in Table 4.12. The optimal conditions studied by Alkabbashi et al. (2009) include: KOH (1.4 wt %) as a catalyst, 1:10 mass ratio of methanol to oil and 60 minutes reaction time at 60°C. The expected yield is about 93 %, resulting in 10.23 liters of biodiesel and a final value of 0.86 GH¢/l. Considering the price of diesel in Ghana (1.27 GH¢/l, see Table 4.8) and the ratio of 11:10 in order to obtain the same heat of combustion, the production of 11 liters of biodiesel would cost approximately GH¢ 9.5, whereas 10 liters of diesel cost GH¢ 12.7. Thus, biodiesel in this case is approximately 75 % of the price of ordinary diesel[53].

Table 4.12: Biodiesel production costs

Supply	Unit	Price (GH¢)	Quantity	Cost (GH¢)
Oil palm[a]	liter	0.82	10.00	8.200
Methanol[b]	liter	0.53	1.00	0.530
Catalyst[c]	kg	0.62	0.14	0.087
Total				**8.817**

[a)] Source: GOPDC, August 2008; [b)] Source: Tin-Global Ltd., September 2008; [c)] Source: Tianjin Chemicals Co. Ltd, September 2008 cited in Martinez Neri, 2009.

The demand for diesel in Ghana is very high so production of biodiesel should be able to provide financial benefits. The cost of a small-scale biodiesel plant with a capacity of 800 liters of biodiesel/day is approximately GH¢ 1,600 (Martinez Neri, 2009).

[53] Source for the price for ordinary diesel in Ghana: ARS, average price 09.2008-09.2009 cited in Martinez Neri (2009).

4.1.6 Fast growing trees for fuel wood

As presented in the introduction (see Section 4), the supply chain discussed in this chapter proposes fertilizing fast growing trees with urine for fuel wood production. Therefore, this section discusses the most important issues regarding short rotation trees.

Almost 54 % of the households in Ghana use wood and 31 % use charcoal as a source of cooking fuel (Ghana Statistical Service, 2008b). In urban areas, almost 19 % and in rural areas, about 80 % of the households still use wood for cooking (Ghana Statistical Service, 2008b). Charcoal use for cooking, on the other hand, is more popular in urban areas (53 %) than in rural areas (31 %) (Ghana Statistical Service, 2008b).

Optimal climatic and soil conditions for a selection of fast growing trees is presented in Table 4.13. The photographs of these tree species can be found in Appendix D.

Table 4.13: Optimal climatic and soil conditions for a selection of fast growing tree species (FAO, 2011b)

Tree species	Temperature (°C)	Rainfall (mm/year)	Max. altitude (m)	Soil pH
Cassia siamea	23-33	650-1,500	1,400	5.5-6.5
Gliricidia sepium	15-30	1,200-2,300	1,600	5.5-6.2
Leucaena leucocephala	20-32	600-3,000	2,100	6.0-7.7
Casuarina equisetifolia	20-35	700-3,500	1,500	5.0-6.5
Gmelina arborea	22-34	1,500-2,500	2,100	5.0-6.0

Mainoo and Ulzen-Appiah (1996) studied growth, wood yield and energy characteristics of *Leucaena leucocephala*, *Gliricidia sepium* and *Cassia siamea* and they concluded that *Cassia siamea* was the best performing species in terms of total fresh wood volume at age of 4 years (and dry wood biomass) and wood energy production per hectare. *Leucaena leucocephala*, on the other hand, was ranked better in terms of fuel burning quality expressed as Fuelwood Value Index (FVI) (Mainoo and Ulzen-Appiah, 1996). Wood with higher lignin content and specific gravity has a higher calorific value, as in the case of *L. leucocephala* (see Table 4.14). Mainoo and Ulzen-Appiah (1996) concluded that among the studied three tree species, *C. siamea* can be a better choice for fuel wood plantation establishments due to its heat energy productivity.

Table 4.14: Fuel wood characteristics of L. leucocephala, G. sepium and C. siamea (adapted from Mainoo and Ulzen-Appiah, 1996)

Characteristics	Tree species		
	L. leucocephala	*G. sepium*	*C. siamea*
Calorific value[a] (kJ/kg)	19,677	19,117	18,744
Specific gravity	0.69	0.67	0.64
Moisture content (%)	39.3	62.3	45.8
Fuel wood Value Index	2,488	1,255	1,327
Lignin content (%)	31.6	26.8	21.7
Energy production[b] (kJ/ha)	761×10^6	770×10^6	$1,611 \times 10^6$

[a)] Calorific value of fuel wood was calculated as gross calorific value

[b)] "The product of component dry wood yields per hectare and the respective calorific value was determined as energy production" (Mainoo and Ulzen-Appiah, 1996, p.71).

Ranking of selected tree species for fuel wood production according to fuel wood yield and average rotation period is presented in Table 4.15.

Table 4.15: Ranking of selected tree species for fuel wood production

Characteristics	Tree species				
	C. siamea	*G. sepium*	*L. leucocephala*	*C. equisetifolia*	*G. arborea*
Trees planted per ha	3,333-10,000[a]	2,500-3,333[b]	5,000-10,000[c]	2,500[d]	2,500[c]
Fuel wood yield (t/ha)	86.15[e]	40.92[e]	39.30[e]	75.00[d]	12.50[b]
Average rotation period (years)	4.0[e]	4.0[e]	4.0[e]	8.5[d]	7.5[f]
Calorific value (kJ/kg)	18,744[e]	19,117[e]	19,677[e]	20,711[g]	19,560-20,539[g]
Fuel wood value[h] (GH¢/year)	8,615	4,092	3,930	7,500	1,250
Rank	1	2	3	4	5

a) World Agroforestry Centre, 2011; b) Ryan, 1994; c) Kannan and Paliwal, 1995; d) National Academy of Sciences, 1980; e) Mainoo and Ulzen-Appiah, 1996; f) Hossain, 1999; g) Webb, 1984; h) Fuel wood value was calculated by multiplying the fuel wood yield with the cost of fuel wood in Accra (100 GH¢/t, as reported by Martinez Neri, 2009).

From the profit generating perspective, *C. siamea* is the best alternative among the examined tree species for establishing of a short rotation plantation for fuel wood production (see Table 4.15). *C. siamea* has the best wood production yield and a short rotation period. The fuel wood and charcoal of *C. siamea* is highly regarded due to its high calorific value, but the wood produces a lot of smoke (Forestry/Fuelwood Research and Development Project, 1994). Roots of this tree grow to a considerable depth so they should not be planted in areas with low groundwater table (FAO, 2011b).

G. sepium and *L. leucocephala* also have a short rotation period, but their fuel wood yield is lower than that of *C. siamea*. The wood of *G. sepium* burns slowly with little smoke (World Agroforestry Centre, 2011). *C. equisetifolia* has an excellent fuel wood yield but a long rotation period, whereas *G. arborea* has poor fuel wood yield and a long rotation period. The wood of *C. equisetifolia* burns with great heat and is often referred to as the best firewood in the world (National Academy of Sciences, 1980).

4.2 Case study Accra

The following sections present three case studies: “Accra 1”, “Accra 2” and “Kade”. Two project alternatives, “Accra 1” and “Accra 2”, propose application of urine as fertilizer on oil palm trees and maize plants. These two projects focus on public male urinals located in the center of Accra (Ghana), where urine can be collected and then possibly sold to farmers. The project “Kade” considers fertilization of oil palms and fast growing trees with urine collected from a urine diverting dry toilet complex that would be located in Kade.

The general supply scheme of the projects is presented in Figure 4.3. The three projects propose production of biodiesel, maize and fuel wood, running trucks on biodiesel and exploiting truck cargo capacity for other industry related services (e.g., transportation of biodiesel, fuel wood, oil palm fresh fruit bunches, poultry manure, etc.) as well as reducing urine storage costs. Table 4.16 summarizes the boundaries for the three proposed projects.

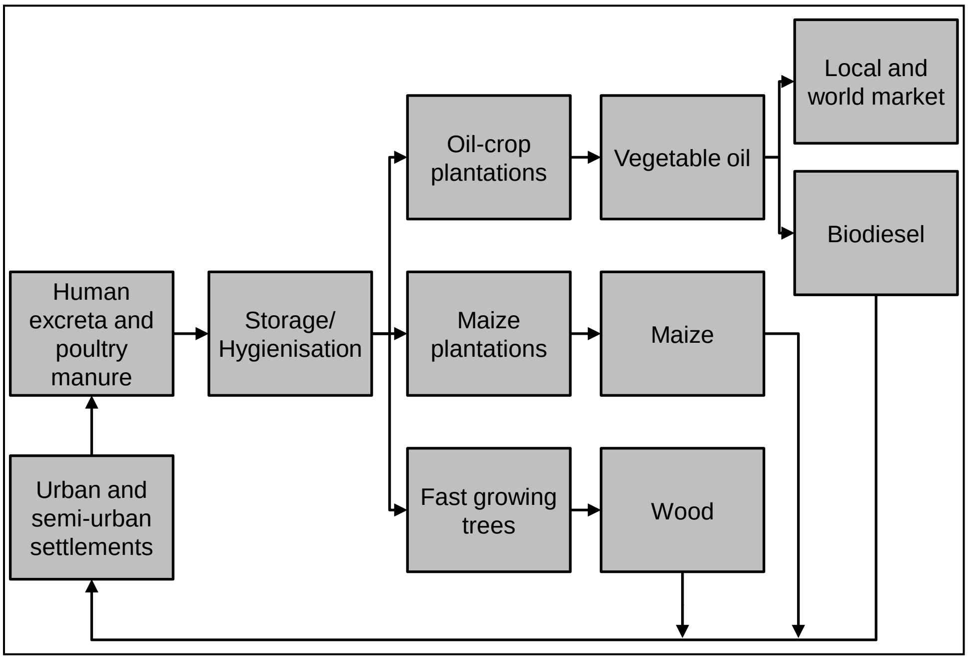

Figure 4.3: *General supply scheme for case studies in Ghana*

Table 4.16: Project boundaries for "Accra 1", "Accra 2" and "Kade"

Urine collection	Accra 1	Accra 2		Kade	
Location:	Accra (CBD[a])	Accra (CBD[a])		Kade (ARS[b])	
Sanitation facilities:	Public urinals	Public urinals		UDDT[c] complex	
No. of urinals:	14[d]	14[d]		2	
No. of UDDTs:	n.a.	n.a.		6	
Urine volume (l/d):	7,000	7,000		250	
Urine storage	**Accra 1**	**Accra 2**		**Kade**	
Location:	Nsawam	Nsawam	Accra (maize farms)	Kade (ARS)	
Transported volume of urine (l/month):	212,900	28,000	185,000	n.a.[e]	
Transportation route:	Accra (CBD)-Nsawam	Accra (CBD)-Nsawam	Accra (CBD)-Accra (maize farms)	n.a.[e]	
Trip distance (km):	40	40	15	n.a.[e]	
Trip frequency (times/month):	30	4	26	n.a.[e]	
Storage duration (months):	1	1	6	1	
No. of storage bladders:	7	1	37	1	
Urine application	**Accra 1**	**Accra 2**		**Kade**	
Location:	Nsawam	Nsawam	Accra (maize farms)	Kade (ARS)	
Urine application:	Oil palms	Oil palms	Maize	a. Oil palms; b. Fast growing trees	
Field size (ha):	Abundant[f]	Abundant[f]	680[g]	a. 200; b. 1 ha planted p.a.	
Transportation efficiency	**Accra 1**	**Accra 2**		**Kade**	
Location:	Nsawam	Nsawam	Accra (maize farms)	Kade (ARS)	Kade (ARS)
Transported good:	Poultry manure	Poultry manure	n.a.[h]	Biodiesel	Fresh fruit bunches
Transported amount:	30 t/month	30 t/month	n.a.[h]	23,400 l/month	375 t/month
Transportation route:	Nsawam-Accra (urban farms)	Nsawam-Accra (urban farms)	Accra (maize farms)-Accra (CBD)	Kade (ARS)-Accra	Kade (ARS)-Kwae (GOPDC[i])
Trip distance (km):	40	40	15	115	25
Trip frequency (times/month):	30	4	26	3	54[j]
Application[g]:	a. maize; b. vegetables; c. mixed	a. maize; b. vegetables; c. mixed	n.a.[h]	Vehicles	Oil palm mills
Field size[g] (ha):	a. 680; b. 47; c. 251	a. 680; b. 47; c. 251	n.a.[h]	n.a.	n.a.

a) CBD – Central Business District in Accra
b) ARS – Agricultural Research Station of the University in Ghana in Kade
c) UDDT – urine -diverting dry toilet
d) Urinals are first modified for urine collection
e) Urine is collected, stored and applied at ARS, so no transportation is required
f) The information on the exact size of oil palm plantations in Nsawam is not available
g) Source: Kufogbe et al., 2005 cited in Obuobie et al., 2006
h) It is assumed that nothing is transported on the way back from maize farms
i) GOPDC- Ghana Oil Palm Plantation Development Company located in Kwae
j) Transportation is carried out by two trucks, payload: 7 t/truck

4.2.1 Introduction to Accra

Accra is the capital of Ghana and the most populated city in the country, which is located in the Greater Accra Region. The Greater Accra Region is divided into ten districts, which include Accra Metropolitan, Adentan Municipal, Ashaiman Municipal, Dangme East, Dangme West, Ga East, Ga South, Ga West Municipal, Ledzokuku-Krowor and Tema Municipal (Ghana Districts, 2006). In 2007, the Greater Accra Metropolitan Area (GAMA), which comprises Accra Metropolitan Area (AMA), Tema Municipal Area (TMA), and urban areas in Ga East and Ga West Districts, had an estimated population of 3.9 million inhabitants (Ghana Statistical Service, 2008a; Ghana Statistical Service, 2008b).

Public toilets are used by over 40 % of the households in GAMA (see Table 4.17) (Ghana Statistical Service, 2008b). Most of the urinals and public toilets in Accra are privately owned (Cofie et al., 2011) and users are charged GH¢ 0.20 for using a toilet and GH¢ 0.05 for urinals (Martinez Neri, 2009). At the same time, a large percentage of households in Dangme East (53.1 %) and Dangme West (43.8 %) Districts practice open defecation (Ghana Districts, 2006). According to Cofie et al. (2011), as much as 95 % of the population in Accra uses on-site sanitation (public toilet, bucket latrine or septic tank) as primary sanitation facilities.

Table 4.17: Type of toilet facility used by households in Accra (GAMA) and other urban areas of Ghana (Ghana Statistical Service, 2008b)

Utility	Accra (GAMA) (%)	Other urban (%)	Overall urban (%)
Flush toilet	33.2	16.7	22.2
Pit latrine	5.0	21.0	15.7
KVIP[54]	15.8	13.8	14.4
Pan/bucket	3.2	2.3	2.6
Public toilet (flush/bucket/KVIP)	41.3	37.5	38.7
Toilet in another house	0.4	1.3	1.0
No toilet facility (bush, beach)	1.1	7.4	5.3
Other	0.0	0.1	0.0

4.2.2 Project "Accra 1"

Cofie and Mainoo (2007) investigated fourteen public urinals in the Central Business District (CBD) in Accra and estimated that they generate almost 7,300 liters of urine per day. The public urinals in the CBD generate different volumes of urine, varying from 1,100 to 120 liters per day. For detailed urine volumes generated at all fourteen public urinals see Appendix E.1. For further considerations in this thesis, the volume of 7,000 liters of urine per day will be used.

Entrepreneurs operating the urinals under the license of the municipality are obliged to pay for urine disposal. However, in practice, the urinals are commonly emptied into drainage polluting the receiving water body – Korle lagoon (Cofie and Mainoo, 2007; Tettey-Lowor, 2008; Cofie et al., 2011). One way of solving this problem could be modifying regular public urinals for urine collection (approx. 770 GH¢/urinal, see Section 4.1.2.2). Urine storage facilities could be located in a semi-urban settlement

[54] The Kumasi Ventilated Improved Pit (KVIP) is a twin-pit VIP latrine, which allows the contents of one pit to compost while the other pit is in use (Thrift, 2007).

called Nsawam, which is located approximately 40 km north of Accra and surrounded by oil palm fields.

In order to transport 7,000 l of urine per day, 24 plastic containers (container volume: 300 l/container) are needed on a heavy duty truck. Urine, after the required storage time of one month (see Section 4.1.3.1 for information on storage time of urine), will be used to fertilize oil palm farms in Nsawam. Seven plastic bladders will have to be purchased in order to accommodate the volume of urine collected in one month. In order to avoid disturbances from heavy traffic in the capital of Ghana, the collection of urine from public toilets should be performed at night. In this case, when rush hours are avoided, the transportation of urine from Accra to Nsawam should take less than one hour.

The value of nutrients contained in 7,000 l of urine collected from public urinals in the CBD per day is estimated at GH¢ 100 (compare with Table 4.5). When comparing it to the estimated transportation costs at different distances (20-300 km) (see Figure 4.4), the maximum distance for which the transportation costs do not exceed the value of the nutrients contained in 7,000 l of urine is 212 km (round trip). The transportation costs include: the cost of fuel, truck maintenance, spare parts, driver's salary[55] and the amortization of the truck and pump per day (for transportation costs, see Appendix E.2). Data presented in Figure 4.4 assumes that the truck does not carry any cargo on its return trip.

The costs of urine storage in a plastic tank and in plastic bladders are also computed against the value of nutrients in urine. As previously discussed (see Section 4.1.3.2), storage of urine in plastic bladders is less expensive than in plastic containers. The maximum distance for which the transportation and storage costs (in plastic bladders) do not exceed the value of nutrients contained in 7,000 l of urine is 208 km (round trip) (for the market value of nutrients contained in urine in Ghana, see Table 4.5).

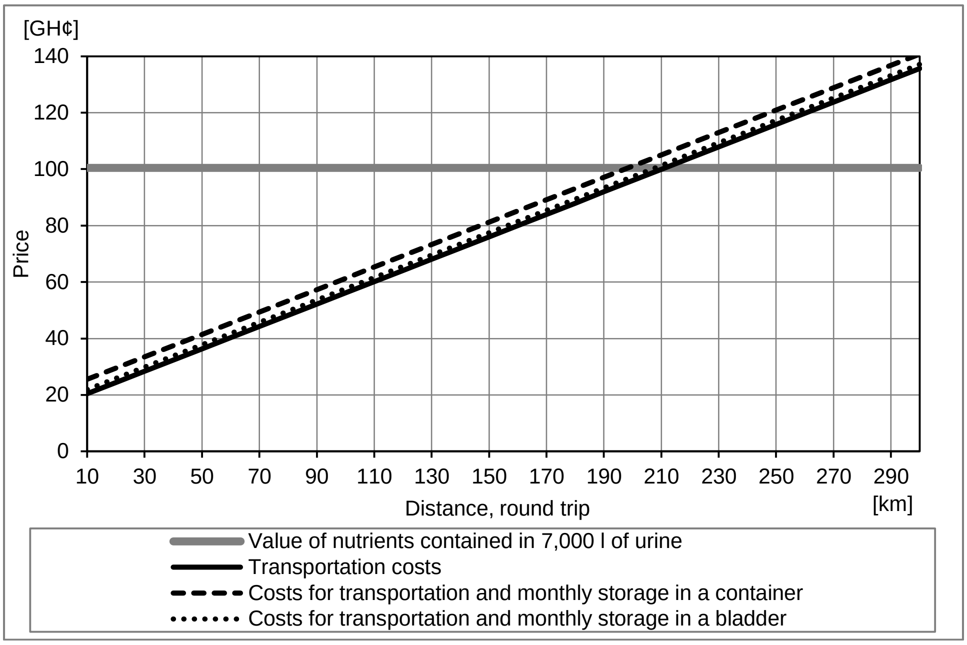

Figure 4.4: Value of nutrients in 7,000 l of urine vs. urine transportation and storage costs

[55] Assumption: loading and offloading of tanks with urine will be performed by an employee staffed at the Central Business District.

The important factor that needs to be considered is the willingness of oil palm farmers to pay for urine to be used as fertilizer. The average oil palm yield (expressed in fresh fruit bunches) in Ghana in 2002-2009 was 5.7 Mt/ha (calculated from data retrieved from Ministry of Food and Agriculture, 2010), whereas achievable yield in Ghana is 15 Mt/ha (Al-Hassan et al., 2008). Such a high yield can only be reached under favorable climate conditions, adequate fertilization and good management of the plantations. In 2002-2009, large oil palm plantations like Ghana Oil Palm Development Company (GOPDC) and Benso Oil Palm Plantation (BOPP) reached an average yield of 12.0 Mt/ha and 13.6 Mt/ha, respectively. However, the average yield of medium farms was 8.0 Mt/ha and of other private holdings only 5.0 Mt/ha (calculated from data retrieved from Ministry of Food and Agriculture, 2011). Many oil palm farmers do not fertilize their plantations due to high prices of mineral fertilizers, thus, fertilizing with urine could offer a viable alternative. Martinez Neri (2009) reported that both large and small scale oil palm producers are currently willing to find a reliable alternative to mineral fertilizers.

In order to achieve cost efficiency, a truck transporting urine from public urinals in Accra to storage facilities in Nsawam should utilize its cargo capacity on its return trip to Accra. One way of doing so is by transporting poultry manure from Nsawam to Accra. Poultry manure can be obtained from farms located in Nsawam and its vicinity. The possible arrangement of empty urine tanks on sacks filled with poultry manure on a truck on its return trip to Accra is presented in Figure 4.5.

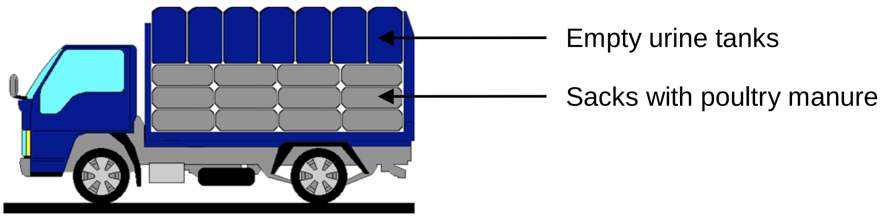

Figure 4.5: Possible truck arrangement for the trip Nsawam-Accra (adapted from Martinez Neri, 2009)

Tettey-Lowor (2008) reported that the consumption of poultry manure on urban farms in Accra is approximately 5 t/ha. Farmers ordering poultry manure pay 8 GH¢/t for a delivery and return trip to farms in Nsawam (Martinez Neri, 2009). Thus, a truck with a payload of 7 tons could generate up to approximately GH¢ 56 per return trip.

The availability of poultry manure in Nsawam is declining due to the fact that farmers have realized its fertilizing effect and they have been applying it on their vegetable farms. The amount of poultry manure available for sale in Nsawam is currently estimated to 30 t/month. Therefore, only a partial coverage of the urine transportation costs from Accra to Nsawam can be achieved[56].

Transportation service can also be offered to transport palm oil fresh fruit bunches (FFB) to oil palm mills and extracted palm oil to small scale biodiesel plants, which may be located in or around Nsawam in the future.

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[56] During the time of this study, this was the information provided from the local perspective. However, the local situation could be studied again in the future in order to find other potential cargo that needs to be transported from Nsawam to Accra.

4.2.2.1 Profitability of the project “Accra 1”

Refer to Section 3.2.2.2 for information on the calculation of net present value (NPV) and internal rate of return (IRR). Assuming that the project runs unchanged for five consecutive years and the nominal interest rate (*i*) is 25 % (typical interest rate on loans in Ghana[57]), the NPV would amount to over GH¢ 32,500 (see Table 4.19) and the nominal IRR would be 54 %. IRR is based on NPV and it is a special case of NPV, where the rate of return calculated is the interest rate corresponding to a zero NPV (refer to Section 3.2.2.2). The IRR was calculated with the built-in Microsoft Excel function, which seeks the IRR for net cash flows as presented in Table 4.19. Table 4.18 presents the data for the calculation of the NPV and the IRR. The NPV higher than zero and the IRR higher than the nominal interest rate (*i*) suggest that the project is expected to be profitable.

Table 4.18: Investment, operational costs and revenues of the project “Accra 1”

Investment	**Cost (GH¢)**	**Total (GH¢)**
Upgrading of 14 public urinals	10,850	
Equipped truck	29,550	
7 bladders for urine storage	4,200	**44,600**
Operational costs	**(GH¢/year)**	**Total (GH¢)**
Labor (1 employee)	2,750	
Fuel, truck labor and maintenance (Accra-Nsawam)	17,600	**20,350**
Revenues	**(GH¢/year)**	**Total (GH¢)**
Revenues from urine sold in Nsawam	36,650	
Revenues from poultry manure transportation	2,900	**39,550**

Table 4.19: Cash flow statement for the project “Accra 1” using current prices and nominal interest rate (inflation included)

Inflation factor $(1+0.16)^t$	**Year (t)**	**Investment (GH¢)**	**Recurrent Costs (GH¢)**	**Yearly Revenues (GH¢)**	**Net cash flow (GH¢)**	**Discount factor $1/(1+0.25)^t$**	**DNCF[a] (GH¢)**
1.00	0	-44,600			-44,600	1.00	-44,600
1.16	1		-23,606	45,878	22,272	0.80	17,818
1.35	2		-27,383	53,218	25,836	0.64	16,535
1.56	3		-31,765	61,733	29,969	0.51	15,344
1.81	4		-36,847	71,611	34,764	0.41	14,239
2.10	5		-42,743	83,069	40,327	0.33	13,214
						NPV	**32,550**

[a)] DNCF refers to discounted net cash flow

Table 4.19 shows the project’s cash flow statement in current prices. The average annual rate of inflation (consumer prices) for the years 2008-2010 in Ghana is approximately 16 % (World Bank, 2011a). Thus, recalculation of the project cash flows in constant prices and the real discount factor (*r*) has to be performed on a yearly basis (refer to Section 3.2.2.2). The real discount factor (*r*) is calculated according to Equation 3.4. The average expected annual rate of inflation (*p*) in Ghana is assumed to be 16 %. The nominal discount rate (*i*) is assumed to be 25 %, which is the nominal interest rate set by banks in Ghana. The NPV from constant and current prices should always be the same and they are. The real IRR is approximately 33 %. It is much higher than the real interest rate (*r*) of 8 %, which

[57] Source: pers. correspondence, D. van Rooijen, IWMI Ghana, 05.02.2010.

indicates that the project is expected to be profitable. For the net cash flows used to calculate the real IRR, refer to Appendix E.3.

4.2.2.2 Sensitivity analysis of the project "Accra 1"

Project income and expenditure is always subject to risk and uncertainty (Romijn and Balkema, 2009). Therefore, it is essential to assess the results in order to prove how sensitive they are to changes in cost and benefit items. Switching value presented in Table 4.20 refers to the change in a cash flow item that is required for the NPV to turn to zero. Switching values were calculated using the built-in Goal Seek function in Microsoft Excel[58]. Using this function, the variables presented in Table 4.20 were run through the Goal Seek function in order to find the value of the particular variable, for which the NPV would turn to zero.

Table 4.20: Current and switching value for selected variables for "Accra 1"

Variable	Current value (GH¢)	Switching value (GH¢)	Switching value (%)
Investment	44,600	77,150	73
Yearly labor cost urinals	2,750	10,861	295
Yearly cost truck	17,600	25,701	46
Yearly revenues from selling urine	36,650	28,549	-22
Yearly revenues from poultry manure transportation	2,900	-5,201	-279

It is important to highlight the significance of the monetary value of nutrients contained in urine. Without revenues generated from it, the NPV would be negative, i.e. the project would yield less than the market interest rate. A drop in revenues from nutrients contained in urine by 22 % would make the NPV equal to zero, which clearly shows how sensitive the project's profitability to this source of income is (see Table 4.20). This is, however, not so likely to happen as urine will be applied on non-food crops (oil palms). Oil-yielding crops belong to cash crops so their high harvest rates are of particular interest to farmers. However, if a poor economic situation of farmers does not allow them to pay for urine or if they are unwilling to apply urine on their farmlands, revenues will drop.

If the initial investment increases by 73 %, the NPV will also be equal to zero. However, this seems unlikely to happen as the estimates are based on market values of existing products. If the yearly truck costs increase by 46 %, the NPV will turn to zero. This is mainly dependent on the price of fuel, the driver's salary and truck maintenance costs. Due to the fact that the revenues from poultry manure transportation are not as significant as from the selling of urine, the project is not sensitive to the changes with regard to this particular variable. The same applies to the consideration of yearly labor costs for maintenance of public urinals, where an increase in labor costs by almost 300 % represents the switching value.

In order to consider factors that can affect transportation costs, a separate sensitivity analysis was performed. The results of this analysis are presented in Table 4.21. If the fuel price increases by 25 %, it will have a definite impact on the IRR (a decrease by 14 %) and NPV (a decrease by 29 %) of the project. A similar impact is seen if the

[58] When goal seeking, Microsoft Excel varies the value in one specific cell until a formula that is dependent on that cell returns the result one wants.

truck price increases by 25 %. If overall transportation costs (excluding the price of the truck) increase by 25 %, it will result in the IRR decreasing by 23 % and the NPV decreasing by 46 %. If, on the other hand, it is possible to decrease the transportation distance by 50 %, this will have a significant positive impact on both IRR (an increase by 34 %) and NPV (an increase by 72 %).

Table 4.21: Sensitivity analysis of variables of transportation costs for "Accra 1"

Variable	Assumption	Effect on nominal IRR	Effect on NPV
Fuel price	25 % increase	14 % decrease	29 % decrease
Truck price	25 % increase	17 % decrease	23 % decrease
Transportation costs[a]	25 % increase	23 % decrease	46 % decrease
Transportation distance	50 % decrease	34 % increase	72 % increase

[a)] It is assumed that all transportation costs with the exclusion of truck price increase by 25 %.

This analysis clearly shows that transportation costs are a significant constituent of the project's recurrent costs and if it is possible to store urine closer to the origin (its pick-up point), this should be done. Nevertheless, it should be highlighted that land in big cities is hardly available or, if available, it is leased for a considerable price. Therefore, an opportunity analysis always needs to be performed.

The effects of changes in investment, recurrent costs and revenues on the IRR and the NPV were studied (see Table 4.22). This analysis shows that small changes in investment and recurrent costs do not have a decisive effect on the IRR nor the NPV. The switching value for investment is high, which shows that the project is not very sensitive to this variable. The switching value for recurrent cost is lower than for investment, but it is still within a safety zone. When it comes to revenues, a 10 % decrease in revenues will have an effect on the IRR, but the IRR will still be much higher than the discount rate (25 %) and the NPV will still be well above zero. If revenues drop by 20 %, the project will not be profitable anymore (see the switching value for revenues in Table 4.22). This shows the sensitivity of the project when considering this variable, in particular to the revenues generated from selling urine. The previous analysis presented in Table 4.20 already proved the sensitivity of the project to revenues generated from the selling of urine. Therefore, the project requires that there is a demand for urine and that the farmers are willing to pay for the urine. Therefore, a well-planned promotional campaign should be carried out. For information on promoting ecosan in Ghana refer to Section 5.5.

Table 4.22: Effects on the IRR and the NPV of changing cash flow items for "Accra 1"

Cash flow item	Assumption[a]	Effect on IRR[b]	Effect on NPV	Switching value
Investment	10 % increase	6 % lower	14 % lower	73 % increase
Recurrent costs	10 % increase	7 % lower	25 % lower	40 % increase
Revenues	10 % decrease	13 % lower	49 % lower	20 % decrease

[a)] It is assumed that investment and recurrent costs increase by 10 % and revenues decrease by 10 %, and not by 25 % as in the case of transportation costs. This is due to the fact that these variables are costs of higher magnitude, i.e. transportation costs are only a fraction of recurrent costs.

[b)] nominal IRR

4.2.3 Project “Accra 2”

In the project “Accra 2“, it is also assumed that 7,000 l of urine is collected daily from fourteen public male urinals located in the Central Business District (CBD) in Accra (refer to Table 4.16 and to Section 4.2.2).

As in the project “Accra 1”, it is assumed that urine is transported to Nsawam (located approx. 40 km north of Accra) to be stored there for 1 month in plastic bladders, prior to being applied as fertilizer on oil palm fields. Due to the fact that there are many urban farms located in and around Accra, the collected urine could also be applied on, for example, maize farms located around the University of Ghana (Legon) (Kufogbe et al., 2005 cited in Obuobie et al., 2006), which is located approximately 15 km from the CBD. This area is located in the Ga East District. Average maize yield in 2010 in Ghana was only 1.7 Mt/ha, whereas under rain fed conditions it can reach up to 6.0 Mt/ha (Ministry of Food and Agriculture, 2011). Urine collected from CBD would be transported four times per month to Nsawam, and poultry manure would be transported on the return trip to Accra (30 t/month of poultry manure on a truck able to carry 7 tons). The rest of the month, urine collected from public urinals in CBD would be transported to maize farms in Accra.

