TAMPERE UNIVERSITY OF TECHNOLOGY

KIRSIKKA PYNNÖNEN

ECOSAN IN SCHOOLS: POST-EVALUATION OF THE OPERATION OF URINE DIVERTING DRY TOILETS IN RURAL SCHOOLS IN KENYA - FACTORS AFFECTING THEIR SUSTAINABILITY

Master of Science Thesis

The topic and the examiners Prof. Tuula Tuhkanen and Christian Rieck were appointed at the Council Meeting of the Faculty of Science and Environmental Engineering November 9th 2011.

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Maailman väestönkasvu saavutti 7 miljardin virstanpylvään vuonna 2011. Näistä lähes 2,6 miljardilla ihmisellä, eli yli kolmasosalla, ei ole mahdollisuutta käyttää kunnollisia ja hygieenisiä sanitaatiotiloja. Puutteellinen jätevesien käsittely ja sanitaatio johtavat usein juomaveden saastumiseen, mikä puolestaan johtaa bakteeri- ja virusperäisten sairauksien leviämiseen. Huonosti hoidettu sanitaatio on ongelma erityisesti kehittyvissä maissa, missä nopea väestönkasvu hankaloittaa tilannetta entisestään. Maailman Terveysjärjestön (WHO) mukaan Keniassa, jonka sanitaatiotilanteeseen tämä diplomityö keskittyy, kaikkiaan 9,9 % kuolemista liittyy likaiseen juomaveteen, riittämättömään sanitaatioon ja huonoon hygieniaan.

Kunnollinen ja hygieeninen sanitaatio kouluissa on äärimmäisen tärkeä asia koko väestön terveydelle, mutta siitä huolimatta asia jätetään usein liian vähälle huomiolle. Jopa kaksi kolmasosaa kehitysmaiden kouluista ei pysty tarjoamaan oppilailleen ja opettajilleen perushygieniaa, kunnollisia käymälöitä ja käsienpesumahdollisuutta. Usein käymälöiden kunto on huono ja hygienia riittämätön, mikä aiheuttaa riskejä terveydelle ja ympäristölle. Monissa kouluissa ei ole minkäänlaisia käymälöitä. Useat tutkimukset ovat osoittaneet, että todennäköisyys lasten koulunkäynnin keskeyttämiselle kasvaa huonosti järjestetyn sanitaation vuoksi. Erityisesti murrosikäiset tytöt joutuvat kärsimään puutteellisen sanitaation aiheuttamasta epähygieenisyydestä kuukautistensa aikana. Huonosta sanitaatiosta johtuvat sairaudet, esimerkiksi ripuli ja parasiittitartunnat, vaikuttavat lasten fyysiseen ja henkiseen kehitykseen, vaikeuttaen koulunkäyntiä. Hyvän ja hygieenisen sanitaation järjestämiseen liittyy tärkeänä osana käsien pesu ja hyvä käsihygenia, mikä on merkittävä terveyttä edistävä ja tautien tartuntaa pienentävä tekijä. Hyvän koulusanitaation tavoite on tarjota lapsille hyvät lähtökohdat terveelle ja hyvälle kouluympäristölle ja näin parantaa oppimista.

Länsi-Keniassa toteutettiin ekologisen sanitaation edistämisprojekti (EPP, *Ecosan Promotion Project*) vuosina 2006–2010. Mukana olivat mm. Euroopan Unioni, saksalainen kehitysyhteistyöjärjestö GIZ (entinen GTZ), sekä ruotsalainen kehitysyhteistyöjärjestö SIDA. Projektin tarkoituksena oli edistää ekologista, kestävää ja turvallista sanitaatiota ja hygieniaa kenialaisissa kouluissa. Projektin tukemana rakennettiin

erottelevat kuivakäymälät (UDDT, *Urine Diverting Dry Toilet*) kaikkiaan 73 kenialaiseen ala- ja yläkouluun, jokaiseen kouluun neljä yksikköä.

Erotteleviin kuivakäymälöihin perustuvan sanitaation avulla voidaan saavuttaa monia etuja ympäristön ja ihmisten terveyden ja hyvinvoinnin edistämiseksi sekä noudattaa kestävän kehityksen periaatteita. UDDT -käymälät ovat hygieenisiä ja hajuttomia. Ne eivät kuluta vettä, joten sähköä tai vesipumppuja ei tarvita. Kulut ovat sekä rakennus että ylläpitovaiheessa pienemmät kuin vesivessoissa. Tarvittaessa erottelevan kuivakäymälän voi rakentaa myös sisätiloihin. Systeemiä ei kuitenkaan ole tarvetta yhdistää vesi- ja viemäriverkostoon. Oikein käytettynä ja ylläpidettynä UDDT -käymälä ei saastuta pohja- tai pintavesiä, sillä mahdolliset taudinaiheuttajabakteerit eivät joudu kosketuksiin ympäristön kanssa. Virtsan ja ulosteen hygienisoituminen perustuu riittävän pitkään varastointiin, kuivatukseen tai kompostointiin. Nämä käsittelyt tuhoavat mahdolliset patogeenit. Erottelevien kuivakäymälöiden avulla ravinteet, joita erityisesti virtsa sisältää, voidaan kierrättää ja hyödyntää helposti ja turvallisesti esimerkiksi maanviljelyssä.

Tärkeä tekijä UDDT -käymälöiden toimivuudelle ja hyötyjen saavuttamiselle on niiden oikeanlainen ja riittävä ylläpito, mikä vaatii enemmän vaivannäköä kuin esimerkiksi perinteiset kuoppakäymälät. Mikäli perusasioista, kuten kuivikkeen saatavuudesta ja käytöstä sekä säiliöiden säännöllisestä tyhjentämisestä, ei pidetä huolta, eivät kuivakäymälät välttämättä toimi halutulla tavalla. Erottelevien kuivakäymälöiden operointi ja ylläpito pitkällä aikavälillä onkin usein osoittautunut kompastuskiveksi niiden kestävän käytön suhteen.

Tämän diplomityön tarkoituksena oli monitoroida ja jälkiarvioida EPP:n rakentamien erottelevien kuivakäymälöiden kunto, käyttö ja ylläpito, nyt kun itse projektista on kulunut 2-4 vuotta. Monitorointi ja arviointi suoritettiin Länsi-Keniassa, Nyanza ja Western –provinsseissa. Marraskuusta 2011 tammikuulle 2012 monitoroitiin kaikkiaan kymmenen koulun UDDTt, jotka oli valittu tutkimukseen esiarvioinnin avulla perustuen niiden hyvään menestykseen erottelevien kuivakäymälöiden operoinnissa ja kunnossapidossa.

Valittujen koulujen UDDT -käymälöiden rakenteellinen kunto, siisteys ja ylläpidon taso arvioitiin paikan päällä. Koulujen rehtoreita, vastuuopettajia, oppilaita sekä sanitaatiosta vastaavia henkilöitä haastateltiin ja heidän kanssaan keskusteltiin sanitaatioon ja erityisesti UDDT -käymälöihin liittyen. Haastattelujen tukena olivat puolistrukturoidut kyselylomakkeet. Haastatteluissa keskityttiin erityisesti erottelevien kuivakäymälöiden operoinnin ja ylläpidon toteutukseen sekä UDDT -tuotteiden, eli virtsan ja ulosteen, käsittelyyn ja hyötykäyttöön lannoitteena. Muita keskustelujen ja haastattelujen näkökulmia olivat sosiaaliset, taloudelliset ja kulttuuriset tekijät, omistussuhde ja projektin toteutus.

Tämä diplomityö keskittyy selvittämään syitä monitoroitujen koulujen hyvään menestykseen kuivakäymälöiden operoinnin ja ylläpidon suhteen. Mitkä ovat avaimet menestykseen UDDT käymälöiden kestävän käytön ja ylläpidon kannalta? Miten kyseiset koulut ovat toteuttaneet ylläpidon käytännössä, kuka on siitä vastuussa ja mitkä ovat

motivoivat tekijät? Lisäksi selvitettiin mihin tulevaisuuden projekteissa olisi kiinnitettävä enemmän huomiota, jotta voitaisiin luoda kestävämpi pohja pitkän tähtäimen onnistumiselle. Usein projektien onnistumisen kompastuskivi on juuri sanitteettitilojen huono hoito ja kunnossapito pitkällä aikavälillä, kun itse projekti ja rahoitus ovat loppuneet.

EP-projektin alaisista 73 koulusta vain suhteellisen pieni osa oli ylläpitänyt UDDT käymälöitään hyvin. Jälkiarviointiin otettiin mukaan 10 koulua, joiden oletettiin esiarviointien perusteella menestyvän hyvin. Paikallisten GIZ konsulttien mukaan hyvin menestyviä kouluja ei kuitenkaan ollut montaa enempää, eivätkä edes kaikki valitut 10 olleet pärjänneet mallikkaasti. UDDT käymälöiden operoinnissa ja ylläpidossa on siis parannettavaa. Yhdeksi suurimmista kompastuskivistä paljastui opettajavaihdon aiheuttama sanitaatiotiedon häviäminen kouluista. Ongelmia aiheutui, mikäli käymälät pääsivät huonoon kuntoon, ja jos tilanteeseen ei heti puututtu, se paheni. Tilojen kunnon huononemiseen johti usein letkujen tukkeutuminen, tilojen ylikuormitus ja väärinkäyttö. Näiden ongelmatilanteiden selvittämiseen ei aina ollut tarvittavaa taitoa eikä tietoa. Lisäksi ylläpidon järjestämistä hankaloitti koulujen taloudellinen tilanne. Operointi oli monitoroiduissa kouluissa järjestetty joko palkatun työntekijän tai oppilaiden ja opettajien yhteistyön avulla. Operointiin ja ylläpitoon kuuluu päivittäinen siivous, tuhkaastian täyttö, roskisten tyhjennys, pienet korjaukset, tukkeutuneiden letkujen avaus, virtsa-säiliöiden tyhjennys viikoittain (tai useammin), sekä lannoitteiden käsittely ja hyötykäyttö. Tulokset osoittivat, että järjestely palkatun työntekijän kanssa toimi usein parhaiten. Eniten parannettavaa kouluilla on käsienpesun järjestämisen kanssa.

Vaikka koulujen sanitaatiotilat eivät olleet kaikissa kouluissa esimerkillisessä kunnossa, UDDT -tiloja ja EP-projektia arvostettiin kouluissa ja niitä pidettiin hyvänä ja tärkeänä asiana. Tämä, sekä UDDT käymälöistä saatavat edut, olivat päätekijöitä kestävän sanitaatiosysteemin luomiselle ja koulujen motivoitumiselle sen ylläpitoon. Monitoroiduissa kouluissa tärkeiksi asioiksi nousivat parantunut hygieenisyys ja käsienpesumahdollisuus, sekä siisteys ja hajuttomuus saniteettitiloissa. Erottelevien kuivakäymälöiden huomattiin soveltuvan paremmin tiettyihin ympäristöihin, ja niitä pidettiin selkeästi parempana ratkaisuna esimerkiksi tulva-alttiilla ja kivisillä alueilla. Käymälöistä saatavaa lannoitetta ja maanparannusainetta arvostettiin, samoin käymälöiden pitkää ikää ja näin säästynyttä tilaa koulun pihalla, sillä maa-alaa ei tarvitse tuhlata perinteisten kuppakäymälöiden vuosittaiseen kaivamiseen ja täyttöön. Useissa kouluissa oli myös ymmärretty erottelevien kuivakäymälöiden taloudellisuus pitkällä aikavälillä, mitä luonnollisesti pidettiin isona etuna. UDDT -käymälät parantavat tasa-arvoa ja erityisesti tyttöjen asemaa, mitä kouluissa osattiin myös arvostaa. Koulujen motivaatiota pitää huolta kuivakäymälöidensä kunnosta kasvatti osaltaan niiden ansiosta saatu hyvä maine, jota haluttiin ylläpitää. Useissa tapauksissa ympäröiviltä alueilta oli esimerkiksi tullut vierailijoita tutustumaan näkemään UDDT -systeemiin ja oppimaan sen käyttöä ja ylläpitoa. Lisäksi ympäröivistä yhteisöistä saatu tuki vaikutti positiivisesti.