According to the information provided in Table 4.23, the urine collected from public urinals in CBD would be enough to fertilize over 170 hectares of maize plantations. However, the risk of social rejection of fertilizing food crops with human urine needs to be considered. Fertilization with 64 kg N/ha, 38 kg P_2O_5/ha and 38 kg K_2O/ha in the Ga District in Ghana is the extension recommendation to achieve a yield of 2.5 t/ha, whereas the farmer’s practice yield is only 0.61 t/ha (IPNIS, 2011). Thus, applying the recommended nutrient amount, one could reach four times higher yields, which could result in farmers’ higher income. Taking into account the producer price for maize in Ghana (2009) of 545 GH¢/t[59] (FAO, 2009b), farmers could gain up to 1,000 GH¢/ha in revenues due to the 1.9 t/ha yield difference that could be achieved. By meeting the nitrogen nutritional requirements of maize plants, 52 % of the phosphorous nutritional requirements and 92 % of the potassium nutritional requirements will be met (refer to Table 4.4 for NPK content of urine in Ghana). Therefore, fertilization of maize plants needs to be complemented, in particular to meet the phosphorous nutritional requirements.

Table 4.23: Facts about fertilizing maize plants with urine in the Ga District, Ghana

Fertilization rate of maize plants[a]	64	kg N/ha*year
Maize yield[a]	2.5	t/ha
Application rate of urine on maize plants[b]	12,737	l/ha*year
Urine available from public urinals in CBD[c]	220,000,000	l/year
Maize plantation fed with collected urine	174	ha/year

a) Source: IPNIS, 2011.

b) Based on nutrient content of urine in Ghana (refer to Table 4.4).

c) The volume of urine available from public urinals in the Central Business District after subtracting the volume of urine transported to Nsawam 4 times per month.

[59] The price was converted from USD to GHS using the average exchange rate of 2009 from OANDA (2012).

4.2.3.1 Profitability of the project "Accra 2"

The investment, operational costs and revenues of the project "Accra 2" are presented in Table 4.24. Based on these variables, it was calculated that the project "Accra 2" will be able to reach the NPV of almost GH¢ 39,900 and the nominal IRR will be equal to 50 % (see Table 4.25). The IRR was calculated with the built-in Microsoft Excel function, which seeks the IRR for net cash flows as presented in Table 4.25. The real IRR using the cash flows in constant prices and the real discount rate (*r*) is 29 %, which is much higher than the real discount rate (*r*) (8 %). For the net cash flows used to calculate the real IRR refer to Appendix E.3.

Table 4.24: Investment, operational costs and revenues of the project "Accra 2"

Investment	**Cost (GH¢)**	**Total (GH¢)**
Upgrading of 14 public urinals	10,850	
Equipped truck	29,550	
38 bladders for urine storage	22,800	**63,200**
Operational costs	**(GH¢/year)**	**Total (GH¢)**
Labor (1 employee)	2,750	
Fuel, truck labor and maintenance (Accra-Nsawam)	2,300	
Fuel, truck labor and maintenance (around Accra)	8,850	**13,900**
Revenues	**(GH¢/year)**	**Total (GH¢)**
Revenues from urine sold in Nsawam	4,800	
Revenues from nutrients sold around Accra	31,850	
Revenues from poultry manure transportation	2,900	**39,550**

Table 4.25: Cash flow statement for the project "Accra 2" using current prices and nominal interest rate (inflation included)

Inflation factor $(1+0.16)^t$	**Year (t)**	**Investment (GH¢)**	**Recurrent Costs (GH¢)**	**Yearly Revenues (GH¢)**	**Net cash flow (GH¢)**	**Discount factor $1/(1+0.25)^t$**	**DNCF[a] (GH¢)**
1.00	0	-63,200			-63,200	1.00	-63,200
1.16	1		-16,124	45,878	29,754	0.80	23,803
1.35	2		-18,704	53,218	34,515	0.64	22,089
1.56	3		-21,696	61,733	40,037	0.51	20,499
1.81	4		-25,168	71,611	46,443	0.41	19,023
2.10	5		-29,195	83,069	53,874	0.33	17,653
						NPV	**39,868**

[a)] DNCF refers to discounted net cash flow

4.2.3.2 Sensitivity analysis of the project "Accra 2"

The project "Accra 2" will become unprofitable if the investment increases by 63 % and if the annual revenues from urine sold in Accra (to maize farmers) drop down by approximately 31 % (see Table 4.26). This proves that the project "Accra 2", just like project "Accra 1", is sensitive to this source of income.

Due to the small volume of urine sold in Nsawam, the project is not sensitive to this variable. Furthermore, yearly labor costs for maintenance of urinals would have to increase by over 360 % to turn the NPV to zero, which is also unlikely to happen.

Costs that are incurred for the transportation of urine to maize farms (within Accra) would have to increase by 112 % to turn the NPV to zero. These costs are dependent on fuel costs, truck maintenance costs and driver's salary. If these costs increase significantly, the costs of transportation of urine would have to be compensated, e.g., by carrying other cargo on the return trip. Income from transportation of poultry manure is not significant as it is mainly for transportation economy, so the project is not sensitive to this particular variable.

Table 4.26: Current and switching value for selected variables for "Accra 2"

Variable	Current value (GH¢)	Switching value (GH¢)	Switching value (%)
Investment	63,200	103,068	63
Yearly labor costs urinals	2,750	12,672	361
Yearly cost truck Nsawam	2,300	12,222	431
Yearly cost truck Accra	8,850	18,772	112
Yearly revenues from selling urine in Nsawam	4,800	-5,122	-207
Yearly revenues from selling urine in Accra	31,850	21,928	-31
Yearly revenues from poultry manure transportation	2,900	-7,022	-342

The sensitivity analysis of variables connected with transportation costs is presented in Table 4.27. Due to the short distance of transportation of urine from the CBD to maize farms (15 km) and a rare trip to transport urine from CBD to Nsawam (approx. 40 km), the project "Accra 2" is not very sensitive to the variables of transportation costs.

Table 4.27: Sensitivity analysis of variables of transportation costs for "Accra 2"

Variable	Assumption	Effect on nominal IRR	Effect on NPV
Fuel price	25 % increase	5 % decrease	11 % decrease
Truck price	25 % increase	13 % decrease	19 % decrease
Transportation costs	25 % increase	10 % decrease	21 % decrease
Transportation distance	50 % decrease	12 % increase	26 % increase

The effects of changes in investment, recurrent costs and revenues on the IRR and the NPV were also studied (see Table 4.28). Small changes in investment and recurrent costs do not have a significant effect on the IRR nor the NPV. Switching values for investment and recurrent costs are high. A 10 % decrease in revenues will have a significant effect on the IRR (a decrease by 10 %), but it will still be much higher than the discount rate and the NPV will still be well above zero. The switching value for revenues represents a decrease by 25 %, which again proves that the project is sensitive to the generation of revenues, in particular from the selling of urine in Accra (compare to Table 4.26).

Table 4.28: Effects on the IRR and the NPV of changing cash flow items for "Accra 2"

Cash flow item	Assumption	Effect on IRR[a]	Effect on NPV	Switching value
Investment	10 % increase	6 % decrease	16 % decrease	63 % increase
Recurrent costs	10 % increase	3 % decrease	14 % decrease	71 % increase
Revenues	10 % decrease	10 % decrease	40 % decrease	25 % decrease

[a)] nominal IRR

4.2.4 Comparison of “Accra 1” and “Accra 2”

The difference in investment in the project “Accra 2” (see Table 4.24) when compared to the project “Accra 1” (see Table 4.18) would be in the larger number of storage bladders which have to be purchased for the longer (6 months) storage time required in the case that urine is applied on maize farms (refer to Section 4.1.3 for considerations on urine storage).

Due to a shorter transportation distance of the urine, the operational costs of the project “Accra 2” (see Table 4.24) are almost 6,500 GH¢/year (over 30 %) lower than the ones of the project “Accra 1” (see Table 4.18). Revenues of the project “Accra 1” and “Accra 2” are the same due to the fact that the same volume of urine is collected and sold in both projects and the same amount of poultry manure is transported from Nsawam to Accra, for which a fee is collected.

Both projects (“Accra 1” and “Accra 2”) are sensitive to the revenues collected from the selling of urine (see Table 4.20 and Table 4.26).

The sensitivity analysis of variables connected with transportation costs showed that the project “Accra 2” (see Table 4.27) is less sensitive than the project “Accra 1” (see Table 4.21) to all variables analyzed. The project “Accra 2” already assumes the decrease in transportation distance of urine by transporting most of the collected volume to maize farms located only 15 km away from the Central Business District (CBD) and a rare trip to Nsawam located 40 km away from the CBD. Therefore, a further decrease in the transportation distance by 50 % has a much smaller effect on the IRR and the NPV than in the case of the project “Accra 1”.

The differences in results of the analysis of the effects of changes in investment, recurrent costs and revenues on the IRR and the NPV for the project “Accra 1” (see Table 4.22) and “Accra 2” (see Table 4.28) can be summarized as follows:

- Switching value for investment is 10 % higher for “Accra 1”.
- Switching value for recurrent costs is 31 % higher for “Accra 2”. Thus, the impact on the IRR and the NPV of a 10 % increase in recurrent costs is higher for the alternative “Accra 1”.
- Switching value for revenues is 5 % higher for “Accra 2”. Thus, the impact on the IRR and the NPV of a 10 % decrease in revenues is higher for the alternative “Accra 1”.

4.3 Case study Kade

This section presents the third proposed project – “Kade”, which encompasses urine collection from urine diverting dry toilets at the Agricultural Research Station (ARS) of the University in Ghana (Kade). This project does not assume selling of collected urine due to the fact that the urine will be applied on oil palm and fast growing trees plantations owned by the ARS. The project proposes production of fuel wood from fast growing trees and biodiesel from palm oil as well as running trucks on biodiesel and using them for the transportation of urine to its storage location (ARS’ plantations) and of fresh fruit bunches to oil mills.

4.3.1 Introduction to Kade

Kade is a semi-urban settlement located in the Kwaebibirem District, Eastern Region of Ghana, where most settlements lack improved sanitary facilities. Household sanitation includes pit latrines (40 %), KVIP (7 %) and flush toilets (3 %) (Ghana

Districts, 2006). Public toilets of any kind (pit latrines, KVIP and flush toilets) are used by 29 % of the population. The fee charged for using a public toilet is GH¢ 0.10 (Martinez Neri, 2009). Still, almost 4 % of the population in the district practices open defecation, over 2 % use a bucket or pan toilet and the same percentage use a facility in another house (Ghana Districts, 2006). Lack of adequate sanitation facilities poses severe health risks to people and negative consequences for the environment.

Agriculture is the biggest economic activity in the district (Ghana Districts, 2006). The largest oil palm mill in West Africa operated by Ghana Oil Palm Plantation Development Company (GOPDC) is located here. Altogether 40,000 ha of land in the district is cultivated with oil palm (Martinez Neri, 2009). Many agricultural problems, including soil erosion, deforestation, limited application of fertilizers, low level of modern agricultural technology and overdependence on the weather lead to usually low agricultural production rates of small scale farms (Ghana Districts, 2006).

4.3.2 Project "Kade"

The Agricultural Research Station (ARS) of the University in Ghana located in Kade needs to build a toilet complex for its dwellers (Martinez Neri, 2009). If a urine diverting dry toilet (UDDT) facility is built, collected urine can be used to help fertilize 200 ha of ARS' oil palm plantation that is currently not fertilized due to economic hardships.

There is a positive attitude of the population living in Kade towards ecosan (Martinez Neri, 2009). Thus, it can be expected that other villages and educational institutions in the district will follow suit when they recognize the advantages of the ecosan approach. Towns and villages in the vicinity of Kade, where urine could be collected, are located at a maximum distance of 8 km from each other, which would make urine collection and transportation cheap. Oil palm fields are also situated in the vicinity, making the storage of urine cost effective, assuming that it can be stored on the plantations.

ARS consumes over 10,000 liters of diesel per year, constituting an expenditure of almost GH¢ 13,000 (Martinez Neri, 2009). If a part of the harvested palm oil (fertilized with liquid urine) is converted into biodiesel, it could reduce their expenditure significantly. The opportunity cost of losing income from selling of palm oil is included in the considerations as the costs of biodiesel production take into account the cost of palm oil (refer to Table 4.12).

Urine can be used to fertilize oil palm trees. Considering that an average of 135 oil palms/ha are planted in the district, it would be necessary to apply over 9,700 liters of urine/ha to meet the nitrogen nutritional requirements of oil palm trees (see Table 4.11). As discussed in Section 4.1.5.5, by meeting the nitrogen nutritional requirements, only 13 % of the P and 20 % of the K nutritional requirements of oil palm trees will be met. Therefore, for example, poultry manure rich in phosphorus (Roy, 2006) and oil palm EFB rich in potassium (Corley and Tinker, 2003) can be used to complement the fertilization.

Fast growing trees for fuel wood production can also be fertilized using urine. Planting fast growing trees for fuel wood production can help minimize the problem of deforestation in Kade.

The climate and soil conditions in Kade (Ghana) allow for planting fast growing trees species such as Kassod tree (*Cassia siamea*), which was reported to have a wood production of approximately 86 t/ha after the short rotation period of four years and an excellent energy productivity (Mainoo and Ulzen-Appiah, 1996)[60]. Other tree species which can be considered for fuel wood production under the climatic and soil conditions found in Kade include: *Gliricidia sepium*, *Leucaena leucocephala*, *Casuarina equisetifolia* and *Gmelina arborea* (for detailed climatic and soil conditions see Table 4.13). The trees do not need extra irrigation as long as they are planted to coincide with the rainy season so that they can get rooted before the dry season.

In Accra, fuel wood transported from the Eastern Region has a value of 150 GH¢/t (Martinez Neri, 2009). Its transportation from the Eastern Region to Accra costs approximately 50 GH¢/t, so the cost of the wood alone is 100 GH¢/t (Martinez Neri, 2009). If urine is to be used to fertilize fast growing trees, the value of fuel wood harvested per hectare after four years will amount to approximately GH¢ 8,600[61] (see Table 4.15).

In fuel wood plantations of *Cassia siamea* spacing ranges from 1m x 1m to 1m x 3m, which can be translated to planting 3,350-10,000 trees per hectare (World Agroforestry Centre, 2011). On fertile land, fertilizer may not be necessary. However, on soils with moderate to low fertility, it is recommended to fertilize the area with nitrogenous fertilizer to increase seedling growth (Kannana and Paliwala, 1996). Depending on soil type, 100 kg-150 kg of NPK 15:15:15 can be applied per hectare to boost the initial growth (Tripathi and Psychas, 1992; Florido and Cornejo, 2002)[62]. Due to the high nitrogen content of urine, urine should be applied at a rate corresponding to the nitrogen requirements of Kassod tree. Thus, a need of approximately 15.0-22.5 kg of N/ha can be satisfied by approximately 3,000-4,500 liters of urine (see Table 4.4). The fertilization should be complemented with poultry manure or composted urban material (both rich in phosphorus and potassium) (Roy, 2006) or oil palm empty fruit bunches rich in potassium (Corley and Tinker, 2003). The rotation period of Kassod tree is as short as 4 years, i.e. it takes 4 years for the first wood harvesting. It is advisable to plant one hectare of the species each year for 4 consecutive years in order to ensure yearly harvesting of wood starting from the fourth year.

4.3.2.1 Profitability of the project "Kade"

The investment, operational costs and revenues which can be generated by the ARS are presented in Table 4.29. Variables for their calculation are presented in Table 4.30.

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[60] Trees were grown under natural conditions, no fertilizers were added and no extra irrigation was performed.

[61] It could be more, since the fuel wood yield for *Cassia siamea* was given for no fertilizer application. Thus, higher fuel wood yield can be expected.

[62] Due to missing literature on fertilizer recommendation for *Cassia siamea*, the fertilizer recommendation presented is based on the one for similar tree species, i.e. *Gmelina arborea* and *Leucaena leucocephala*.

Table 4.29: Investment, operational costs and revenues of the project "Kade"

Investment	**Cost (GH¢)**	**Total (GH¢)**
Biodiesel plant	1,600	
UDDT sanitation complex	5,500	
1 bladder for urine storage	600	
2 equipped trucks[a] (with 6 containers and water pump)	56,400	**64,100**
Operational costs	**(GH¢/year)**	**Total (GH¢)**
Labor (2 employees)	5,500	
Fuel, truck labor and maintenance (Accra-Kade)	4,300	
Fuel, truck labor and maintenance (FFB to GOPDC)	23,100	
Biodiesel production	251,650	**284,550**
Revenues	**(GH¢/year)**	**Total (GH¢)**
Revenues from biodiesel sales	281,000	
Revenues from transportation of FFB to GOPDC	47,250	**328,250**
Revenues from fuel wood sales, after 4th year	8,600	**336,850**

[a)] Truck 1: equipped with 6 containers (mainly for urine transportation) and a diesel-powered water pump to pump urine into containers; Truck 2: equipped with 22 containers (for biodiesel transportation). Both trucks are also used to transport fresh fruit bunches to oil palm mills.

Table 4.30: Variables for the calculation of investment, operational costs and revenues for "Kade"

Biodiesel plant capacity	800	l/day
UDDT sanitation complex users	500	people/day
Urine production[a]	0.5	l/person, day
Biodiesel transportation cost (Kade-Accra)	107	GH¢/round trip
Transportation radius, Kade-Accra, round trip	230	km
Frequency of biodiesel transportation	40	times/year
Cost of biodiesel production	0.86	GH¢/l
ARS' own biodiesel consumption	11,000	l/year
Biodiesel selling price	1.00	GH¢/l
Amount of FFB transported to GOPDC	4,500	t/year
Frequency of FFB transportation to GOPDC	645	times/year
FFB transportation cost (to GOPDC)	36	GH¢/round trip
Transportation radius to GOPDC, round trip	50	km
Price for transportation of FFB	11	GH¢/t

[a)] Own assumption based on literature review: Mann, 1976 cited in Aalbers, 1999; Heinss et al., 1998; Rauch et al., 2002; SuSanA, 2009. Due to the fact that it is not a household toilet facility, the volume of urine generated needs to be assumed to be less than found in the literature (approx. 40 % of the volume found in the literature was assumed).

Looking at the price for the transportation of poultry manure (see Section 4.2.2), it was assumed that the price for the transportation of FFB can be set at 11 GH¢/t. The transportation needs for FFB to GOPDC can be estimated to approximately 140,000 t/year[63], whereas a feasible assumption is to cover only about 3 % of the

[63] Based on the following information: GOPDC has 18,750 hectares of oil palm plantations at Kwae, of which the nucleus estate of 4,750 ha (Business in Ghana, 2011) has a yield rate of 12 t/ha (Ministry of Food and Agriculture, 2010), whereas the remaining 14,000 ha are outgrower and smallholder farms (Business in Ghana, 2011) with a yield rate of approximately 10 t/ha (pers. correspondence, I. Martinez Neri, 15.11.2010).

transportation needs as a lot of FFBs are already transported by independent carriers.

The calculated NPV (see Table 4.31) is positive (almost GH¢ 117,500) and the nominal IRR (89 %) is much higher than the nominal interest rate (*i*) (25 %), which suggests that the project is expected to be more profitable than the cost of financing it.

It is necessary to highlight the fact that the value of nutrients in urine collected from the UDDT complex is not included as monetary benefits in this profitability analysis. It was assumed that the urine would be used to fertilize fast growing trees and some area of the oil palm farm owned by the ARS.

The real IRR calculated using the cash flows in constant prices and the real discount rate (*r*) is 63 %, which is much higher than the real discount rate (*r*) (8 %). For the net cash flows used to calculate the real IRR refer to Appendix E.3.

Table 4.31: Cash flow statement for the project "Kade" using current prices and nominal interest rate (inflation included)

Inflation factor $(1+0.16)^t$	Year (t)	Investment (GH¢)	Recurrent Costs (GH¢)	Yearly Revenues (GH¢)	Net cash flow (GH¢)	Discount factor $1/(1+0.25)^t$	DNCF[a] (GH¢)
1.00	0	-64,100			-64,000	1.00	-64,100
1.16	1		-330,078	380,770	50,692	0.80	40,554
1.35	2		-382,890	441,693	58,803	0.64	37,634
1.56	3		-444,153	512,364	68,211	0.51	34,924
1.81	4		-515,217	594,342	79,125	0.41	32,410
2.10	5		-597,652	707,500	109,848	0.33	35,995
						NPV	**117,416**

[a)] DNCF refers to discounted net cash flow

4.3.2.2 Sensitivity analysis of the project "Kade"

The project is sensitive to the costs of producing biodiesel. If they rise by only 12 %, the NPV of the project will be equal to zero (see Table 4.32). The reason for this is the low price of biodiesel which has been set in order to offer a price advantage on the market. In order to alleviate the effects of production costs, the price of biodiesel could be increased in order to secure a considerable income or a biodiesel plant with a larger production capacity could be built instead. Furthermore, ARS consumes a considerable amount of produced biodiesel. If not enough revenue is generated from the sales of biodiesel (down by 10 %), the project will not be profitable any longer. The sensitivity analysis proves that the project will fail in case the demand for biodiesel is not in place or if the cost of producing biodiesel rises and the selling price remains the same.

Table 4.32: Current and switching value for selected variables for “Kade”

Variable	Current value (GH¢)	Switching value (GH¢)	Switching value (%)
Investment	64,100	181,516	183
Yearly labor costs	5,500	34,721	531
Yearly truck cost for biodiesel	4,300	33,521	680
Yearly truck cost for FFB	23,100	52,321	126
Yearly biodiesel production costs	251,650	280,871	12
Yearly revenues from biodiesel	281,000	251,779	-10
Yearly revenues from wood sales (after 4th year)	8,600	-162,003	-1,984
Yearly revenues from transportation of FFB to GOPDC	47,250	18,029	-62

If yearly costs of transportation of FFB to GOPDC increase by 126 % and if the revenues from transportation of FFB to GOPDC go down by 62 %, the project’s NPV will be equal to zero.

The project is not sensitive to the labor costs and costs incurred for the transportation of biodiesel as the transportation frequency is low (40 times a year). Also, the sales of fuel wood can only start after the rotation period of Kassod tree, which takes approximately four years. Thus, the project is not sensitive to this variable.

A more detailed analysis of variables connected to transportation costs was performed and the results are presented in Table 4.33. Due to the fact that revenues from transportation of FFB constitute a significant part of the project’s income, the revenue variable is sensitive to different variables of transportation costs.

Table 4.33: Sensitivity analysis of variables of transportation costs for “Kade”

Variable	Assumption	Effect on nominal IRR	Effect on NPV
Fuel price	25 % increase	7 % decrease	11 % decrease
Truck price	25 % increase	18 % decrease	12 % decrease
Transportation costs	25 % increase	13 % decrease	19 % decrease
Transportation distance	50 % decrease	18 % increase	28 % increase

Analyzing the effects of 10 % changes in investment, recurrent costs and revenues on the IRR and the NPV values leads to two conclusions. First of all, the project “Kade” is highly sensitive to a decrease in revenues (see Table 4.34). If revenues turn out to be 11 % lower than assumed, the project will turn unprofitable (the NPV will be equal to zero and the IRR will be lower than the discount rate). Even though the project’s NPV is positive, it is not advisable to implement this project unless realistic measures can be taken to reduce the risk of an unfavorable revenue scenario. Secondly, the project is designed to be self-sustaining (i.e. to cover its operational costs with a small surplus), and therefore, it is also sensitive to the change in recurrent costs. If these costs increase by a bit more than 10 %, the NPV will be equal to zero and the IRR will be lower than the discount rate. On the other hand, the project’s switching value with regard to the investment is considerably high. It can be attributed mainly to the fact that the project’s initial investment is rather low.

Table 4.34: Effects on the IRR and the NPV of changing cash flow items for "Kade"

Cash flow item	Assumption	Effect on IRR[a]	Effect on NPV	Switching value
Investment	10 % increase	8 % decrease	5 % decrease	183 % increase
Recurrent costs	10 % increase	62 % decrease	97 % decrease	c. 10 % increase
Revenues	10 % decrease	74 % decrease	113 % decrease	11 % decrease

a) nominal IRR

4.4 Interaction of projects "Accra 1", "Accra 2" and "Kade"

The two supply chains proposed[64] are designed to interact with each other. Figure 4.6 and Figure 4.7 summarize the supply chains discussed.

If other villages and educational institutions in the Kwaebibirem District install UDDTs in the future, a heavy duty truck can be used to collect and transport urine from UDDTs to its storage location and to transport other cargo within the area. There is a lot of transportation service required in the district, including fresh fruit bunches (FFB) to oil mills, poultry manure from farms to oil palm fields, oil palm and other tree seedlings[65] to other areas in Ghana as well as supplies for biodiesel production, once biodiesel plants are installed. The truck can also transport fuel wood obtained from fast growing trees in Kade. If a large scale biodiesel processing plant is built in Kade in the future, biodiesel could also be transported to Accra and, on the return trip, supplies (alcohol and catalyst) for biodiesel production could be transported.

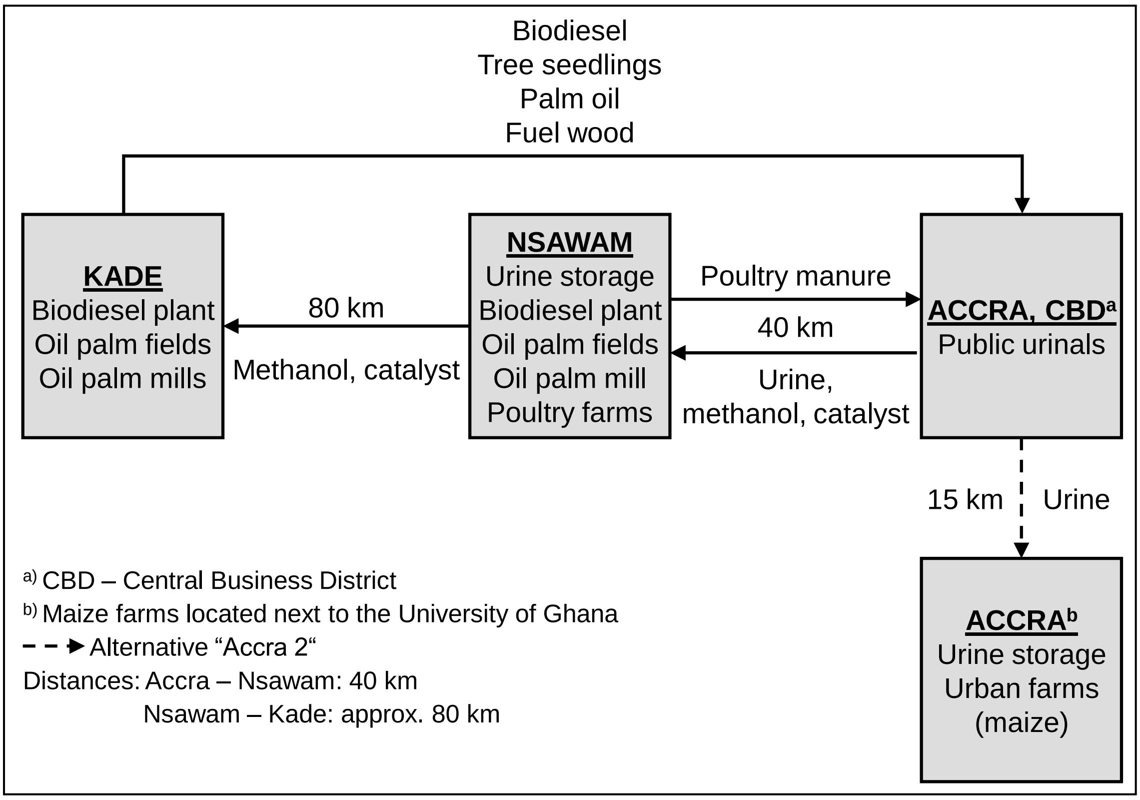

Figure 4.6: Supply chain: Kade-Nsawam-Accra

64 "Accra 1" and "Accra 2" are considered as two alternatives of one supply chain.

65 The ARS nurses various tree seedlings, which are then transported to different locations in Ghana (Martinez Neri, 2009).

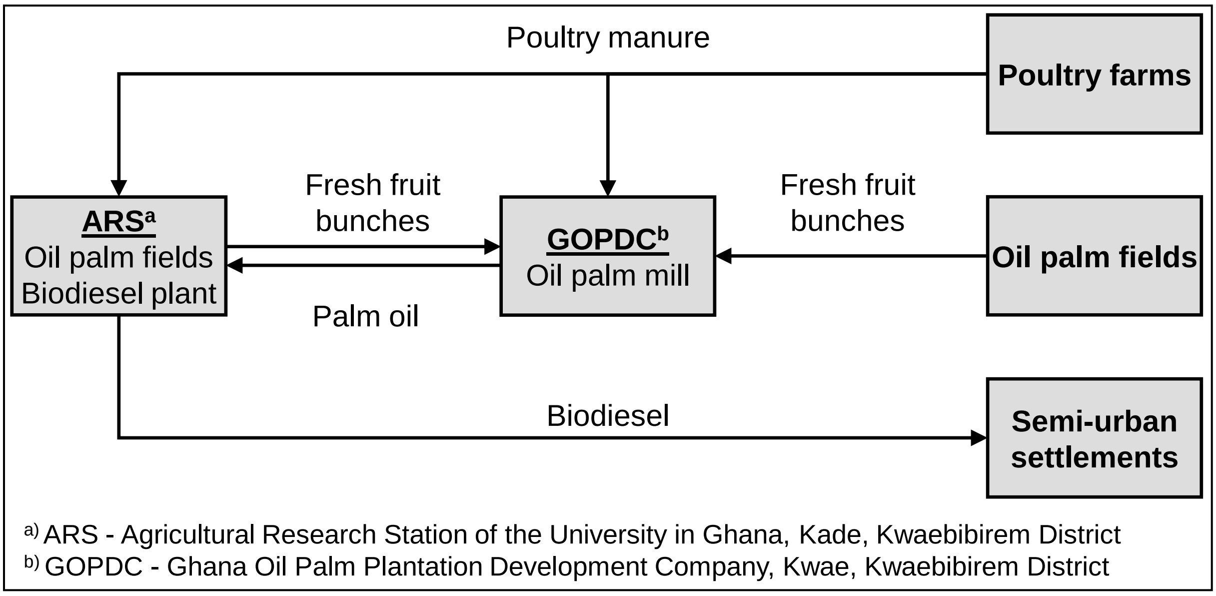

Figure 4.7: Supply chain: Kade-Kwaebibirem District

4.5 Further discussion

The profitability of the project, expressed as the NPV, IRR and PBP, proved that they are all expected to be financially profitable (refer to Table 4.35). The two alternatives for the project in Accra show that a higher NPV can be reached if urine is sold to maize farmers due to the proximity of maize farms to the Central Business District (urine pick-up point). However, the risk of social rejection when applying urine on land used to cultivate edible crops needs to be taken into account. A previous study showed that farmers have restricted acceptance towards excreta in general and its reuse in agriculture (Schröder, 2010). A recent study in Ghana revealed that consumers were willing to purchase vegetables fertilized with human urine, however, they were concerned about the possible health effects of their consumption (Koomson, 2010 cited in Cofie et al., 2011). The same study concluded that farmers with a positive perception of the quality of urine will be willing to apply it on their vegetable farms and it is more probable for young than old farmers to fertilize with urine.

The project “Accra 2” has a lower IRR value than that of the project “Accra 1” (refer to Table 4.35) due to the larger investment that has to be made in order to accommodate the longer storage time required for urine when it is to be applied on land used to cultivate food crops. Higher NPV and IRR values for the project “Kade” result from much higher revenues than in the projects “Accra 1” and “Accra 2”. Also, for the project “Kade”, a relatively low investment is required, which is mirrored in the payback period of 1.5 years.

Table 4.35: Comparison of projects "Accra 1", "Accra 2" and "Kade"

Variable	"Accra 1"	"Accra 2"	"Kade"
NPV (GH¢)	32,600	39,900	117,500
Real IRR	33 %	29 %	63 %
Nominal IRR	54 %	50 %	89 %
PBP (years)	2.3	2.5	1.5
Risk of social rejection	no	yes	no
Income from:	- urine as fertilizer - transportation of poultry manure	- urine as fertilizer - transportation of poultry manure	- biodiesel - fuel wood - transportation of FFB
NPV=0, if:			
investment increases by	73 %	63 %	183 %
transportation costs increase by	46 %	112 %[a]	126 %[b]
biodiesel production costs increase by	n.a.	n.a.	12 %
revenues from nutrients decrease by	22 %	31 %[a]	n.a.
revenues from biodiesel decrease by	n.a.	n.a.	10 %
revenues from transportation decrease by	negligible	negligible	62 %
If project's lifetime extended from 5 to 8 years:			
NPV increases by	105 %	115 %	79 %

a) These values refer to the transportation costs to urban maize farms (Accra) and revenues from nutrients collected from urban maize farmers. The switching values for transportation costs to Nsawam and revenues from urine sold in Nsawam are very high, hence negligible.

b) The value refers to transportation costs of FFBs.