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
Master's Degree Programme in Environmental and Energy Engineering
PYNNÖNEN, KIRSIKKA: Ecosan in Schools: Post Evaluation of the Operation of Urine Diverting Dry Toilets in Rural Schools in Kenya - Factors Affecting their Sustainability
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The Ecosan Promotion Project (EPP) in Kenya, funded by EU, GTZ and Sida, was promoting appropriate ecological sanitation (ecosan) technologies during the project period (2006-2010). Urine Diversion Dry Toilets (UDDTs) were built in 73 primary and secondary schools throughout Kenya with four units in each school.

The purpose of the research in question was to monitor and post-evaluate UDDTs implemented by the EPP, two years after the constructions. In November 2011 and January 2012 five schools were visited and evaluated in southern Nyanza province and five in Western province in Kenya. The schools were pre-evaluated and selected for this research on the basis of their good performance in operation and maintenance (O&M) of their UDDTs. The constructions of the UDDTs were financed by EPP but maintenance is organized and funded by the schools themselves. Generally a common problem for sanitation projects is poor long term maintenance of the facilities, after the donor funding for construction and initial training has ended.

Monitoring and post-evaluation of the UDDTs focused on how the facilities are being managed and used. Methods for this were on-site observations, interviews and discussions together with teachers, pupils and caretakers. The research objective was to determine the reasons for the good practice, but also to identify the problems and reflect the results to improve O&M systems in the future. One major problem observed was gradual or sudden disappearance of the initial motivation and knowledge from the school, often when the person in charge of sanitation left the school.

According to the results of this research, an important factor motivating the schools to keep their UDDT facilities clean and in good condition, were the actual benefits received from the sanitation systems such as clean and comfortable toilet facilities, healthier environment, e.g. very low risk for ground water pollution and spreading of pathogens into the surroundings, saved space on the school yard as UDDTs can last long at the same spot, and possibility to use the UDDT products either as fertilizers or soil conditioner. These benefits and good results lead to motivation and deeper engagement and to continuity. Especially utilization of UDDT products indicates that the concept of ecological sanitation and technology of UDDTs have been accepted.

PREFACE

I want to thank my professor and supervisor Tuula Tuhkanen, for encouraging me to choose this topic and for her support and help trough the project. Thank you GIZ unit in Germany in Eschborn, Christian Rieck and Elisabeth von Münch, for providing me possibility to work with this very interesting topic, and for supervising me and for offering me support, help and ideas through the whole project. Special thanks to the former eco-san implementing officers in Kenya, Moses Wakala and Wycliffe Osumba, for their hospitality and irreplaceable help on the field. I also want to thank personnel in GIZ office in Nairobi, especially Patrick Onyango, for offering me a place in the office in Maji house and material for working. Many thanks also for the interviewed school personnel, principals, teachers, sanitary specialists and pupils, for participating my research and helping me to achieve my research objectives.

Special thanks also to my friends for support and encouragement to go to Kenya and choose this important topic. Many thanks to the ones who had time to proof-read parts of my text. I want especially thank Matthias, who encouraged me with my decisions. And of course, I want to thank my parents, who despite all the worry let me go to Africa.

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Kirsikka Pynnönen

Ahotie 34 a 7
33800 Tampere
kirsikka.pynnonen@gmail.com

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TERMS AND DEFINITIONS

Ecosan	Ecological sanitation, refers also to ecological sanitation systems, e.g. UDDTs
EPP	Ecosan Promotion Project
FPE	Free Primary Education -programme
GIZ	*Deutsche Gesellschaft für Internationale Zusammenarbeit* (*GIZ*) *GmbH*, German Society for International Cooperation. Since 1 January 2011, GIZ has brought together under one roof the long-standing expertise of DED, GTZ and Inwent.
Grey water	Wastewater generated from domestic activities such as laundry, dishwashing, and bathing
GTZ	*Gesellschaft für Technische Zusammenarbeit*, German Technical Cooperation (GIZ nowadays)
JMP	Joint Monitoring Programme (JMP) for Water Supply and Sanitation by the WHO and UNICEF
MDG	Millennium Development Goals
MoE	Ministry of Education
MoPHS	Ministry of Public Health and Sanitation
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
Pit latrine	*Pit latrine* is the cheapest and most basic form of improved sanitation. It is a dry toilet system which collects human excrement in a large hole or container, and can range from a simple slit trench to more elaborate systems with ventilation.
SIDA	Swedish International Development Cooperation Agency
UDDT	Urine Diverting Dry Toilet
UN	United Nations
WECF	Women in Europe for a Common Future
WHO	World Health Organization

1 INTRODUCTION

The world population reached 7 billion mark in 2011. Nearly 2.6 billion people in the world do not have improved sanitation facilities (WHO/UNICEF, 2006). Population growth causes a strain for essential services such as provision of adequate water and sanitation according to human rights principle. In Kenya, according to the World Health Organisation, 9.9 percentages of the total deaths are related to inadequate water, sanitation and hygiene (Prüss-Üstün, et al., 2008).

Every year 1.6 million children die due to unsafe water and lack of basic sanitation (WHO, 2004). School sanitation is a highly important issue for public health; nevertheless its importance is often neglected. Children are the most vulnerable victims of poor sanitation conditions and sanitation related diseases, particularly diarrhoea and parasite infections, hinder children's physical and intellectual development (Deegener, et al., 2009). Even two thirds of the schools in developing countries do not have sanitation facilities, and where facilities do exist, they are often inadequate and therefore causing risks for health and environment (CARE, 2010). Several evaluations in a number of countries have shown that pupils are dropping out of school due to bad toilet conditions. This seems to be particularly the case for adolescent girls and leads to lower educational standards and attainment. (Deegener et al., 2009.)

The United Nations' Millennium Development Goals (MDG), agreed at the UN Summit 2000, set a goal that half of the people without access to safe drinking water and sanitation today, should have access by 2015. This goal was completed at the UN World Summit 2002 in Johannesburg, South Africa, with the formulation of the demand for access to basic sanitation. (UN, 2002.)

Ecosan Promotion Project (EPP) by European Union, German Society for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit* GIZ, former GTZ) and Swedish International Development Agency (SIDA) was promoting ecological sanitation technologies during the project period (2006-2010) in Kenyan schools. This was supported by the Kenyan Ministries of Water and Irrigation, Education, Public Health and Sanitation with regard to meet the UN Millennium Development Goals of ensuring environmental sustainability and to halve the proportion of people without access to safe drinking water and adequate sanitation (Onyango, et al., 2009).

In Lake Victoria area in Western Kenya, urine diverting dry toilets (UDDTs) with double diverting vaults were built altogether in 73 primary and secondary schools by the Ecosan Promotion Project. The main objectives of the project were to improve safe and sustainable sanitation in schools, hygiene education and utilization of the products from the UDDTs. (Ecosan Network Kenya, 2009.) The aim of this Master Thesis

research was to post-evaluate some of these schools to define the current situation, now 1-4 years after the UDDT implementation.

The aim of this research was to monitor the condition and usage of the UDDTs. In addition arrangement and functionality of the operation and maintenance was evaluated. Other aspects were ownership, economic issues, social issues such as general acceptance and attitudes towards UDDTs, utilization of urine and faeces as fertilizer or soil conditioner, success of the project implementation, the main problems emerged and benefits received. In order to reach the goals 10 schools were visited from November 2011 to January 2012 in Western and Nyanza provinces in Kenya. The condition of the UDDTs was defined with onsite observations. Additional information was collected by interviews and discussions with head- or sanitary teachers, pupils, caretakers and former ecosan implementing officers.

The research was confined to evaluation of the schools that were already initially performing well with operation and maintenance of their UDDT facilities. Therefore a representative set of these well performing schools of the EPP was chosen for this research by the former EPP implementing officers. The main focus was to define reasons for the good performance of these schools in operation and maintenance of their UDDT facilities. A common problem related to project implementation is poor long term maintenance of the facilities, after the project itself.

Mainly two different options for organizing O&M were observed; either an employed caretaker (grounds man, cleaner) or pupils, together with help of their teachers, were in charge of cleaning, litter disposal, small repairs, unblocking the pipes, provision of ash, emptying the containers, and utilizing the urine and compost from UDDTs on the school farms. In the best performing schools there was always at least one very motivated person leading and taking responsibility of the sanitation and its maintenance.

According to the results of this research, an important factor motivating the schools to keep their UDDT facilities clean and in good condition, were the benefits received from the sanitation systems. These benefits were clean and comfortable toilet facilities and healthier environment, as the risk for ground water pollution and spreading of pathogens into the surroundings is much lower compared to the traditional sanitation solutions such as pit latrines. Also saved space on the school yard, as UDDTs last long in good condition and at the same place, was considered as an important factor as well as possibility to utilize nutrients present in urine and faeces for example in agriculture. Utilizing treated urine and faeces from UDDTs as fertilizers in farming or in soil conditioning and tree planting indicates that the concept of ecological sanitation and the technology of UDDTs have been accepted.

This Master of Science Thesis provides great amount of photos from the Thesis project, but more photos from the monitored schools and their UDDTs are available on Sustainable sanitation's photostream on Flickr:
http://www.flickr.com/photos/gtzecosan/sets/72157629413395685/ and
http://www.flickr.com/photos/gtzecosan/sets/72157629399616383/.

2 LITERATURE REVIEW

2.1 Ecological Sanitation

The concept of ecological sanitation (ecosan) is presented as a possible solution for the global sanitation problems. The main problems worldwide are the consequences of inadequate drinking water sources and lack of sanitation facilities, which causes serious health and environmental problems and water pollution. (Langergraber & Müllegger, 2004.) Other problematic issues are over-exploitation of limited renewable water sources, pollution of soil and groundwater, waste of valuable components in wastewater and the difficulty for an effective removal of pollutants (GTZ, 2003).

Sanitation systems that provide option for ecological sanitation can be ideated as cycles; sustainable, closed-loop systems, closing gaps between sanitation and agriculture. The ecosan approach is resource oriented ideology that represents a holistic concept towards ecological and economical sanitation (Langergraber & Müllegger, 2004). The aim is to close local nutrient and water cycles using as little material and energy as possible, for contributing sustainable development. Human excreta is considered and treated as a resource. Nutrients contained in urine and faeces are recycled by using them, e.g. in agriculture. (Langergraber & Müllegger, 2004.)

As Langergraber and Mülleger (2004) state, ecosan is more a systemic approach and an attitude than single eco-technologies, which are not necessarily ecological themselves, but means for achieving the end. Technologies range from near-natural wastewater treatment techniques to compost toilets and from biogas plants to waterless urinals, as well as from simple household installations to complex, mainly decentralised systems.

2.2 Sustainable School Sanitation

School sanitation is a highly important issue for public health (von Münch et al., 2012; Onyango, et al., 2009). Nevertheless, its importance is often neglected. Children are the most vulnerable victims of poor sanitation conditions, diseases related to lack of basic sanitation, particularly diarrhoea and parasite infections, hinder children's physical and intellectual development (Elliot et al., 2007). Several evaluations have shown that pupils, especially girls, are dropping out of school due to bad toilet conditions in many countries (UNISEF 2009, Deegener et al., 2009).

2.2.1 Poor Sanitation Conditions

There are many difficulties considering arrangement of safe and sustainable sanitation in schools, especially in developing countries. Even two-thirds of the schools in developing countries do not have sanitation facilities at all (CARE et al., 2010). According to United Nations Children's Fund country office annual reports (2008), of the 60 surveyed developing countries, only 33 provided data on access to water in primary schools and 25 have data on sanitation (CARE et al., 2010). Where facilities do exist, there are often too few of them and they are inadequate. Inadequate toilets are causing hygienic and environmental risks (Grimason et al., 2000). Hygienic and sanitary conditions of many rural school toilets range from bad to terrible. If there are too few toilets, they are overloaded, which leads to long queues, waiting and frequent need for cleaning and maintaining (von Münch et al., 2012).

In many cases sanitation facilities in developing countries, for example in Kenya, consist of simple pit latrines with little or no standard of cleansing (Onyango et al., 2009). The system of pit latrines is based on simple and low cost drop and store technique (Winblad et al., 2004). When pit is full it is usually just abandoned on site. Pit latrines are already considered as improved sanitation method, compared to defecating in the bushes, and they can be liable solution in rural areas (von Münch et al., 2012), but they have many drawbacks (Winblad et al., 2004). Pit latrines cannot be used in crowded areas, on rocky ground, where ground water level is high, or in periodically flooding areas (Winblad et al., 2004). Pit latrines are causing serious hazards for human health and for the environment (von Münch et al., 2012). Especially in highly populated institutions such as schools, pits usually fill up quickly and are unhygienic and smelly (Abraham et al., 2011). They can also collapse or sink, especially in areas where soil is wet, or during rain seasons and therefore new pit latrines have to be digged every few year (Winblad et al., 2004). Groundwater can easily get polluted with faecal bacteria and nitrates by faecial infiltration of the toilet pits, which causes a constant risk of waterborne diseases for human, i.e. for school children and teachers as well as local population, through drinking water pollution (Grimason et al., 2000; Barret, 2001).

In many cases of school sanitation, especially in developing countries, hand washing facilities are totally lacking or inappropriate, poorly located i.e. far away from the toilets, or have other shortcomings (Abraham et al., 2011). According to a research in Colombia, provision of hand washing facilities in schools resulted in a reduction of 30 % in diarrhoea cases (CARE et al., 2010). The same study revealed that 40 % of diarrhoea cases were transmitted in schools instead of children's home.

Implementing hygienic, safe and sustainable sanitation in schools contributes solving the health and environmental problems of rural areas. Demonstrations and trainings about hygienic and sanitation issues, for both pupils and teachers, will lead to higher educational standards and raise the awareness of the whole communities via the children. (von Münch et al., 2012; Hasan et al., 2011.)

Also in industrialized countries sanitation gets often too little attention and public discussion. Even in theory sanitation is well arranged in western world, many schools still have problems with hygiene, proper use and adequate maintenance of their toilet facilities (Abraham et al., 2011).

2.2.2 Political and Financial Issues

Often a lack of financial resources for cleaning and maintaining school toilets leads to inappropriate and poorly managed facilities, which is not providing healthy environment for education. One reason for this is lack of political motivation and attention as well as lack of knowledge considering the importance of safe and sustainable sanitation. (Abraham et al., 2011.) In addition to the political deficiency, also school administrations and inspectorates are often lacking interest or responsibility for prioritizing sanitation and maintenance of the toilet facilities as highly as they should be, to enable good performance. Head masters and teachers would more likely implement ecological sanitation approaches in their schools, if they were guided and encouraged from higher institutional levels e.g. from the government, by a policy or a strategy. Even if some kinds of policies do exist, they are often contradictory or unclear, due to the fact that school sanitation is often covered by three or four different ministries: Educational ministry, Ministries of Water, Health and Public Works. (Abraham et al., 2011.) Schools and other public institutions are often not in charge of their own annual budget. This can lead decisions that are not so cost effective or economical, which often goes hand in hand with ecological issues. (Abraham et al., 2011.)

In the end, solutions for sanitation problems are not rocket science. A simple, low cost toilet can meet all the principles of sustainable sanitation. A good, health, hygiene, environmentally friendly, economical and acceptable toilet can be built with low budget. (Abraham et al., 2011.) According to Rieck & von Münch (2011) costs for building an appropriate UDD toilet, are ranging worldwide from EUR 120 to 580. Besides the direct and indirect costs (i.e. maintaining), indirect benefits should also be taken into account. These include health improvements and reduced need for medicines, as well as benefits from recycled products (soil conditioner, fertilizers and reclaimed water). (Deegener et al., 2009.) More emphasis should be laid on how to finance long term costs related to cleaning and maintenance and possible reparations.

2.2.3 Users with special needs

In schools attention should be paid on needs of special user groups such as small children, adolescent girls and children with disabilities. Small children may face difficulties with the size of the squatting pan or drop wholes of pit latrines, as well as the height of the pedestal. This can lead to children defecating in the entrance of the latrine or in the corners of it, which results in unhygienic and dirty toilets. (Abraham et al., 2011.)

For children with disabilities, for example those who have to use wheelchair or other ancillaries, special design is required. Urine diverting dry toilets (UDDTs) usually

have faeces vaults partly or fully above the ground level and since have stairs up to the entry of the toilet. (Rieck et al., 2012.) A design with bench type or ramps does exist but is not widely introduced.

Teenage girls are also one group that needs special attention in terms of sanitation. It has been reported that a lack of proper toilets disadvantage girls' education (Gacheiya & Mutua, 2010; Nahar & Ahmed, 2006). If a school does not have proper toilet facilities, it is likely that girls do not attend lessons during their menstruation periods. Considering the fact girls menstruate approximately 3 to 5 days a month, girls loose approximately 40 school days a year. According to Deegener et al. (2009) it would be necessary to have a brush, some water and a waste bin for sanitary napkins available in the girls' toilets. According to girls themselves, many of them do avoid going to the toilet during their periods because they feel ashamed if they cannot clean the pans from their menstrual blood.

In the school environment, design of the toilet facilities should always have children centred approach (Deegener et al., 2009). Dimensions should be appropriate for small children and there should be some source of light, a window for instance. There should be enough toilet capacity to minimize the time of queuing. The problem often is that most of the pupils are about to use toilet facilities during the breaks when facilities get crowded. According to the guidelines by the Kenyan Ministry of Public Health and Sanitation (2005), recommended ratio for the toilets per the amount of the pupils is for girls 1:25 and for boys 1:30. To courage children using the facilities they should not be located too far away from the school buildings. (Deegener et al., 2009.)

Schools are identified as good invention points for introducing new sanitation systems. A huge number of persons can be reached as a big number of students are using the toilets in the school and further students bring the news about their new school sanitation system home to their families. (Gacheiya & Mutua, 2010.)

2.2.4 Principles for Safe and Sustainable Sanitation in Schools

The major goal of sustainable school sanitation is to provide a healthy school environment and therefore to optimize children's learning capacity. To meet this goal the facilities should be safe and hygienic and have proper hand washing facility. To achieve also the aspect of sustainability, the sanitation system should be environmentally friendly and the excreta should be collected, treated and used safely. (Deegener et al., 2009.)

Abraham et al. (2011) stated that over-riding element for success is stakeholder involvement and ownership. In schools active engagement together with teachers, pupils, parents, caretakers and school administration is very important. Collaboration of all stakeholders in selection, design and construction of the facilities, organizing the management and long term monitoring, is the key for success. In this way local and appropriate decisions are made to create sustainable sanitation system. Stakeholders should always be involved into decision making and planning for creating good leadership, responsibility and ownership.

For successful implementation of sustainable sanitation in schools, creating enough knowledge is an important factor (Shangwa & Morgan, 2009). Awareness creation especially among the decision makers and promotion of ecological sanitation via media are important issues to overcome possible suspiciousness and norms against ecological sanitation. (Abraham et al., 2011.)

A wide variety of innovative school sanitation solutions exist, for example decentralised systems with low flush toilets connected to constructed wetlands, urine diverting dry toilets (UDDTs) and simple grey water treatment, low flush toilets connected to biogas systems and many more (von Münch et al., 2012, Deegener et al., 2009). Suitability of these different solutions depends on local conditions, for instance availability of funds and materials, climate, water supply systems, local engineering skills etc. This paper focuses on one application of the available solutions, urine diverting dry toilet systems (UDDTs).

To meet the need of pupils and school staff, there should be enough toilets and they should not be located too far away from the school buildings. Deegener et al. (2009) recommend locating facilities inside the school if possible, which would be convenient for users. This holds true for cold areas, but for example in rural areas of Kenya, where cold climate is not an issue, sanitation facilities are often located outside on the school yard. The thing that should be taken into account is the distance. Toilets should not be located too far from the class rooms to ensure that pupils use them regularly (Abraham et al., 2011). Depending on the size of the school the number of the toilets must be determined. According to guidelines by the Kenyan Ministry of Public Health and Sanitation (2005) and WHO standards there should be ratio of toilets and users of 1:25 for girls (one toilet for 25 girls) and 1:30 for boys. Separated rooms for boys and girls are obligatory as well as walls separating the toilet cubicles to secure the pupils´ privacy (von Münch et al., 2012). The problem is often lack of financial resources which hinders the implementation of the recommended number of toilets. This can lead to queues in front of the toilets, as well as quick filling up of the containers and vaults. On the other hand according to the experience of Deegener et al. (2009) toilet-facilities with the amount of the cubicles below the given number did not lead to queues in front of the toilets.

Training is one very important key for successful school sanitation, especially considering operation and maintenance of the facilities. After toilet construction all the school staff, including pupils, teachers and other employees, should be trained how to operate facilities correctly. (Shangwa & Morgan 2009.)

2.2.5 Education and training

All the relevant stakeholders should be trained and educated about ecological sanitation, to ensure that the importance of sufficient operation and maintenance is adopted. Thus, after toilet constructions all the school staff, including pupils, teachers and other employees, should be trained how to operate the facilities correctly. (Shangwa & Morgan, 2009.)

According to Deegener et al. (2009) the best training for pupils is done by their teachers. Teachers should explain the principles of ecological sanitation, UDDTs and how to use them correctly. One possibility is that one or two pupils (e.g. class-representatives) receive training by the teachers and afterwards educate the other pupils. These trainings should be carried out before the implementation of the toilets and in the beginning of every new semester for the new pupils. In addition explanatory posters should exist inside each toilet cubicle, on the eye level of the pupils. The posters should be simple to ensure that also the smallest pupils can understand. For example too many pictures can be confusing for young children. UDDTs offer the possibility to combine the hygiene education and the inter-linkages between ecology, agriculture, nutrient- and water-cycles. (Deegener et al., 2009.)

It is very essential that caretakers and cleaning personnel are well trained on how to ensure and maintain facilities hygienic and clean. If the toilets get dirty or smelly the whole project can fail. The crucial role of caretaking and cleaning is not dependent on the sanitation technology, all the systems need proper maintaining.

The question is who is responsible for the educating caretakers and the teachers who will further be responsible for training the pupils. Possibilities could for example be NGOs, health inspectors or agricultural schools.

2.3 Situation in Kenya

Kenya is ranked amongst the water scared countries of Africa dealing with challenges related to delivering clean drinkable water for domestic use as well as providing adequate sanitation services (Onyango et al., 2009). Therefor the situation of sanitation systems throughout Kenya is an issue of concern. Most of the urban and rural areas are lacking appropriate sanitation facilities, while the available facilities are misused or poorly maintained causing public health and environmental risks. According to the Ministry of Water and Irrigation (2007), the national coverage of sanitation increased from 45% in 1990 to 48% in 2006. This indicates that approximately 50% of Kenyans do not have access to adequate sanitation. Kenya is categorized in the group of sub Saharan countries that are not on the track to meet the Millennium Development Goals (MDGs) of sanitation target (WHO/UNICEF, 2006) and is therefore in the need of alternative solutions for sanitation. (Munrich, et al., 2010.)

According to Joint Monitoring Programme (JMP) estimations for Water Supply and Sanitation by the WHO and UNICEF coverage of improved sanitation in Kenya, in both urban and rural areas in 2010, was 32%. In urban areas shared and other unimproved facilities had coverage of 48% and 18%. In rural areas these percentages were 21% and 29% respectively. Open defecation had coverage of 2% in urban areas, which is much lower than in rural areas where it was 18%. Table 1summarizes these statistics.

Table 1, Sanitation coverage in 2010 in Kenya

	improved	shared	other unimproved	open defecation
Urban	32%	48%	18%	2%
Rural	32%	21%	29%	18%

According to JMP the following sanitation options are considered as "unimproved" sanitation:

- Flush/pour flush to elsewhere
- Pit latrine without slab
- Bucket
- Hanging toilet or hanging latrine
- No facilities or bush or field

Following options are listed as "improved" sanitation by JMP:

- Flush toilet
- Piped sewer system
- Septic tank
- Flush/pour flush to pit latrine
- Ventilated improved pit latrine (VIP)
- Pit latrine with slab
- Composting toilet

Even considered as improved, these options have many drawbacks and cannot be considered sustainable. Either (drinking) water is used as transport medium (Lettinga et al., 2001) when system mixes comparatively small quantities of potentially harmful substances with large amounts of water and the magnitude of the problem is multiplied, or risks for ground water pollution and therefore spreading of the diseases are high (Langergraber & Müllegger, 2004). Ecological sanitation, which is a sustainable solution worldwide, was introduced in Kenya already late nineties, but implementing sanitation is a challenge, as in many developing countries. Despite its economic aspects, improved hygiene and other advantages, up to date ecological sanitation is not widely tested as a viable alternative to conventional sewage systems (Otieno, et al., 2010).