The sensitivity analyses for the projects "Accra 1" and "Accra 2" proved that the revenues from nutrients contained in collected urine play an important role to the project's profitability (see Table 4.35). Nevertheless, the alternative "Accra 2" is less sensitive to the decrease in revenues from the selling of urine and to the increasing transportation costs. It is important to highlight the influence of fertilizer price fluctuations on the value of nutrients contained in urine (refer to Section 4.1.1 for the calculation of the value of nutrients contained in urine). Another important variable in this context is the nutrient composition of urine. This differs with the type of the diet (it may not only vary between countries but also between individuals), the digestibility of this diet (digested nutrients will be excreted with urine, whereas undigested nutrients with feces), the volume of consumed liquids or the level of sweating (excessive sweating will result in concentrated urine, whereas consumption of large volumes of liquids in diluted urine) (Jönsson et al., 2004; Jönsson and Vinnerås, 2004; WASTE, 2005).

The project "Kade" is highly sensitive to both the cost of biodiesel production and to the demand for biodiesel. Also, the demand for transportation of FFB is important for the profitability of the project. The project "Kade" should not be implemented unless it is possible to ensure that the demand for biodiesel and transportation of FFB is in place.

The highest contributor to the costs in both projects is transportation. This can best be seen with the two alternatives for the project “Accra”. With “Accra 1”, urine is transported over 80 km (round trip). Only 13 % of the time there is enough cargo (poultry manure) to bring on the return trip to compensate for the transportation costs. The rest of the return trips the truck comes back empty. With “Accra 2”, urine is transported over 80 km only as often as the cargo capacity on the return trip allows (4 times per month), and the rest of the time urine is sold closer to the origin (30 km, round trip) – to maize farmers. This change results in a slightly higher NPV (approx. 22 % higher) as well as lower dependence on potentially increasing transportation costs.

Transportation is also a considerable cost in the project “Kade”, together with biodiesel production costs. In order to increase the profit, the price of biodiesel could be increased once the market presence is ensured. In addition, other profit generating activities should be explored, e.g., building more UDDTs and selling collected and sanitized urine as fertilizer to farmers or using it to cover ARS’ own fertilizer requirements.

The analysis of external and internal factors related to the transportation costs showed that the project “Accra 1” is the most sensitive to these variables due to the longer distances over which urine needs to be transported (see Table 4.36). The nature of the product to be transported plays an important role and urine has a considerably low fertilizing value to volume ratio. The project “Accra 2” is the least sensitive to the variables analyzed in Table 4.36 due to the fact that transportation distance has been significantly decreased in comparison to the project “Accra 1” and due to the fact that the revenues for project “Kade” are comprised of transport related activities.

Table 4.36: Summary of the sensitivity analysis of variables of transportation costs for all projects

(1= most important effect, 2= important effect, 3= least important effect)

Variable	**"Accra 1"**	**"Accra 2"**	**"Kade"**
Fuel price	1	3	2
Truck price	1	2-3	2-3
Transportation costs (excluding truck price)	1	2-3	2-3
Transportation distance	1	3	2

The investment for the project “Accra 2” is higher than for “Accra 1” and the revenues are exactly the same, whereas the investment for the project “Kade” is similar to the one for “Accra 2”, but the revenues are much higher. Thus, if the project’s lifetime is extended from 5 years to 8 years, it will have a more significant effect on the NPV of project “Accra 2” than on “Accra 1” and “Kade”. The extension of the project’s lifetime illustrates the contribution of the depreciation or lifetime of the investments (Schröder, 2010).

Even though the potential profitability of the projects has been proven by the extensive profitability analysis, its practicability needs to be tested on the ground. It is important to consider the risks related to road conditions and the high rate of road accidents in Ghana, which might impede the project’s successful execution. The big advantage of the proposed projects is that the collection and transportation of urine is performed in bulk. A study on the marketability of human excreta in Uganda concluded that collection of urine from individual toilet facilities is not feasible and the system required setting up of collection points (Schröder, 2010). This is not necessary with regard to the discussed projects due to the origin of the urine (e.g., public urinals in the congested area in the center in Accra) and its related high collection volumes. However, if the project is to expand to other areas and collect urine from single households, setting up of collection points might be required.

Fertilization needs satisfied with urine

Fertilization needs that can be met using urine for all three projects are presented in Table 4.37. In the case of maize farms located in Accra, almost 26 % of the fertilizer needs can be offset with the urine collected from fourteen public urinals in the center of Accra. There are also other farms located in Accra, including 47 ha under vegetable cultivation and 251 ha under mixed cereal-vegetable systems (Kufogbe et al., 2005 cited in Obuobie et al., 2006). Urban farmers spread over Accra may be considered as possible buyers of urine for its application as fertilizer on their farms. Even though it seems that selling urine to, for example, vegetable farmers might be a good solution, it needs to be handled with precaution as farmers might be reluctant to apply urine on land used to cultivate edible crops due to the risk of social rejection.

Table 4.37: Fertilization needs[a] that can be met by using urine with projects "Accra 1", "Accra 2" and "Kade"

Project	**"Accra 1"**	**"Accra 2"**		**"Kade"**	
Location	Nsawam	Nsawam	Accra	Kade	Kade
Crop fertilized	Oil palm	Oil palm	Maize	Oil palm	Kassod tree
Urine volume (l/year)	2,556,000	336,000	2,220,000	87,518	3,732
Urine applied (l/ha)	9,672	9,672	12,737	9,672	3,732
Area fertilized with urine (ha/year)	264	35	174	9	1
Area available (ha)	n.a.[b]	n.a.[b]	680	200	1
Fertilization needs met using urine (%)	n.a.	n.a.	25.6 %	4.5 %	100.0%

[a)] Due to the high nitrogen content of urine, fertilization needs were calculated based on the nitrogen nutritional requirements of the crops listed in the table above.

[b)] Information on the exact size of oil palm plantations in Nsawam is not available.

Using stored urine for fertilization of non-food crops will play an important role in the acceptance by the society. In the case of the ARS with a single UDDT complex, it is possible to offset about 4.5 % of the fertilizer needs for the ARS' oil palm farm and all the fertilizer needs of the Kassod tree planted for fuel wood production (see Table 4.37). Also, production of biodiesel makes it possible to fully cover fuel consumption of the ARS. Public toilet owners, palm oil producers and the agricultural sector can also benefit from this project. A project of this type requires a rather small capital investment. Employment generation, improvement of the sanitary situation and the standard of living for urban inhabitants and environmental sustainability are among the clear benefits of the discussed development. Finding multi-tasked options such as utilizing cargo capacity of trucks will help to minimize the costs of urine transportation. Further research should consider making use of sanitized feces in the proposed supply chain.

Results presented in Table 4.37 show that the projects presented have a potential of covering some of the fertilization needs, however, an expansion of the presented projects is necessary in order to meet substantial fertilization needs.

Energy

Using urine in place of mineral fertilizer saves energy. The calculation is based on average primary energy consumption for N, P and K production after Patyk and Reinhardt (1997). The results are summarized in Table 4.38. The highest energy savings can be potentially achieved with the “Accra 1” and “Accra 2” project due to the large volumes of urine available (2,550,000 l/year) and the resulting large area fertilized with urine (264 ha/year) (refer to Table 4.37).

Table 4.38: Average energy savings through application of urine in projects “Accra 1”, “Accra 2” and “Kade”

Average energy saved	**"Accra 1"**	**"Accra 2"**		**"Kade"**	
	Nsawam	Nsawam	Accra	Kade	Kade
	Oil palm	Oil palm	Maize	Oil palm	Kassod tree
K (kWh/year)	14,122	1,857	12,270	484	21
N (kWh/year)	175,111	23,028	152,152	5,998	256
P (kWh/year)	3,746	493	3,255	128	5
Total	192,980	25,378	167,677	6,610	282

Parameters for the calculation of the potential energy savings possible through the application of urine in place of mineral fertilizers are presented in Appendix E.4.

Further opportunities for urine collection

Opportunities for urine collection in the Kwaebibirem District and Accra for future application as fertilizer are presented in Table 4.39. The variables for the calculations include: 0.5 l of urine excreted per person per day, pupils attending school 200 days a year, 72 l of urine to meet nitrogen nutritional requirements of an oil palm tree (see Table 4.11) and a value of nutrients contained in urine of 0.014 GH¢/l (see Table 4.5).

As already mentioned, current yields on oil palm plantations in Kwaebibirem District are low (see Table 4.39). Damang village with a population of 5,500 permanent and temporary residents, has 250 ha of oil palm plantation. Building or modifying existing sanitation facilities for urine collection will allow the village to meet 38 % of their oil palm fertilizer needs. If a UDDT complex is built for Adventist Preparatory and Junior High located in Kade with 800 students, 27 % of their oil palm fertilizer needs will be met. A school in Dumpong village with 200 students can collect 20,000 l of urine per year. The school can potentially sell the urine to neighboring farms and earn up to 290 GH¢/year. If ARS builds another UDDT complex to provide sanitation for both permanent and temporary residents, it can collect urine to satisfy 4.8 % of their fertilizer needs. The oil palm plantation of GOPDC extends over 4,500 ha, and consequently, covering sanitation needs with urine diverting facilities and collecting urine for application on oil palm fields can meet only 1 % of the fertilizing needs.

Table 4.39: Opportunities for urine collection in Accra and the Kwaebibirem District

	GOPDC	Damang Village	Adventist Preparatory & Junior High	School in Dumpong village	ARS
Location	Kwae	Damang	Kade	Dumpong	Kade
Population	500	5,000	0	0	150
Temporary workers	1,200	0	0	0	100
Students/pupils	0	500	800	200	500
Total population (permanent and temporary)	1,700	5,500	800	200	750
Assumed amount of urine collected (l/year)	310,250	962,500	80,000	20,000	95,625
Plantation (ha)	4,750[a]	250	30	0	200
Plants planted per ha	140	140	140	0	140
Current yield (t FFB/ha)	12.0	6.0	2.5	-	5.0
Urine required for plantation (l/year)	47,644,717	2,507,617	300,914	0	2,006,093
Urine lacking (l/year)	47,334,467	1,545,117	220,914	0	1,910,468
Urine lacking (%)	99	62	73	0	95

a) GOPDC has 18,750 hectares of oil palm plantations at Kwae, of which 4,750 ha is the nucleus estate, whereas the remaining 14,000 ha are outgrower and smallholder farms.

Information presented in the table is based on the following sources: Martinez Neri, 2009; Ministry of Food and Agriculture, 2010; pers. correspondence, I. Martinez Neri, 11.15.2010; Business in Ghana, 2011 and pers. correspondence, Dr. G. Ofosu-Budu, Research Officer at ARS, 17.11.2010.

5 PROMOTION OF ECOSAN

In water and sanitation programs, continued access to sanitation services is not enough to sustain hygienic behavior (Shordt, 2004). In order to create demand for sanitation facilities and prompt behavioral change, it is important to consider software aspects of sanitation interventions. In this chapter, first, different promotion strategies are described. Then, sanitation culture in Ghana and Ethiopia is illustrated. Subsequently, promotion through media in Ghana and Ethiopia is discussed. In addition, possible campaign partners are described. Finally, an exemplary sanitation promotional campaign for Arba Minch in Ethiopia is presented.

5.1 Promotion strategies

Promotion strategies have to be in line with the local situation analysis. A selection of promotional strategies are discussed further.

5.1.1 Social marketing

There are many modern concepts that could be exercised by sanitation entrepreneurs in developing countries. One of them is sanitation marketing, which is a type of social marketing. For more information on sanitation marketing refer to Section 2.4.6.4. Using marketing tools to stimulate demand and sell sanitary products as desirable goods proved successful in developing countries, as already discussed on the example of Kentainers and Ecotact in Kenya (refer to Section 2.4.5).

5.1.2 Media

Promoting ecosan can be performed through media, e.g., radio, newspaper and television. Media can be used in order to broadcast paid advertisements and to publish or broadcast reports on a particular sanitation project or event. For media to be willing to report on it, it is necessary to attract their interest.

Media will be interested in reporting on topics that can be related to current events and that have a link to other up-to-date issues such as education, food security or restoring soil fertility. The topic of sanitation should appear in media on a regular basis to attract more interest. For example, organization of a news conference would allow presenting information all around the topic of ecosan.

Prior to contacting the media, one should check what topics a radio station or a newspaper deals with and whether they match the message of the campaign. Media could also broadcast interviews with employees that are working on an ecosan project.

In general, in order to attract attention of media and general public, the message needs to be provocative or even controversial. Journalists who do not know much about sanitation and are to produce informative accurate stories, need to be properly briefed (Simpson-Hébert and Wood, 1998). It can be done through a press briefing, which is thought to educate journalists on the topic. It is helpful to provide information material in a form of information sheets or advocacy publications to distribute (Simpson-Hébert and Wood, 1998). Press briefing should be arranged prior to an important event already planned. Journalists should be then briefed on key developments and issues relating to ecosan and the company’s relevant work and policy.

Visuals are always important for a newspaper to report on a story. The best and most cost-effective way is to organize a photo opportunity, where journalists could take photos of, e.g., demonstration toilets and farmlands where urine was applied as fertilizer.

5.1.3 Participatory methods

A wide variety of participatory methods, e.g., community mapping, training of trainers, three pile sorting cards and a sanitation ladder approach, is commonly used by NGOs implementing water and sanitation interventions.

Mapping of water and sanitation facilities in a community helps to develop a common vision and understanding of ways in which water can get contaminated, to examine hygiene behavior, analyze good and bad hygiene practices, identify existing barriers and jointly come up with possible measures. In training aspects, it is important to remember that women should be taught by women in a language they feel comfortable with. When teachers share the same culture and heritage, it is easier to deliver the sanitation message.

Three pile sorting cards are cards with pictures, words or sentences (depending on the literacy rate) which provide positive, negative or neutral aspects of different sanitation options and their use. By sorting the cards and discussing them, knowledge of the participants can be assessed (Wegelin-Schuringa, 2000).

The sanitation ladder approach is a very common participatory method, where different sanitation technologies are shown on cards, participants sort the cards by the level of technology and express their temporary and future position (Wegelin-Schuringa, 2000).

5.1.4 Slogan and logo

Every successful promotional campaign has a logo or a slogan. Slogans must be short and catchy in order to attract attention. A logo has to be aesthetic and eye-catching. A slogan should not be limited to health aspects due to the fact that they are not common reasons for sanitation adoption (Saywell and Cotton, 1998; Jenkins and Curtis, 2005; Baskovich, 2010). Simple slogans such as: “Sanitation. A right of every citizen.”; “Toilets are good for you!”; “Don’t waste your waste!”; “Toilets are dignity!”; “Privacy is not costly.”; “Sanitation saves money.” could be used (Blume, 2009). Furthermore, an agreed logo could be drawn on walls of households that adopted ecosan so that they could be recognized as contact persons (Meier, 2008).

Using slogans, logos and posters, a sanitation promotional package could be created. It could be used to win new partners and to convince community members about the advantages of the ecosan approach.

5.1.5 Market stand

In many cities in developing countries, including Arba Minch (Ethiopia) and Accra (Ghana), there are regular market days, which are visited by a large number of people. Therefore, a market stand could be set up, where people could get information regarding ecosan. In order to make the market stand more interesting, musicians or local politicians could be invited to participate. Music and refreshing drinks would attract people. In addition, ecosan products (composted feces and stored urine) could be displayed so that people could see that these products do not smell, thus a good attitude could be created. Information materials, contact details to toilet builders, ecosan users, companies producing toilet slabs and information on the costs of ecosan components could be available at the market stand.

5.1.6 Demonstration facilities

Sanitation facilities for demonstration can be provided at schools, universities, public institutions, private households (preferably of political and religious leaders), church plots, private companies selling ecosan components and show parks or toilet centers (sani-marts). It is important to build demonstration toilets that are replicable and from components that are readily available (Ayele, 2005). Private companies and toilet centers can provide a variety of options for demonstration purposes, including, e.g., urinals for men and women, sitting and squatting options, options for washers, in order to show a variety of technology options available for adoption. By experiencing a sanitation facility, people can understand its benefits and make an informed choice.

5.2 Right message

The right message is crucial for an ecosan campaign. It is important to direct the message at a particular audience, taking into account their expressed reasons for sanitation adoption and constraints. Sanitation campaigns revolving around health aspects have not been successful and reasons other than health are often the ones that influence investment in sanitation facilities (Saywell and Cotton, 1998; Jenkins and Curtis, 2005; Baskovich, 2010).

Information on the sanitation culture in a particular country will help to prepare an appropriate campaign. In order to deliver the message of the campaign effectively, one should narrow it down to the essential core and use only a few simple key messages that will be easily understood by the audience. It should be a message that draws attention (e.g., provocative), is appropriate (e.g., gender-specific) and is delivered timely (e.g., before elections, farming period).

5.3 Potential campaign partners

It is important to have local partners because such a delicate topic as sanitation cannot be brought to the community from the outside, by people whom they may not trust. Local partners can obtain and spread information as well as carry out activities that are limited to the people knowing the local reality. Ecosan should be presented by peers. Otherwise it could be perceived as something unnecessary as the communities had managed without it for so long. Consequently, it is crucial to work together with communities and their decision-makers and leaders. There have been cases of “leaders sabotaging sanitation projects or redirecting sanitation funds into their own pockets” because they “may fear the loss of authority as foreign ideas begin to spread” (McConville, 2003, p.4). While working with partners, it is significant that both sides can benefit from the cooperation in order to generate the necessary motivation. For example, cooperating with NGOs helps to reach a wider range of people, provides professional help from people working in the area and knowing the local reality.

5.4 Promotion of ecosan in Ethiopia

As already discussed, an adequate sanitation promotion campaign needs to be planned in line with local conditions.

5.4.1 Sanitation culture in Ethiopia

O'Loughlin et al. (2006) found out that latrine ownership in Amhara, Ethiopia was connected with education, relative wealth, urban residence and history of travel. These findings are in line with other studies (Mukherjee, 2001; Jenkins and Curtis, 2005). It was also found out that the main reported advantages of latrines in Amhara were cleanliness, health benefits, privacy and convenience (O'Loughlin et al., 2006). In Amhara, reasons for non-adoption of sanitation included lack of manpower, lack of time and lack of awareness of latrines and sanitation (O'Loughlin et al., 2006), which clearly shows the importance of an appropriate awareness raising campaign.

Another study in Ethiopia (in Arsi located in the Oromia Region and Gondar located in the Amhara Region) revealed the following aspects affecting sanitation adoption (Ayele, 2005, p.3-4):

- “a lack of appreciation of health risks associated with open defecation
- cultural factors which favor open defecation or discourage latrine use
- traditional beliefs affecting the perception of latrines
- past experiences affecting attitudes towards latrine construction and use
- various factors affecting local and individual preferences”.

Obstacles to sanitation adoption observed by WaterAid Ethiopia include the availability of other options such as open field or bush, bad reputation of public toilets in urban areas and economic constraints (pers. communication, K. Mamo, WaterAid Ethiopia, Addis Ababa, 26.09.2008).

An interviewee from Oxfam Ethiopia listed the following obstacles to sanitation adoption in Ethiopia: cultural barriers, lack of knowledge about the health-sanitation link, priority of allocation of resources for food security, lack of local capacity (local government, NGOs) and lack of building materials (pers. communication, S. Mekonnen, Oxfam Ethiopia, Addis Ababa, 25.09.2008).

A representative of the Catholic Mission, another NGO working in Arba Minch, stated that the challenge of sanitation adoption is in people being reluctant to allocate their resources for sanitation (pers. communication, A. Tadesse, Catholic Mission, Arba Minch, 16.09.2008). Generally, communities cannot understand the immediate consequences of poor sanitation. They also tend to give their own justification to the fact why it is not their main priority. They see open spaces as a sanitation option and they do not understand why it should be fixed in one place, on which they are expected to spend their limited resources.

While planning a promotional campaign, it is important to study the local area. The message behind the campaign should be tailored to the local reality, relating to the economic aspects of open defecation, status, privacy and safety. For example, a competition between households proved to be a successful motivation for sanitation adoption in Amhara. Households which fulfilled all hygiene and sanitation criteria were awarded a white flag (pers. communication, K. Mamo, WaterAid Ethiopia, Addis Ababa, 26.09.2008). This can be also attributed to the prestige factor acting as a motivator. The white flag could be seen from a distance, indicating that this particular household is modern and able to afford sanitation facilities.

Understanding local culture is crucial for the sanitation project to become successful. A sanitation campaign needs to be in line with local beliefs, preferences and cultural sensitivity. Generally, handling of human excreta is a cultural problem in Ethiopia. Nevertheless, if a necessary care is taken and cultural concerns and fears are considered, it is also possible to implement resource-oriented sanitation systems in feacophobic societies (Warner et al., 2006).

There are many examples of behavior patterns that need to be known in order to design and carry out a successful sanitation promotion campaign. For example, in some villages in southern Ethiopia, women are not allowed defecating in the same place as men (Pickford, 2001). In northern Ethiopia, people refused to use latrines, around which no trees were located as they used leaves for anal cleaning (Pickford, 2001). Even though the community-led total sanitation (CLTS) approach of the NGO called Vita was successful in many villages in the SNNP Region (refer to Section 2.3.4.1), it failed in Turmi (also located in the SNNP Region), which is dominated by semi-nomadic and pastoral communities. A similar problem was faced by Oxfam in the Somali Region, while working with pastoral communities (pers. communication, S. Mekonnen, Oxfam Ethiopia, Addis Ababa, 25.09.2008). The NGO found it hard to promote sanitation there due to the fact that open defecation is widely practiced, the area is not densely populated, the evaporation rate is high and the awareness levels are low.

According to the Society for Urban Development in East Africa (SUDEA), “culture should not be taken as a hindrance to promote recycling of human excreta as fertilizer even though cultural sensitivity is important” (Terrefe and Edstrom, 2005, p.2). The cultural aspects have been discussed prior to the implementation of the SUDEA project in Ethiopia. SUDEA’s experience in Ethiopia shows that the most difficult to convince were the groups of autocrats and medical personnel. The groups of agronomists, who are used to applying animal excreta as fertilizer, were easier to convince. The method that proved best was showing how sanitized feces and urine is applied. When people see how the system works and that it does not involve any odors, they are able to accept it. Consequently, good communication is the prerequisite for promoting ecosan. Promoters need to have adequate knowledge about how the system works and be convinced of its appropriateness. They need to answer any arising questions without hesitation.

Gender is an important consideration in sanitation campaigns. In the SNNP Region, women have been identified as the main drivers of latrine construction (Bibby and Knapp, 2007). They were the ones who complained about how open defecation affects their lives and highlighted the risks of contact with feces in open spaces (Bibby and Knapp, 2007). Their self-respect often deters them from practicing open defecation in daytime and leads to health problems such as urinary tract infections. Shame was often cited as a strong motivator for latrine construction in the SNNP Region and it referred both to households and administrative levels (Bibby and Knapp, 2007).

5.4.2 Sanitation promotion through media in Ethiopia

Different media channels for sanitation promotion in Ethiopia are discussed further.

5.4.2.1 Radio

Radio is one of the most important communication means in Ethiopia and it has a large coverage area. According to 2007 statistics, as many as 74 % of the housing units[66] in Arba Minch owned a radio (CSA, 2007). In the SNNP Region, the “Voice of South, FM 100.9” is the most popular radio station. It is owned by the southern regional state and it has a regional coverage of 250 km radius from Awassa (Getahun, 2006). This radio has already been used for broadcasting spots related to community mobilization (e.g., on immunization) or reporting on the events of the Global Hand Washing Day.

In 2006, Forum of Social Studies launched via the radio “Voice of South” a development-oriented radio program called “Jember” (Forum for Social Studies, 2009). The goal of this program is to develop educational programs and promote development in the region through disseminating information to a large audience. The program covers many issues, among which the methods of improving hygiene practices are discussed. The program is also designed to help boost the services of various governmental organizations, NGOs and CBOs, which are currently operating in different areas of the region, carrying out development activities.

Looking at the examples above, it makes sense to advertise ecosan on radio and to engage journalists to report on the most important events around the topic of health and sanitation in the SNNP Region. One can reach a large audience through a regional radio. Therefore, the radio “Voice of South” could be used for broadcasting advertisements and report on current programs, projects and activities related to ecosan. The cooperation with the radio station could include, for example, a report on current activities at schools, interviews with students and teachers who use ecosan and viewing of demonstration toilets or school gardens, where excreta based fertilizers are applied. Students can prepare a song about ecosan, which could be later used as a radio jingle. An expert could be invited to a call-in radio program where listeners could ask questions regarding, e.g., the operation and maintenance of toilets, material availability for toilet building and agricultural application of excreta based fertilizers. Call-in radio programs are very popular in Africa. It is important to consider the language chosen for such a radio program so that it reaches the majority of people living in the region (refer to Figure 5.1).

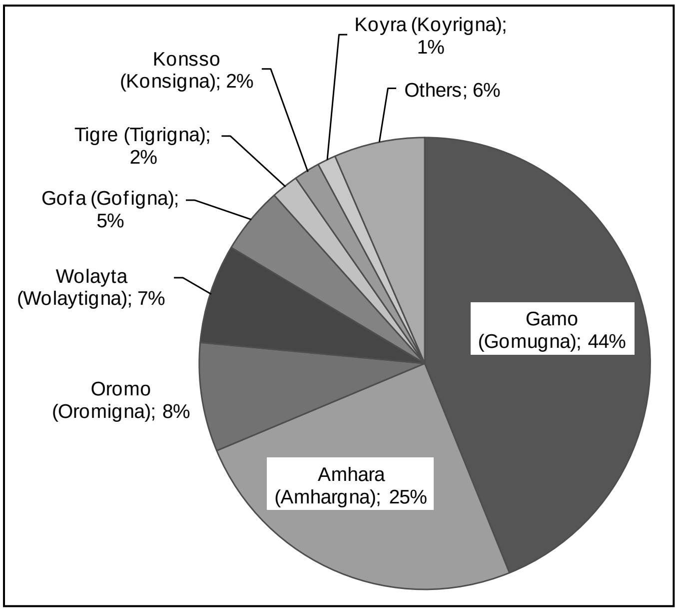

Figure 5.1: Languages spoken in Arba Minch (based on AMU and ARB, 2007)

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[66] In the SNNP Region, a housing unit consists of 1.036 households (CSA, 2007).

5.4.2.2 Newspapers

According to the information obtained at the Information and Culture Department in Arba Minch (pers. communication, Arba Minch, 25.05.2009), “Addis Zemen”, “Debub Nigat” and “Ethiopian Herald” are the most read newspapers in Arba Minch. Other popular newspapers include “Qum Nager”, “Addis Admass” and “Ethiopian Reporter”.

“Debub Nigat” is published by the Regional Bureau of Information in Awassa. The core topics of the newspaper include regional legislation, agriculture, health, tourism and entertainment (Ahlert et al., 2008). The topics of agriculture and health provide good links to the topic of ecosan.

When using newspapers for sanitation promotion, it is important to consider the illiteracy rate in Arba Minch, which was estimated at 30 % (DHV Consultants, 2002).

5.4.2.3 Television

According to 2007 statistics, 25 % of the housing units in Arba Minch own a television (CSA, 2007). Almost 18 % of the housing units in urban areas and only 0.4 % of the housing units in rural areas in the SNNP Region own a television (CSA, 2007).

Using television for advertising of ecosan in Arba Minch would reach only a limited number of people. However, due to their economic and social status, they can be considered as key persons. These people could be decision-makers and they would be financially capable of installing different types of toilets and possibly make them available for viewing.

Advertising through television makes sense in cities like Addis Ababa, where as many as 56 % of the housing units[67] owned a television in 2007 (CSA, 2007). Thus, the high cost of advertising can be compensated by reaching a large number of people. In a city like Arba Minch, where only a small number of households has access to television, other forms of advertising should be explored first.

5.4.3 Possible campaign partners in Ethiopia

Potential partners for an ecosan promotional campaign in Ethiopia are discussed further.

5.4.3.1 Community-based organizations

Many CBOs are active in Arba Minch, of which idirs, equbs, religious and youth groups are the most common (Schubert, 2008). CBOs have different financial structures; some of them provide credits for their members, others finance projects, make state credits available and use their experience in the collection, management and allocation of finance. CBOs operating in Arba Minch are discussed further.

Idirs

The original purpose of idirs is financing and organizing of funerals for their members. However, their activities also include building and running of public water taps, helping the poor by distributing food, paying rents for member households that

[67] In Addis Ababa, a housing unit consists of 1.042 households (CSA, 2007).

cannot afford it, buying learning materials for children, educating on AIDS, etc. Idirs do not provide credits to their members.

The main motivation to become an idir member is the socio-economic security and support that the CBO provides (Schubert, 2008). A membership allows taking part in the life of a community and raises the social status. The idir membership rate of households in Arba Minch and its vicinity varies between 25-100 % (Schubert, 2008). Idir members are of different ethnicity, religion, political affinity and income level. However, very poor inhabitants who are not able to afford the average membership fee of ETB 5 or people living in informal settlements are not idir members (Schubert, 2008).

Idirs have well-established organizational structures that could be used in an ecosan campaign. They create good potential links to communities. Some idirs have already worked with local administration, e.g., by cooperatively building infrastructure; others have participated in trainings organized by kebeles, where they were taught about health and hygiene issues (Schubert, 2008). Groups like idirs are a good panel for dissemination of knowledge as their members trust each other and meet on a regular basis. Also, idirs invite experts from local administration or NGOs to carry out awareness raising campaigns on health-related issues.

Equbs

Equbs are rotating saving and credit associations. In equbs, members collect money and distribute it among themselves following set rules. However, equbs are not profit oriented. They can be described as an alternative to banks.

The main aim of equbs is to strengthen the financial capacity of their members, by placing a relatively high amount of money at their disposal, so that they can invest it in a new or upgrade an existing business. A regular fee is collected from members and on a given date the amount is distributed to one of the members. The decision on which member receives the money is made by drawing lots.

Equbs are not area based. Members choose an equb due to its reputation, recommendations of friends or business partners, the reliability of other members and the leadership (Schubert, 2008). Theoretically, everyone can join equbs, providing that they can pay the membership fee.

A membership in an equb is connected with social status and good reputation within a community (Schubert, 2008). The clear motivation to become an equb member is to receive a credit without having to pay an interest rate. Equbs offer the opportunity to receive money fast and without any interest or service fee. However, this advantage depends on luck. If someone needs money urgently, they have the possibility of applying to receive it but they have to pay an interest rate that is nevertheless lower than that of a bank. Therefore, equbs could start providing short term loans with competitive interest rates compared to that of banks and microfinance institutions, e.g., for sanitation hardware.

Youth groups

The aim of youth groups is to improve the life of the youth. The main focus of the “ras agez” youth group is the provision of support for single members in difficult situations, whereas the aim of the “Secha” youth group is to prevent the youth from misbehavior (Schubert, 2008).

The “ras agez” group is founded and organized by young people and their work is based on social commitment. The “Secha” group is organized by kebele administration and is responsible for the Secha sub-city in Arba Minch. Nearly every young person in Arba Minch belongs to some kind of a youth group. Youth groups collect a monthly fee and have regular meetings. The motivation of joining a youth group is the social advantage that it brings along.

Youth groups in Arba Minch have already worked in the sanitary field and often perform road cleaning campaigns (Schubert, 2008). They do not receive money from kebele administration for the work they carry out. Even though youth groups have already worked with the city administration, they have not partnered with NGOs yet.

Religious groups

The majority of the population in Arba Minch is Orthodox (56 %), followed by Protestants (39 %) and Muslims (4 %), as presented in Figure 5.2 (CSA, 2007).

Schubert (2008) investigated two orthodox groups in Arba Minch. These groups can be identified as communities with close bonds to their members. They feel responsible for each other and help one another. They also support people outside of their group. They meet once a month in a house of one of their members. The motivation for the membership lies mainly in religious beliefs, but also a sense of social belonging. They pay a monthly fee, which is kept low so that poor people can also become members.

Church groups in Arba Minch have not been active in the sanitation field (Schubert, 2008). Their main problem is the lack of financial capacity. Their members are sometimes not able to pay the monthly fee, so they do not have a financial capacity to participate in other activities.