In the schools the condition of sanitation is not good either. There are 18,000 public primary schools in Kenya, and in addition to this non-formal and private schools. The school population in Kenya has risen rapidly since 2003 when Free Primary Education (FPE) program in 2003 was introduced by Kenyan Government. The school population has risen from 5.9 million pupils (2002) to 7.2 million (2003) and to 8.8 million in 2007 (UNICEF, 2011). 2007 - 2009 primary school net enrolment ratio was 83 %, reported by UNESCO Institute of Statistics and national household survey reports of attendance at primary school. The school infrastructure and the amount of the facilities have not increased at the same phase. Even before the FPE program facilities were inadequate. Government was funding the schools in the beginning of the new program but funding ended in year 2004-2005. The Ministry of Education (MoE), in collaboration

with the Ministry of Public Health and Sanitation (MoPHS) and other partners, developed a National School Health Policy and National School Health Guidelines in 2009 to improve children's health. In 2010 Sanitation & Hygiene Interagency Coordinating Committee (ICC) of the health sector was established and has constituted a School WASH (Water, Sanitation and Hygiene) Working Group to improve and raise the WASH profile in Kenyan schools. (UNICEF, 2011.)

2.4 UDDT Technology

UDDT, referring to urine diverting dry toilet or urine diversion dehydration toilet, and also called ecosan toilet in some contents, are dry sanitation systems based on faeces dehydration (Rieck et al., 2012). UDDTs are designed for keeping urine and faeces separated with a special seat or a squatting pan. UDDTs have at least two outlets and two collection systems, one for urine and one for faeces. The diverting system enables recover of urine for beneficial use and allows faeces to dehydrate safely (Tilley, et al., 2008).

2.4.1 Superstructure

In general a standard UDDT has two vaults above the ground level for collecting faeces. In double vault systems there are two vaults below each toilet cubicle. Faeces are collected in one vault (No 1) until it is filled. After this, the vault rests and is closed for hygienisation of the content, and vault No 2 is used. When the vault No 2 is filled, vault No 1 is emptied and used again. Vault set up above the ground level provides a good protection against rain and flooding, which would be harmful for the continuous drying process. This also is an effective way to prevent groundwater pollution as faeces are dry and do not cause any seepage of pathogens and other pollutants into the soil. (Rieck et al., 2012.)

The toilet cubicles of UDDTs should provide enough space for users to move around freely. The inside dimensions should be 1.20 m in length. For single vault systems a minimum width of 1 m and for double-vault rooms a minimum width of 1.20 m should be provided. (Deegener, et al., 2009.)

Figure 1 and Figure 2 provide a general diagram picture of UDDT double vault system. This model was used for example in Ecosan Promotion Project in Kenya. Faeces are collected alternately in two above ground vaults, while one is in use the other one is dehydrating. Vaults are emptied after six months, or after the second vault is full. The WHO Guidelines (2006) for safe use of wastewater, excreta and grey water in agriculture and aquaculture recommends the minimum dehydration period of six months for faeces. Treated faeces can be used as soil conditioner for trees or vegetables. Vaults have doors that can be opened from the back of the toilet. Urine is directed via pipes into one or two containers, which work as short term storage for few days. From these tanks the urine is transported manually either to larger storing tanks or directly to utilization Holes in the back of the cubicle enhance air ventilation. Ash or other dehydration

materials (lime, sawdust, dried soil) should be provided in each cubicle and thrown on faeces frequently. Hand washing water can be collected with a rain water harvesting system from the roof of the toilet, and stored in a water tank with a tap.

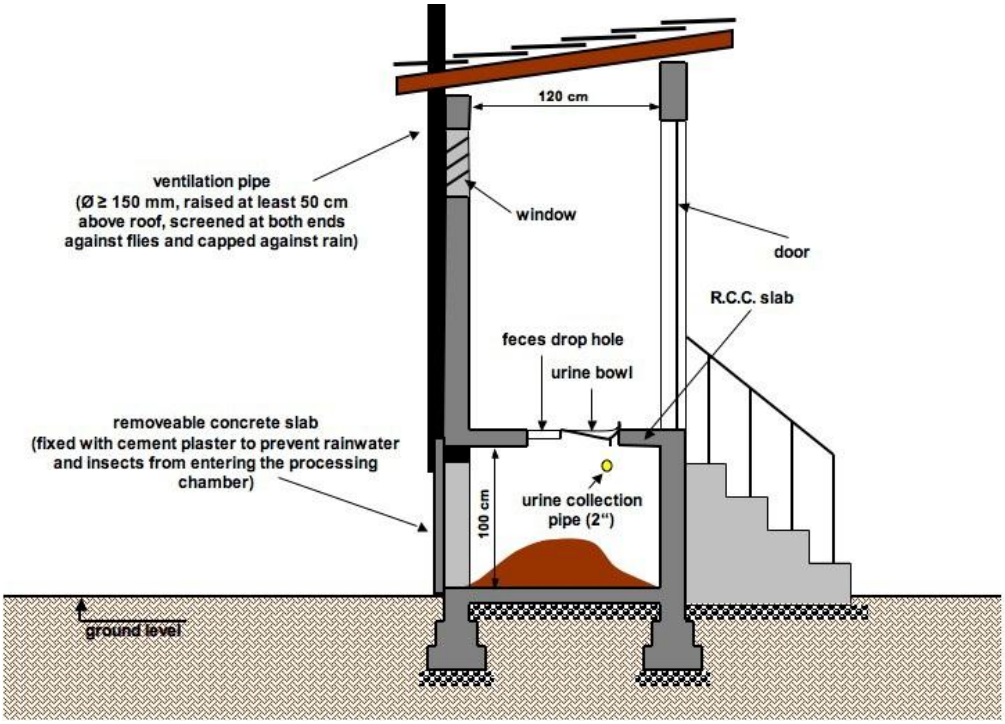

Figure 1, *Conceptual sketch of UDD-Toilet (Panse et al., 2009)*

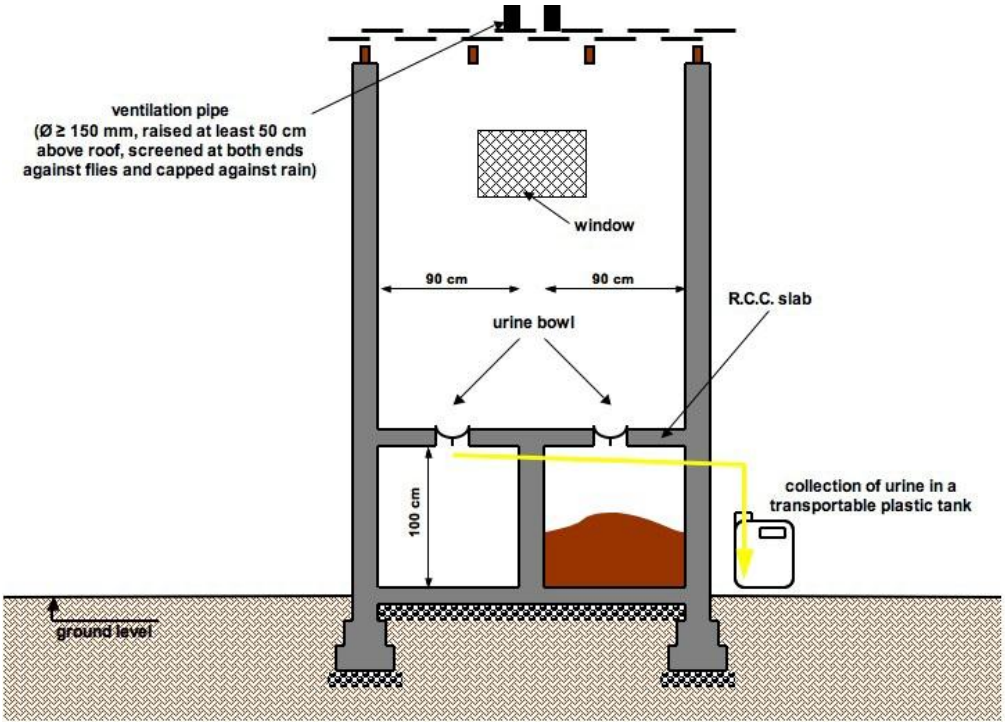

Figure 2, *Conceptual sketch of UDD-Toilet (Panse et al., 2009)*

Also other options for stabilizing collected faeces exist in addition to above ground vaults. Composting faeces is one option and can be performed in shallow and

unlined pits. Both processes, dehydration and composting, similarly enhance the hygienisation process of faeces which provides relatively safe operation, removal, transportation and utilization or disposal of the product. Some sanitation systems require an external composting or drying set up for treating the collected faeces. (Rieck et al., 2012.) Variations of waterless sanitation systems based on urine diversion to manage collected faeces are presented in Table 2:

Table 2, Variation of systems for managing separately collected faeces

Faeces dehydration systems	**Faeces composting or dehydration systems in external locations**	**Faeces composting systems in shallow pit latrines**	**Faeces composting is chambers**
UDDTs with double vault (alternating double pit)	*Single vault systems (transferable containers)*	*-Arborloos(single pit with tree planted after filling)* *-Fossa Alterna (alternating double pit)* [1]	*Composting toilets with leachate collection system*

[1] Beat Stauffer (seecon international gmbh)

2.4.2 Diverting Urine and Faeces

The technology for diverting urine is based on a special toilet seat or a pan with a divider that drains the urine separately away from the faeces. This is based on the anatomy of human body i.e. excreting urine and faeces separately, to different directions. Seat for sitting as well as pans/slabs for squatting are both options for urine-diversion.

Examples of diverting seat and pan can be seen in Figure 3 by Sandec/Eawag. Urine is drained via a small hole at the front part of the toilet seat or pan, while faeces fall through a larger hole in the back section into a vault or container. (Rieck & von Münch, 2011.) This kind of seats and pans can be used for single vault systems. Pans for double vault systems have to have three holes, two directing into two vaults and one, in the middle, connected to a urine tank. Only one of the holes for faeces is used at time. The other one is conveying to a storing vault and is closed e.g. with a lid without a handle. An example of a pan for double vault systems is presented in Figure 4.

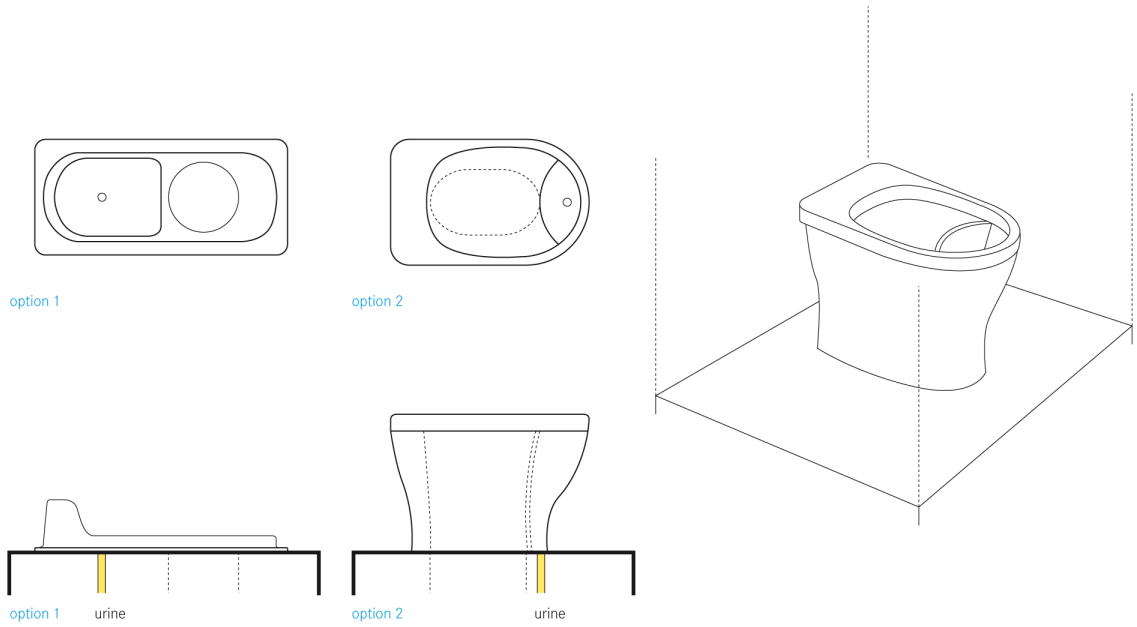

Figure 3, *Diverting seats and pans, picture by Sandec/Eawag, www.sandec.ch*

Figure 4, *A squatting pan for a double vault UDDT system.*

For cleaning intimate regions, all types of solid cleansing materials can be used, toilet paper or plant leaves for instance, but all non-degradable materials should be discarded separated (Tilley, et al., 2008). Key to UDDT technology is to keep the faecal material as dry as possible in the vaults by diversion of urine and use of covering material. Anal cleansing water, toilet cleaning and shower water as well as any other liquid should never be directed into the dehydration vaults (Rieck et al., 2012). Moreover the dehydration vaults should be well protected from rainwater and flooding water. Anal

cleansing water should be separated from the faeces. In case urine is not utilized in agriculture, cleansing water can be mixed with urine before transferred to a soak pit, but if urine is used in agriculture, anal cleansing water should be kept separate and treated along with grey water (Tilley, et al., 2008).

For public places and schools, WECF (Women in Europe for a Common Future) recommends pans/slabs due to hygienic reasons. Moreover, often users do not even want to sit down in public toilets to prevent possibly unhygienic contact with the seat (Deegener, et al., 2009).

2.4.3 Urine Piping and Storage

In waterless urine diversion systems urine can be disposed of easily and without risks to the environment as it is generated in relatively small volumes and is nearly sterile (Tilley, et al., 2008). According to Tilley, et al. (2008) urine can be either diverted directly to the ground for utilization or disposal, or stored in tanks for storage treatment. Also irrigation and soil infiltration through a soak pit are suitable options.

If urine is collected in a tank, the distance between the urine tank and the toilets should be as short as possible to minimise the length of the pipes, which minimises the possibility of blockages. Also edges should be smooth, i.e. as few 90° bends as possible. (Deegener, et al., 2009.) All urine-pipes should be easily available for regular maintenance. The slopes should be minimum 1% downwards to prevent stagnant urine, which can cause smell and blockages. Deegener et al. (2009) recommend preferably Poly-Propylene (PP) wastewater pipes for urine, or if not available, PVC. The diameter should be minimum 50 mm where pipes are accessible and 110 mm where not accessible, e.g. underground. For the connection between the pans and the PP-pipes a flexible hose with a smooth inner surface is a good option. (Deegener, et al., 2009.)

Urine from UDDT systems should be stored before possible utilization in the agriculture. Deegener et al. (2009) recommend plastic containers made of Polyethylene (PE) or Glassfibre Reinforced Plastic (GRP) for the collection and storage of urine, either with few high volume tanks or several smaller containers. Size of the dehydration containers should be big enough to assure the recommended storage time by WHO (2006), minimum 6 months.

The main maintenance difficulties considering urine piping is the formation of blockages in the pipes. The cause can be that dehydrating materials (ash, sawdust, lime, dried soil) end up in the urine hole due to careless use. Another possible reason for blockages is precipitation of struvite i.e. magnesium ammonium phosphate. Microbial ureolysis is the main cause for precipitation of struvite with rising pH and release of ammonia and carbonate. Ureolysis is catalysed by the enzyme urease. Precipitation is an issue in waterless urinals, diverting toilet systems and conventional urinals, as dilution with water prevents the composition of precipitates. By blocking pipes, precipitates diminish the functionality and comfort of toilets. In addition precipitation influences the nutrient content of source-separated urine, and therefore affects its later use e.g. as fertiliser in agriculture. (Udert et al., 2003.)

2.4.4 Faeces Collection and Treatment

Faeces are collected together with additional dehydrating materials (ashes, lime, sawdust or dried soil) into the faeces vault placed under the toilet. There are two different principles of UDDTs: single and double vault systems. According to e.g. Rieck et al. (2012) urine diversion dry toilets with only one vault should not be considered as UDDTs since they do not provide dehydration of faeces inside the toilet. Single-vault UDDT system is possible to realise with transportable containers (Deegener, et al., 2009). The vaults of the double vault system are used alternately; only one vault is used at time until it is full. The period of time that one vault generally needs to fulfil ranges from 6 to 12 months, depending of course on the amount of users. During this time the other vault can rest and dehydrate, and faeces dry out and therefore get treated. (Tilley, et al., 2008.) After the minimum of six months of storing the containers can be emptied and dried faeces delivered for furhter treatment or for example utilized for soil conditioning.

Chambers should have doors with a minimum size of 60 cm * 60 cm for emptying the vaults. Alternatively easily removable bricks can also be used. For both systems the height of the chamber should be minimum 80 cm, better 1m. A typical size of one compartment in double-vault toilets is 1m height, 65 cm width and 1m length. This results in a volume of 650 litres. (Deegener, et al., 2009.)

2.4.5 Recommended Equipment of the UDD toilets

Additional important factors for the success of UDDTs are ventilating, keeping faeces dry and providing hand washing facilities. For the ventilation of UDDTs both, active and passive ventilation systems are used (Deegener, et al., 2009). Generally, ventilation needs more attention when toilets are attached to or inside the building, but also outside-toilets require sufficient ventilation system (Deegener, et al., 2009). A vent pipe for the faeces vault reduces odours and moisture and makes urine diversion systems also suitable for indoor installations (Rieck et al., 2012).

Covering material (such as wood ash, lime, sand, dry soil) should be added on faeces after each defecation as it soaks up moisture and controls odours, keeps flies away and gets the faeces “out of sight”. It also has some extent benefits for the composting process. (Rieck et al., 2012.) A litter bin is important especially in women toilet cubicle to dispose sanitary pads (Deegener, et al., 2009).

To maintain hygiene all toilets should have hand washing facilities at or near the toilets. Hand washing with soap is highly important for preventing spreading of infectious diseases. Simple facilities (e.g. tippy taps, hand washers with cans, plastic bottles or tanks with taps) can be installed if there is no piped water available. (Rieck et al., 2012.)

2.4.6 Benefits of Urine Diversion

Oldenburg et al. (2009) listed several reasons for not mixing urine and faeces. First of all, the volume of potentially dangerous material (faeces that are possibly contaminated with pathogens) is kept as minimum while urine remains free from pathogens and other pollutants. Secondly, urine and faeces can be easily treated differently if collected separately as they require different treatments and this simplifies pathogen destruction in faeces. Above all this, UDDT system can be used everywhere, and it is especially suitable for rocky areas where digging is difficult, areas with high ground water tables that can easily contaminate, and also regions with scarce of water (Tilley, et al., 2008). Benefits of UDDTs after Deegener et al. (2009):

- High level of comfort and hygiene.
- No smell or flies.
- No need for flushing water.
- No need for electricity to pump water.
- No need for a connection to water supply and sewerage.
- Can also be built inside.
- Less expensive to build and maintain than water flush toilets.
- Less costly than conventional sanitation.
- Do not pollute groundwater like latrines do.
- Do not pollute rivers, lakes or seas with micro pollutants and nutrients as wastewater treatment plants often do.
- Produce good fertilizer and soil conditioner.
- Preserve nutrients.

Even it is possible, in theory, to achieve total pathogen die-off with dehydration or composting, there are always uncertainties such as human factor and unexpected weather conditions that might affect to hygienization process. Therefore total destruction of all pathogens is rather unrealistic in such systems. (Rieck & von Münch, 2011)

2.5 Operation and Maintenance of Ecological Sanitation Systems

2.5.1 What is Operation and Maintenance?

Operation and Maintenance, O&M, refers to activities needed for operating, maintaining and managing sanitation systems. Such activities include collection, transport, treatment, utilization and final disposal of sanitation products. (Tilley et al., 2008.) Operation refers to all the daily activities needed for running and handling the infrastructure, for example correct using and handling of the facilities by users, services and technical activities to run the infrastructure (Sohail, et al., 2001). Maintenance includes the

activities needed for sustaining the constructed facilities and keeping them in good condition (WHO, 2000).

An effective and efficient operation and maintenance requires organizing and financing. Often projects are funded for the design and construction of the facilities, but planning of long term financing is neglected. This can lead to a lack of qualified caretakers as well as shortcoming of cleaning materials and other items. To frequently carry out all the necessary tasks, a strategy for operation and maintenance is needed. Beside the daily basic maintenance, also possible repairs should be taken under consideration. (Müllegger et al., 2011.)

2.5.2 The Importance and challenges of O&M

Operation and maintenance is the key for the sustainability of sanitation projects. Without a well-designed O&M strategy, the constructed infrastructure will sooner or later break down (Müllegger & Freiberger, 2010). Sufficient O&M of constructed ecosan facilities is highly important in means of sustaining the good condition and long term functioning of the system (Oldenburg, et al., 2009).

Despite the noted importance of operation and maintenance, it is often neglected, especially in developing countries (Müllegger & Freiberger, 2010). This problem is often a result of weak ownership and responsibility, difficulties with financing O&M, poor understanding of technology and its functions (Müllegger et al., 2011), deficiency of training and awareness raising, a lack of skilled labour, unaffordable repair and replacement expenses, etc. (Müllegger & Freiberger, 2010). Additionally, the chosen technical options are not always the best ones for the environment in which they are supposed to be operated.

Benefits of appropriate sanitation are achieved only if sanitation facilities are constantly operated and maintained. Neglecting O&M tasks leads to non-functioning sanitation systems that can pollute the environment and are a risk for human health. (Müllegger et al., 2011.) Money invested in construction is vain if the facilities are not taken care of. Already at the project set up stage attention should be paid on creating ownership, management strategies, responsibilities and long term sustainability. In schools a committed school administration and care-take are the keys for the success (Müllegger & Freiberger, 2010).

2.5.3 O&M of UDDTs

Ecological sanitation solutions for developing countries, especially for rural areas, are simple low tech systems and do not require complicate operation or maintenance (Müllegger, et al., 2011). But still it is very important to clarify and agree on responsibilities and roles, already at the planning stage.

The key operational factor for the successful operation of UDDTs is keeping moisture at minimum, therefore ash, or other additives (dry soil, lime, sawdust), should always be available in each toilet cubicle. According to Oldenburg et al. (2009) addi-

tives should be sprinkled over the faeces by the cleaning lady three times per day, approximately a cupful (250 ml) each time. According to some other resources e.g. Rieck et al. (2012) ash should be added after each use. Added ash will absorb inherent moisture in faeces aiding the dehydration process. This is also controlling flies and odours. The elimination of odours makes the toilet pleasant to use. Reducing the amount of insects, particularly flies, is important as they can spread deceases. Furthermore, ash, particularly wood ash, has relatively high pH (approximately 10), which is useful for reducing pathogenic organisms in faeces. (Oldenburg et al., 2009.)

As with any type of toilet, cleanliness is essential for good hygiene. Urine receptacles of the urine diversion pans, as well as urinals, must be cleaned on a regular basis (Oldenburg et al., 2009). If UDDT pans become soiled, it may be cleaned with a damp toilet brush or a wet cloth (Oldenburg et al., 2009). Water and disinfectant must be used to dip the cloth or brush in, but it should not be soaking wet. Water must be prevented from falling into the faeces receptacle as far as possible. (Oldenburg et al., 2009.)

Oldenburg et al. (2009) observed great advantage of UDDT system where the faeces are contained in a removable bin instead of static vaults. This makes empting the containers easier and the system can be washed down completely once the faeces collection bin has been removed.

Common problems related to operating of UDDTs are blockages in urine pipes, overflow of urine tanks and misuse by visitors and/or men (Ahluwalia & Nema, 2006). If no ash is available or used on solid waste odours may occur (Müllegger & Freiberger, 2010).

Resource-oriented sanitation systems require special attention considering transportation, storing and utilization of ecosan products i.e. urine and faeces. In small closed loops systems, UDDT products can be stored and utilized on-site, near the product source. This is possible especially in rural areas. Urine from UDDTs can be used as fertiliser in the owners' garden or farm. Also faecal compost product can be utilized, for example as soil conditioner. But in urban areas, where on-site utilizing of the ecosan products may not be possible, other solutions for collection, transportation and composting are needed. Traditionally, municipalities and public utilities are responsible for operation and maintenance of centralized systems, but this arrangement has failed in many developing countries (Muchiri, et al., 2010). Collection, transportation and composting of ecosan products can be alternatively arranged by private sector service providers (Muchiri, et al., 2010).