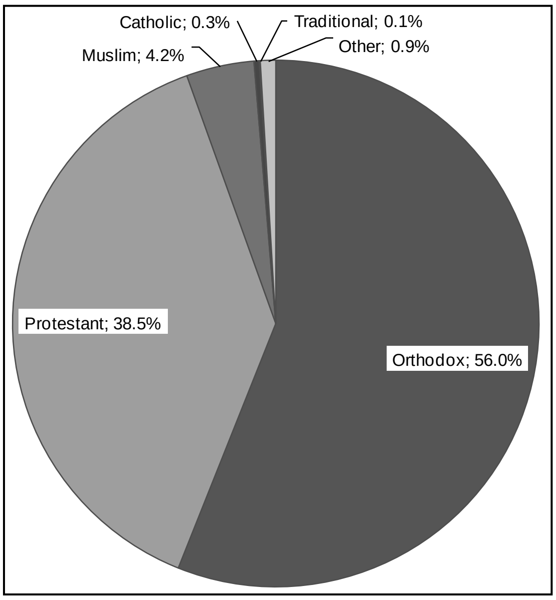

Figure 5.2: Religion in Arba Minch (based on CSA, 2007)

Small and medium enterprises (SMEs)

The main purpose of SMEs is to reduce the unemployment rate and to generate income possibilities for the population (Schubert, 2008). Schubert (2008) investigated three SMEs working in the field of safe management and reuse of resources in Arba

Minch. “Wubet” is mainly focused on road cleaning, waste disposal from households[68] and institutions and waste reuse through composting. “Egnan Naew Mayet Compost Product Association” produces compost and sells vegetables and flowers, which have been treated with compost. “Yeabsira Magedo Kotabi” produces and sells stone circles which are used to cook on, reducing the need for firewood.

SMEs pursue economic goals and work on the improvement of the local environmental conditions. The main motivation to become a member in an SME is to earn money and to improve one’s financial situation. Other reasons include the willingness to contribute to the improvement of the environment in the neighborhood and a sense of social belonging.

SMEs cooperate with the town administration and NGOs (Schubert, 2008). “Yeabsira Magedo Kotabi” is founded and supported by the women affairs office, which is a part of the town administration, whereas some of the other SMEs are supported by NGOs. Despite the willingness to cooperate, SMEs in Arba Minch do not participate in any other projects organized by the town, kebele administration or NGOs (Schubert, 2008).

SMEs should finance themselves through revenues from products (e.g., compost) or services (e.g., waste collection, cleaning of roads). However, none of the three investigated SMEs was able to sustain themselves (Schubert, 2008). It can be attributed to the fact that their activities started only recently and they have not yet become well known in Arba Minch. Another reason is that the population is not willing to pay the demanded fee for a supplied service, like in the case of “Wubet” (Schubert, 2008). Also, the missing awareness regarding the value of the product results in no demand, like in the case of “Egnan Naew Mayet Compost Product Association”.

SMEs are interested in new activities and are willing to try out new concepts and ideas. “Wubet“ started their compost-related activities in cooperation with the ROSA project and they also expressed their willingness to transport urine and feces from ecosan systems, whereas “Egnan Naew Mayet Compost Product Association” is planning to work with biogas technologies (Schubert, 2008).

Cooperation with CBOs

Many of the CBOs operating in Arba Minch have never participated in any projects of the town, kebele administration or NGOs. They are rarely invited to participate even though they are generally willing to become involved. CBOs’ role in sanitation interventions should not be neglected and their ability to reach out to the communities should be explored.

Idirs and the “ras agez” youth group can be used for the dissemination of information as they are deeply rooted in the society and concentrate on self-help. Due to the fact that they are limited to a particular area, they know exactly what problems their neighborhoods are facing. Another advantage is their heterogeneous structure, i.e. one can reach different social strata, age and profession groups and people belonging to different religions.

[68] In Arba Minch, almost 4 % of the housing units have their waste collected by the municipality, almost 64 % of the housing units burn it, almost 21 % of the housing units dump their waste into open spaces and approx. 7 % of the housing units dump it into a river (CSA, 2007).

CBOs reach out over large areas so they can be used for the dissemination of information materials. Their structure can also be used for the allocation and re-payment of loans or for lending of equipment, e.g., tools for toilet building. CBOs could be used as knowledge brokers and take part in different campaigns such as building of demonstration toilets or monitoring and maintenance of existing toilets. CBO members could be trained in cooperation with NGOs, for example, with Vita on the community-led total sanitation (CLTS) approach or Participatory Hygiene and Sanitation Transformation (PHAST).

In order to promote ecosan, demonstration toilets should be built and arranged for viewing by community members. CBOs could organize visits of their members to households where such toilets are available. CBOs leaders could build demonstration toilets and act as a trigger for sanitation adoption as many people look up to them, trust them and follow their advice.

SMEs can be used as suppliers of new products or services, e.g., transportation and storage of urine, composting of excreta, selling excreta based fertilizers to farmers and as good contact partners.

CBOs that have an ideological background (religious groups and “Secha” youth group) could be used for the dissemination of knowledge to their members as long as the content of the information goes hand in hand with their principles. Such CBOs play a very important role in the lives of their members and they have a certain authority over them. People will trust the information they provide and follow their advice. However, these CBOs have a rather homogenous structure so the promotion program should be matched with a particular group that is planned to be reached.

As already mentioned before, equbs could be used for providing credits to their members for, e.g., household toilet building or for the establishment of sanitation centers (so-called sani-marts) (refer to Section 2.4.6.5).

5.4.3.2 Schools and public institutions

First of all, a workshop for headmasters in the region should be organized to inform and educate them on the ecosan approach. It could work as a trigger for them to implement ecosan. Toilet facilities should be built in cooperation with students, their parents and teachers. They have to be functional and visually attractive.

In public institutions such as kebele offices, schools, kindergartens and hospitals, posters on ecosan could be displayed (Blume, 2009). These posters could include possibilities of visiting demonstration toilets (at schools or private households) or participating in courses or open discussions. Posters could be prepared by pupils during their health education, where the concept of ecosan could be included in the curriculum. Ideally, pupils would then bring their knowledge home, where they could discuss it with their relatives. Pupils can also participate in the promotional campaign by recording videos or distributing flyers at markets (Meier, 2008).

In order for teachers to be able to promote health education, they should be trained, e.g., by CBOs or NGOs. College students could also be involved in the construction of toilets either at school plots or for private households.

On the World Toilet Day (19.11), a school festival could be organized, where posters would be created by pupils in a drawing contest (Blume, 2009). Such a festival could be visited by other schools and inhabitants of the area, who would get the opportunity to visit demonstration toilets. Media could also be invited to report on the festival.

Pupils could be organized in ecosan clubs, where teachers would educate them on the importance of sanitation and pupils could create school plays, posters, write songs on the topic of sanitation and health. “[E]ducation is more effective if people enjoy it, can participate actively in it, if it challenges their thinking or if it gives them new skills and self-confidence” (Mathewson and Ayele, 2005, p.7). Ecosan or sanitation clubs could cooperate with clubs at other schools or universities.

In order to use excreta based fertilizers, a school garden should be set up. The ROSA project built UDDTs in three schools in Arba Minch. In Nelson Mandela school, it is used by 213 people, in Chamo Elementary school by 61 people and in Hibret le lemat school by 25 people (AMU and ARB, 2009). It would be useful to plant different beds, a control one without using any fertilizers and another one with urine and feces used as fertilizer and soil conditioner. If a school has a canteen, it could use the products grown in a school garden (Blume, 2009). During an open day, a school garden could be presented to parents, journalists, local politicians, in order to show the advantage of adopting ecosan. Ideally, installing toilets at schools would result in spontaneous copying after parents have been informed about the system and its benefits.

5.4.3.3 Artists

Artists are role models that are looked up to and adored. If artists are invited to cooperate in a promotional campaign, it would make the campaign more attractive, in particular to young people. Therefore, singers and musicians are valuable partners for a sanitation campaign.

In Mozambique, a singer – Feliciano dos Santos campaigns for clean water and sanitation (Kinver, 2008). One of his songs goes: “Mothers, listen to me; grandmothers, listen to me, she doesn't listen to me. The slab is so good; the slab is easy to clean". It is a simple message and people follow it. As a result of the song, the demand for toilets soared and the project even struggled to cope with the increasing demand (Kinver, 2008). The singer also managed to influence politicians to join awareness raising campaigns, e.g., on the importance of hand washing.

If it is possible to bring artists on board, a promotional campaign could benefit from it. Painters could also be contacted in order to paint toilet facilities, either at schools or public toilets as it has been proven that colorful slabs attract children to use toilets (Simpson-Hébert, 2007). This was recognized, for example, by the Catholic Relief Services in Ethiopia and Arborloo slabs were painted in bright colors in order to attract children.

5.4.3.4 Church

Building of demonstration toilets on plots belonging to a church and offering them for viewing and use would be a great opportunity to convince people of their appropriateness and overcome any taboos or prejudice associated with sanitation. Priests could disseminate flyers on the topic of health and sanitation. Priests are role models and highly respected by communities so hearing the information from their mouths will add credibility to the promotional campaign.

In Ethiopia, the NGO Oxfam wants to embark on health and sanitation promotion through churches (pers. communication, S. Mekonnen, Oxfam Ethiopia, Addis Ababa, 25.09.2008). People go to church on a regular basis, listen to and respect their religious leaders. However, it is necessary that church organizations are educated on hygiene and sanitation issues in order to be capable of passing the knowledge further.

5.4.3.5 Politicians and leaders

Politicians could be good advocates of a sanitation promotional campaign. They are generally respected, recognized and powerful. They could influence numerous associations and organizations to participate in the sanitation campaign. They are also decision-makers so they can influence political decisions regarding sanitation. Media will also put them in the spotlight, together with the campaign that they are involved in. One can use a strategic time, e.g., before elections, as a motivation for politicians to participate in such a campaign. Politicians and traditional leaders are role models and they set standards. When they use ecosan, it will be a motivation for community members to adopt it. Demonstration toilets built at their premises would be the best promotion method.

5.4.3.6 Local NGOs

There are many local NGOs in Arba Minch and its vicinity that carry out water supply and sanitation projects. Vita works with community-led total sanitation (CLTS). The NGO approaches a community and together with kebele leaders introduces the objectives of their intervention. The community is given an opportunity to participate through, e.g., creating social maps, counting households with and without sanitation facilities, and finally, choosing the sanitation option and building their sanitation facilities. In nine villages, Vita managed to achieve 100 % sanitation adoption without any money-related incentives. The NGO teaches construction, operation and maintenance of toilets, and other health and sanitation issues. Vita also offers financial support for training of community health promoters (CHPs) (pers. communication, Yalemtsehay, Arba Minch Health Center, Arba Minch, 15.09.2008). Cooperation with Vita could be launched in order to educate teachers and other NGOs on health and sanitation issues, CLTS and ecosan.

There are numerous NGOs working in Ethiopia and some of them are presented in Table 5.1. Information summarized in Table 5.1 is based on the information gathered through personal interviews in Ethiopia. As a result of the information gathered, it can be concluded that sanitation and health promotion is performed by NGOs through the following methods:

- household visits of CHPs,
- involving community and religious leaders in a promotion campaign,
- discussions and question-answer sessions during coffee ceremonies, at mosques, churches, at market places and at CBOs meetings,
- training of CHPs, teachers as well as water and sanitation committees in the PHAST method as well as sanitation and health aspects, and
- creating sanitation clubs at schools.

Promotion materials used by NGOs commonly include brochures, flipcharts, leaflets and posters. WaterAid performs sanitation and hygiene promotion at schools, believing that children will be able to teach their families and reach out to the next generations by teaching their own children. Sanitation clubs are established at schools where dramas, role plays and songs are created for hygiene and sanitation promotion.

During the interviews with representatives of NGOs in Ethiopia, certain prerequisites for a successful sanitation project were identified. It is important that an intervention is prompted in a legal manner and by the future beneficiary community. This makes acceptance and cooperation easier and makes the project potentially sustainable. Furthermore, many NGOs work through CHPs because they are respected, culturally based and well accepted by communities. Some NGOs work with water and sanitation (WATSAN) committees, which are formed at a village level and comprise of female and male community members. Such a committee is held responsible for the operation and maintenance of sanitation facilities within its community. This makes the functioning of sanitary facilities more efficient and it is put in the hands of the communities, which gives them a sense of belonging. It is also important that communities can decide on the sanitation technology and that they are actively involved in the intervention.

Table 5.1: Examples of NGOs working in the water and sanitation field in Ethiopia

NGO	Sanitation promotion	Special approaches	Sanitation facilities	Partners	Sanitation component	Geographical reach
African Medical and Research Foundation (AMREF)	· Through CHPs[a], training of CHPs · Monthly sanitation campaigns · Household visits, group discussions at coffee ceremonies · Posters, hygiene manual for CHPs, PHAST[b] material	· PHAST	· Shared sanitation blocks in slums (showers, toilets, hand washing facilities, water points) to prevent the practice of flying toilets[c]	· City, sub-city and kebele administration · Communities (WATSAN committees, poor women, teachers, volunteers)	· Slogan: "better health for Africa"	· Addis Ababa · Afar · South-Omo
Water Action	· Through CHPs, training of CHPs · Household visits · Brochures, flipcharts, posters	· n.a.	· Sanitation ladder approach · Using locally available materials · Employing sanitarians and casting own slabs · Ecosan – first implementations with CRS Ethiopia	· Local government · Other NGOs · Communities (WATSAN committees, water management board)	· Integrated with water supply and health, protection of natural resources and development	· South · South-East
Catholic Relief Services (CRS) Ethiopia	· Through CHPs, training of CHPs and HEWs[d], religious and community leaders · Community discussions and solution-finding sessions · Materials based on the local context	· PHAST	· VIP[e] latrines (failed – high cost) · Traditional pit latrines (failed – hard to link to health improvement, high cost) · Ecosan (Arborloo, Fossa Alterna) – successful · Painting slabs in bright colors to attract children	· Federal, regional and local government · WASH movement · International and local NGOs · Agricultural agencies · Research institutes and universities · Private companies (plastic slabs producers) · Communities	· Integrated with water supply and health · Integral human development approach	· Amhara · Oromia · Somali · SNNP · Tigray

NGO	Sanitation promotion	Special approaches	Sanitation facilities	Partners	Sanitation component	Geographical reach
WaterAid Ethiopia	· Through CHPs, training of CHPs · Household visits, discussions during CBOs or church meetings, coffee ceremonies, at market places (not interfering with women's daily activities), competition system between households, school sanitation clubs (drama, role plays, songs) · Pictorial aids based on the local context, in local languages (e.g., flip charts, posters)	· PHAST · CLTS	· Sanitation ladder (mostly traditional pit and VIP latrines) · Ecosan (compost toilets and toilets with biogas production)	· No direct project implementation, through partner organizations · Federal, regional and local government · WASH movement · Church organizations · Indigenous NGOs · Private sector (e.g., for baseline studies, drilling) · Communities (WATSAN committees)	· Integrated with water supply and health	· Addis Ababa · Amhara · Oromia · SNNP · Tigray
Oxfam GB Ethiopia	· Through community leaders and elders · At churches, schools · PHAST material, material developed by the UNICEF	· Approaching people with hygiene and sanitation promotion at churches · PHAST	· VIP latrines · Willing to implement ecosan; argument quoted against ecosan: cultural barrier of handling of urine and feces	· Federal, regional and local government · WASH movement · Local NGOs · Private sector · Communities (e.g., leaders and elders)	· First priority in the SNNP Region: food security, then sanitation	· Afar · Oromia · SNNP · Somali
Vita (formerly known as Refugee Trust International)	· Through CHPs, health officers, kebele leaders · Peer-to-peer discussions, active community involvement · Pictorial aids, dramas, role plays in local languages	· CLTS	· Chosen and constructed by communities · The NGO offers technical support, selects sites for toilet construction, teaches how to construct, operate and maintain	· Local government · Electricity and water suppliers · CBOs · Communities (e.g., kebele and political leaders)	· CLTS approach, showing the economic advantage of sanitation adoption	· South-Omo · SNNP

NGO	Sanitation promotion	Special approaches	Sanitation facilities	Partners	Sanitation component	Geographical reach
Catholic Mission Ethiopia	· Through HEWs, healthcare workers and CHPs · Household visits · Community stories, mapping water and sanitation facilities, picture-based tool kits, observation, manual for CHPs	· CLTS (through Vita)	· Mainly sanitation at public institutions or for communal use	· Local government · Other NGOs · Private sector (for supplies) · Communities	· Sanitation as a component of a water supply program	· Gamo Gofa Zone · South-Omo
Red Cross Ethiopia	· Through public committees · Household visits · Brochures, leaflets and posters	· n.a.	· Mainly VIP latrines · Argument quoted against ecosan: rural communities not interested	· Federal and local government · Other NGOs · Communities	· Previous focus: public toilets · Current focus: household toilets for the poorest	· Chencha · Konso
Anonymous NGO	· Through influential people, teachers and students · Sanitation clubs at schools · The NGO developed teaching materials to use at schools	· CLTS (through Vita)	· Mainly VIP latrines, made of locally available materials	· Local government · Other NGOs (e.g., WaterAid, Vita) · Communities	· Elimination of blinding trachoma · Link: improved sanitation prevents fly breeding	· SNNP

[a] CHPs- community health promoters

[b] PHAST- Participatory Hygiene and Sanitation Transformation

[c] The use of plastic bags for defecation, which are then thrown into ditches, onto a roadside, or simply as far away as possible.

[d] HEWs- health extension workers

[e] VIP- ventilated improved pit

5.5 Promotion of ecosan in Ghana

Similarly as in the case of Ethiopia (refer to Section 5.4), crucial factors influencing sanitation promotion, in particular of ecosan, are discussed for Ghana.

5.5.1 Sanitation culture in Ghana

A study surveyed a representative national sample of 536 households in Ghana and revealed the following reasons for building a household toilet (Jenkins and Scott, 2007)[69]:

- convenience (51.4 %),
- easy to keep clean (43.1 %),
- good health (41.9 %)[70],
- general cleanliness (27.8 %).

The same study revealed the following constraints on building a household toilet (Jenkins and Scott, 2007):

- limited space (48.4 %),
- high costs (33.6 %),
- no one to build (32.3 %),
- competing priorities (31.8 %),
- savings and credit issues (30.1 %).

Jenkins and Scott (2007) distinguish between three stages of the decision to adopt a sanitation change: preference, intention and choice. In order to increase preference, the authors suggest a large scale marketing communications campaign using advertising and consumer information dissemination methods. The campaign should highlight the benefits and generate motivation, put emphasis on convenience, safety and cleanliness and increase the awareness of negative aspects of current defecation practices.

Similarly to other countries, the motivation for sanitation adoption in Ghana is largely unrelated to the fecal-oral transmission of disease (Jenkins and Scott, 2007). Cleanliness and neatness in Ghana are tied to moral and social purity, whereas diseases associated with feces are believed to be transmitted via sighting feces and by fecal heat and odor from latrines (Jenkins and Scott, 2007). For increasing the intention to build household toilets, the authors reflect that marketing is unlikely to fulfill the problems arising on this stage and it is due to public policies to address these.

When it comes to increasing the final choice, the common reasons for failure to adopt sanitation include: perceived high costs, no one to construct, complexity of construction, lack of info and water table/soil problems (Jenkins and Scott, 2007). A proper marketing mix will provide actions to improve the quality, range and costs of toilet technologies, innovative ways and incentives to extend the private sector supply chain of these products and related services needed to construct, operate and

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[69] Percentages do not add up to 100 % because the respondents were asked to list three top reasons of building a household toilet.

[70] One third of the respondents believe that germs are the cause of bad health, whereas two thirds of the respondents believe it is caused by heat, smell, feces or dirt.

maintain toilets closer to these households. Sales promotion and product education will reduce households' transaction time and effort costs involved in searching for good information about technologies and how to construct sanitation facilities.

Another study was performed in Nkawie, 13 km of Kumasi, where 70 % of the population does not have household sanitation facilities and uses public toilets (Jenkins and Curtis, 2005). The key motivating factors for latrine adoption were distinguished. They are presented in Table 5.2, together with ecosan's performance in the light of these factors.

Table 5.2: Key motivating factors for sanitation adoption in Ghana and the respective ecosan performance

Motivating factor[a]	Ecosan's performance
· Comfort	· Indoor options, household, community or public toilets
· Status/Prestige	· Household toilets, modern approach
· Safety/Security	· Permanent structures, indoor options
· Good health (the heat from public latrines mentioned as the reason for falling sick, with possible adverse effect on one's sexual productivity)	· Improved sanitation facilities linked to health benefits
· Cleanliness	· No odors if toilets used and maintained properly · Clean if toilets maintained properly
· Socio-economic gain/loss (spend much money in buying soap for bathing and washing clothes after using a public latrine)	· Clean if toilets maintained properly · Possible income from selling of excreta based fertilizers
· Embarrassment (not holding feces for a long time in a line, people teasing and pointing fingers, having to borrow money from neighbors to pay for using a public toilet)	· Indoor options, toilets that do not smell and are maintained clean make users feel comfortable and respected
· Convenience	· Indoor toilets (no standing in line, walking, struggling to find a place for defecation)
· Being modern	· New concept, shows open-mindedness
· Concern for others (defecating near a stream is environmentally unfriendly and leads to the pollution of water bodies, which serve as a source of drinking water)	· Environmentally-sound and sustainable concept, allowing reuse of nutrients and conservation of water
· Other reasons including superstition, e.g., a public latrine is a home for evil spirits	· Indoor options, no odors, not dangerous for children to fall into

[a)] Source: Jenkins and Curtis, 2005.

The same study by Jenkins and Curtis (2005) found out key constraining factors for latrine adoption. Table 5.3 presents them together with possible solutions offered by ecosan and a properly designed promotional campaign.

Table 5.3: Constraining factors for sanitation adoption in Ghana and possible solutions

Constraint[a]	**Solution**
· Space restrictions	· Different options available, e.g., single vault urine diverting dry toilets (UDDT) or community toilets
· Water table/Soil condition	· UDDTs built above ground · Arborloos built with shallow pits
· Difficulty of obtaining a subsidy	· Subsidy for demonstration toilets, software project's components (dissemination materials, training on toilet construction, slab casting, health aspects, etc.) to trigger spontaneous copying
· Permit (prior to constructing a latrine, the land legislation demands that the owner of the house must obtain permission from the local land survey department)	· Ecosan promotion combined with gaining advocacy and cooperating with local authorities
· Cost/Finance	· Different construction options · Possible income from excreta based fertilizers · Water savings
· Lack of awareness	· Making ecosan demonstration facilities available · Showing different options available (e.g., sitting vs. squatting, male and female urinals, low cost vs. luxurious designs, etc.)
· Intra-family relations (if the decision maker in a compound cannot afford to install a latrine, difficult to convince the rest of the family members)	· Promoting ecosan to a wide variety of people (men, women, school children, political leaders, etc.)
· Operation and performance	· Using good quality products · Making ecosan demonstration facilities available
· Presence of a public toilet	· Promoting ecosan as clean and comfortable · Making ecosan demonstration facilities available

[a)] Source: Jenkins and Curtis, 2005.

A study by Tsiagbey et al. (2005) on 60 households in Nima, a suburb of Accra, revealed the following reasons of low and middle income households for accepting urine diverting toilets (UDTs):

- convenience,
- affordability (in comparison to paid public toilets),
- hygiene,
- source of fertilizer,
- easiness of use and maintenance,
- safety,

- privacy,
- better than current facility,
- portability, and
- mobility.

On the other hand, high income households perceived UDTs to be unhygienic due to the fact that they do not need water to clean and maintain the facility (Tsiagbey et al., 2005). This study did not compare the willingness to adapt other sanitation options so it cannot be considered as fully representative. The authors found out that 80 % of the surveyed households had not been aware of UDTs, which clearly shows that an extensive promotional campaign on ecosan should be performed.

Another survey in Ghana showed that 90 % of the interviewed households knew that excreta can be a valuable source of nutrients in agriculture (Danso et al., 2004). Concerning the use of human excreta, on average 72 % of the interviewed households had a positive perception to its use as manure and 80 % of the interviewed households believed that there should be a market for dried excreta (Danso et al., 2004). These numbers show a quite positive attitude of Ghanaians towards the ecosan approach and the potential for applying excreta based fertilizers in agriculture.

A recent study performed in Ghana surveyed farmers, marketers and consumers on their perception of vegetables fertilized with urine (Koomson, 2010 cited in Cofie et al., 2011). The study revealed a number of concerns raised by farmers, e.g., the fertilizing effect of urine on vegetables, storage efficiency of urine in the soil, fertilization rate and application techniques for various vegetables, etc. Thus, it was concluded that demonstration farms need to be set up in order address the technical concerns raised by farmers.

Among the surveyed marketers in Ghana, 54 % believed that urine is a waste and is not to be used for vegetable production (Koomson, 2010 cited in Cofie et al., 2011). The surveyed marketers who considered urine as not suitable for vegetable production were concerned about the health hazard of applying urine on vegetables and the fact that consumers might not be willing to buy vegetables fertilized with urine.

Approximately 44 % of the surveyed consumers were willing to purchase vegetables fertilized with human urine due to the fact that they perceived urine as a resource (Koomson, 2010 cited in Cofie et al., 2011). Despite the positive attitude towards vegetables fertilized with urine, the consumers shared their concerns regarding health risks connected with the consumption of such vegetables, however, none of the surveyed consumers was able to identify a specific disease with this respect.

Knowing the issues discussed above, it is easier to design a promotional campaign as the focus can be brought to the particular motivating or constraining factors that ecosan is able to address.

5.5.2 Sanitation promotion through media in Ghana

Different media channels for sanitation promotion in Ghana are discussed further.

5.5.2.1 Radio

Listening to radio in Ghana is even more popular than in Ethiopia (BBC World Service Trust, 2006). Radio is the most preferred and powerful communication medium in Ghana and there are numerous stations available in the country. In Accra alone, there are almost 30 FM stations (GhanaWeb, 2010). There are public radio stations owned by the Ghana Broadcasting Corporation, experimental radios such as “Univers” (radio of the University of Ghana) and community radios, which cover smaller areas, but are run by communities (Meier, 2008). The most popular are the latter ones. Some of them are sponsored by NGOs. The language used depends on the community. Call-in radio programs are popular in Ghana as they give people a feeling of having their voices heard. Community radios can be used for knowledge dissemination and raising awareness on ecosan. It is also important to highlight the fact that household radio ownership in Ghana is higher in rural areas (almost 56 %) than in urban areas (42 %) (Ghana Statistical Service, 2008b).

Different radio stations can be used to address a wide range of target groups divided by age, gender and profession as well as educational level (Meier, 2008). Call-in programs can be used to discuss the current sanitary situation and possibilities of solving sanitation related problems. In addition, different aspects of ecosan systems and their benefits can be discussed daily. Listeners can ask questions and give feedback on issues being discussed. Also, interviews with people using ecosan technologies can be broadcasted in a call-in program, followed by an invitation to visit a demonstration toilet or an agricultural field where sanitized excreta and urine were applied.

5.5.2.2 Newspapers

The most popular newspapers in Ghana include the “Daily Graphic”, followed by the “Daily Guide” and the “Accra Daily Mail” (Meier, 2008). While most of the newspapers focus on politics, there is also a tendency of specialized magazines to deal with other topics, e.g., education (Kafewo, 2006).

Many newspapers are published in English but some are published in local languages. The decision on the use of newspapers depends on the literacy rate in English and indigenous languages of the target group (refer to Figure 5.3).

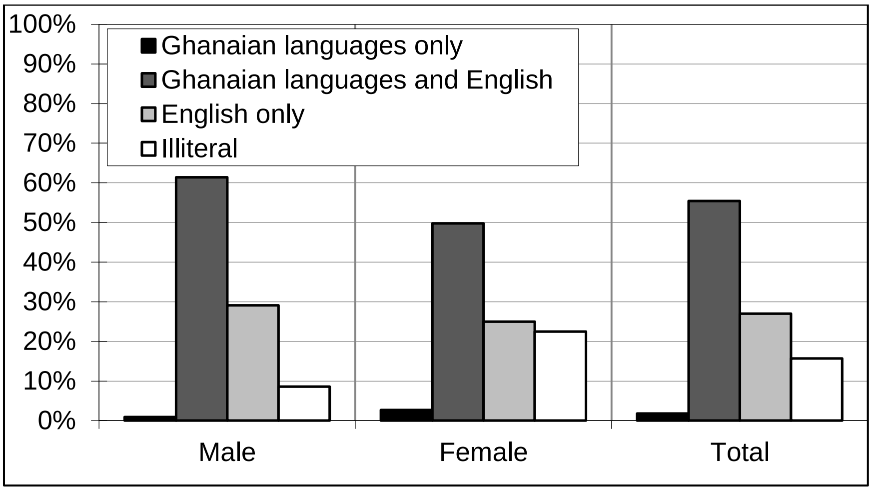

Figure 5.3: Adult literacy rates in English and Ghanaian languages by gender in Accra (based on Ghana Statistical Service, 2008b)

In non-literacy communities, promotion through newspapers can be useful if reading clubs exist, where English newspapers could be translated to local languages and the other way round (Karikari, 2000). In highly literate target groups, e.g., on the political level, promotion through newspapers could be effective.

5.5.2.3 Television

Television ownership by households in urban areas is much higher than in rural areas (56 % and almost 16 %, respectively) and in Accra alone, almost 73 % of the households own a television (Ghana Statistical Service, 2008b). Among television stations available in Ghana, Metro TV, which is focused on urban areas, is one of the most famous ones (Meier, 2008). The use of this medium is independent of the literacy rate but highly dependent on a household's financial status. Using television for ecosan promotion makes sense in Accra and other larger urban areas, where there is high television ownership. Through advertising on television, one has to reach a large number of people as it is much more expensive than advertising through other media. Television is often watched collectively. Consequently, broadcasting ecosan promotional campaign on television could trigger lively discussions.

5.5.3 Possible campaign partners in Ghana

Potential partners for an ecosan promotional campaign in Ghana are discussed further.

5.5.3.1 Community-based organizations

Similarly to the case of Ethiopia (refer to Section 5.4.3.1), CBOs play an important role in the lives of the Ghanaian population. Even though information on CBOs active in Ghana was sought, it could not have been found. It is, however, known that there are CBOs involved in health related activities in Ghana. For example, a local CBO called the Youth Agenda provided tents in order to cater for basic health services to the inhabitants of a poor neighborhood located in the Central Accra and to educate on issues related with material health, child care, AIDS and environmental hygiene (Asiedu, 2002). Consequently, knowing the CBOs active in the local area, it should be pursued to take advantage of their status and presence in the lives of the local inhabitants in order to involve them in sanitation campaigns.

5.5.3.2 Schools and public institutions

Activities at schools and universities can be similar to the ones in Ethiopia, as already described in Section 5.4.3.2.

At some universities in Ghana (Valley View University (VVU), Kwame Nkrumah University of Science and Technology), ecosan was already introduced into the curriculum. Moreover, the ecosan approach (e.g., urine diverting dry toilets, waterless urinals) was implemented at the VVU, which is located in the Greater Accra Region (Berger, 2010). More information on the ecosan project at the VVU can be consulted in Geller et al. (2006) and Berger (2010).

The International Water Management Institute (IWMI) is an international research center and an NGO with offices in ten countries located in Asia and Africa. The IWMI West-Africa main office is located in Accra, Ghana. The IWMI integrates Ghanaian students in their research on, e.g., urban and peri-urban agriculture, land and water management and safe wastewater and excreta reuse.

Other universities still focus on conventional sanitation techniques. In order to trigger the paradigm shift, ecosan clubs should be established at universities, where the knowledge about ecosan and sanitation is already present. The information on the related activities could be broadcasted by, e.g., radio “Univers” of the University of Ghana. Networking with other universities and cooperation for project implementation should be pursued. Lectures or workshops for students on sanitation and health could be organized and international lecturers could be invited to share their experience.

5.5.3.3 Artists

For details on cooperating with artists in an ecosan campaign refer to Section 5.4.3.3.

Two Ghanaian artists, Rocky Dawuni and Batman Samini already produced a song in collaboration with UNICEF about water and sanitation problems in Ghana (Hickling, 2007). They also visited communities that struggle with shortages of safe drinking water and sanitation facilities. They appealed to chiefs, elders and community members for safe water and hygiene practices. These artists should be contacted for further cooperation in the promotion of sanitation.

5.5.3.4 Church

Religion is important to many Ghanaians, thus churches could be a good communication channel for a sanitation campaign. The opinion of well-respected religious leaders can influence the community.

In the case of Christians, which is the largest religious group in Accra (refer to Figure 5.4), prejudice against urine and feces is mainly related to hygiene and it might be overcome if safe handling and treatment is guaranteed (Martinez Neri, 2009). The second biggest group, Muslims is required by religion to minimize any contact with human excreta and perform ablutions. Thus, it is necessary to educate them on the availability of ecosan options for washers.

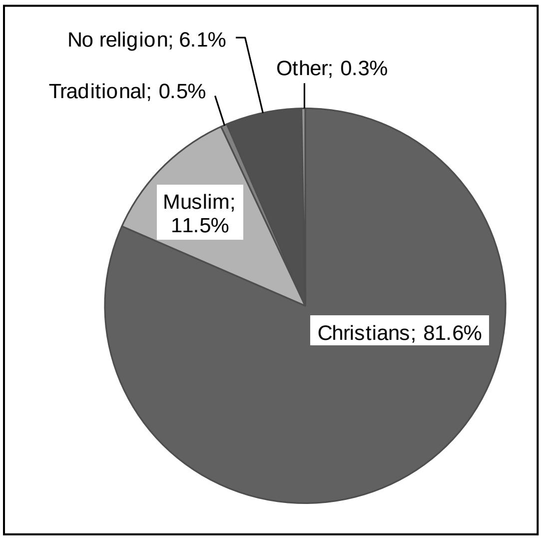

Figure 5.4: Religion in Accra (based on Ghana Statistical Service, 2008b)

5.5.3.5 Politicians and leaders

For details on involving politicians and leaders in an ecosan campaign refer to Section 5.4.3.5.