A research from Müllegger and Freiberger (2010) reveals that the majority of interviewed locals in Kitgum, Uganda, are employing someone to empty the vaults of their household UDDTs. In Nakuru, Kenya, the situation for private UDDTs is similar: households have only very little interest to use urine/faeces and are willing to pay a service provider (Müllegger & Freiberger, 2010). But for school facilities the situation is different. For example at Crater View Secondary School and Egerton Primary School (both in Nakuru, Kenya) collected urine is then used for flowers and tree fertilization.

Faeces are dried, further treated and used in the school gardens. (Müllegger & Freiberger, 2010.)

2.5.4 O&M in Schools

Operation and maintenance in schools is highly important to sustain comfortably and hygiene, but also very challenging due to high population of young toilet users. Also in schools there are several options for arranging O&M: schools can manage these activities entirely by themselves, or involve a private sector provider to empty and transfer urine and faeces.

One successful example of how O&M activities can be entirely managed by the school, is found by Müllegger and Freiberger´s (2010a) research in Kalungu Girls Secondary School in Uganda. In this school implementation of resource-oriented sanitation systems led to a great improvement of the sanitation situation. In this case an employed caretaker was responsible for all the O&M tasks of ecosan facilities, such as cleaning, ash provision, empting or removing the vaults and containers, and utilizing the fertilizer in the agriculture. Also students were involved in O&M. They were arranged in groups that work with different tasks as cleaning the toilets, empting the containers and fertilizing. Teachers are responsible of awareness creation among the pupils. As a result of this new innovative sanitation concept, the school became famous and got visitors from all over the country, and even from abroad. Visitors wanted to see the ecosan facilities of the school and learn about the technology. Extra benefits were gained, besides using the compost in the garden, as the school administration fixed a fee for visitors to gain funds for maintaining the sanitation system. (Müllegger & Freiberger, 2010a.) This kind of development is motivating and encouraging factor and engages the school staff as well as the pupils to sustain their sanitation facilities.

The study form Muchiri et al. (2010), presents an example how ecosan product operation can be arranged alternatively by a private sector service provider. In Nakuru, Kenya, a community based group MEWAREMA (Menengai Waste Recycling Management Group), licensed to collect solid waste from the area where pilot UDDTs were located. MAWAREMA provided sanitation services for two public schools. They operated collection, transportation and treatment of faecal matter from UDDTs. The collected faecal material was further composted together with organic waste at a dump site. The service provider was also in charge of selling the compost and its management. (Muchiri, et al., 2010.)

According to Deegener et al. (2009) the best results are reported when at least one full-time-caretaker is responsible of the facilities. Good examples are also experienced with a team of caretakers cleaning in shifts. For bigger schools, minimum of two trained caretakers should be available, e.g. in case of illness or holiday. A plan or strategy for cleaning and maintaining is needed for the caretakers and cleaning staff to carry out all the tasks. One option is that pupils clean the toilets (partly) themselves, but special care, training and monitoring are needed to secure the success. (Deegener et al., 2009.)

Cleaning and maintaining the toilet facilities does not always have high priority in relation to other needs of the schools. Schools often have to rely on support from parents or communities to get funds for cleaning (Müllegger, et al., 2011). Project funds are often concentrated only on the construction of the toilets, but not for support afterwards.

2.6 Utilization of UDDT Products

2.6.1 Human Excreta as a Resource

Human excreta contains nutrients such as nitrogen (N), phosphorous (P) and potassium (K) which are essential for plants to grow and live, but causing eutrophication and pollution if end up to lakes and rivers. Majority of these nutrients are in urine. They also are essential for agricultural purposes (Langergraber & Müllegger, 2004). After appropriate storage and/or treatment nutrients in urine and faeces can be utilized safely in agricultural purposes or soil conditioning. Concentration of nitrogen in urine is up to 9 g/l, 90 % of total in excreta, and phosphorous around 0.7 g/l which is 50 % of the total (Winker, 2009). In addition there are potassium, sulphur and micronutrients (Winker, 2009). Table 4 presents other characteristics of urine and faeces.

Table 2, Characteristics of Urine and Faeces, after Oldenburg et al. (2009) and Rieck et al. (2012)

Urine	**Faeces**
hygienically uncritical	hygienically critical, potentially containing a series/array of pathogens, leading to waterborne diseases (e.g. bacteria, viruses, protozoa, nematodes, worm eggs)
a well-balanced nitrogen-rich fertiliser, containing nitrogen (N), phosphorus (P) and potassium (K) as well as micronutrients, which can replace and give the same yields as chemical fertiliser in crop production contains the largest proportion of nutrients available to plants, and very little organics, therefore no need for stabilization	consists mainly of organics submitted to decomposition processes and a minor proportion of nutrients
may contain hormones or medical residues	improves soil quality and increase its water retention capacity

2.6.2 Safe Utilization and Disposal of Urine from UDDTs

Rieck et al. (2012) underlined that utilization of urine and faeces from UDDTs in agriculture is an option, but not a must. Anyhow, utilization of UUDT products has several advantages, e.g. increase in crop production and sustained fertility of the arable land. Also disadvantages do exist, especially concerning possibility of spreading of diseases

via utilization and handling of urine and faeces. In terms of user acceptance and practicability, disposal of the UDDT products is often easier. (Rieck et al., 2012.)

Urine is sterile from a healthy person, meaning it does not contain pathogens. But, urine can get cross-contaminated with pathogens through faeces. The risk of cross-contamination is higher in large-scale systems where urine is collected from several different users, especially in public and institutional environments. Some diseases, caused by certain parasite and bacteria (e.g. *Schistosoma haematobium* and *Salmonella typhi/paratyphi*), can spread via urine from a sick person (Richert, et al., 2010). Above all, according to Winker (2009), contamination with micro-pollutants such as hormones and pharmaceuticals is a serious quality concern considering utilization of urine. These micro-pollutants might be taken up by plants and could in theory enter the human food chain. But von Münch and Winker (2009) state this risk is very small compared to other environmental health risks.

In the treatment process during storage of collected urine, the main determinants decreasing the survival of pathogens are high temperature (>20°C), high pH (above 9) and ammonia over time, referring to dilution of urine with water (Niwagaba, 2009). The sanitisation of urine is based on a rapid conversion of urea to ammonia, by an enzyme called urease, and increase of the pH above 9. (Rieck et al., 2012.)

At household level sufficient storing time for urine is 1-2 weeks, large scale communal systems require a storage time of at least one month for urine, if urine is used as fertilizer for food crops which will be cooked or roasted before eating. But if crops will be eaten raw, the recommended storage time is 6 months (WHO, 2006). According to Richert et al. (2010) unstored urine should never be used as fertiliser in areas where typhoid/paratyphoid cases are suspected. Further introductions for urine utilisation are collected to Table 5 below.

Table 3, How to utilize urine

How much urine is needed for fertilisation?	*The urine from one person during one year is sufficient to fertilise 300 – 400 m² of crop to a level of about 50-100 kg N/ha.*
Need for dilution?	*Urine can be applied pure or diluted with water. Ratio for dilution depends e.g. on the season (dry or rain) and the composition of the soil.*
Where and how to apply?	*For the best fertilising effect and to avoid ammonia losses and plant injuries, urine should be applied close to the soil. Subsequent irritation with water and incorporation into soil is a plus. Common practice I to make a small depression next to the plant, apply the urine and cover with soil.*
The length of withholding period?	*The longer the time between application of urine and harvest, the less risk of disease transmission. A withholding period of at least 1 month prior to harvest time is recommended as a safety barrier.*

2.6.3 Safe Utilization and Disposal of Faeces from UDDTs

The aim of the UDDT treatment is to decrease the possible pathogen load in faeces to acceptable levels for safe handling and further treatments or disposal of the product. Nevertheless, UDDT treatment of faeces cannot provide a complete removal of all possibly contained pathogens, especially worm eggs. The main objective for primary treatment in double vaults is to generate a dry and odourless product that can easily be handled and to reduce health risks for disposal and utilization (Rieck et al., 2012). It is recommended to use additional health protection measures when handling UDDT products, to reduce the risks of contamination. A series of measures and barriers from "toilet to table" reduces health risks to a reasonable level for field workers, households and consumers, and is called multi-barrier approach (Richert, et al., 2010). Multi-barriers include source separation, dehydration, farming related barriers (e.g. application techniques, crop restriction, withholding period), protective equipment, hand washing, food handling and cooking as well as health and hygiene promotion. (WHO, 2006.)

Treatment of faeces in UDDTs aims to pathogen removal, and is done through storage, gradual drying and pH increase. Firstly the natural evaporation in the ventilated vaults causes gradual reduction of water of faeces over the time. The time factor of storage also leads to pathogen die-off. The addition of alkaline covering material (e.g. wood ash or lime) is leading to elevated pH levels of above 9 which reduce pathogen levels as well. (Rieck et al., 2012.) To achieve a dry and odourless UDDT product, recommended minimum storage time in the vault is 6 months. In colder and wet climates longer storage time, 6 to 24 months, is required. These are sufficient storage periods at household level to achieve safe disposal or utilization of faeces in agriculture. In large scale systems, the use of faeces in agriculture requires a secondary treatment in order to reach stipulated guidelines values of WHO. (Rieck et al., 2012.)

For dispose of faeces, burring in shallow pits is a viable option, as long as they are protected from re-exposure by erosion, human and animal activities. The groundwater should also be protected. (Rieck et al., 2012.)

2.6.4 Linking Sanitation and Nutrition in Schools

Sanitation systems in which the products of the UDDTs are treated and used on-site are the simplest and the most ideal closed loop systems (Müllegger, et al., 2011). In many cases this is not possible, for example in densely populated urban areas. But in rural schools on site utilization is possible and advisable.

The major nutritional shortfalls among the young pupils are malnutrition and deficiencies of iron and zinc. Productive aspect of ecological sanitation offers a good possibility to improve school gardening and provide children more food that is also healthier. Ecological sanitation training can be combined to food and agriculture awareness creation as well as health education. Improved gardening has also economical aspect as schools can provide more from their own gardens without having to buy external fertilizers. Vegetables from the school gardens can also be sold to get more incomes.

(Drescher, 2002; Morgan & Shangwa, 2010.) If the fertilizer production has real value for the school it can encourage to maintain and to take care of the facilities. In case there are some cultural or social norms hindering the utilization, more information about the nutritional and economic benefits should be given. (Abraham, et al., 2011.)

2.7 Financial Aspect of Ecological Sanitation

There is a wide range of designs and costs for UDDTs (Rieck et al., 2012). This challenges the widely held view that UDDTs are too expensive. Costs are ranging worldwide from EUR 120 to 580 depending on material choice, local prices, contribution in terms of locally available materials and unskilled labour as well as desired level of comfort (Rieck et al., 2012). Various design options from simplistic up to luxurious are possible. UDDTs can become more affordable with design creativity of the owners, the contribution of own unskilled labour and use of locally available building materials such as recycled materials like plastic containers or sacks for urine and faeces collection. (Rieck & von Münch, 2011)

Also operation and maintenance of the toilet facilities requires financing. Table 6 after Rieck et al. (2012) lists the most common operation and maintenance costs of UDDTs.

Table 4, Operation and Maintenance costs of UDDTs

O&M cost item	**Frequency**	**Comments**
Water for anal cleansing / toilet cleaning	daily	Varies, small amount
Cleaning (labour)	daily to weekly	Usually done by households
Dry covering materials (such as wood ash, dry soil, leaves, lime, wood chips etc.)	weekly	use what is available for free
Toilet paper and soap	weekly	varies
Emptying and transport of urine (in case it is not disposed or used onsite)	daily to weekly	could be done by service provider
Emptying and transport of faeces (in case it is not disposed or used onsite)	every 6-12 months	
Clearing of urine pipe blockages	rarely	usually done by households
Repair or replacement of door locks, vault doors, ventilation pipes, doors etc.	months to years	Varies, similar to any kind of toilet

An important aspect that should be often highlighted more for decision makers, is that UDDTs have several economic benefits. First, the life span of a UDDT is usually,

under usual circumstances, over 15 year, or longer. This depends on the quality of used materials, craftsmanship and required regular emptying of the dehydration vaults. In comparison, pit latrines have usually quite short life spans, especially at schools since they often get abandoned when full or might collapse when an attempt is made to empty the pit. Therefore in most cases capital investment in long-term is reasonably lower for UDDTs than for example pit-latrines. Above all, health and environmental benefits should also be noted. A specific economic benefit of a UDDT is the improved crop production through excreta utilization. (Rieck et al., 2012.)

3 MATERIALS AND METHODS

3.1 General

3.1.1 Background - Ecosan Promotion Project

The Ecosan Promotion Project (EPP) was co-funded by the European Union, SIDA and GTZ (present GIZ) and a project component of the Water Sector Reform Programme in Kenya. The aim of the project was to develop, test and promote the concept of ecological sanitation in public institutions such as schools, individual households and public places. The project started in the end of the year 2006 and continued until June 2010. (Onyango, et al., 2009.)

EPP implemented a number of UDDTs in schools as part of the project. The focus on school sanitation had several long-term objectives e.g. to improve the learning conditions of the pupils through improved sanitation facilities and accompanied hygiene education. The sanitation solutions had a focus on the utilization of human excreta as a resource. Children were engaged as effective agents of change as they pass on their knowledge of better hygiene and improved facilities from school to their parents and thus influence the communities. The toilets built under this project were mainly served as an entry point for promotion and awareness raising about ecological sanitation. The number of UDDTs built per school (usually four cubicles) was too few to have a real impact on the everyday life of the pupils. (Kraft & Rieck, 2011.)

One of the driving factors for Ecosan Promotion Project was a concern about the numerous school days that are annually missed due to the poor sanitation which causes lack of hygiene and leads to illnesses such as diarrheal diseases (Onyango, et al., 2009). Ecological sanitation offers an alternative solution for many schools in Kenya as it has various advantages to conventional pit latrines (Kraft & Rieck, 2011). Figure 5 presents pupils in front of their UDDTs built by EPP in Kakichuma Primary School in Western Province, Kenya.

Figure 5, *Toilets built by EPP and pupils in Kakichuma Primary School, Western Province, Kenya.*

3.1.2 This Research

For this research altogether ten schools in Nyanza and Western Provinces in Kenya were visited. Figure 6 shows all the schools of EPP on the map. Nine of them were evaluated by on-site observations, interviews and discussions by this project. These nine schools were chosen based on their assumed good performance considering operation and maintenance of their UDDT facilities. 8 of the schools were part of Ecosan Promotion Project (EPP) from 2006 to 2010.

Total amount of schools participating the EP project was 73. In addition to the schools from EPP, two self-sponsored schools were also visited and evaluated (Hope and Kindness in Nyanza Province and Eldoret Educational Centre in Western Province). The selection of these schools was done by former EPP implementing officers, who were aware of the current situation. Implemented UDDT systems were not monitored or evaluated officially after the EPP before this research. Some of the schools were pre-visited by the former EPP implementing officers, and according to these visits and phone conversations altogether 10 schools were selected for the research, based on their good performance in maintaining and operating their UDDTs. In the end this research covered only nine of the schools, as one of them was excluded due to its poor practise in operation and maintenance.

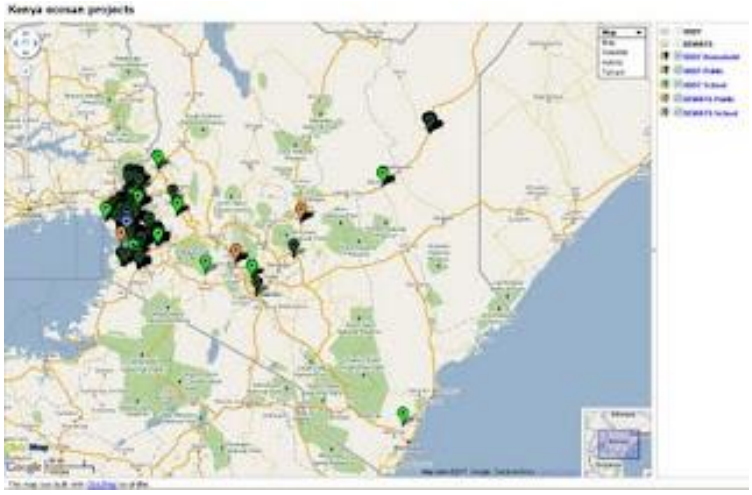

Figure 6, *Map of the EPP targets in Kenya.*

The main focus of this research was to figure out if there are some particular reasons for the good performance of the selected schools and evaluate the condition and use of their UDDT facilities. Also ownership, social, cultural and economic issues were considered. Means for obtaining these goals were on-site monitoring and post evaluation of the constructed ecosan facilities on the field at the present time, after one to three years after the implementation. As a result of the field work a report of the situation is drawn to provide information about ecological school sanitation in practise as well as about O&M including success and problems. Methods for this research included observations on the field about the condition of the facilities, conduction of on-site research using structured interviews and group discussions.

3.2 Monitoring and Evaluation

3.2.1 The Importance and Use of the Monitoring and Evaluation

Monitoring and post-evaluation of sanitation facilities is focusing on how the facilities are being managed and used. Thus possible problems can be identified and reflected in future projects and strategies. The results from the monitoring and evaluation, the information itself as well as the communication process, will improve the operation of the system in future. The aim is to provide information on whether this type and technology is suitable for other similar projects on institutional level. Future enchantments can be done e.g. with technology modification and hygiene education. (Oldenburg, et al., 2009.)

According to Oldenburg et al. (2009) monitoring of the sanitation systems should be performed throughout the entire process. The aim of the monitoring is to ensure proper and hygienic use and operation of the facilities, as well as documentation for research and development purposes of the change compared to the original situation. Impacts of the project on the environment, hygiene, user satisfaction, costs, profits, resource use, productivity, increase in harvests, job creation etc. should be reported.

Monitoring activities can be divided into two parts: technical monitoring and social monitoring. Both are shortly described below.

3.2.2 Technical Monitoring

Technical monitoring is evaluating the structural conditions of the facilities. In this aspect the convenience of the facilities for use as well as maintenance can be evaluated. Monitored factors for this perspective are existence of blockages in pipes, condition of vaults, odours, flies and insects, toilet unit usage, cleaning, resistance against urine and spillages. (Oldenburg, et al., 2009.)

In this research technical monitoring was done by on-site observations in each school. Condition of the facilities was evaluated by visual inspections following a monitoring sheet. The sheet was modified and specialized for this research, the original version was used for previous studies by GIZ. The sheet covered monitoring the conditions of the structure, e.g. walls, doors, floors, vaults, doors of the vaults, water harvesting systems, hand washing equipment, stairs, urine tanks, possible blockages, cleanliness, presence of flies and odours etc. The monitoring sheet for field observations is available in Appendix 1. More specific information about toilet usage and management as well as operation and maintenance, was collected from teachers or principals, or persons in charge of sanitary (often agricultural teachers or other school employees e.g. caretakers) via interviews that were based on semi structured oral questionnaires (Salkind, 2002) and conversations. Also pupils were interviewed, when the main approach was group discussion. Questionnaire sheets that were the base for the interviews are found in Appendix 2 and 3.

3.2.3 Social monitoring

Social monitoring includes evaluation of health impacts and level and acceptance of the utilization. Also treatment of urine and faeces are part of social monitoring, and it is based on perceptions of teachers, pupils, caretakers, cleaners and visitors. As a result of social monitoring, problem analysis could be carried out to name possible improvements as well as comfort and convenience factors. (Oldenburg et al., 2009.)

As mentioned in the previous chapter, for this research, teachers, caretakers, pupils and also some other stakeholders were interviewed, among the other things to evaluate social aspects of the ecological sanitation. Social monitoring included topics related to ownership, level of utilization and other treatments of sanitation products, acceptance of utilization as well as general acceptance and attitudes towards UDDTs. Also economic and cultural issues were slightly discussed.

4 RESULTS

In this chapter the state of sanitation in each school under the investigation is presented. Situation in some schools is described more detailed than the others, depending on the gained information and its significance.

4.1 Kendu Muslim Secondary School

4.1.1 School information

Kendu Muslim Secondary School is located in Kendu-Bay, Rachuonyo area in Nyanza province. It is mixed day school for 400 pupils. The schools sponsorship is listed as Religious Organization. The basic information of the school is presented in Table 7. The principal of the school was interviewed to get information about ecosan facilities, arrangements to operate and maintain them, received benefits, main issues that still needs to be improved and also about the utilization of the end products.

Table 5. Basic information of Kendu Muslim Secondary School

Issue		**Comments**
Date	7.11.2011	
Pupils: total/ boys/ girls	400/250/150	
Age range of the pupils	13-20	*Secondary School*
Teachers	15	
GPS coordinates	0°21'46.86"S, 34°38'51.46"E	
Number of UDDTs	6	*3 more are under construction, but due to financial issues construction was interrupted.*
UDDTs for teachers	1	*One UDDT for both genders*
UDDTs for boys, ratio	2, 1:125	*Recommendation 1:30*
UDDTs for girls, ratio	3, 1:50	*Recommendation 1:25*
Locked UDDTs (out of service)	1	*One of the girls' cubicles, so actual ratio at the moment is 1:75*
Pit latrines in use, boys	6	*For boys 4 new pit latrines, built in 2010*
Pit latrines in use, girls	2	
Hand washing facilities	Yes	*On the other side of the school yard, a water pump*
Soap available	No	*According to the principal soup is usually available, but not at the time of visit.*
Ash available	Yes	*Ash was available in each toilet cubicle.*

Bins in girl's toilets	No	
Toilet paper	No	*Neither anal cleansing water in UDDTs*
In charge of maintenance	Caretaker	
A school garden	Yes	*A small garden, no crops at the time of the visit.*

4.1.2 Condition of the UDDT Facilities

UDDTs had been mainly well maintained. Floors and walls were clean and in good condition. Also squatting pans were relatively tidy and no remarkable amounts of ash was observed in the urine section of the pan, even though ash was available in all cubicles that were in use. Figure 7 and Figure 8 provide a view inside two of the toilet cubicles. There were two different applications of squatting pans, a plastic squatting pan is presented in Figure 7. Figure 8 presents application of squatting pan that is model (/casted) of concrete into the floor. Figure 8 shows how one vault is used at time while the other one was closed with a lid without a handle. In the corner of the cubicle is a bucket for ash provision. Toilets were clean, odourless and no flies were observed. In each toilet cubicle there should be a poster of correct usage of the ecosan toilet, the explanatory poster is seen in the latter picture.

Figure 7, *Squatting pan of a double vault UDDT in Kendu Muslim Secondary School.*

Figure 8, *An UDDT squatting pan application that is molded (/casted) of concrete into the floor.*

Doors of the UDDTs as well as vault doors were in right position and not ramshackle. As seen in Figure 9, UDDTs were in relatively good shape, but paint has worn out a bit from the door and the upper batten, and they were slightly deteriorated. There is no tank for harvesting rain water, even the harvesting system i.e. launder and a pipe do exist. Other visible damages on the superstructure did not exist. Vault doors and the back of the UDDT can be seen Figure 10. Vault doors were in good shape. There was no odours or flies inside the toilets. Condition of the drying chambers, urine tanks and storing closets was good, no visible damage emerging. Water harvesting system (lander and directing pipe) and ventilation holes are also visible in Figure 10.