For example, in Dangme East (Greater Accra Region), chiefs of clans mobilize people for development in communities and collaborate with the District Assembly

(Ghana Districts, 2006). They would therefore be good contact partners for sanitation promotion.

5.5.3.6 Local NGOs

NGOs are embedded in local structures and have the knowledge that is essential for a successful sanitation campaign. Thus, their involvement is crucial. Examples of NGOs working in the water and sanitation field in Accra are listed in Table 5.4.

Safi Sana (Ghana) Ltd., which was founded by a Dutch NGO Aqua for All, is testing the collection and treatment of fecal sludge and other organic wastes in order to produce biogas and organic fertilizer (Tettey-Lowor et al., 2009). The Safi Sana Multi Service Block (MSB), is run as a franchise that, if successfully tested, can be rolled out to other areas (Safi Sana Ghana Ltd., 2011). The MSB includes a paid public toilet, water kiosk, hygiene products and wash services. The company's waste reuse concept is based on the collection and hygienic processing of the collected waste into marketable products (energy and organic fertilizers). Thus, Safi Sana should be seen an ideal partner for the promotion of ecosan.

The international NGO WaterAid works on water and sanitation projects through local partners. WaterAid should become involved in a sanitation promotion campaign in Ghana due to its large network of partners within the water and sanitation sector and an important role that the NGO plays in the sector, e.g., by taking part in advocating for policy.

Nature Conservation Research Center (NCRC) and World Vision International could help promote the ecosan approach at the national level as they are active in many regions of the country and could easily disseminate the knowledge on ecosan countrywide.

The Ghana Coalition of NGOs in Water and Sanitation (CONIWAS) located in Accra partners with sector players to influence policies, remove barriers and promote access to portable water, sanitation and improved hygiene for the poor and vulnerable. CONIWAS is an important partner for a sanitation campaign due to its recognized presence in Ghana and valuable partners, which include big donor agencies (e.g., WaterAid Ghana, World Bank, UNICEF, DANIDA, etc.) and key players in the water and sanitation sectors (the Ministry of Water Resources, Works and Housing, the Ministry of Local Government Rural Development and Environment, Community Water and Sanitation Agency). CONIWAS also organizes the annual national sector conference – the Mole Conference Series (refer to Section 2.1.4), which is a recognized national forum for sharing ideas on water and sanitation.

Professional Network Association (ProNet), an NGO that was established with the assistance of WaterAid, also plays a key role in the organization of the Mole Conference Series.

Table 5.4: Examples of NGOs that work in the water and sanitation field in Ghana

NGO	Geographical reach	Activities
· Aqua for All[a]	· Greater Accra (pilot project in Accra: public toilet block in Teshie and Ashaiman)	· founder of Safi Sana Ltd.: franchise concept for public water and sanitation facilities · Safi Sana runs a business unit which helps design, build and operate a centralized waste digestion and processing plant which produces bio-energy and organic fertilizer
· Danish International Development Assistance (Danida)[b]	· Central · Eastern · Greater Accra · Volta	· contribute to sustainable poverty reduction through: a) improved water supply, sanitation and hygiene education; b) increased knowledge and better use of the water resources · focus on the poor living in rural areas and small towns slums · support to NGOs and civil society organizations in the water and sanitation sector
· Nature Conservation Research Center (NCRC)[c]	· All 10 regions in Ghana	· promote the awareness and protection of Ghana's nature and wild species through conservation activities (link to ecosan: conservation of water and recycling of nutrients)
· Professional Network Association (ProNet)[d]	· Ashanti · Eastern · Greater Accra · Northern · Upper East · Upper West	· implement water, sanitation and hygiene promotion projects · strengthen capacity of partners so they can design, implement and manage an integrated program of water, sanitation and hygiene promotion in the community · focus on the rural and urban poor
· WaterAid[e]	· Northern · Eastern · Greater Accra · Upper East · Upper West	· works through local NGOs (e.g., ProNet), local government departments or private companies to conduct the projects · provide financial support, training and technical advice as well as assistance in planning, budgeting and institutional development · engage in policy debate/advocacy · empower the poor communities to know their rights of access to safe water and effective sanitation
· World Vision International[f]	· All 10 regions in Ghana	· teach about better hygiene and sanitation, constructing latrines · support micro-enterprise development · implement the Ghana Rural Water Project (water supply in rural areas)

a) Aqua for All, n.d.; Tettey-Lowor et al., 2009, b) Danida, 2004; Fuest et al., 2005, c) Martinez Neri, 2009, d) WaterAid Ghana, n.d.; Fuest et al., 2005, e) Fuest et al., 2005, f) Fuest et al., 2005; World Vision Africa, 2010

5.6 Example of a sanitation promotion campaign

Table 5.5 presents an example of an ecosan promotion campaign that could be organized in Arba Minch, Ethiopia. Important aspects to consider include the rainy seasons (April to May and September to October) (AMU and ARB, 2007) when transportation and outdoor activities are limited. Additional to the proposed campaign, the promotion of ecosan should be performed in the “Debub Nigat” newspaper, on the “Voice of South” radio and through leaflets, which would contain information on, e.g., available toilet types, their operation and maintenance requirements, contact information to toilet slab producers, distribution centers as well as possibilities of visiting demonstration toilets in the vicinity.

The already installed UDDTs at schools in Arba Minch (refer to Section 5.4.3.2) should also be used as demonstration toilets. Excreta based fertilizers could be applied in school gardens. Furthermore, existing UDDTs, Arborloo and Fossa Alterna toilets with agricultural trial plots at the premises of the ROSA office as well as toilets installed in private households should also be used for demonstration purposes. Cooperation with local NGOs could lead to training and education activities of campaign employees, teachers, CBO members as well as local and religious leaders in sanitation and hygiene.

A promotional campaign for Accra would have to be designed taking into account two rainy seasons: May to mid-July and mid-August to October (Ghana Districts, 2006). Also, the message of the campaign needs to be matched after having studied the local conditions and sanitation preferences (refer to Section 5.5.1 for information on the sanitation culture in Ghana). In Accra, an affordable in-house sanitation facility showing the household’s status, providing safety, especially for women, and convenience would be a good message for a sanitation campaign. Furthermore, the advantage of applying excreta based fertilizers on urban and peri-urban agricultural farms in Accra and its vicinity should be highlighted. Urban and peri-urban agriculture is widely practiced in Accra (refer to Section 2.1.3.2).

In Accra, another important message is the flexibility of the ecosan approach, with options suitable as household and community/shared toilets, toilet designs that are suitable for children, options for washers, etc. On plots where space is not available, promoting shared sanitation facilities is recommended. In Ghana, shared sanitation facilities are widely used, with 70 % of the urban population and 38 % of the rural population using shared facilities in 2008 (refer to Section 2.1.2) (WHO and UNICEF, 2010). However, it needs to be highlighted that only proper operation and maintenance will lead to health benefits of using these facilities. Here, the easiness of keeping the facilities clean should be discussed in order to encourage communities to adopt these sanitation options. Furthermore, dry toilets, e.g., urine diverting dry toilets allow users to become less dependent on water providers as water needs to be supplied only for household use and hand washing.

It is also recommended to use existing facilities, e.g., at the Valley View University (refer to Section 4.1.2.1 and Section 5.5.3.2) in order to organize an excursion and present their operation and maintenance as well as the agricultural area where excreta based fertilizers were applied. Furthermore, market days in different districts of the city should be used as an opportunity to inform about ecosan and provide contacts to toilet constructors, companies manufacturing toilet slabs, NGOs educating on health and sanitation, microfinance institutions offering micro loans for sanitation facilities, etc.

In Accra, advertising on television would make sense if enough budget is available for the sanitation campaign. Also, advertising through radio and newspapers is advisable. As already discussed in Section 5.5.2.1, radio is deeply rooted in the Ghanaian culture and it reaches a large part of the population in Ghana, especially in Accra. Radio "Univers" of the University of Ghana should be used for broadcasting information on school and university events related to ecosan, including scheduled role plays and song or artistic contests.

Table 5.5: Sanitation promotion campaign for Arba Minch (adapted from Blume, 2009)

Action	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**
Local situation analysis	■	■	■									
Contacting and mobilizing of campaign partners	■	■	■									
Partnering activities and further development of cooperation				■	■	■	■	■	■	■	■	■
Preparation of information packages for the media			■	■								
Establishment of WASH committees, community health clubs, sanitation clubs at schools and Arba Minch University (AMU)	■	■	■									
Education and training of employees and campaign partners[a]	■	■	■	■	■	■	■	■	■	■	■	■
Slogan and logo creation contest			■	■								
Education and training of teachers and CBO members in cooperation with NGOs[b]	■	■	■									
Design of promotional packages	■	■	■									
Health and sanitation education at schools[c] and AMU			■	■	■	■	■	■	■	■	■	■
Songs and role play preparation at schools and AMU			■	■	■	■	■					
Information day for journalists					19.11							
World Toilet Day celebration at schools and AMU					19.11							
Garden planting and maintenance at school premises[d]					■	■	■	■	■	■	■	■
Invitation of journalists, administration officers and parents to join an open day at schools							■					
Open day at schools								■				
Newspaper article on school ecosan								■				
Ecosan market stand[e]	■	■	■	■	■	■	■	■	■	■	■	■
Demonstration toilets viewing	■	■	■	■	■	■	■	■	■	■	■	■

a) Intensive training at the beginning of the campaign with follow-up training sessions

b) Teachers training prior to the beginning of the school year

c) School year in Ethiopia: September-June

d) Garden activities for students (first months of theory, then practice)

6 CONCLUSIONS

The main objective of this study was to analyze economic, social and technical aspects of low-tech sustainable sanitation systems, on the example of Ethiopia and Ghana.

Due to the fact that economic benefits can be considered as the main driver of the private sector to become involved in the sanitation sector, they have been put under close consideration.

In general, the demand and supply need to correspond to each other. Not only are the customers for products to be applied under the ecosan principle crucial, but the product must also be affordable, appealing, available in different designs, durable and easy to maintain. In order to achieve this, ecosan systems should be implemented in large scale.

On the supply-side, large-scale implementation would provide necessary resources to develop new technologies and achieve economies of scale. In order for this to happen, governmental support and regulation is required, e.g., for financing mechanisms, at the product development stage, for quality assurance or marketing and promotion. This would encourage technological innovations and help to adapt existing sanitary options to local conditions. Governmental support could also be channeled to training for the capacity development of the private sector and provision of efficient services. Furthermore, selling products in bulk to associations (e.g., to CBOs or NGOs) can benefit both the company, by avoiding expensive local dealers, and the customers, who can benefit from credit options, e.g., as a member of a CBO.

On the demand-side, it is necessary to implement appropriate marketing techniques such as sanitation marketing or product branding. Studying local conditions, in particular the reasons for adoption and non-adoption of sanitation, is necessary in order to understand the needs of the local population. In this way, it is possible to offer products that solve the problems stated by non-adopters (e.g., space restrictions, high groundwater table or problems with operation and maintenance) and meet the expectations of adopters (e.g., comfort, prestige, safety or health benefits).

For the ecosan approach to bring along maximum benefits, it is necessary to treat it as a holistic system, where suitable products are available on the market, where people (i.e. farmers, toilet builders, users) are trained and willing to undergo a behavioral change and where the logistics of the system are well-designed and executed (e.g., regular collection and appropriate sanitization of human excreta is performed when necessary). With large-scale implementation of ecosan it is possible to identify optimization options and how to maximize the economic benefit of these systems, both for the private sector and for the users (e.g., for farmers through crop productivity as a result of human excreta application in agriculture).

The summary of the analysis performed in this study and resulting recommendations is as follows:

Toilet manufacturing

- Production of plastic toilet slabs to be applied under the ecosan approach can be profitable in a country like Ethiopia.
- The biggest business risk is related to the demand for products. For this reason, the manufacturing line should be designed in a flexible way, allowing for

changes in production in case of failure or a decrease in demand for a particular product.

- Mass production results in lower operational costs but requires a higher investment, which may be problematic in a country like Ethiopia.
- Rising operational costs, i.e. costs of raw material, can pose a certain risk to the business.
- Cost minimization options are mainly related to machinery costs (e.g., purchasing used machinery) and cost of raw materials (e.g., recycling of scrap plastic, using blends of post-consumer resins and virgin raw material instead of virgin raw material).
- Further cost minimization options include choosing a location that is close to the demand for the products manufactured and where land-related expenses (e.g., land lease) are cheap.

<u>Urine as fertilizer</u>

- In the case of Ghana, the market value of human urine was calculated to be 0.014 GH¢/l (0.008 €/l).
- The market value of urine will generally change with the market prices of mineral fertilizers, the nutrient content of urine and the local demand for nutrients.
- The social acceptance for the application of human urine as fertilizer plays a crucial role in urine marketing. Therefore, urine application options on both non-food crops (e.g., oil palms and fast growing trees for biodiesel and fuel wood production) and food crops (e.g., maize plants) should be considered.
- The amount of mineral fertilizer that can be offset with urine, and the resulting fertilization needs that can be satisfied, depend on the available amount of urine and the size of plantations. The bigger the ecosan system, the larger fertilization needs can be satisfied, however, a utilization concept of ecosan products needs to be in place.

<u>Supply chain</u>

- The investment required for the supply chain of an ecosan system is rather small, which might attract the interest of the private sector.
- The biggest contributor to the project costs was identified to be the cost of urine transportation.
- In the case of collecting 7,000 l of urine per day, which corresponds to a small to medium size system, it would be economically feasible to transport it approximately 210 km (round trip). This distance will differ, depending on the local transportation costs (fuel price, truck maintenance costs, driver’s salary, the cost of the truck and auxiliary equipment that influences depreciation costs and the type and cost of containers used for urine transportation).
- With the increasing transportation distance, the project’s sensitivity towards transportation costs also increases. Finding ways of shortening the transportation distance has a positive effect on the profitability of the project.
- Ways of lowering or even covering urine transportation costs include transporting urine in bulk (urine collected from a number of public urinals located in close vicinity to each other) and exploiting truck’s cargo capacity on its return

trip by involving it in other transportation services. However, hygienic aspects need to be considered when choosing this solution.

- It is important to make transportation of urine flexible, i.e. to make it possible to transport empty containers together with other cargo on a return trip. Therefore, it is easier to equip a truck with a number of smaller containers than fit it with one big tank, also making loading and offloading easier for operators.
- It is possible to decrease urine storage costs by using plastic bladders instead of plastic containers and by storing urine on farmlands where it is to be applied.
- Designing projects that can interact with each other can help achieve savings on, e.g., transportation costs (truck can be used to collect and transport urine to its storage location and to transport other cargo on its return trip).

<u>Ecosan as a holistic system</u>

- Studying the local area for the design of a holistic system will allow exploring many options and come up with the best arrangement for local conditions:
  - Due to economic hardships, mineral fertilizers are often not applied on local oil palm plantations in the Kwabebibirem District in Ghana. Therefore, building urine-separating toilets would allow for separate urine collection and its application as liquid fertilizer.
  - It would also be possible to produce biodiesel from oil palm and run trucks on it, saving on fuel costs.
  - The abundance of oil palm plantations would make it possible to involve a truck in industry related transportation services (e.g., oil palm fresh fruit bunches to oil palm mills).
  - The problem of deforestation in the Kwabebibirem District could be addressed by establishing short rotation plantations, where fast growing tree species would be planted for fuel wood production. They could also be fertilized with urine.
- A successful implementation of an ecosan system will contribute to the economic development of the country by solving the problem of low access levels to sanitation and meeting the sanitation needs of the growing urban population. Further advantages include the improvement of the standard of living for inhabitants, environmental sustainability, employment opportunities as well as the potential involvement of local small and medium enterprises in the logistics of an ecosan system.
- Applying urine in agriculture can benefit farmers through a higher crop productivity, which would have a direct impact on farmers' income, and could make them independent of mineral fertilizer.

Outlook

Even though the potential economic feasibility of the projects has been proven by an extensive profitability analysis, their practicability needs to be tested on the ground.

It is necessary to create and innovate toilet designs to successfully follow technological trends, for example, for the application in the Terra Preta Sanitation concept. Ecosan could benefit from a large-scale project where different toilet designs would be tested, whereby problems would be monitored and solved through communicating them to engineers and redesigning toilets. Sanitation is not only about technology. A major part of it is rooted in local aspects such as availability of infrastructure, raw material, space, spare parts, groundwater table level, water scarcity and weather patterns, to name just a few. Once toilet designs are successfully field-tested, they could be implemented in large scale.

Marketing of human excreta is not yet widely practiced, with only a few examples surfacing here and there (e.g., urine sold to local farmers from public urine diverting dry toilets installed by the NGO Whenever the Need in India) (Gröber et al., 2011a). The social acceptance of excreta based fertilizers in agriculture should be addressed to make marketing of human excreta possible. This will require a suitable awareness raising campaign. Furthermore, showing the economic benefits of excreta based fertilizer application in agriculture should be explored by, for example, setting up demonstration farms. Further research should consider making use of sanitized feces in the proposed supply chain. With the declining soil fertility worldwide, returning nutrients back into agriculture will be gaining in importance more and more. Also, safe application of ecosan products (urine and feces) in agriculture needs to be the focal point of reuse. In this aspect, methods of urine treatment for successful removal of pharmaceutical residues need to be studied.

References

Handelsgesetzbuch: Einschließlich Seehandelsrecht, Gesellschaftsrecht, Wertpapierrecht, Gütertransportrecht, Wettbewerbsrecht (2003). Beck, München, ISBN 3-406-49898-1.

Sustainable sanitation service delivery Arba Minch Town. Sanitation Project in Peri-Urban Areas of Africa (SPA) Business plan (2010).

Aalbers H. (1999). *Resource recovery from faecal sludge using constructed wetlands*. A survey of the literature. UWEP Working Document. WASTE, The Netherlands.

Abdul-Ghaniyu A., Kranjac-Berisavljevic G. and Yakubu I.B. (2002). Sources and quality of water used in urban vegetable production in Tamale Municipality, Ghana. In: *Urban Agriculture Magazine*. vol 8, 10.

Adamtey N. (2005). *Recycling and evaluation of agricultural and agro-industrial residues for agricultural use in Ghana: A case study in the Kwaebibirem District.* M. Phil. thesis, School of Research and Graduate Studies, Faculty of Science, University of Ghana, Legon, Ghana.

African Initiatives (n.d.). *Ghana: Developing sustainable livelihoods in Northern Ghana*. http://www.african-initiatives.org.uk/projects/ghana.htm (accessed 09 November 2011).

Ageba G. and Amha W. (2006). Micro and small enterprises (MSEs) finance in Ethiopia: empirical evidence. In: *Eastern Africa Social Science Research Review*. vol 22(1), 63-86.

Agyarko K. and Adomako W.J. (2007). Survey of the use of organic manure among vegetable farmers in selected districts in Ghana. In: *Journal of Sustainable Development in Africa*. vol 9(4).

Ahlert D., Ahlert M., Van Duong Dinh H., Fleisch H., Heußler T., Kilee L. and Meuter J. (2008). *Social franchising. A way of systematic replication to increase social impact.* Bundesverband Deutscher Stiftungen, Berlin, Germany. http://www.stiftungen.org/fileadmin/bvds/de/Projekte/Projekttransfer/Social_Franchise_Manual_Englisch.pdf (accessed 28 July 2011).

Akinpelu D. (2008). *DMT Mobile Toilets to produce gas from human waste*. http://www.punchng.com (accessed 21 July 2011).

Al-Hassan R., Breisinger C., Diao X. and Thurlow J. (2008). *Agriculture for development in Ghana: New opportunities and challenges*. ReSAKSS Working Paper No. 16. International Food Policy Research Institute. http://pdf.usaid.gov/pdf_docs/PNADS618.pdf (accessed 15 November 2011).

Alkabbashi A.N., Alam M.Z., Mirghani M.E.S. and Al-Fusaiel A.M.A. (2009). Biodiesel production from crude palm oil by transesterification process. In: *Journal of Applied Science*. vol 9(17), 3166-3170.

Amha W. (2008). *Innovations in the delivery of financial services through the deposit taking microfinance institutions (MFIs) in Ethiopia*. A paper presented at AFRACA workshop on innovations in addressing rural finance challenges in Africa, Addis Ababa, Ethiopia.

Amoah P. (2008). *Wastewater irrigated vegetable production: Contamination pathway for health risk reduction in Accra, Kumasi and Tamale – Ghana.* PhD thesis, Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Amoah P., Drechsel P., Abaidoo R.C. and Henseler M. (2007). Irrigated urban vegetable production in Ghana: Microbiological contamination in farms and markets and associated consumer risk groups. In: *Journal of Water and Health*. vol 5(3), 455-466.

AMU and ARB (2007). *Baseline study report of Arba Minch town*. Report for the Project "Resource Oriented Sanitation Concept for Peri-Urban Areas in Africa (ROSA)". Arba Minch University (AMU) and Arba Minch Town Water Service (ARB).

AMU and ARB (2009). *Arba Minch town ROSA project booklet*. Arba Minch University (AMU) and Arba Minch Town Water Service (ARB), Arba Minch, Ethiopia.

Appeaning A.K. (2010). Urban and peri-urban agriculture in developing countries studied using remote sensing and in situ methods. In: *Remote Sensing*. vol 2(2), 497-513.

Aqua for All (n.d.). *Corporate brochure*. http://www.aquaforall.nl/documents/aqua4all/html_page/corporate_brochure_en.pdf (accessed 09 March 2012).

AquaSanTec (2007). *Company homepage*. http://www.kentainers.com/kent/home.html (accessed 07 February 2012).

ARM (n.d.). *Rotational molding. The introductory guide to designing rotationally moulded plastics parts*. Association of Rotational Molders (ARM), Oak Brook, Illinois, USA.

ARM (2000). *Rotational molding. The basic process*. Association of Rotational Molders (ARM), Oak Brook, Illinois, USA.

Asiedu A.B. (2002). Poverty reduction among the urban poor in Accra, Ghana - A comparative study of the roles of two community based organizations (CBOs). In: *Transforming Civil Society, Citizenship and Governance: The Third Sector in an Era of Global (Dis)Order: Proceedings of the International Society for Third Sector Research (ISTR) 5th International Conference*. Cape Town, South Africa, 7-10 July, 2002.

Ayele M. (2005). *Water is life, sanitation is dignity: Sanitation preference and household latrine designs*. Briefing Note 1. WaterAid, Ethiopia. http://www.wateraid.org/documents/plugin_documents/sanitation_briefing_note_1.pdf (accessed 28 July 2011).

Bahri A. (2007). Water reuse in Africa: Challenges and opportunities. In: *International Symposium on Water Supply and Sanitation for All: Obligation of the water professionals for our common future*. H. Huber; P. Wilderer and S. Paris (Eds.). Hans Huber AG. Berching, Germany.

Banful A.B. (2009). *Operational details of the 2008 fertilizer subsidy in Ghana: Preliminary report*. Ghana Strategy Support Program Background Paper 18. International Food Policy Research Institute, Washington, D.C. http://www.ifpri.org (accessed 28 February 2011).

Baskovich M.R. (2010). *Promoting sanitation markets at the Bottom of the Pyramid in Peru: A win-win scenario for government, the private sector and communities*. http://smartlessons.ifc.org/smartlessons/lesson.aspx?id=1344 (accessed 25 October 2011).

BBC World Service Trust (2006). *Research Summary Report: African Media Development Initiative*. http://downloads.bbc.co.uk/worldservice/trust/pdf/AMDI/AMDI_summary_Report.pdf (accessed 28 April 2010).

Beall G.L. (1998). *Rotational molding: Design, materials, tooling, and processing*. Hanser, Munich, Germany, ISBN 1-56990-260-7.

Berger W. (2010). *Ökologische Kreislaufwirtschaft an der Valley View University Accra (Ghana)*. Schlussbericht BMBF- Verbundvorhaben. Teilprojekt 2: „Sanitärtechnik innerhalb von Gebäuden“. http://www.susana.org/docs_ccbk/susana_download/2-810-schlussberichtvvughana02wd04731.pdf (accessed 24 February 2011).

Bibby S. and Knapp A. (2007). *From burden to communal responsibility: A sanitation success story from Southern Region in Ethiopia. Sanitation and Hygiene Series*. Water and Sanitation Program - Africa, World Bank, Nairobi Kenya. http://www.wsp.org/UserFiles/file/2122007111721_From_Burden_to_Communal_Responsibility-Ethiopa.pdf (accessed 19 April 2010).

Blume G. (2009). *Low-cost sanitation: technologies, marketing and promotion for Arba Minch, Ethiopia.* Project work, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany.

British Plastics Federation (n.d.). *Plastipedia: Rotational Moulding*. http://www.bpf.co.uk/Plastipedia/Processes/Rotational_Moulding.aspx (accessed 06 February 2012).

Business in Ghana (2011). *Ghana Oil Palm Development Company Limited - GOPDC. Ghana Business Pages: The Ghana Business Insight Center*. http://business.everythinghana.ceom/index.php?option=com_mtree&task=viewlink&link_id=42&Itemid=26 (accessed 16 November 2011).

Caminiti M., Cassal M., OhEigeartaigh M. and Zeru Y. (2007). *Feasibility study of biofuel production in Ghana: Assessing competitiveness and structure of the industry's value chain*. Elliott School of International Affairs - The George Washington University. http://elliott.gwu.edu/assets/docs/acad/ids/capstone/ghana07.pdf (accessed 08 February 2011).

Central Statistical Agency of Ethiopia (2011). *2010 National statistics (abstracts): Agriculture 2010*. http://www.csa.gov.et/index.php?option=com_rubberdoc&view=category&id=75&Itemid=561 (accessed 22 November 2011).

Chary V.S., Narender A. and Rao K.R. (2003). Pay-and-use toilets in India. In: *Waterlines*. vol 21(3), 12-14.

CIA (2005). *The World Fact Book: Labor force - by occupation. Central Intelligence Agency of the United States of America (CIA)*. https://www.cia.gov/library/publications/the-world-factbook/fields/2048.html# (accessed 25 November 2011).

CLARA (2011). *Project homepage*. http://clara.boku.ac.at/ (accessed 28 February 2012).

Cofie O. and Mainoo O.K. (2007). *The potential for urine recovery and reuse in densely populated districts within the Accra Metropolitan Area*. Exploratory study report prepared for the IWMI-SWITCH Project. Unpublished document.

Cofie O., Amoah P., Egyir I., Adamtey N. and Tettey-Lowor F. (2011). *Demonstration on the use of urine in urban agriculture*. SWITCH demo final report. http://www.switchurbanwater.eu/outputs/pdfs/W5-2_GEN_RPT_D5.2.4_Demonstration_on_the_use_of_urine_in_urban_agriculture.pdf (accessed 21 November 2011).

Cofie O., Drechsel P., Obuobie E., Danso G. and Keraita B. (2004). Environmental sanitation and urban agriculture in Ghana. In: *Towards the Millennium Development Goals - Actions for water and environmental sanitation: Proceedings of the 29th WEDC Conference*. Abuja, Nigeria, 2003. P. Harvey

(Ed.). Water Engineering and Development Centre. Loughborough, UK, pp. 9-12.
Cofie O., Kranjac-Berisavljevic G. and Drechsel P. (2005). The use of human waste for peri-urban agriculture in Northern Ghana. In: *Renewable Agriculture and Food Systems*. vol 20(2), 73-80.
Cohen R. (2010). Toilets and cellphones. In: *New York Times*. http://www.nytimes.com/2010/05/25/opinion/25iht-edcohen.html (accessed 25 October 2011).
Cordell D. (2010)*. The story of phosphorus: Sustainability implications of global phosphorus scarcity for food security.* PhD thesis, The Tema Institute, Department of Water and Environmental Studies, Linköping University, Linköping, Sweden.
Cordell D., Schmid-Neset T., White S. and Drangert J.O. (2009). Preferred future phosphorous scenarios: A framework for meeting long-term phosphorous needs for global food demand. In: *International Conference on Nutrient Recovery from Wastewater Streams*. Vancouver, British Columbia, Canada, 10-13 May, 2009. K.I. Ashley; D.S. Mavinic and F.A. Koch (Eds.). IWA Publishing. London, UK, pp. 23-44.
Corley R.H.V. and Tinker P.B. (2003)*. The oil palm.* 4th ed. Blackwell Science Ltd., Oxford, ISBN 0-632-05212-0.
Crawford R.J. and Kearns M.P. (2003)*. Practical guide to rotational moulding*. Rapra Technology Limited, Shawbury, UK, ISBN 1-85957-387-8.
Crawford R.J. and Throne J.L. (2002)*. Rotational molding technology*. Plastics Design Library / William Andrew Publishing, Norwich, NY, ISBN 1-884207-85-5.
Crundwell F.K. (2008)*. Finance for engineers: Evaluation and funding of capital projects*. Springer-Verlag, London, ISBN 978-1-8480-0032-2.
CSA (2007)*. Statistical tables for the 2007 Population and Housing Census of Ethiopia*. Central Statistical Agency of Ethiopia (CSA). http://www.csa.gov.et/index.php?option=com_rubberdoc&view=category&id=72&Itemid=521 (accessed 19 December 2011).
Dabire L. (2011)*. Sanitation policy. Western Africa / Ghana*. http://www.washwatch.org/western-africa/ghana (accessed 20 July 2011).
Danida (2004)*. Ghana-Denmark partnership*. Strategy for Development Cooperation 2004-2008. http://amg.um.dk/NR/rdonlyres/8B2275C0-D52A-4930-8288-3AC00F410763/0/GhanaDenmarkPartnership.pdf (accessed 08 March 2012).
Danso G., Drechsel P. and Gyiele L. (2004). Urban household perception of urine-excreta and solid waste source separation in urban areas of Ghana. In: *Ecosan - closing the loop: Proceedings of the 2nd International Symposium on Ecological Sanitation, incorporating the 1st IWA Specialist Group Conference on Sustainable Sanitation*. Lübeck, Germany, 7-11 April 2003. C. Werner (Ed.). GTZ Div. 44. Eschborn, Germany, pp. 191-196.
Davis J. (2005). Private-sector participation in the water and sanitation sector. In: *Annual Review of Environment and Resources*. vol 30(1), 145-183.
Dejene A. (2000)*. Report on food security, environment and population in the context of a policy framework for sustainable development. Case study of Ethiopia.* UNECA, SRDC-EA, Kigali.
Dejene A. (2003)*. Integrated natural resources management to enhance food security: The case for community-based approaches in Ethiopia.* Food and Agriculture Organization of the United Nations, Rome, Italy.

ftp://ftp.fao.org/docrep/fao/005/Y4818E/Y4818E00.pdf (accessed 21 November 2011).

Demirbas A. (2008). *Biodiesel: A realistic fuel alternative for diesel engines*. Springer, London, ISBN 1601195818.

Devereux S. (2006). *Agriculture and social protection in Ghana: A leap in the dark?* Policy Brief 30.

Devine J. (2010). Sanitation marketing as an emergent application of social marketing: Experiences from East Java. In: *Cases in Public Health Communication & Marketing*. vol 4, 38-54.

DHV Consultants (2002). *Environmental Support Project, Component 3. Arba Minch Water Supply and Sanitation.* Ministry of Water Resources, Ethiopia.

DMT Toilets (2010). *Company homepage*. http://www.dmttoilet.com (accessed 21 July 2011).

Dockhorn T. (2009). About the economy of phosphorus recovery. In: *International Conference on Nutrient Recovery from Wastewater Streams*. Vancouver, British Columbia, Canada, 10-13 May, 2009. K.I. Ashley; D.S. Mavinic and F.A. Koch (Eds.). IWA Publishing. London, UK, pp. 145-158.

Drechsel P., Giordano M. and Gyiele L. (2004). *Valuing nutrients in soil and water: Concepts and techniques with examples from IWMI studies in the developing world. Research Report 82*. International Water Management Institute, Colombo, Sri Lanka, ISBN 92-9090-570-0.

Drechsel P., Graefe S., Sonou M. and Cofie O.O. (2006). *Informal irrigation in urban West Africa: An overview*. IWMI Research Report 102. International Water Management Institute, Colombo, Sri Lanka. http://www.iwmi.cgiar.org/publications/iwmi_research_reports/pdf/pub102/rr102.pdf (accessed 08 November 2011).

Drewko A. (2007). *Resource-oriented public toilets in developing countries: Ideas, design, operation and maintenance for Arba Minch, Ethiopia.* M.Sc. thesis, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany. http://www.susana.org/docs_ccbk/susana_download/2-563-drewko-2007-public-toilets-arbaminch-ethiopia-en.pdf (accessed 31 October 2011).

Drewko A. and Otterpohl R. (2009). Analysis of stakeholders in the sanitation sector on the example of Arba Minch, Ethiopia. In: *Water, sanitation and hygiene. Sustainable development and multisectoral approaches: Proceedings of the 34th WEDC International Conference*. Addis Ababa, Ethiopia, 18-22 May 2009. R. Shaw (Ed.). Water Engineering and Development Centre. Loughborough, UK, pp. 174-178.

Drewko A. and Otterpohl R. (2010). Potential and limitations for the private sector involvement in sanitation in Ethiopia. In: *Young Water Professionals Conference: Proceedings of the 5th YWP Conference and 3rd IWA-AWA National Conference*. Sydney, Australia, 5-7 July 2010.

Drewko A., Martinez Neri I.F. and Otterpohl R. (2010). Closing the loop - ecological sanitation supply chain on the example of Accra and Kade, Ghana. In: *Sustainable Solutions for Small Water and Wastewater Treatment Systems: Proceedings of the 9th IWA Specialised Group Conference on Small Water and Wastewater Systems and 2nd IWA Specialised Group on Resource-oriented Sanitation*. Girona, Spain, 19-24 April 2010.

Economic Commission for Africa (2001). *Booklet on Population, Environment, Development and Agriculture (PEDA) Model*. Projections for Ethiopia.

http://www.uneca.org/popia/Peda/PEDA_Advo_Book_Eth.pdf (accessed 23 November 2011).

Egziabher A.G., Lee-Smith D., Maxwell D.G., Memon P.A., Mougeot L.J. and Sawio C.J. (1994). *Cities feeding people: An examination of urban agriculture in East Africa*. International Development Research Centre, Ottawa, ISBN 0-88936-706-X.

Elsbett G. and Bialkowsky M. (2003). Engines running on pure vegetable oil as regrowing fuel: *History, development, experience, chances*. Shanghai International Symposium on I.C. Engine, Shanghai, China. http://www.elsbett.com/fileadmin/elsbett/archiv/de/svohistory.pdf (accessed 08 February 2011).

Energy Commission (2010). *Bioenergy policy for Ghana: Draft*. http://new.energycom.gov.gh/downloads/BIOENERGY.pdf (accessed 08 February 2011).

Environmental Protection Authority (2003). *Standards for industrial pollution control in Ethiopia*. Prepared by the Federal Environmental Protection Authority and the United Nations Industrial Development Organisation under the Ecologically Sustainable Industrial Development Project, Addis Ababa, Ethiopia.

Ethiopian Investment Agency (2008a). *Ethiopian investment guide*, Addis Ababa, Ethiopia.

Ethiopian Investment Agency (2008b). *Factor costs*, Addis Ababa, Ethiopia.

Factura H., Bettendorf T., Buzie C., Pieplow H., Reckin J. and Otterpohl R. (2010). Terra Preta Sanitation: re-discovered from an ancient Amazonian civilisation - integrating sanitation, biowaste management and agriculture. In: *Water Science and Technology*. vol 61(10), 2673-2679.

FAO (2005a). *Fertilizer use by crop in Ghana*. Food and Agriculture Organization of the United Nations (FAO). 1st version, Rome, Italy. ftp://ftp.fao.org/docrep/fao/008/a0013e/a0013e00.pdf (accessed 28 February 2011).

FAO (2005b). *National soil degradation maps.* Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/landandwater/agll/glasod/glasodmaps.jsp (accessed 21 November 2011).

FAO (2008). *Current world fertilizer trends and outlook to 2012*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. ftp://ftp.fao.org/agl/agll/docs/cwfto12.pdf (accessed 05 December 2011).

FAO (2009a). *Food and agricultural commodities production*. Food and Agriculture Organization of the United Nations (FAO). http://faostat.fao.org (accessed 21 September 2011).

FAO (2009b). *PriceSTAT. Food and Agriculture Organization of the United Nations (FAO)*. http://faostat.fao.org/site/570/DesktopDefault.aspx?PageID=570#ancor (accessed 17 November 2011).

FAO (2011a). *CountrySTAT Ethiopia. Food and Agriculture Organization of the United Nations (FAO)*. http://213.55.92.108/countrystat/index.asp?ctry=ETH&lang= (accessed 21 November 2011).

FAO (2011b). *Ecocrop*. Food and Agriculture Organization of the United Nations (FAO). www.ecocrop.fao.org (accessed 09 February 2011).

FAO (2012). *FAOSTAT.* Food and Agriculture Organization of the United Nations (FAO). http://faostat.fao.org (accessed 10 March 2012).

Faurès J.M. and Santini G. (2010). *Interventions in water to improve livelihoods in rural areas*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Ferriman A. (2007). *BMJ readers choose the "sanitary revolution" as greatest medical advance since 1840*. British Medical Journal (BMJ). http://www.bmj.com/content/334/7585/111.2.extract (accessed 25 October 2011).

Fewtrell L., Kaufmann R.B., Kay D., Enanoria W., Haller L. and Colford M.J. Jr. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: A systematic review and meta-analysis. In: *Lancet Infectious Diseases*. vol 5(1), 42-52.

Florido L.V. and Cornejo A.T. (2002). *Yemane Gmelina arborea (Roxb.)*. Research Information Series on Ecosystems, vol 14 (3). http://erdb.denr.gov.ph/publications/rise/r_v14n3.pdf (accessed 02 February 2012).

Fonseca C. (2006). *Microfinance for water supply services*. http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/Micro%20for%20water.htm (accessed 08 March 2012).

Forestry/Fuelwood Research and Development Project (1994). *Growing multipurpose trees on small farms*. Module 9: Species Fact Sheets. 2nd ed., Winrock International, Bangkok, Thailand.

Forum for Social Studies (2009). *FSS launches a development-oriented radio program in Debub*. http://www.fssethiopia.org.et/Jember.htm (accessed 08 March 2012).

Foster V. and Briceño-Garmendia C. (Eds.) (2010). *Africa's infrastructure: A time for transformation*. International Bank for Reconstruction and Development / World Bank, Agence Française de Développement. Agence Française de Développement, Paris, France.

Fuest V., Ampomah B., Haffner S. and Tweneboah E. (2005). *Mapping the water sector of Ghana: An inventory of institutions and actors. GLOWA Volta research documentation*. http://131.220.109.9/fileadmin/template/Glowa/Downloads/Fuest_et_al_Maping_the_Water_Sector_of_Ghana_-_Institutions_and_Actors.pdf (accessed 08 March 2012).

Geller G., Berger W., Fries N., Germer J., Glücklich D., Hörner G., Laryea S. and Sauerborn J. (2006). Ecological development of settlements: *The case study Valley View University, Accra, Ghana. In: Research and Development in Sub-Saharan Africa*. 2-5.

Germany Trade and Invest (2009a). *Wirtschaftsdaten kompakt: Äthiopien*. http://www.gtai.de/ext/anlagen/PubAnlage_6116.pdf?show=true (accessed 01 July 2009).

Germany Trade and Invest (2009b). *Wirtschaftsentwicklung 2008/09 Äthiopien*. http://www.gtai.de/fdb-SE,MKT200909298015,Google.html (accessed 25 March 2010).

Germany Trade and Invest (2011). *Wirtschaftsdaten kompakt: Äthiopien*. https://www.gtai.de/GTAI/Content/DE/Trade/Fachdaten/PUB/2011/11/pub201111178006_151060.pdf (accessed 02 March 2012).

Germer J. and Sauerborn J. (2008). *Urine diverting dehydration toilets to harness nutrients: An estimation for Ghana*. http://www2.gtz.de/Dokumente/oe44/ecosan/en-urine-diverting-dehydration-toilets-to-harness-nutrients-2008.pdf (accessed 18 June 2010).

Getahun N. (2006). *The theory and practice of community radio in Ethiopia: The case study of Sidama and Kore Radio Development Initiative.* M.Sc. thesis, Addis Ababa University, Addis Ababa, Ethiopia. http://home.mediehogskolen.no/aau/GetahunNigatu.pdf (accessed 14 April 2010).

Ghana Districts (2006). *Homepage*. http://www.ghanadistricts.com (accessed 09 March 2012).

Ghana Statistical Service (2008a). *Ghana in figures*. http://www.statsghana.gov.gh/docfiles/gh_figures_2008.pdf (accessed 30 November 2011).

Ghana Statistical Service (2008b). *Ghana living standards survey: Report of the fifth round*. http://www.statsghana.gov.gh/docfiles/glss5_report.pdf (accessed 08 November 2010).

GhanaWeb (2010). *Radio*. http://www.ghanaweb.com/GhanaHomePage/communication/radio.php (accessed 27 April 2010).

Girmai A. (2007). The role of urban agriculture in ensuring food security: The case of Addis Ababa. In: *Fostering new development pathways: Harnessing rural-urban linkages (RUL) to reduce poverty and improve environment in the highlands of Ethiopia: Proceedings of a planning workshop on Thematic Research Area of the Global Mountain Program*. Addis Ababa, Ethiopia, 29-30 August, 2006. G. Zeleke; P. Trutmann and A. Denekew (Eds.).

GNIB (2008). *Water for agriculture and energy in Africa: The challenges of climate change. Ghana National Investment Brief (GNIB)*. www.sirtewaterandenergy.org/docs/reports/Ghana-Draft2.pdf (accessed 08 November 2011).

Gröber K., Crosweller D., Schröder E., Panchal-Segtnan A., Zurbrügg C. and Kappauf L. (2011a). *Sanitation as a business - Factsheet of Working Group 9a*. Sustainable Sanitation Alliance (SuSanA). http://www.susana.org/docs_ccbk/susana_download/2-832-9a-wg09asusana-factsheet-decdraft22122011-es.pdf (accessed 19 January 2012).

Gröber K., McCreary C., Panzerbieter T., Rück J. and Kappauf L. (2011b). *Public awareness raising and sanitation marketing - Factsheet of Working Group 9b. Sustainable Sanitation Alliance (SuSanA)*. http://www.susana.org/docs_ccbk/susana_download/2-749-9b-wg09b-susana-factsheet-awareness-raising.pdf (accessed 08 March 2012).

Gurmit S., Lim Kim H., Teo L. and David Lee K. (1999). *Oil palm and the environment: A Malaysian perspective*. Vol. 1. Malaysian Oil Palm Growers Council.

Hammond A.L., Kramer W.J., Katz R.S., Tran J. and Walker C. (2007). *The next 4 billion. Market size and business strategy at the Base of the Pyramid*. World Resources Institute and International Finance Corporation, Washington DC, USA. http://www.wri.org/publication/the-next-4-billion (accessed 07 October 2011).

Heierli U. and Frias J. (2007). *One fly is deadlier than 100 tigers: Total sanitation as a business and community action in Bangladesh and elsewhere.* Swiss Agency for Development and Cooperation (SDC). http://www.poverty.ch/documents/one_fly.pdf (accessed 17 October 2011).

Heinss U., Larmie S.A. and Strauss M. (1998). *Solids separation and pond systems for the treatment of faecal sludges in the tropics: Lessons learnt and recommendations for preliminary design*. EAWAG/SANDEC, Switzerland.

Henao J. and Baanante C. (2006). *Agricultural production and soil nutrient mining in Africa: Implications for resource conservation and policy development*. IFDC, Muscle Shoals, USA.

Hickling A. (2007). *'Clean Water' song hits Ghana's airwaves on World Water Day*. http://www.unicef.org/infobycountry/ghana_39177.html (accessed 26 May 2010).

Höglund C. (2001). *Evaluation of microbial health risks associated with the reuse of source-separated humane urine.* PhD thesis, Royal Institute of Technology, Stockholm, Sweden. http://www.bvsde.paho.org/bvsacd/cd68/HoglundCaroline.pdf (accessed 08 November 2010).

Höglund C., Ashbolt N., Stenström T.A. and Svensson L. (2002). Viral persistence in source-separated human urine. In: *Advances in Environmental Research*. vol 6(3), 265-275.

Holland H. (2011). Cholera epidemic kills 60 in Ghana. In: *Reuters Africa*. http://af.reuters.com/article/ghanaNews/idAFLDE72H1WJ20110318?sp=true (accessed 27 October 2011).

Hossain M.K. (1999). *Gmelina arborea: A popular plantation species in the tropics. Fact sheet, quick guide to multipurpose trees from around the world*. http://www.winrock.org/fnrm/factnet/factpub/FACTSH/Gmelina%20arborea1.pdf (accessed 09 February 2011).

Howard S. (2005). *Tapping into private sector? Private sector participation in water supply and sanitation*, Ethiopia. http://www.wateraid.org/documents/plugin_documents/private_sector_briefing_note_final_7new.pdf (accessed 08 March 2012).

Hulme D. (2008). *The story of the Grameen Bank: From subsidised microcredit to market-based microfinance. BWPI Working Paper 60*. Brooks World Poverty Institute, Manchester, ISBN 978-1-906518-59-2.

Hutton G. and Bartram J. (2008). *Regional and global costs of attaining the water supply and sanitation target (Target 10) of the Millennium Development Goals.* World Health Organization, Geneva, Switzerland. http://www.who.int/water_sanitation_health/economic/mdg_global_costing.pdf (accessed 04 February 2012).

Hutton G., Haller L. and Bartram J. (2007). Global cost-benefit analysis of water supply and sanitation interventions. In: *Journal of Water and Health*. vol 5(4), 481-502.

ICMSF (1974). *Micro-organisms in foods. Sampling for microbiological analysis: Principles and specific applications.* The International Commission on Microbiological Specifications for Food (ICMSF), University of Toronto Press, Toronto, Canada.

IFAD (2010). *Desertification.* International Fund for Agricultural Development (IFAD), Rome, Italy. http://www.ifad.org/pub/factsheet/desert/e.pdf (accessed 18 January 2012).

IPNIS (2011). *IPNIS database. Integrated Plant Nutrition Information System (IPNIS).* Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/ag/agp/ipnis/index.asp (accessed 17 November 2011).

Jenkins M.W. and Curtis V. (2005). Achieving the "good life": Why some people want latrines in rural Benin. In: *Social Science and Medicine*. vol 61(11), 2446-2459.

Jenkins M.W. and Scott B. (2007). Behavioral indicators of household decision-making and demand for sanitation and potential gains from sanitation marketing in Ghana. In: *Social Science and Medicine*. vol 64(12), 2427-2442.

Johnston M. and Holloway T. (2007). A global comparison of national biodiesel production potentials. In: *Environmental Science and Technology*. vol 41(23), 7967-7973.

Jönsson H. and Vinnerås B. (2004). Adapting the nutrient content of urine and faeces in different countries using FAO and Swedish data. In: *Ecosan - closing the loop: Proceedings of the 2nd International Symposium on Ecological Sanitation, incorporating the 1st IWA Specialist Group Conference on Sustainable Sanitation*. Lübeck, Germany, 7-11 April 2003. C. Werner (Ed.). GTZ Div. 44. Eschborn, Germany, pp. 623-626.

Jönsson H., Richert Stintzing A., Vinnerås B. and Salomon E. (2004). *Guidelines on the use of urine and faeces in crop production*. EcoSanRes Publication Series. Report 2004-2, Stockholm Environment Institute: Stockholm, Sweden. http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR2web.pdf (accessed 15 September 2011).

Kafewo S. (2006). *Ghana - research findings and conclusions: African Media Development Initiative*, London, UK. http://downloads.bbc.co.uk/worldservice/trust/pdf/AMDI/ghana/amdi_ghana_full_report.pdf (accessed 28 April 2010).

Kannan D. and Paliwal K. (1995). Effect of nursery fertilization on Cassia siamea seedlings growth and its impact on early field performance. In: *Journal of Tropical Forest Science*. vol 8(2), 203-212.

Kannana D. and Paliwala K. (1996). Fertilization response on growth, photosynthesis, starch accumulation, and leaf nitrogen status of Cassia siamea Lam. seedlings under nursery conditions. In: *Journal of Sustainable Forestry*. vol 4(1-2), 141-157.

Karikari K. (2000). The development of community media in English – speaking West Africa. In: *Promoting community media in Africa*. K.S.T. Boafo (Ed.). Paris, France, pp. 43-60. http://www.unesco.org/webworld/publications/community_media/pdf/chap3.pdf (accessed 28 April 2010).

Kinver M. (2008). *BBC NEWS Science/Nature: Singer shines light on sanitation*. http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/7342789.stm (accessed 08 March 2012).

Kleiner K. (2007). The backlash against biofuels. In: *Nature Reports Climate Change*. http://www.nature.com/climate/2008/0801/full/climate.2007.71.html (accessed 29 November 2011).

Knothe G. and Steidley K.R. (2005). Kinematic viscosity of biodiesel fuel components and related compounds. Influence of compound structure and comparison to petrodiesel fuel components. In: *Fuel*. vol 84(9), 1059-1065.

Koomson P. (2010). *Perception and willingness of market actors on use of human urine and its products for urban in the city of Accra.* Unpublished M.Phil. thesis, Department of Agricultural Economics and Agribusiness, University of Ghana.

Koppaka R. (2011). Ten great public health achievements – worldwide, 2001-2010. In: *Morbidity and mortality weekly report (MMWR)*. vol 60(24), 814-818. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6024a4.htm?s_cid=mm6024a4_w (accessed 08 September 2011).

Krausova M. and Banful A.B. (2010). *Overview of the agricultural input sector in Ghana*. IFPRI Discussion Paper 01024. International Food Policy Research Institute. http://www.ifpri.org/sites/default/files/publications/ifpridp01024.pdf (accessed 21 September 2011).

Kufogbe S.K., Forkuor G. and Muquah G. (2005). *Exploratory studies on urban agriculture in Accra. Land use mapping and GIS*. Final Report. RUAF-IWMI, Accra, Ghana.

Kvarnström E., Emilsson K., Stintzing R.S., Johansson M., Jönsson H., af Petersens E., Schönning C., Christensen J., Hellström D., Qvarnström L., Ridderstolpe P. and Drangert J.O. (2006). *Urine diversion: One step towards sustainable sanitation*, Stockholm Environment Institute: Stockholm, Sweden. http://59.92.116.99/eldoc1/d70d/01jan06sei1.pdf (accessed 15 September 2011).

Lamba D. (1993). *Urban agriculture research in East Africa: Record, capacities and opportunities*. Cities Feeding People Series. Report 2. IDRC, Ottawa, Canada. http://idl-bnc.idrc.ca/dspace/bitstream/10625/13007/1/103007.pdf (accessed 23 November 2011).

Lesschen J.P., Stoorvogel J.J. and Smaling E.M.A. (2004). *Scaling soil nutrient balances: Enabling mesolevel applications for African realities*. Food and Agriculture Organization of the United Nations, Rome, ISBN 92-5-105237-9.

Mahider and Demie (2005). *Water and sanitation for all? Study on community based organisations and options for WATSAN credit scheme in Ticho*, Ethiopia. http://www.wateraid.org/documents/plugin_documents/ticho_cbo_micro_credit_2005.pdf (accessed 08 March 2012).

Mainoo A.A. and Ulzen-Appiah F. (1996). Growth, wood yield and energy characteristics of Leucaena leucocephala, Gliricidia sepium and Senna siamea at age 4 years. In: *Ghana Journal of Forestry*. vol 3, 70-79.

Mainoo N.O.K. (2007). *Feasibility of low cost vermicompost production in Accra, Ghana.* M.Sc. thesis, Department of Bioresource Engineering, McGill University, Montreal. http://webpages.mcgill.ca/staff/deptshare/FAES/066-Bioresource/Theses/theses/387NanaOseiMainoo2009/387NanaOseiMainoo2009.pdf (accessed 09 November 2011).

Mankiw N.G. (2004). *Principles of economics*. Thomson/South-Western, Mason, Ohio, ISBN 0-324-20403-5.

Mann H.T. (1976). *Sanitation without sewers*. Overseas building notes no. 168.

Martinez Neri I.F. (2009). *Design of a supply chain for a sustainable sanitation system on the example of Accra and Kade, Ghana.* M.Sc. thesis, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany. http://www.susana.org/docs_ccbk/susana_download/2-1052-en-design-of-a-supply-chain-for-a-sustainable-sanitation-system-2009.pdf (accessed 28 July 2011).

Mastny L. (2008). *Biofuels for transport: Global potential and implications for sustainable energy and agriculture*. Earthscan, London, ISBN 978-1-84407-422-8.

Mathewson P. and Ayele M. (2005). *A healthy debate: A discussion paper around sanitation and hygiene promotion, focusing on WSSHP project in Tigray, Ethiopia*. http://www.wateraid.org/documents/plugin_documents/healthy_debate.pdf (accessed 07 March 2012).

McConville J. (2003). *How to promote the use of latrines in developing countries.* M.Sc. thesis, Department of Civil and Environmental Engineering, Michigan Technological University, USA. http://www.cee.mtu.edu/sustainable_engineering/resources/technical/latrine_promotion_FINAL.pdf (accessed 18 December 2011).

McDaid J. (1998). *The grinding of PE powders for use in rotational moulding.* PhD thesis in Mechanical and Manufacturing Engineering, The Queen's University, Belfast, United Kingdom.

Mehta M. (2008). *Assessing microfinance for water and sanitation: Exploring opportunities for sustainable scaling up*. A study for the Bill & Melinda Gates Foundation, Ahmedabad, India.

Mehta M. and Virjee K. (2003). *Financing small water supply and sanitation service providers: Exploring the microfinance option in sub-Saharan Africa*. Water and Sanitation Program, Nairobi, Kenya.

Meier A.G. (2008). *A concept proposal to promote ecological sanitation systems in Accra, Ghana.* Project work, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany.

Ministry of Food and Agriculture (2010). *Agriculture in Ghana: Facts and figures (2009)*. http://www.mofa.gov.gh (accessed 21 November 2011).

Ministry of Food and Agriculture (2011). *Agriculture in Ghana: Facts and figures (2010)*. Statistics, Research and Information Directorate. http://www.mofa.gov.gh (accessed 08 March 2012).

MoFED (2006). *Ethiopia: Building on progress. A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10)*. Federal Democratic Republic of Ethiopia, Ministry of Finance and Economic Development (MoFED), Addis Ababa, Ethiopia.

MoH (2005). *National Hygiene and Sanitation Strategy*. Federal Democratic Republic of Ethiopia, Ministry of Health (MoH). http://www.wsp.org/UserFiles/file/622200751450_EthiopiaNationalHygieneAndSanitationStrategyAF.pdf (accessed 08 March 2012).

MoH (2006). *National Protocol for Hygiene and "On-site" Sanitation: To enable universal coverage of community-led improved hygiene and improved on-site sanitation in Ethiopia*. Federal Democratic Republic of Ethiopia, Ministry of Health (MoH).

Morgan P. (2004). *An ecological approach to sanitation in Africa: A compilation of experiences*, Harare, Zimbabwe. http://www.ecosanres.org/PM_Report.htm (accessed 01 July 2010).

Mougeot L.J. (2000). *Urban agriculture: Definition, presence, potentials and risks, and policy challenges*. Cities Feeding People Series. Report 31. International Development Research Centre, Ottawa, Canada. http://idl-bnc.idrc.ca/dspace/bitstream/10625/26429/12/117785.pdf (accessed 13 December 2011).

MoWR (2001). *Ethiopian Water Resources Strategy*. Ministry of Water Resources (MoWR), Addis Ababa, Ethiopia.

MoWR (2006). *Universal Access Plan*. Federal Democratic Republic of Ethiopia, Ministry of Water Resources (MoWR), Addis Ababa, Ethiopia.

MoWR (2007). *Water Supply, Sanitation & Hygiene (WASH) Multi-Stakeholder Forum-2 Statement*. Ministry of Water Resources (MoWR), Addis Ababa, Ethiopia.

MoWR, MoH and MoE (2006). *Memorandum of Understanding between Ministry of Water Resources, Ministry of Health and Ministry of Education on the Integrated Implementation Modality of Water Supply, Sanitation and Hygiene Education Programs (WASH) in Ethiopia*. Federal Democratic Republic of Ethiopia, Ministries of Water Resources (MoWR), Health (MoH) and Education (MoE), Addis Ababa, Ethiopia.

MoWR, MoH, MoE, MoUD and EUWI (2007). *Needs assessment to achieve universal access to improved hygiene and sanitation by 2012: To enable 100% adoption of improved hygiene and sanitation*. Federal Democratic Republic of Ethiopia, Ministries of Water Resources (MoWR), Health (MoH), Education (MoE) and Urban Development (MoUD), European Union Water Initiative (EUWI).

Mukherjee N. (2001). *Achieving sustained sanitation for the poor*. Water and Sanitation Program- East Asia and the Pacific, Washington DC, USA.

Müller A. (2003). *Coloring of plastics: Fundamentals - colorants - preparations*. Hanser, München, ISBN 3-466-22346-0.

Murray A., Cofie O. and Drechsel P. (2011). Efficiency indicators for waste-based business models: fostering private-sector participation in wastewater and faecal sludge management. In: *Water International*. vol 36(4), 505-521.

MWRWH (2009). *Ghana water and sanitation sector performance report*. Ministry of Water Resources, Works and Housing (MWRWH), Accra, Ghana. http://wsmp.org/downloads/4d8ca15ec1a12.pdf (accessed 11 October 2011).

National Academy of Sciences (1980). *Firewood crops. Shrub and tree species for energy production. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development Commission on International Relations*, Washington DC, USA.

NCDEX (2010). *Linear low-density polyethylene. Product Note. National Commodity and Derivatives Exchange (NCDEX)*. http://www.ncdex.com/upload/product_note/78%C2%A71%C2%A7Polyethylene.pdf (accessed 21 March 2010).

Nersesian R.L. (2010). *Energy for the 21st century: A comprehensive guide to conventional and alternative sources.* 2nd ed. M.E. Sharpe, Armonk, N.Y., ISBN 978-0765624123.

Niwagaba C.B. (2009). *Treatment technologies for human faeces and urine.* PhD thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Nordin A., Nyberg K. and Vinnerås B. (2009). Inactivation of Ascaris eggs in source-separated urine and faeces by ammonia at ambient temperatures. In: *Applied and Environmental Microbiology*. vol 75(3), 662-667.

OANDA (2012). *Historical exchange rates*. http://www.oanda.com/lang/de/currency/historical-rates (accessed 10 March 2012).

Obuobie E., Keraita B., Danso G., Amoah P., Cofie O.O., Raschid-Sally L. and Drechsel P. (2006). *Irrigated urban vegetable production in Ghana: Characteristics, benefits and risks*. IWMI-RUAF-IDRC-CPWF, Accra, Ghana, ISBN 92-9090-628-6.

O'Loughlin R., Fentie G., Flannery B. and Emerson P.M. (2006). Follow-up of a low cost latrine promotion programme in one district of Amhara, Ethiopia: characteristics of early adopters and non-adopters. In: *Tropical Medicine and International Health*. vol 11(9), 1406-1415.

ORAAMP (2000). *Urban agriculture in Addis Ababa*. Office for the Revision of the Addis Ababa Master Plan (ORAAMP). Addis Ababa City Council, Addis Ababa, Ethiopia.

Osswald T.A. (1998). *Polymer processing fundamentals*. Hanser, Munich, ISBN 3-446-19571-8.

Otterpohl R. (2011). Fruchtbarer Boden, unsere wichtigste Energiequelle: Terra Preta. In: *erneuerbare energie*. vol 2011(2), 26-29.

Otterpohl R., Braun U. and Oldenburg M. (2004). Innovative technologies for decentralised water-, wastewater and biowaste management in urban and peri-urban areas. In: *Water Science and Technology*. vol 48(11), 23-32.

Otterpohl R., Grottker M. and Lange J. (1997). Sustainable water and waste management in urban areas. In: *Water Science and Technology*. vol 35(9), 121-133.

Panesar A., Bracken P., Kvanstroem E., Lehn H., Luethi C., Norstrom A., Rued S., Saywell D. and Schertenleib R. (2008). *Sustainable sanitation for cities: SuSanA thematic paper*. Sustainable Sanitation Alliance (SuSanA). http://www.susana.org/docs_ccbk/susana_download/2-458-en-susana-thematic-paper-wg06-cities-version-12.pdf (accessed 28 July 2011).

Panesar A.R. and Werner C. (2006). Overview of the global development of ecosan. In: *Ecosan-symposium: New sanitation concepts - international project experiences and dissemination strategies*. Eschborn, Germany, 2006

Paterson C., Mara D. and Curtis T. (2007). Pro-poor sanitation technologies. In: *Geoforum*. vol 38(5), 901-907.

Patyk A. and Reinhardt G.A. (1997). *Düngemittel - Energie- und Stoffstrombilanzen*. Vieweg, Braunschweig, ISBN 3-528-06885-X.

Pickford J. (2001). *Low-cost sanitation: A survey of practical experience.* Reprint. ITDG Publ., London, UK, ISBN 1853392332.

Pinson L. (2008). *Anatomy of a business plan: The step-by-step guide to building your business and securing your company's future.* 7th ed. Out of Your Mind…and into the Marketplace, Tustin CA, ISBN 0-944205-37-2.

Plan Nederland, WASTE, SNS REAAL Water Fund (2007). *Sanitation in peri-urban areas in Africa.*

Poku K. (2002). *Small-scale palm oil processing in Africa*. Food and Agriculture Organization of the United Nations, Rome, ISBN 92-5-104859-2.

Population Census Commission (2008). *Summary and statistical report of the 2007 population and housing census: Population Size by Age and Sex*. Federal Democratic Republic of Ethiopia, Population Census Commission, Addis Ababa, Ethiopia. http://www.csa.gov.et/pdf/Cen2007_firstdraft.pdf (accessed 28 July 2011).

Pötsch G. and Michaeli W. (2008). *Injection molding: An introduction.* 2nd ed. Hanser, Munich, ISBN 978-3-446-40635-3.

PSPC (2003). *The role of urban agriculture in urban development: The case of Addis Ababa*. Addis Ababa City Government – Policy Study and Plan Commission (PSPC).

Public Citizen/ Water for All (2002). *Report of the international fact-finding mission on water sector reform in Ghana*. http://www.cesr.org/downloads/factfindingmissionGhana.pdf (accessed 27 October 2011).

Raschid-Sally L. and Jayakody P. (2008). *Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment*. IWMI Research Report 127. International Water Management Institute, Colombo, Sri Lanka.

Rauch W., Brockmann D., Peters I., Larsen T.A. and Gujer W. (2002). Combining urine separation with waste design: an analysis using stochastic model for urine production. In: *Water Research*. vol 37(3), 681-689.

Rogers M. (2001). *Engineering project appraisal: The evaluation of alternative development schemes*. Blackwell Science, Oxford, ISBN 0-632-05606-1.

Romano S.D. and Sorichetti P.A. (2011). *Dielectric spectroscopy in biodiesel production and characterization*. Springer-Verlag London Limited, London, ISBN 978-1-84996-518-7.

Romijn H. and Balkema A. (2009). Cost-benefit analysis of projects. Part I: Financial Cost-Benefit Analysis, School of Innovation Sciences, Eindhoven, The Netherlands.

Rosemarin A. (2010a). Peak phosphorous and the euthrophication of surface waters: *A symptom of disconnected agricultural and sanitation policies.* In: *On the Water Front: Selections from the 2010 World Water Week in Stockholm*. J. Lundqvist (Ed.). Stockholm International Water Institute (SIWI). Stockholm, pp. 73-82. http://www.siwi.org/documents/Resources/Best/2010/2011_OTWF_Arno_Rosemarin.pdf (accessed 09 September 2011).

Rosemarin A. (2010b). *Peak phosphorus, the next inconvenient truth?* 2nd International Lecture Series on Sustainable Sanitation, World Bank, Manila, October 15, 2010. http://www.susana.org/docs_ccbk/susana_download/2-819-en-rosemarin-peak-phosphorus-manila-2010.pdf (accessed 09 September 2011).

Roto PLC (2012). *Company homepage*. http://rotoplc.com/ (accessed 07 February 2012).

Rowe N. (2007). *Factors affecting the cost of prefabricated water storage tanks for use with domestic roofwater harvesting systems in low-income countries.* Informally published manuscript. M.Sc. thesis, Natural Resources Department, Cranfield University, Cranfield, United Kingdom.

Roy R.N. (2006). *Plant nutrition for food security: A guide for integrated nutrient management*. Food and Agriculture Organization of the United Nations, Rome, ISBN 92-5-105490-8. ftp://ftp.fao.org/agl/agll/docs/fpnb16.pdf (accessed 10 November 2011).

Ryan P.A. (1994). The use of tree legumes for fuelwood production. In: *Forage tree legumes in tropical agriculture*. R.C. Gutteridge and H.M. Shelton (Eds.). CAB International. Wallingford, UK, pp. 257-266.

Safi Sana Ghana Ltd. (2011). *Company homepage*. http://safisana.org (accessed 09 March 2012).

Sanitation and Water for All (2011a). *Ethiopia: Sanitation and drinking water country profile. Draft*. http://www.sanitationandwaterforall.org/files/Ethiopia_Country_Profile.pdf (accessed 05 December 2011).

Sanitation and Water for All (2011b). *Ghana: Sanitation and drinking water country profile. Draft*. http://www.sanitationandwaterforall.org/files/Ghana_Country_Profile.pdf (accessed 05 December 2011).

Saywell D. and Cotton A. (1998). User perceptions in urban sanitation. In: *Sanitation and water for all: Proceedings of the 24th WEDC Conference*. Islamabad, Pakistan, 1998. J. Pickford (Ed.). Water Engineering and Development Centre. Loughborough, UK, pp. 45-48.

Schaub-Jones D. (2010). *Sanitation - just another business? The crucial role of sanitation entrepreneurship and the need for outside engagement.* Building Partnerships for Development.

Schönning C. and Stenström T. A. (2004). *Guidelines for the safe use of urine and faeces in ecological sanitation systems.* EcoSanRes Publication Series. Report 2004-1, Stockholm Environment Institute: Stockholm, Sweden.

http://www.netssaftutorial.com/fileadmin/DATA_CD/06_Step6/SE6._Guidelines_for_the_safe_use_of_urine_and_faeces.pdf (accessed 15 September 2011).

Schröder E. (2010). *Marketing human excreta - A study of possible ways to dispose of urine and faeces from slum settlements in Kampala, Uganda*. http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=752 (accessed 02 February 2011).

Schubert S. (2008). *Community based organizations as gateway for the integration of resource oriented sanitation in urban areas: A case study of Arba Minch, Ethiopia.* Internship report, Hamburg University of Technology, Hamburg, Germany.

Schwab Foundation for Social Entrepreneurship (n.d.). *David Kuria. Ecotact*. http://www.schwabfound.org/sf/SocialEntrepreneurs/Profiles (accessed 21 July 2011).

Sengogo G. (2009). *A case study on the status of Ethiopian Water Supply, Sanitation and Hygiene (WASH) Program*. Ministry of Water Resources. Presentation from the 2009 World Water Week in Stockholm, Stockholm, Sweden.

Shim J.K. and Siegel J.G. (2007). *Handbook of financial analysis, forecasting, and modeling.* 3rd ed. Wolters Kluwer/CCH, Chicago IL, ISBN 978-0-8080-1593-2.

Shim J.K. and Siegel J.G. (2008). *Financial Management.* 3rd ed. Barron's Educational Series, New York, ISBN 978-0-7641-3940-6.

Shordt K. (2004). Sustainability of hygiene promotion and education: a six country research study. In: *People-centred approaches to water and environmental sanitation: Proceedings of the 30th WEDC Conference*. Vientiane, Lao PDR, 2004. S. Godfrey (Ed.). WEDC: Loughborough University; Published for distribution within Lao PDR by State Printing Enterprise. Vientiane Lao PDR, pp. 145-148.

Sijbesma C., Diaz C., Fonseca C. and Pezon C. (2008). Financing sanitation in poor urban areas. In: *Sanitation for the Urban Poor: Partnerships and Governance*. Delft, The Netherlands, 19-21 November 2008. J. Verhagen; C. da Silva Wells; I. Krukkert; P. McIntyre and P. Ryan (Eds.). IRC International Water and Sanitation Centre. The Hague, The Netherlands, pp. 137-161.

Sim J., Groeber K. and Greenlee T. (2010). Making a business of sanitation: Establishing a world trade hub for the poor. In: *Sustainable Sanitation Practice*. vol 10/2010(5), 25-29.

Simpson-Hébert M. (2007). Low-cost Arborloo offers Ethiopians health and agriculture benefits. In: *Waterlines*. vol 26(2), 12-14.

Simpson-Hébert M. and Abaire B. (2009). 40,000 eco-toilets in Ethiopia in 4 years: What makes it work? In: *Water, sanitation and hygiene. Sustainable development and multisectoral approaches: Proceedings of the 34th WEDC International Conference*. Addis Ababa, Ethiopia, 18-22 May 2009. R. Shaw (Ed.). Water Engineering and Development Centre. Loughborough, UK, pp. 820-825.

Simpson-Hébert M. and Wood S. (1998). *Sanitation promotion*, Geneva, Switzerland. http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp1-140.pdf (accessed 08 March 2012).

Smith-Asante E. (2010). *Government approves National Environment and Sanitation Policy*. http://www.ghanabusinessnews.com/2010/03/31/government-approves-national-environment-and-sanitation-policy-2 (accessed 24 October 2011).

Stedman L. (2008). Support for Africa's sanitation crisis. In: *Water 21*. vol August 2008, 42-48.

Stoorvogel J.J. and Smaling E.M.A. (1990). *Assessment of soil nutrient depletion in sub-Saharan Africa: 1983-2000*. Report 28. Winand Staring Centre, Wageningen, The Netherlands.

Suominen A., Mekonnen E. and Pankhurst H. (2008). *Ethiopia water supply, sanitation and hygiene sector (WaSH) EUWI Ethiopia Country Dialogue: Evaluation of implementation of the Multi-Stakeholder Forum undertakings*. http://www.euwi.net/files/FINAL_REPORT_of_the_Evalution_of_EUWI_CD_Ethiopia_first_MSF_.pdf (accessed 20 October 2011).

SuSanA (2008). *Towards more sustainable solutions - SuSanA Vision Document*. Sustainable Sanitation Alliance (SuSanA). http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=267 (accessed 07 October 2011).

SuSanA (2009). *Compilation of 24 SuSanA case studies. Pre-Print for the 10th SuSanA meeting*. Sustainable Sanitation Alliance (SuSanA). http://www2.gtz.de/Dokumente/oe44/ecosan/en-case-study-book-2009.pdf (accessed 22 September 2011).

Terrefe A. and Edstrom G. (1999). ECOSAN- ecological sanitation. In: *Integrated development for water supply and sanitation: Proceedings of the 25th WEDC Conference*. Addis Ababa, Ethiopia, 1999. J. Pickford (Ed.). Water Engineering and Development Centre. Loughborough, UK, pp. 16-17.

Terrefe A. and Edstrom G. (2005). *ECOSAN – Economy, ecology and sanitation*. http://conference2005.ecosan.org/papers/terrefe.pdf (accessed 14 April 2010).

Terrefe A. and Edstrom G. (2007). *Ecological sanitation history, Sweden-Ethiopia*. http://www.ecosan.ph/index2.php?option=com_docman&task=doc_view&gid=25&Itemid=45 (accessed 04 October 2010).

Tettey-Lowor F. (2008). *Closing the loop between sanitation and agriculture in Accra, Ghana.* M.Sc. thesis, Wageningen University, Wageningen, The Netherlands.

Tettey-Lowor F., Urlings L. and Acheampong N. (2009). Safi Sana; water and sanitation provisions in urban slums - closing the loop. In: *West Africa Regional Sanitation and Hygiene Symposium*. Accra, Ghana, 3-5 November 2009

Tewodros F. (2007). *Livelihood dependence on urban agriculture in Addis Ababa, Ethiopia.* M.Sc. thesis, Department of International Environment and Development Studies, Norwegian University of Life Sciences, Ås, Norway. http://www.umb.no/statisk/noragric/publications/master/2007_tewodros_firdissa_duressa.pdf (accessed 23 November 2011).

Thrift C. (2007). *Sanitation policy in Ghana: Key factors and the potential for ecological sanitation solutions*. http://www.ecosanres.org/pdf_files/SanitationPolicyInGhana-CharlesThrift.pdf (accessed 08 March 2012).

Transparency International (2012). *Corruption Perceptions Index 2010 results*. http://www.transparency.org/policy_research/surveys_indices/cpi/2010/results (accessed 23 February 2012).

Tripathi B.R. and Psychas P.J. (Eds.) (1992). *The AFNETA alley farming training manual*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Tsiagbey M., Danso G., Leslie A. and Sarpong E. (2005). Perceptions and acceptability of urine-diverting toilets in a low-income urban community in Ghana. In: *Ecological sanitation: A sustainable, integrated solution: Proceedings of the 3rd International Conference on Ecological Sanitation*. Durban, South Africa, 23-27 May 2005.

UAESCP (2010). *The role, potential and challenges of composting in urban agriculture*. Urban Agricultural Extension Service Core Process (UAESCP), Addis Ababa, Ethiopia.

UN (2010a). *General Assembly declares access to clean water and sanitation is a human right*. United Nations (UN) News Center. http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=SANITATION (accessed 18 January 2012).

UN (2010b). *World Urbanization Prospects: The 2009 Revision (Highlights)*. Department of Economic and Social Affairs of the United Nations (UN) Secretariat, New York, USA. http://esa.un.org/unpd/wup/Documents/WUP2009_Highlights_Final.pdf (accessed 28 July 2011).

UN (2011a). *Millennium Development Goals indicators. United Nations (UN)*. http://mdgs.un.org/unsd/mdg/Default.aspx (accessed 30 November 2011).

UN (2011b). *The Millennium Development Goals Report 2011*. United Nations (UN), New York, USA. http://www.beta.undp.org/content/dam/undp/library/MDG/english/MDG_Report_2011_EN.pdf (accessed 09 September 2011).

UNDESA (2011). *World Population Prospects 2010 Revision*. United Nations, Department of Economic and Social Affairs (UNDESA). http://esa.un.org/wpp/Excel-Data/population.htm (accessed 09 September 2011).

UNDP (2006a). *Beyond scarcity: Power, poverty and the global water crisis*. United Nations Development Programme (UNDP), New York, NY, ISBN 0-230-50058-7. http://hdr.undp.org/en/media/HDR06-complete.pdf (accessed 08 March 2012).

UNDP (2006b). *Human Development Report 2006: Beyond scarcity: Power, poverty and the global water crisis*. United Nations Development Programme (UNDP), New York, USA. http://hdr.undp.org/en/media/HDR06-complete.pdf (accessed 23 September 2009).

UNDP (2008). *Creating Value for All: Strategies for Doing Business with the Poor*. United Nations Development Programme (UNDP), New York, USA. http://www.undp.org/gimlaunch/press/docs/GIM_EN.pdf (accessed 02 July 2009).

UNDP (2011a). *International Human Development Indicators: Human Development Index (HDI) - 2011 Rankings. United Nations Development Program (UNDP)*. http://hdr.undp.org/en/statistics (accessed 06 December 2011).

UNDP (2011b). *Sustainability and equity: A better future for all. United Nations Development Program (UNDP)*. Palgrave Macmillan, Houndmills, NY, USA, ISBN 978-0-230-36331-1. http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf (accessed 06 December 2011).

UNEP (2009). *Towards sustainable production and use of resources: Assessing biofuels. United Nations Environment Programme (UNEP)*, Nairobi, Kenya, ISBN 978-92-807-3052-4. http://www.unep.org/pdf/biofuels/Assessing_Biofuels_Full_Report.pdf (accessed 28 November 2011).

UNEP/GRID-Arendal Maps and Graphics Library (2002). *Degraded soils*. http://maps.grida.no/go/graphic/degraded-soils (accessed 19 July 2011).

UN-HABITAT (2010). *The State of African Cities 2010: Governance, Inequality and Urban Land Markets*. UN-HABITAT, Nairobi, Kenya. http://www.unhabitat.org (accessed 08 March 2011).

UNICEF, WHO, World Bank and UNPD (2010). *Levels and Trends in Child Mortality, Report 2010*. Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation. United Nations Children's Fund (UNICEF), World Health Organization (WHO), the World Bank, United Nations Population Division (UNPD), New York, USA. http://www.childinfo.org/files/Child_Mortality_Report_2010.pdf (accessed 09 March 2011).

UN-Water (2009). *Sanitation is an investment with high economic returns. Factsheet No. 2*. World Health Organization, Geneva, Switzerland. http://www.wsscc.org/sites/default/files/sfa_factsheet_economic_benefits_2009_en_0.pdf (accessed 07 October 2011).

USAID (2011). *Results from working at scale for better sanitation and hygiene in Amhara, Ethiopia: Baseline and endline comparisons of institutional, household, and school surveys*. United States Agency for International Development (USAID) Hygiene Improvement Project, Washington, DC.

USAID HIP (2010). *Sanitation marketing for managers: Guidance and tools for program development.* USAID Hygiene Improvement Project (HIP), Washington, DC. http://pdf.usaid.gov/pdf_docs/PNADW499.pdf (accessed 13 December 2011).

Van-Rooijen D.J., Biggs T.W., Smout I. and Drechsel P. (2010). Urban growth, wastewater production and use in irrigated agriculture: a comparative study of Accra, Addis Ababa and Hyderabad. In: *Irrigation Drainage Systems*. vol 24(1-2), 53-64.

Vinnerås B., Nordin A., Niwagaba C. and Nyberg K. (2008). Inactivation of bacteria and viruses in human urine depending on temperature and dilution rate. In: *Water Research*. vol 42(15), 4067-4074.

von Münch E. and Winker M. (2011). *Technology review of urine diversion components. Appendix 3: Worldwide listing of suppliers for urine diversion pedestals/seats (for UDDTs or for UD flush toilets).* Deutsche Gesellschaft für Technische Zusammenarbeit (GIZ). http://www.gtz.de/en/dokumente/giz2011-en-appendix-3-UD-pedestals-suppliers-list.pdf (accessed 07 February 2012).

Warner W., Heeb J., Jenssen P., Gnanakan K. and Kondrandin K. (2006). *Management: Planning, implementation and operation. Socio-cultural aspects*. http://www2.gtz.de/dokumente/oe44/ecosan/cb/en-m42-ecosan-socio-cultural-aspects-tutorial-2006.pdf (accessed 21 April 2010).

Warren C.S., Reeve J.M. and Duchac J.E. (2009). *Financial & managerial accounting.* 11th ed. South-Western Cengage Learning, Mason Ohio, ISBN 978-0-518-48089-5.

WASTE (2005). *Fact sheet on sanitation: Introduction to the main characteristics of human excreta and grey water.* WASTE, Gouda, The Netherlands. http://www.ecosan.nl/page/732 (accessed 18 November 2011).

WaterAid (2011). *Off-track, off-target: Why investment in water, sanitation and hygiene is not reaching those who need it most*. http://www.wateraid.org/documents/Off-track-off-target.pdf (accessed 10 March 2012).

WaterAid Ghana (n.d.). *Ghana/Our Partners/ProNet*. http://www.wateraid.org/ghana/our_partners/4417.asp (accessed 27 May 2010).

Webb D.B. (1984). *A guide to species selection for tropical and sub-tropical plantations.* 2nd ed., revised. Unit of Tropical Silviculture Commonwealth Forestry Institute University of Oxford, Oxford, UK, ISBN 0-85074-068-1. http://idl-bnc.idrc.ca/dspace/bitstream/10625/7025/1/62758.pdf (accessed 12 February 2011).

Webster W. (2003). *Accounting for managers*. McGraw-Hill, New York, ISBN 0-07-142174-2.

Wegelin-Schuringa M. (2000). Public awareness and mobilisation for ecosanitation. In: *International Symposium on Ecological Sanitation. Ecosan- Closing the Loop in Wastewater Management and Sanitation*. IRC International Water and Sanitation Centre, Bonn, Germany, 30-31 October 2000. http://www2.gtz.de/dokumente/oe44/ecosan/en-ecosan-public-awareness-mobilisation-irc-2000.pdf (accessed 04 May 2010).

Weldesilassie A.B. (2008). *Economic analysis and policy implications of wastewater use in agriculture in the Central Region of Ethiopia.* PhD thesis, Faculty of Agricultural Sciences, University of Hohenheim, Stuttgart, Germany. http://opus.ub.uni-hohenheim.de/volltexte/2008/319/pdf/Economic_Analysis_of_Wastewater_ThesisZ_liberary1.pdf (accessed 21 November 2011).

Weldesilassie A.B., Boelee E., Drechsel P. and Dabbert S. (2010). Wastewater use in crop production in peri-urban areas of Addis Ababa: impacts on health in farm households. In: *Environment and Development Economics*. vol 16(1), 25-49.

WELL (2003). *Water, sanitation and service delivery in Ghana. Draft*. A paper prepared for the WELL Resource Centre Network for Water, Sanitation and Environmental Health (based on scoping studies carried out in Ghana).

WHO (2006). *WHO guidelines for the safe use of wastewater, excreta and greywater. Vol IV: Excreta and greywater use in agriculture*. World Health Organization (WHO), Geneva, Switzerland, ISBN 92-4-154685-9. http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html (accessed 10 March 2012).

WHO (2007). *Public policy and franchising reproductive health : Current evidence and future directions. Guidance from a technical consultation meeting*. World Health Organization (WHO), Geneva, Switzerland, ISBN 978-92-4-159602-1. http://whqlibdoc.who.int/publications/2007/9789241596021_eng.pdf (accessed 10 March 2012).

WHO (2008). *The global burden of disease: 2004 update*. World Health Organization (WHO), Geneva, Switzerland, ISBN 978-92-4-156371-0. http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf (accessed 10 March 2012).

WHO (2009). *Global health risks: Mortality and burden of disease attributable to selected major risks*. World Health Organization (WHO), Geneva, Switzerland, ISBN 978-92-4-156387-1. http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf (accessed 10 March 2012).

WHO and UNICEF (2000). *Global water supply and sanitation assessment 2000 report*. World Health Organization (WHO) and United Nations Children's Fund (UNICEF), USA, ISBN 92-4-156202-1. http://www.who.int/water_sanitation_health/monitoring/jmp2000.pdf (accessed 10 March 2012).

WHO and UNICEF (2008). *Progress on drinking water and sanitation: Special focus on sanitation*. World Health Organization (WHO) and United Nations Children's Fund (UNICEF) Joint Monitoring Programme for Water Supply and Sanitation (JMP), USA, ISBN 978-92-806-4313-8. http://www.who.int/water_sanitation_health/monitoring/jmp2008.pdf (accessed 10 March 2012).

WHO and UNICEF (2010). *Progress on sanitation and drinking-water: 2010 Update*. World Health Organization (WHO) and United Nations Children's Fund (UNICEF) Joint Monitoring Programme (JMP) for Water Supply and Sanitation, France, ISBN 978-92-4-156395-6. http://www.wssinfo.org/fileadmin/user_upload/resources/1278061137-JMP_report_2010_en.pdf (accessed 10 March 2012).

Winblad U. and Simpson-Hébert M. (2004). *Ecological sanitation: Revised and enlarged edition*. Stockholm Environment Institute, Stockholm, Sweden, ISBN 91-88714-98-5. http://www.ecosanres.org/pdf_files/Ecological_Sanitation_2004.pdf (accessed 08 March 2012).

Winker M. (2010). Are pharmaceutical residues in urine a constraint for using urine as a fertiliser? EcoSan Club. In: *Sustainable Sanitation Practice*. vol 3, 18-24.

Woldu Z. (2010). *Urbanization: Market opportunities*. Ethiopia: Country Position Paper, Addis Ababa, Ethiopia. http://www.globalhort.org/media/uploads/File/Video%20Conferences/VC7%20Ethiopia%20Position%20Paper.pdf (accessed 23 November 2011).

Wood B.J. and Corley R.H. (1993). The energy balance of oil palm cultivation. In: *Proceedings 1991 PORIM International Oil Palm Conference: Progress, Prospects and Challenges towards the 21st Century*. Kuala Lumpur, Malaysia, 9-14 September 1991. Y. Basiron; J. Sukaimi; K.C. Chang; S.C. Cheah; I.E. Henson; N. Kamaruddin; K. Paranjothy; N. Rajanaidu and T.H.T.a.A.D. Dolmat (Eds.). Palm Oil Research Institute of Malaysia, pp. 130-143.

World Agroforestry Centre (2011). *AgroForestryTree database: A tree species reference and selection guide*. http://worldagroforestrycentre.org (accessed 09 February 2011).

World Bank (2006). *Ethiopia: Country Profile 2006*. http://www.enterprisesurveys.org/~/media/FPDKM/EnterpriseSurveys/Documents/Profiles/English/Ethiopia-2006 (accessed 19 January 2012).

World Bank (2007). *Ghana: Country Profile 2007*. http://www.enterprisesurveys.org/~/media/FPDKM/EnterpriseSurveys/Documents/Profiles/English/Ghana-2007 (accessed 19 January 2012).

World Bank (2011a). *Data. Indicators*. http://data.worldbank.org/indicator (accessed 10 March 2012).

World Bank (2011b). *Private participation in infrastructure projects database*. http://ppi.worldbank.org/index.aspx (accessed 25 October 2011).

World Bank (2012a). *Commodity price data.* The World Bank, Washington, DC, USA. http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1111002388669/829392-1325803576657/Pnk_0112.pdf (accessed 19 January 2012).

World Bank (2012b). *Doing business data*. http://www.doingbusiness.org/data (accessed 24 February 2012).

World Bank (2012c). *Doing business in a more transparent world*, Washington, DC. http://www.doingbusiness.org/~/media/FPDKM/Doing%20Business/Documents/Annual-Reports/English/DB12-FullReport.pdf (accessed 24 February 2012).

World Bank (2012). *World Bank Enterprise Surveys, 2006–2009*. http://www.enterprisesurveys.org (accessed 19 January 2012).

World Vision Africa (2010). *Ghana: World Vision in Ghana*. http://www.wvafrica.org/index.php?option=com_content&view=article&id=138&Itemid=155 (accessed 27 May 2010).

WSP (2005). *A review of ecosan experience in Eastern and Southern Africa*. Water and Sanitation Program (WSP). http://www.wsp.org/wsp/sites/wsp.org/files/publications/af_ecosan_esa.pdf (accessed 20 October 2011).

WSP (2008a). *Economic impacts of sanitation in Southeast Asia: A four-country study conducted in Cambodia, Indonesia, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)*. Water and Sanitation Program (WSP), Jakarta. http://www.wsp.org/wsp/sites/wsp.org/files/publications/Sanitation_Impact_Synthesis_2.pdf (accessed 09 September 2011).

WSP (2008b). *The eThekwini Declaration and AfricaSan Action Plan*. Water and Sanitation Program (WSP). http://www.wsp.org/wsp/sites/wsp.org/files/publications/eThekwiniAfricaSan.pdf (accessed 14 July 2011).

WSP (2011a). *Water supply and sanitation in Ethiopia: Turning finance into services for 2015 and beyond*. Water and Sanitation Program (WSP). http://www.wsp.org/wsp/sites/wsp.org/files/publications/CSO-Ethiopia.pdf (accessed 09 September 2011).

WSP (2011b). *Water supply and sanitation in Ghana: Turning finance into services for 2015 and beyond*. Water and Sanitation Program (WSP). http://www.wsp.org/wsp/sites/wsp.org/files/publications/CSO-Ghana.pdf (accessed 12 September 2011).

WSP (2011c). *WSP news: Ten African countries losing at least 1% of GDP annually due to poor sanitation*. http://www.wsp.org/wsp/sites/wsp.org/files/newsletter/August2011.html#africa1 (accessed 24 October 2011).

WSSCC (2009). *Sanitation sector status and gap analysis: Ethiopia*. Water Supply and Sanitation Collaborative Council (WSSCC). http://www.wsscc.org/sites/default/files/gsf_ethiopia_sector_review.pdf (accessed 18 July 2011).

WTO (2011). *Statistics database: Trade profiles. World Trade Organization (WTO)*. http://stat.wto.org/CountryProfile/WSDBCountryPFHome.aspx?Language=E (accessed 25 November 2011).

Appendices

List of Appendices

Appendix A: Toilet product selection in Ethiopia

Appendix A summarizes a selection of toilets available in Ethiopia as described in Section 3.3.1. Products manufactured by AquaSan Manufacturing Ethiopia PLC/Kentainers Ltd., Roto PLC, EthioFibre Glass and Tabor Ceramics are presented.

Product selection of AquaSan/Kentainers, Ethiopia

Product name	Image[a]	Material	Producer	Price (ETB)[b]	Dimensions (cm)
Eco-slab for urine diversion[c]		LLDPE	Kentainers/ AquaSan	*510* *985* *1,020* *1,350*	80x60 100x100 120x120 140x160
Eco-plate for sitting (pedestal)		LLDPE	Kentainers/ AquaSan	600 *940* *1,420* *1,450* *1,785*	60x60 80x60 100x100 120x120 140x160
Eco-plate for squatting		LLDPE	Kentainers/ AquaSan	150	45x30
Eko-loo (slab & superstructure)		LLDPE	Kentainers/ AquaSan	*3,860*	98x100x190
Wonder-loo		LLDPE	Kentainers/ AquaSan	*500*	n.a.

Product name	Image[a]	Material	Producer	Price (ETB)[b]	Dimensions (cm)
Mobilet		LLDPE	Kentainers/ AquaSan	*4,190*	170x160x190

[a)] Source: own photos and Kentainers' product brochures (pers. correspondence, F.Waliji, Marketing Manager, Kentainers Limited, 13.10.2008).

[b)] The prices were requested from AguaSan in Ethiopia and Kentainers in Kenya. The prices in italics were converted from KES to ETB using an average exchange rate as of 2009 from OANDA (2012).

[c)] The price of an eco-slab for urine diversion includes the price of a pit latrine slab in a given size and the price of a urine diversion insert (KES 1,000).

Product selection of Roto PLC, Ethiopia

Name	Image[a]	Material	Producer	Price (ETB)	Dimensions (cm)	Comments
Roto toilet hut		HDPE	Roto PLC	*4,990* *4,460* *4,800* *5,300*	106x99x215 106x99x215 106x99x215 106x99x215	Slabs available: · seat · floor · bathroom · ceramic
Pit latrine slab		HDPE	Roto PLC	*1,590* *1,145*	146(Ø)x11 116x116x16	Forms available: · round · square

[a)] Source: Roto PLC, 2012.

[b)] The prices in italics were converted from KES to ETB using an average exchange rate as of 2009 from OANDA (2012).

Product selection of EthioFibre Glass and Tabor Ceramics, Ethiopia

Name	**Image**[a]	**Material**	**Producer**	**Price (ETB)**	**Dimensions (cm)**
Urine diverting pedestal toilet		Fiberglass	EthioFibre Glass Ethiopia	1,530	654x600x816[b]
Urine diverting squatting toilet		Fiberglass	EthioFibre Glass Ethiopia	375	1060x32
Urine diverting squatting toilet		Ceramics	Tabor Ceramics	310	60x50

a) Source: own photos and Mojen (Ed.), 2008.

b) The dimensions include the box that the toilet is fitted with.

Appendix B: Parameters of the case study Ethiopia

Appendix B contains data used as parameters in the case study Ethiopia.

B.1 Parameters required for the calculation of the volume of production

The data presented in RotoCycle Machine Simulation Reports is used as parameters for the calculation of the volume of production as presented in Section 3.5.1.

Simulation report for Machine 1 before extension (M1-2600) (courtesy of FERRY INDUSTRIES, INC., Stow, Ohio, USA)

RotoCycle Machine Simulation Summary

Filename: Simulation1.cyc **Machine Details** Shuttle - 1 Arm

	Arm 1
Primary Part Name	
Oven (mins)	20
	0
Cooler 1 (mins)	20
	0
Demolding (mins)	15
	0

Oven Door Open/Close Time (s)	10	Cooler Door Open/Close Time (s)	0	Arm Move Time (s)	20

Simulation Summary - Completed Cycles		Arm 1
	8 hours	8
	12 hours	12
	24 hours	25
	5 days	

Simulation Details

	Arm 1	Mins	% Util
Oven Time - Normal Cycle	520	*520*	36.1
Oven Time - Cycle Held-Up			
Move from Oven to Wait	13	*13*	0.9
Wait Time - Normal Cycle			
Wait time - Cycle Held-up			
Move from Wait to Cool1			
Cool time 1 - Normal Cycle	519.5	*519.5*	36.1
Cool time 1 - Cycle Held-up			
Move from Cool1 to Cool2			
Cool time 2 - Normal Cycle			
Cool time 2 - Cycle held-up			
Move from Cool2 to Demold			
Demold time - Normal Cycle	375	*375*	26
Demold time - Cycle Held-up			
Move from Demold to PreOven	12.5	*12.5*	0.9
PreOven time - Forced Delay			
PreOven time - Oven Full			
Move from PreOven to Oven			
Starting Location	Oven		
Total Completed Cycles	25	1440	Mins/Arm
Ending Location	Cool 1		

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Simulation report for Machine 1 after extension (M2-2600) (courtesy of FERRY INDUSTRIES, INC., Stow, Ohio, USA)

RotoCycle Machine Simulation Summary

Filename: Simulation1.cyc **Machine Details** Shuttle - 2 Arm

	Arm 1	Arm 2
Primary Part Name		
Oven (mins)	20	20
	0	0
Cooler 1 (mins)	20	20
Cooler 2 (mins)	0	0
Demolding (mins)	15	15
	0	0

Oven Door Open/Close Time (s) 10 **Cooler Door Open/Close Time (s)** 0 **Arm Move Time (s)** 20

Simulation Summary - Completed Cycles		Arm 1	Arm 2
	8 hours	8	8
	12 hours	12	12
	24 hours	25	25
	5 days		

Simulation Details

	Arm 1	Arm 2	Mins	% Util
Oven Time - Normal Cycle	520	519	***1039***	72.2
Oven Time - Cycle Held-Up				
Move from Oven to Wait	13	12.5	***25.5***	1.8
Wait Time - Normal Cycle				
Wait time - Cycle Held-up				
Move from Wait to Cool1				
Cool time 1 - Normal Cycle	519.5		***519.5***	36.1
Cool time 1 - Cycle Held-up				
Move from Cool1 to Cool2				
Cool time 2 - Normal Cycle		500	***500***	34.7
Cool time 2 - Cycle held-up				
Move from Cool2 to Demold				
Demold time - Normal Cycle	375	390	***765***	53.1
Demold time - Cycle Held-up		5.9	***5.9***	0.4
Move from Demold to PreOven	12.5	12.6	***25.1***	1.7
PreOven time - Forced Delay				
PreOven time - Oven Full				
Move from PreOven to Oven				
Starting Location	Oven	Demold		
Total Completed Cycles	25	25	**1440**	**Mins/Arm**
Ending Location	Cool 1	Oven		

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Simulation report for Machine 2 (R3-2600) (courtesy of FERRY INDUSTRIES, INC., Stow, Ohio, USA)

RotoCycle Machine Simulation Summary

Filename: Simulation1.cyc **Machine Details** Indep. - 3 Arm / 5 Station

	Arm 1	Arm 2	Arm 3
Primary Part Name			
Oven (mins)	20	20	20
Wait (mins)	0	0	0
Cooler 1 (mins)	20	20	20
	0	0	0
Demolding (mins)	15	15	15
Pre-Oven Delay (mins)	0	0	0

Oven Door Open/Close Time (s)	10	**Cooler Door Open/Close Time (s)**	10	**Arm Move Time (s)**	20

Simulation Summary - Completed Cycles	Arm 1	Arm 2	Arm 3
8 hours	7	7	7
12 hours	11	11	10
24 hours	22	22	22
5 days			

Simulation Details

	Arm 1	Arm 2	Arm 3	Mins	% Util
Oven Time - Normal Cycle	460	460	451.6	***1371.6***	95.2
Oven Time - Cycle Held-Up					
Move from Oven to Wait	11.5	11.5	11	***34***	2.4
Wait Time - Normal Cycle					
Wait time - Cycle Held-up					
Move from Wait to Cool1	11.5	11.5	11	***34***	2.4
Cool time 1 - Normal Cycle	460	451.6	440	***1351.6***	93.9
Cool time 1 - Cycle Held-up					
Move from Cool1 to Cool2	11.5	11	11	***33.5***	2.3
Cool time 2 - Normal Cycle					
Cool time 2 - Cycle held-up					
Move from Cool2 to Demold					
Demold time - Normal Cycle	342.2	330	345	***1017.2***	70.6
Demold time - Cycle Held-up			6	***6***	0.4
Move from Demold to PreOven	7.3	7.3	7.7	***22.3***	1.5
PreOven time - Forced Delay					
PreOven time - Oven Full	125	145.5	145.2	***415.7***	28.9
Move from PreOven to Oven	11	11.5	11.5	***34***	2.4
Starting Location	Oven	Pre-Oven	Demold		
Total Completed Cycles	22	22	22	**1440.3**	**Mins/Arm**
Ending Location	Demold	Cool 1	Oven		

B.2 Calculation of part weight

The calculation of part weight for the rotational molding process is needed to define the amount of raw materials required for the production of a respective part (refer to Section 3.4.2.1).

Part weight calculation for Products 1, 2, 3 and 4

Product 1	**Pan**
L [cm]	50
W [cm]	60
H [cm]	24.1
Surface area [cm^2][a]	8,546.92
Density [g/cm^3]	0.9185
Thickness [cm]	0.4760
Part weight [kg][b]	3.74

a) Information taken from AutoCad 3D drawing of the part

b) Part weight = Surface area [cm^2] x thickness [cm] x density [g/cm^3]

Product 2	**Pan**	**Squat hole**
L [cm]	55	7.5
r [cm]		
W [cm]	30	
H [cm]	18	4.5
Surface area [cm^2][c]	6,360	565
Density [g/cm^3]	0.9185	0.9185
Thickness [cm]	0.4760	0.4760
Part weight [kg]	2.78	0.25
Part weight - squat hole [kg]	2.53	

c) Calculated with (L*W* 2 + L* H* 2 + H* W*2) and (Pi*r2*2 + Pi*d*H)

Product 3	**Pan**	**Squat hole**
r [cm]	40	
a [cm]		15
b [cm]		7.5
H [cm]	4	4
Surface area [cm^2][d]	11,058	1,005
Density [g/cm^3]	0.9185	0.9185
Thickness [cm]	0.4760	0.4760
Part weight [kg]	4.83	0.44
Part weight - squat hole [kg]	4.40	

d) Calculated with (Pi*r2*2 + Pi*d*H) and (Pi*a*b*2 + Circumference*H)

Product 4	**Pan**	**Squat hole**
L [cm]	90	
W [cm]	120	
a [cm]		15
b [cm]		9.5
H [cm]	4	4
Surface area [cm^2][e]	23,280	1,211
Density [g/cm^3]	0.9185	0.9185
Thickness [cm]	0.4760	0.4760
Part weight [kg]	10.18	0.53
Part weight - squat hole [kg]	9.65	

e) Calculated with (L*W* 2 + L* H* 2 + H* W*2) and (Pi*a*b*2 + Circumference*H)

B.3 Personnel costs

Monthly salaries in Arba Minch, Ethiopia (Ethiopian Investment Agency, 2008b; pers. communication at Gamo Gofa Trade, Industry and Tourism Main Department, Arba Minch, 25.05.2009)

Job title	Salary (ETB/month)
Manager	4,000
Engineer	3,500
Unskilled production staff	470
Plant maintenance staff	515
Office staff	750
Guard	400
Driver	500

Headcount plan for Scenario 1

Year	1		2		3		4		5	
Job title	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**
Manager	1	48,000	1	48,000	1	48,000	1	48,000	1	48,000
Production (skilled)	1	42,000	2	84,000	2	84,000	2	84,000	2	84,000
Production (unskilled)	1	5,640	2	11,280	3	16,920	4	22,560	4	22,560
Plant maintenance	1	6,180	1	6,180	2	12,360	2	12,360	2	12,360
Office staff	1	9,000	1	9,000	1	9,000	1	9,000	1	9,000
Guard	1	4,800	1	4,800	1	4,800	1	4,800	1	4,800
Driver	0	0	0	0	0	0	2	16,800	2	16,800
Total	**6**	**115,620**	**8**	**163,260**	**10**	**175,080**	**13**	**197,520**	**13**	**197,520**

Headcount plan for Scenario 2

Year	1		2		3		4		5	
Job title	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**	**No.**	**(ETB/ year)**
Manager	1	48,000	1	48,000	1	48,000	1	48,000	1	48,000
Production (skilled)	2	84,000	2	84,000	2	84,000	2	84,000	2	84,000
Production (unskilled)	2	11,280	2	11,280	4	22,560	4	22,560	6	33,840
Plant maintenance	1	6,180	1	6,180	2	12,360	2	12,360	2	12,360
Office staff	1	9,000	1	9,000	1	9,000	1	9,000	1	9,000
Guard	1	4,800	1	4,800	1	4,800	1	4,800	1	4,800
Driver	1	8,400	1	8,400	2	16,800	2	16,800	2	16,800
Total	**9**	**171,660**	**9**	**171,660**	**13**	**197,520**	**13**	**197,520**	**15**	**208,800**

Total personnel expenses as presented in the headcount plan for Scenario 1 and Scenario 2 above differ slightly from the personnel expenses as presented in the

Profit and Loss statements for Scenario 1 and Scenario 2 (refer to Table 3.29 and Table 3.30) due to rounding of numbers.

B.4 Advertising costs

Advertising costs for radio and newspaper[a]

Radio 100.9 SNNP	(ETB/30 seconds) including VAT
Prime plus (Sat-Sun, before & after news)	712
Prime (Mon-Fri, before & after news)	647
Basic plus (middle of entertaining program)	427
Basic (Mon-Fri, far from news)	388
Newspaper Debub Nigat	**(ETB) including VAT**
Full page	3,560
Half page	1,780
Quarter page	890

[a)] Source: Information on advertising costs was provided by the press and radio departments of the SNNP Region Mass Media Agency in Awassa, Ethiopia in August 2009.

B.5 Administrative costs

Projected telecommunication expenses (Ethiopian Investment Agency, 2008a)

Item	Costs (ETB/year)
Telephone bill	10,800
Rental for main telephone line connected to PABX	204
Rental for extension line connected to PABX (2 extension lines)	216
Cell phone bills (3 cell phones)	5,400
Monthly fax rental maintenance & other cost	516
Fax for direct line	204
Monthly Internet fee (inclusive 900 minutes)	720
Internet bill	6,000
Total	**24,060**

B.6 Transportation costs

Distances[a] *between Arba Minch and selected woredas in the Gamo Gofa Zone and Awassa*

Distance (round trip)	(km)
Max. distance between kebeles in Arba Minch	35
Arba Minch-Chencha woreda	75
Arba Minch-Kucha woreda	100
Arba Minch-Bonke woreda	100
Arba Minch-Mirab Abaya woreda	100
Arba Minch-Dita woreda	150
Arba Minch-Kemba woreda	170
Arba Minch-Melekoza woreda	250
Arba Minch-Geze Gofa woreda	480
Arba Minch-Awassa	550

[a)] The distances were estimated based on geographical location.

Parameters for the calculation of the number of trips for Scenario 1

Parameter	Year				
	1	2	3	4	5
Weight to be transported (t/month)	4	6	12	18	18
No. of toilets sold per year	6,480	10,800	21,696	32,544	32,544
Average weight per product (t)	0.007	0.007	0.007	0.007	0.007
Max. no. of products on truck	308	306	307	307	307
No. of trips per month	2	3	6	9	9

Parameters for the calculation of the number of trips for Scenario 2

Parameter	Year				
	1	2	3	4	5
Weight to be transported (t/month)	9	9	15	15	21
No. of toilets sold per year	17,136	17,136	28,560	28,560	39,408
Average weight per product (t)	0.006	0.006	0.006	0.006	0.006
Max. no. of products on truck	309	309	308	308	311
No. of trips per month	5	5	8	8	5

Parameters for the calculation of transportation costs for Scenario 1 and Scenario 2

Transportation cost with a third party (ETB/t*km)[a]	0.75
Truck cost (ETB)[b]	770,000.00
Truck payload (t)	2
Fuel economy (km/l)[c]	5.00
Price of gasoline (ETB/l)[d]	12.95
Life span of the equipped truck (years)[c]	10.00
Maintenance cost (ETB/5,000 km)[c]	2,000.00
Spare parts each (ETB/5,000 km)[c]	2,000.00

a) Source: pers. correspondence, W. Ayele, Project Coordinator at ROSA office, Arba Minch, Ethiopia, 17.03.2009, W. Ayele, b) Source: pers. communication with A. Woldemariam, Director of Investment Promotion and Public Relation at Ethiopian Investment Agency, Addis Ababa, Ethiopia, 15.05.2009; c) Own assumption; d) Source: World Bank, 2011

Calculation of distance for transportation of finished parts for Scenario 1

Destination	**Year**				
	1	**2**	**3**	**4**	**5**
	No. of trips per year				
Arba Minch woreda	21	16			
Mirab Abaya woreda		22			
Chencha woreda			39		
Kucha woreda			30	12	
Bonke woreda				35	
Dita woreda				43	
Kemba woreda				17	39
Melekoza woreda					42
Geze Gofa woreda					30
Calculated distance (km/month)	61	227	488	1,158	2,610
Assumed distance (km/month)	100	250	500	1,200	2,600

Calculation of distance for transportation of finished parts for Scenario 2

Destination	**Year**				
	1	**2**	**3**	**4**	**5**
	No. of trips per year				
Arba Minch woreda	37				
Mirab Abaya woreda	22				
Chencha woreda		38			
Kucha woreda		14	27		
Bonke woreda			35		
Dita woreda			31	12	
Kemba woreda				56	
Melekoza woreda				25	16
Geze Gofa woreda					28
Awassa					81
Calculated distance (km/month)	286	359	902	1,462	5,239
Assumed distance (km/month)	300	400	900	1,500	5,200

Summary of product transportation costs for Scenario 1

Parameter	**Year 1[a]**	**Year 2[a]**	**Year 3[a]**	**Year 4[b]**	**Year 5[b]**
Distance [km/month]	100	250	500	1,200	2,600
Costs [Birr/year]	3,150	13,250	20,350	48,800	105,800

[a)] Transportation of finished products within Arba Minch (1st year) and to selected woredas in the Gamo Gofa Zone with a third party; [b)] Transportation of finished products within the Gamo Gofa Zone with own vehicle

Summary of product transportation costs for Scenario 2

Parameter	**Year 1[a]**	**Year 2[a]**	**Year 3[a]**	**Year 4[a]**	**Year 5[a]**
Distance [km/month]	300	400	900	1,500	5,200
Costs [Birr/year]	12,200	16,300	36,600	61,000	211,550

[a)] Transportation of finished products to selected woredas in the Gamo Gofa Zone and to Awassa with own vehicle

B.7 Profitability analysis using current prices

Cash flow statements for Scenario 1 and Scenario 2 for normal case, worst case and best case scenarios using current as described in Section 3.6.3.2 are presented further.

Cash flow statement for Scenario 1 (normal case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF[a] (ETB)
1.00	0	-9,610,600			-9,610,600	1.00	-9,610,600
1.08	1	0	-1,644,840	3,639,168	1,994,328	0.91	1,813,025
1.17	2	-299,881	-2,694,442	6,550,502	3,556,179	0.83	2,938,991
1.26	3	-1,038,129	-5,029,337	14,211,945	8,144,479	0.75	6,119,068
1.36	4	-1,052,746	-7,937,229	23,023,419	14,033,444	0.68	9,585,031
1.47	5	-81,254	-8,656,106	24,865,292	16,127,933	0.62	10,014,177
						NPV	**20,859,692**
						nominal IRR	**53%**

[a] DNCF refers to discounted net cash flow

Cash flow statement for Scenario 1 (worst case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF (ETB)
1.00	0	-9,610,600			-9,610,600	1.00	-9,610,600
1.08	1	0	-1,644,840	2,695,680	1,050,840	0.91	955,309
1.17	2	-299,881	-2,694,442	4,891,065	1,896,741	0.83	1,567,555
1.26	3	-1,038,129	-5,029,337	10,564,650	4,497,184	0.75	3,378,801
1.36	4	-1,052,746	-7,937,229	17,012,846	8,022,871	0.68	5,479,729
1.47	5	-81,254	-8,656,106	18,373,874	9,636,515	0.62	5,983,517
						NPV	**7,754,312**
						nominal IRR	**29%**

Cash flow statement for Scenario 1 (best case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF (ETB)
1.00	0	-9,610,600			-9,610,600	1.00	-9,610,600
1.08	1	0	-1,644,840	4,582,656	2,937,816	0.91	2,670,742
1.17	2	-299,881	-2,694,442	8,297,303	5,302,979	0.83	4,382,628
1.26	3	-1,038,129	-5,029,337	17,922,175	11,854,709	0.75	8,906,618
1.36	4	-1,052,746	-7,937,229	29,203,712	20,213,737	0.68	13,806,254
1.47	5	-81,254	-8,656,106	31,540,009	22,802,649	0.62	14,158,651
						NPV	**34,314,293**
						nominal IRR	**72%**

Cash flow statement for Scenario 2 (normal case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF (ETB)
1.00	0	-13,085,900			-13,085,900	1.00	-13,085,900
1.08	1	0	-4,006,908	9,623,556	5,616,648	0.91	5,106,044
1.17	2	-304,314	-4,036,969	10,393,440	6,052,158	0.83	5,001,783
1.26	3	-8,062	-6,941,857	18,708,235	11,758,316	0.75	8,834,197
1.36	4	-179,448	-7,530,851	20,204,894	12,494,595	0.68	8,533,976
1.47	5	-14,399	-10,440,090	30,112,630	19,658,140	0.62	12,206,159
						NPV	**26,596,259**
						nominal IRR	**57%**

Cash flow statement for Scenario 2 (worst case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF (ETB)
1.00	0	-13,085,900			-13,085,900	1.00	-13,085,900
1.08	1	0	-4,006,908	7,143,552	3,136,644	0.91	2,851,495
1.17	2	-304,314	-4,036,969	7,715,036	3,373,754	0.83	2,788,226
1.26	3	-8,062	-6,941,857	13,897,546	6,947,627	0.75	5,219,855
1.36	4	-179,448	-7,530,851	15,009,350	7,299,050	0.68	4,985,350
1.47	5	-14,399	-10,440,090	22,371,402	11,916,912	0.62	7,399,465
						NPV	**10,158,490**
						nominal IRR	**31%**

Cash flow statement for Scenario 2 (best case scenario) using current prices and nominal discount rate (inflation included)

Inflation factor $(1+0.08)^t$	Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.1)^t$	DNCF (ETB)
1.00	0	-13,085,900			-13,085,900	1.00	-13,085,900
1.08	1	0	-4,006,908	12,130,560	8,123,652	0.91	7,385,138
1.17	2	-304,314	-4,036,969	13,101,005	8,759,722	0.83	7,239,440
1.26	3	-8,062	-6,941,857	23,581,809	16,631,890	0.75	12,495,785
1.36	4	-179,448	-7,530,851	25,468,353	17,758,054	0.68	12,128,990
1.47	5	-14,399	-10,440,090	37,958,034	27,503,544	0.62	17,077,537
						NPV	**43,240,990**
						nominal IRR	**81%**

B.8 Profitability analysis using constant prices

Cash flow statements for Scenario 1 and Scenario 2 for normal case, worst case and best case scenarios using constant as described in <u>Section 3.6.3.2</u> are presented further.

Cash flow statement for Scenario 1 (normal case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-9,610,600			-9,610,600	1.00	-9,610,600
1	0	-1,523,000	3,369,600	1,846,600	0.98	1,813,025
2	-257,100	-2,310,050	5,616,000	3,048,850	0.96	2,938,991
3	-824,100	-3,992,450	11,281,900	6,465,350	0.95	6,119,068
4	-773,800	-5,834,100	16,922,900	10,315,000	0.93	9,585,031
5	-55,300	-5,891,200	16,922,900	10,976,400	0.91	10,014,177
					NPV	**20,859,692**
					real IRR	**42%**

Cash flow statement for Scenario 1 (worst case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-9,610,600			-9,610,600	1.00	-9,610,600
1	0	-1,523,000	2,496,000	973,000	0.98	955,309
2	-257,100	-2,310,050	4,193,300	1,626,150	0.96	1,567,555
3	-824,100	-3,992,450	8,386,560	3,570,010	0.95	3,378,801
4	-773,800	-5,834,100	12,504,950	5,897,050	0.93	5,479,729
5	-55,300	-5,891,200	12,504,950	6,558,450	0.91	5,983,517
					NPV	**7,754,312**
					real IRR	**20%**

Cash flow statement for Scenario 1 (best case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-9,610,600			-9,610,600	1.00	-9,610,600
1	0	-1,523,000	4,243,200	2,720,200	0.98	2,670,742
2	-257,100	-2,310,050	7,113,600	4,546,450	0.96	4,382,628
3	-824,100	-3,992,450	14,227,200	9,410,650	0.95	8,906,618
4	-773,800	-5,834,100	21,465,600	14,857,700	0.93	13,806,254
5	-55,300	-5,891,200	21,465,600	15,519,100	0.91	14,158,651
				7,066,700	**NPV**	**34,314,293**
					real IRR	**60%**

Cash flow statement for Scenario 2 (normal case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-13,085,900			-13,085,900	1.00	-13,085,900
1	0	-3,710,100	8,910,700	5,200,600	0.98	5,106,044
2	-260,900	-3,461,050	8,910,700	5,188,750	0.96	5,001,783
3	-6,400	-5,510,670	14,851,200	9,334,130	0.95	8,834,197
4	-131,900	-5,535,400	14,851,200	9,183,900	0.93	8,533,976
5	-9,800	-7,105,350	20,494,150	13,379,000	0.91	12,206,159
					NPV	**26,596,259**
					real IRR	**46%**

Cash flow statement for Scenario 2 (worst case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-13,085,900			-13,085,900	1.00	-13,085,900
1	0	-3,710,100	6,614,400	2,904,300	0.98	2,851,495
2	-260,900	-3,461,050	6,614,400	2,892,450	0.96	2,788,226
3	-6,400	-5,510,670	11,032,320	5,515,250	0.95	5,219,855
4	-131,900	-5,535,400	11,032,320	5,365,020	0.93	4,985,350
5	-9,800	-7,105,350	15,225,600	8,110,450	0.91	7,399,465
				-1,773,900	**NPV**	**10,158,490**
					real IRR	**21%**

Cash flow statement for Scenario 2 (best case scenario) using constant prices and real discount rate (no inflation included)

Year (t)	Investment (ETB)	Recurrent Costs (ETB)	Yearly Revenues (ETB)	Net cash flow (ETB)	Discount factor $1/(1+0.02)^t$	DNCF (ETB)
0	-13,085,900			-13,085,900	1.00	-13,085,900
1	0	-3,710,100	11,232,000	7,521,900	0.98	7,385,138
2	-260,900	-3,461,050	11,232,000	7,510,050	0.96	7,239,440
3	-6,400	-5,510,670	18,720,000	13,202,930	0.95	12,495,785
4	-131,900	-5,535,400	18,720,000	13,052,700	0.93	12,128,990
5	-9,800	-7,105,350	25,833,600	18,718,450	0.91	17,077,537
					NPV	**43,240,990**
					real IRR	**67%**

B.9 Parameters for the calculation of depreciation

Projected useful life of different items required for the calculation of depreciation

Item	Useful life (years)
Rotational molding machine	40
Extra arm for rotational molding machine	40
Other plant machinery (e.g., burner, extruder, generator, high-speed mixer, pulverizer,)	10
Buildings	20
Car	10
Steel molds[a]	3 (Scenario 2)
	4 (Scenario 1)
Office equipment	10
Computer and printer	5

[a)] Steel molds are depreciated taking into account their useful life of 25,000 parts per mold (in Scenario 1, it leads to the depreciation over 4 years and in Scenario 2, to the depreciation over 3 years).

Appendix C: Biodiesel properties

Properties of biodiesel compared to standard diesel (adapted from Elsbett and Bialkowsky, 2003)

Properties	Biodiesel to Diesel	Importance
Density	approx. 10 % higher	Brake specific fuel consumption is higher than diesel
Flash point by P.-M.[a]	much higher	Makes transportation and handling of biodiesel safer
Calorific value	10 % less	Reduction in power More amount of biodiesel to give same power output as standard diesel
Kinematic viscosity	for most vegetable oils slightly higher	Big differences between different kinds of seeds If too high, the oil cannot pass the fuel circuit Heating is one of the measures to enable engines to run on vegetable oil
Sulfur content	normally no sulfur in vegetable oil	No sulfur dioxide emissions
Carbon residue	less	Correlation to the residues in the combustion chamber, piston rings and valves Carbon residue should be kept low
Cetane number	higher	Ignition delay is shortened for biodiesel
Lubricity	higher	Improved life and performance of fuel-pump and injectors

[a)] The lowest liquid temperature at which a test flame causes the vapors to ignite.

Appendix D: Tree species for short rotation plantations

Appendix D presents photographs of selected tree species suitable for short rotation plantations as described in Section 4.1.6.

Cassia siamea (Photo by S. Gassouma retrieved from EcoPort, n.d.)

Gliricidia sepium (Photo by H.M. Shelton retrieved from FAO, n.d.)

Leucaena leucocephala (Photo by S.G. Reynolds retrieved from FAO, n.d.)

Gmelina arborea (Photo by P. Oudhia retrieved from EcoPort, n.d.)

Casuarina equisetifolia (Photo by R. Scherbaum retrieved from EcoPort, n.d.)

Appendix E: Parameters of the case studies Accra 1, Accra 2 and Kade

Appendix E presents parameters required for the calculation of urine volume, transportation costs for the case studies “Accra 1”, “Accra 2” and “Kade” as they appear in Section 4.2.2, Section 4.2.3 and Section 4.3.2.

E.1 Potential urine volume collected in Accra, Ghana

Urine generation in the Central Business District, Accra in Ghana (adapted from Cofie and Mainoo, 2007)

Public urinal location	Urine volume (l/day)
Kojo Thompson Road – Makola Market	1,100
Nkrumah Avenue 2	980
Nkrumah Avenue 1	840
Rawlings Park 1	640
Kinbu Road – Tudu Station	600
Kantamanto 1	600
Kantamanto 2	560
Rawlings Park 2	550
Kantamanto 3	520
Novotel Market 1	290
Novotel Market 2	160
Tema Station 1	160
Metro Mass Transit Station	120
Mobil – Independence Avenue	120
Total	**7,240**

E.2 Transportation costs

Calculation of transportation costs for projects “Accra 1” and “Accra 2”

Distance, round trip (km)	Transportation costs (GH¢)	Value of 7,000 l of urine[a] (GH¢)	Costs of urine transportation and monthly storage in a tank[b] (GH¢)	Costs of urine transportation and monthly storage in a bladder[c] (GH¢)
10	20.40	100.46	25.55	21.86
20	24.37	100.46	29.52	25.83
30	28.35	100.46	33.50	29.81
40	32.32	100.46	37.47	33.78
50	36.30	100.46	41.45	37.76
60	40.27	100.46	45.42	41.73
70	44.25	100.46	49.40	45.71
80	48.22	100.46	53.37	49.68
90	52.20	100.46	57.35	53.66
100	56.17	100.46	61.32	57.63
110	60.15	100.46	65.30	61.61
120	64.12	100.46	69.27	65.58
130	68.10	100.46	73.25	69.56
140	72.07	100.46	77.22	73.53
150	76.05	100.46	81.20	77.51

Distance, round trip (km)	Transportation costs (GH¢)	Value of 7,000 l of urine[a] (GH¢)	Costs of urine transportation and monthly storage in a tank[b] (GH¢)	Costs of urine transportation and monthly storage in a bladder[c] (GH¢)
160	80.02	100.46	85.17	81.48
170	84.00	100.46	89.15	85.46
180	87.97	100.46	93.12	89.43
190	91.95	100.46	97.10	93.41
200	95.92	100.46	101.07	97.38
210	99.90	100.46	105.05	101.36
220	103.87	100.46	109.02	105.33
230	107.85	100.46	113.00	109.31
240	111.82	100.46	116.97	113.28
250	115.80	100.46	120.95	117.26
260	119.77	100.46	124.92	121.23
270	123.75	100.46	128.90	125.21
280	127.72	100.46	132.87	129.18
290	131.70	100.46	136.85	133.16
300	135.67	100.46	140.82	137.13

a) For the monetary value of urine refer to Table 4.5.

b) Cost of storage in a plastic tank (GH¢/month): 0.735×10^{-3} (see Table 4.7).

c) Cost of storage in a plastic bladder (GH¢/month): 0.208×10^{-3} (see Table 4.7).

Calculation of transportation costs for the project "Kade"

Distance, round trip (km)	Transportation costs (GH¢)	Value of 7,000 l of urine[a] (GH¢)	Costs of urine transportation and monthly storage in a tank[b] (GH¢)	Costs of urine transportation and monthly storage in a bladder[c] (GH¢)
10	20.03	100.46	25.18	21.49
20	24.00	100.46	29.15	25.46
30	27.98	100.46	33.13	29.44
40	31.95	100.46	37.10	33.41
50	35.93	100.46	41.08	37.39
60	39.90	100.46	45.05	41.36
70	43.88	100.46	49.03	45.34
80	47.85	100.46	53.00	49.31
90	51.83	100.46	56.98	53.29
100	55.80	100.46	60.95	57.26
110	59.78	100.46	64.93	61.24
120	63.75	100.46	68.90	65.21
130	67.73	100.46	72.88	69.19
140	71.70	100.46	76.85	73.16
150	75.68	100.46	80.83	77.14
160	79.65	100.46	84.80	81.11
170	83.63	100.46	88.78	85.09
180	87.60	100.46	92.75	89.06
190	91.58	100.46	96.73	93.04
200	95.55	100.46	100.70	97.01
210	99.53	100.46	104.68	100.99
220	103.50	100.46	108.65	104.96
230	107.48	100.46	112.63	108.94
240	111.45	100.46	116.60	112.91

Distance, round trip (km)	Transportation costs (GH¢)	Value of 7,000 l of urine[a] (GH¢)	Costs of urine transportation and monthly storage in a tank[b] (GH¢)	Costs of urine transportation and monthly storage in a bladder[c] (GH¢)
250	115.43	100.46	120.58	116.89
260	119.40	100.46	124.55	120.86
270	123.38	100.46	128.53	124.84
280	127.35	100.46	132.50	128.81
290	131.33	100.46	136.48	132.79
300	135.30	100.46	140.45	136.76

a) For the monetary value of urine refer to Table 4.5.

b) Cost of storage in a plastic tank (GH¢/month): 0.735×10^{-3} (see Table 4.7).

c) Cost of storage in a plastic bladder (GH¢/month): 0.208×10^{-3} (see Table 4.7).

Variables for the calculation of transportation costs of 7,000 l of urine (adapted from Martinez Neri, 2009)

Variable	Value	Unit
Equipped truck cost (“Accra 1” and “Accra 2”)[a]	28,350.00	GH¢
Equipped truck cost (“Kade”)[b]	27,000	GH¢
Life span of the equipped truck	10.00	years
Diesel powered liquid pump cost	1,200.00	GH¢
Life span of the pump	5.00	years
Fuel economy of the truck	4.00	km/l
Price per liter of diesel	1.27	GH¢
Maintenance cost each 5,000 km	200.00	GH¢
Spare parts each 5,000 km	200.00	GH¢
Daily salary of the driver	8.00	GH¢

a) The truck is equipped to transport 7,000 l of urine. The unequipped truck costs GH¢ 26,550 (for details see Table 4.8) and it is fitted with 24 containers of 300 l each (GH¢ 75/container) to carry 7,000 l of urine.

b) The truck is equipped to transport urine and biodiesel. The truck is fitted with 6 containers of 300 l each (GH¢ 75/container) to carry 250 l of urine per day. The extra containers are bought to allow for transportation of other goods.

E.3 Profitability analysis using constant prices

Cash flow statement for the project "Accra 1" using constant prices and real interest rate (no inflation included)

Year (t)	Investment (GH¢)	Recurrent Costs (GH¢)	Yearly Revenues (GH¢)	Net cash flow (GH¢)	Discount factor $1/(1+0.08)^t$	DNCF (GH¢)
0	-44,600			-44,600	1.00	-44,600
1		-20,350	39,550	19,200	0.93	17,818
2		-20,350	39,550	19,200	0.86	16,535
3		-20,350	39,550	19,200	0.80	15,344
4		-20,350	39,550	19,200	0.74	14,239
5		-20,350	39,550	19,200	0.69	13,214
					NPV	**32,550**
					real IRR	**33 %**

Cash flow statement for the project "Accra 2" using constant prices and real interest rate (no inflation included)

Year (t)	Investment (GH¢)	Recurrent Costs (GH¢)	Yearly Revenues (GH¢)	Net cash flow (GH¢)	Discount factor $1/(1+0.08)^t$	DNCF (GH¢)
0	-63,200			-63,200	1.00	-63,200
1		-13,900	39,550	25,650	0.93	23,803
2		-13,900	39,550	25,650	0.86	22,089
3		-13,900	39,550	25,650	0.80	20,499
4		-13,900	39,550	25,650	0.74	19,023
5		-13,900	39,550	25,650	0.69	17,653
					NPV	**39,868**
					real IRR	**29 %**

Cash flow statement for the project "Kade" using constant prices and real interest rate (no inflation included)

Year (t)	Investment (GH¢)	Recurrent Costs (GH¢)	Yearly Revenues (GH¢)	Net cash flow (GH¢)	Discount factor $1/(1+0.08)^t$	DNCF (GH¢)
0	-64,100			-64,100	1.00	-64,100
1		-284,550	328,250	43,700	0.93	40,554
2		-284,550	328,250	43,700	0.86	37,634
3		-284,550	328,250	43,700	0.80	34,924
4		-284,550	328,250	43,700	0.74	32,410
5		-284,550	336,850	52,300	0.69	35,995
					NPV	**117,416**
					real IRR	**63 %**

E.4 Parameters for the calculation of potential energy savings

Parameters for the calculation of energy potentially saved by urine application in place of mineral fertilizers

Project	"Accra 1"	"Accra 2"		"Kade"	
Location	Nsawam	Nsawam	Accra	Kade	Kade
Crop fertilized	Oil palm	Oil palm	Maize	Oil palm	Kassod tree
Fertilizer recommendation[a]					
K (kg/ha)	109.4	109.4	31.5	109.4	18.8
K needs (l urine/ha)[b]	47,878	47,878	13,809	47,878	8,209
K needs satisfied	20%	20%	92%	20%	45%
N (kg/ha)	48.6	48.6	64.0	48.6	18.8
N needs (l urine/ha)[b]	9,672	9,672	12,737	9,672	3,732
N needs satisfied	100%	100%	100%	100%	100%
P (kg/ha)	50.6	50.6	16.7	50.6	18.8
P needs (l urine/ha)[b]	73,885	73,885	24,402	73,885	27,365
P needs satisfied	13%	13%	52%	13%	14%

a) Fertilizer recommendation for 1) oil palm trees: calculated with information retrieved from Table 4.11 and the number of palm oil trees planted per hectare being 135, 2) maize: IPNIS, 2011, 3) Kassod tree: Tripathi and Psychas, 1992; Florido and Cornejo, 2002.

b) Fertilizer needs covered with urine calculated based on nutrient content of urine in Ghana (refer to Table 4.4).

Primary energy consumption for K, N and P production (Patyk and Reinhardt, 1997)

Primary energy consumption for	Average	Unit
K production	2.42	kWh/kg K
N production	13.64	kWh/kg N
P production	2.14	kWh/kg P

References (Appendices)

Cofie O. and Mainoo O.K. (2007). *The potential for urine recovery and reuse in densely populated districts within the Accra Metropolitan Area*. Exploratory study report prepared for the IWMI-SWITCH Project. Unpublished document.

EcoPort (n.d.). *EcoPort picture data bank*. http://ecoport.org/ep?SearchType=displayMenu&menu=Pictures (accessed 30 November 2011).

Elsbett G. and Bialkowsky M. (2003). Engines running on pure vegetable oil as regrowing fuel: *History, development, experience, chances*. Shanghai International Symposium on I.C. Engine, Shanghai, China. http://www.elsbett.com/fileadmin/elsbett/archiv/de/svohistory.pdf (accessed 08 February 2011).

Ethiopian Investment Agency (2008a). *Ethiopian investment guide*, Addis Ababa, Ethiopia.

Ethiopian Investment Agency (2008b). *Factor costs*, Addis Ababa, Ethiopia.

FAO (n.d.). *Picture gallery*. http://www.fao.org/ag/AGP/AGPC/doc/Gallery/pic.htm (accessed 30 November 2011).

Florido L.V. and Cornejo A.T. (2002). *Yemane Gmelina arborea (Roxb.)*. Research Information Series on Ecosystems, vol 14 (3). http://erdb.denr.gov.ph/publications/rise/r_v14n3.pdf (accessed 02 February 2012).

IPNIS (2011). *IPNIS database. Integrated Plant Nutrition Information System (IPNIS).* Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/ag/agp/ipnis/index.asp (accessed 17 November 2011).

Martinez Neri I.F. (2009). *Design of a supply chain for a sustainable sanitation system on the example of Accra and Kade, Ghana.* M.Sc. thesis, Institute of Wastewater Management and Water Protection, Hamburg University of Technology, Hamburg, Germany. http://www.susana.org/docs_ccbk/susana_download/2-1052-en-design-of-a-supply-chain-for-a-sustainable-sanitation-system-2009.pdf (accessed 28 July 2011).

Mojen A. (Ed.) (2008). *Ecological Sanitation Ethiopia: Introduction of ecological sanitation to large scale housing programmes*. http://www.susana.org/images/documents/nl32/gtz-ecosan-nl-32-flyer-ecosan-ethiopia.pdf (accessed 11 January 2012).

OANDA (2012). *Historical exchange rates*. http://www.oanda.com/lang/de/currency/historical-rates (accessed 10 March 2012).

Patyk A. and Reinhardt G.A. (1997). *Düngemittel - Energie- und Stoffstrombilanzen*. Vieweg, Braunschweig, ISBN 3-528-06885-X.

Roto PLC (2012). *Company homepage*. http://rotoplc.com/ (accessed 07 February 2012).

Tripathi B.R. and Psychas P.J. (Eds.) (1992). *The AFNETA alley farming training manual*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

World Bank (2011). *Data. Indicators*. http://data.worldbank.org/indicator (accessed 10 March 2012).