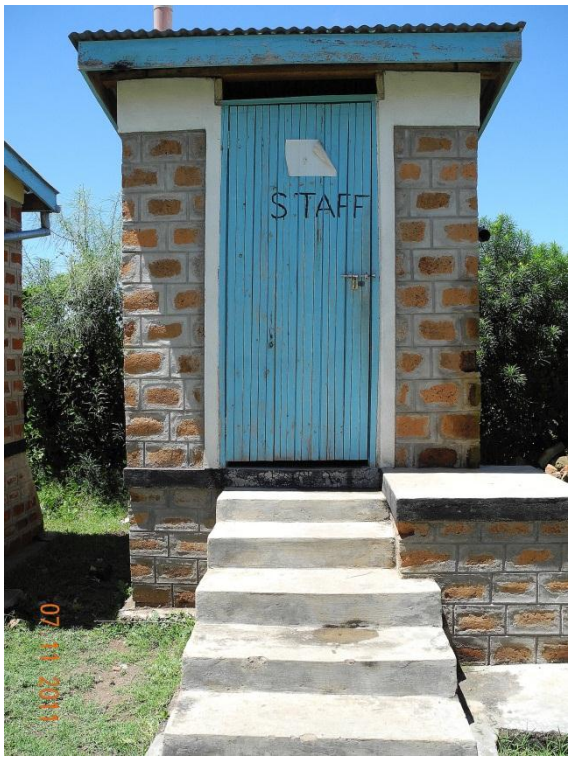

Figure 9, *Staff UDDT in Kendu Muslim Secondary School.*

Figure 10, *Back of the UDDTs: Vault doors, water harvesting system (lander and directing pipe) and ventilation holes.*

One of the girls' UDDTs has been locked as the urine pipe was blocked. This means there is actually only two functioning UDDTs for girls. According to the grounds

man the pipe has been blocked for approximately six months. Repairer has been informed about it, but the pipe had not been fixed at the time of the visit.

There were no litter bins in the toilets, neither in girls' or boys' cubicles. As a result faeces in the vaults were mixed with plastics and other un-decomposable material to some extent. According to the implementing officers, right after the project there were litter bins in each toilet cubicle as they were provided by the project implementation team. Probably bins were stolen afterwards.

There were no water tanks for harvesting system, so the harvested rain water pours onto the ground. Therefore pupils have to use pumped water for hand washing. Pump is located relatively far away, on the other side of the school yard, approximately 150-200 meters from the toilets.

4.1.3 Usage of the facilities

Four UDDTs were built by Ecosan Promotion Project, two for boys, one for girls and one for the school staff. After the project itself, more UDDTs were built by the school, which shows that the ecosan concept was accepted and perceived to be good. At the time of the visit two new UDDTs for girls were finished. As can be seen Figure 11 below, new UDDTs for girls have ramps instead of stairs which enables unlimited use of the toilets also for disable children. All the toilets were located in a row behind the school buildings. There were four more UDDTs under construction, but project is delayed because of lack of financing.

Figure 11, *Four of the UDDTs in Kendu Muslim Secondary School. On the left UDDT for girls (locked due the pipe blockage) and next to it UDDT for School stuff. Two UDDTs on the right are built after EPP by the school.*

Pupils were using both, UDDTs and pit latrines. As can be seen on Table 7 in Chapter 4.1.1, the total amount of UUDTs was six, of which three were for girls, but

one was not functioning, two for boys and one for school staff. In addition, there were several pit latrines, for girls altogether two and for boys six. Therefore the ratio of the toilet cubicles, including both pit latrines and UDDTs, was for girls 1:37 and for boys 1:16. For boys this is sufficient as the guidelines by the Kenyan Ministry of Public Health and Sanitation (2005) and WHO standards state that there should be ratio of toilets and users of 1:30 for boys. For girls the ratio is 1:25, which was not reached in Kendu Muslim Secondary.

According to the interview with the principal and discussions with the pupils there were no negative attitudes or traditional believes in this school towards the usage of UDDTs, and neither towards the utilization of excreta. According to the interviews and discussions, pupils prefer UDDTs to pit latrines, as they usually are clean and there is no bad smells. But, even the UDDTs are more convenient to use in general, it depends on the length of the queue whether or not pupils use them.

Even the facility for hand washing was on the other side of the school, according to the principal and interviewed pupils, everyone always wash their hands after using toilet. Soap is not provided by the school. The source of water for hand washing and other demands is ground water, and a pump is used for delivering it. The pump was in good condition and it was working during the time of visit. But according to the principal during dry seasons ground water level is often too low, and there is no water available from the pump.

New pupils are always trained by a teacher to use UDDTs correctly. Agricultural teacher is in charge of utilization and awareness creating about it. Interviewed pupils knew the benefits of ecological sanitation, but they also concerned a risk of utilization of the product on the field.

There was discussion with some of the female pupils about the menstrual management. A picture of interviewed girls is presented Figure 12. The girls said they usually come to school even during their periods. Getting pads, which are relatively expensive, is an issue. Sometimes some organisations or school has provided pads for female pupils, but not lately. As there were no litter bins in the toilet cubicles, disposing the pad waste has been a problem.

Figure 12, *Girls from Kendu Muslim Secondary School, interviewed for the research.*

4.1.4 Project implementation

The school administration helped the project implementation team to locate the toilets on the school yard. Also a timber was provided by the school. All the teachers and children attended the workshops about how to use UDDTs. But according to the principal there was no training on the utilization and there would be a need for that. The principal also stated that there would be a need for a workshop on how to train others for example if a teacher in charge leaves the school he / she would be able to train a follower.

4.1.5 Operation and Maintenance

There was one person in charge of cleaning the toilets and providing the ash. According to the principal the toilets were cleaned once a day, in the morning, but he also stated that they should be cleaned more often. An employee, who is paid 6.000 Kenyan shillings (approximately 55 euro) a month works 8 hours a day and takes care of the school ground. This employee is also in charge of empting the urine containers when they are full, and empting the vaults. If something needs to be repaired, the principal is in charge of calling a repairman. The repairman should also be called if a urine pipe is blocked. Sometimes pupils clean the toilets as a punishment of some offence.

4.1.6 Utilization of the ecosan products

The same employee who was in charge of maintaining the toilet facilities and empting the urine containers was also the one who takes care of empting the vaults. According to the principal treated faeces from the vaults are manually transferred moved and utilized on the small farm as soil conditioner. Usually vegetables, maize and beans are grown on the farm but at the time of the visit there was nothing growing. Urine was not utilized,

just disposed in pits. According to the principal, the reason for this is the lack of knowledge. More training would be needed.

According to the pupil interviews, some pupils were having sceptical attitude towards the utilization of ecosan products. But in general most of them had accepted the concept after ecosan training by the implementation team and learning the benefits.

4.1.7 Challenges

According to the principal of Kendu Muslim Secondary School, urine containers could be bigger to make the maintenance easier as they fill up so fast. Blockages in pipes are a problem. One UDDT of girls has been closed for a long time because of that. Perhaps fields of responsibility should be clearer, who is responsible of taking care of unblocking, and who of arranging someone to do it. If the pipes were wider in diameter they wouldn't get block so easily.

There is a need for more training, especially about the utilization of ecosan products. For the next training, if arranged, one of the sanitary teachers should attend to arrange the training and workshops. In this way in future someone from the school would have ability and routine to train the others.

According to the principal toilets should be cleaned more than once a day as the population of the students is high. UDDTs are popular among the pupils and thus overloaded, this leads to quicken untidiness and possibly to misuse. One consequence of popularity and overload is also that boys often end up urinating behind the toilet cubicles. This might lead to surface disintegration of the foundation materials and thus shorten the life span of the toilets.

UDDTs were lacking some of the basic equipment such as rubbish bins and soap. Also considerable shortcoming is lack of water tanks for hand washing next to the toilets. This deteriorates hygiene. A study by the SWASH+ program reveals that the in schools where children are able to use toilets but are lacking proper hand washing facilities, has higher disease load of children compared to children in schools without sanitation facilities, where kids rather defecate at home with higher changes of washing hands at some point. This indicates that building toilets in schools is vain in aspect of hygiene if hand washing with soap is not practiced.

The new UDDTs under construction will have a new model: chambers for faeces will be partly underground, this kind of design allows bigger volume of vaults, but makes empting possibly harder.

In Kendu Muslim Secondary School, as in many other schools as well, finding funding for the future projects to construct new ecosan toilets will be a challenge. There is a clear urge to replace pit latrines with a better option. But often initial costs are too burdensome. The fact about economic benefits in long run should be underlined to the school administration and other decision makers.

The issues needing urgent improvement in Kendu Muslim Secondary School considering sanitation:

- Overload of the facilities should be prevented by providing more UDDTs.
- Facilities need more frequent maintenance.
- UDDT that was out of service should fixed (urine pipe unblocked).
- In general faster action with blockages in urine pipes.
- Bigger urine containers, wider urine pipes.
- Hand washing facility (water pump) should be near the toilets, and water delivery during the rain seasons should be arranged.
- Soap should be provided.
- More training about utilization of urine required; urine is not utilized at the moment, due to lack of knowledge how to do it.

4.1.8 Keys for success?

It is obvious that the benefits and the importance of ecosan toilets were adopted in this school. Building new UDDTs after the EPP is a living proof of it. There was even more UDDTs under constructions but the project had delayed due to lack of financing.

Kendu Muslim Secondary School had earned good reputation in the region, due to their new comfort and odourless toilets. Visitors from surrounding areas have visited the school just to see and learn about these ecological sanitation toilets. This kind of good reputation probably has strengthened the ownership and has engaged the school administration to take good care of the toilet facilities and remain as a good example of school sanitation. In general this kind of public interest concerning ecological sanitation i.e. visitors in schools just to see and learn about UDDTs was a good sign of the promotion of the ecosan concept.

It is often well-tried way of maintaining the toilets to have an employed caretaker, who is responsible of the maintenance and has enough time for it. Caretaker should be well trained about eco-sanitation and especially about the handling, utilization or dispose, of the urine and faeces. Often teachers have so many duties and might not have enough time and to maintain toilets as much as would be required.

The main driving factors for motivation to maintain the UDDTs in Kendu Muslim Secondary School:

- Clean and odorless facilities, no flies.
- UDDTs highly appreciated as pupils (and also teachers) prefer them to pit latrines.
- The school has good reputation in the surrounding areas of their well-arranged sanitation and hygiene and the school wants to maintain this reputation.
- Possibility to utilize treated faeces in the agriculture.
- More UDDTs built after EPP by the school, and they enable use also for disable pupils.

4.2 Hope and Kindness

4.2.1 School information

Hope and Kindness is a home and school for 170 orphan children. The school was founded 2002 by an English couple who went to Kenya to set up a small school and orphanage. Ecosan project was self-sponsored. In 2012 Hope and Kindness is planning to open a self-sufficient school to train young people in agricultural and business skills.

The school is located in South Nyanza, in a small village called Kosele. This part of Kenya is extremely poor and frequent droughts, HIV, unsafe drinking water and a lack of affordable treatment for diseases like malaria, TB and typhoid continue to make Kosele a very tough place to live.

Basic information about the school and sanitation is collected into Table 8. For the information the school founder and financier as well as the head manager were interviewed. Also some of the pupils were discussed with.

Table 6. Basic information of Hope and Kindness

Issue		**Comments**
Date	8.11.2011	
Pupils: total/ boys/ girls	170/ 90/ 80	
Age range of the pupils	3-18	*From baby class to 8th class*
Teachers	12	
Number of UDDTs	5	
UDDTs for teachers, ratio	1, 1:5	
UDDTs for boys, ratio	2, 1:45	*Recommendation 1:30*
UDDTs for girls, ratio	2, 1:40	*Recommendation 1:25*
Pit latrines in use	None	*7 pit latrines locked permanently*
Hand washing facilities	Yes	*Rain water harvesting, also a borehole*
Soap available	Yes	*Mixed with the hand washing water*
Ash available	Yes	*Provided from the school kitchen*
Bins in girls' toilets	Yes	
Toilet paper	Yes	
In charge of maintenance	Employees	*Two persons*
A school garden	Yes	*A big one; maize, beans, vegetables*

4.2.2 Condition of the UDDT Superstructure

In Hope and Kindness UDDTs facilities were very well maintained. They were all clean: floors, walls and squatting pans. Doors were lockable, functioning and intact. There was no damage on the super structure. Ash was available in each toilet as well as explanatory posters. Also rubbish bins for not degradable material existed in girl's UDDTs. Even toilet paper was provided.

Hand washing tanks were connected to the rain water harvesting system from the roofs of UDDTs. Liquid soap was mixed with the water from the tank. Harvesting

system was expanded to the roofs of the main buildings, where water is collected for showers. During the dry seasons water tanks are filled from a 91 m deep bore hole, where also drinking water is drilled from.

4.2.3 Usage of the facilities

There are two compounds of UDDTs, one behind the school buildings, including three cubicles, one for teachers, one for boys and one for girls. The other compound is next to the school ground and the playing field, consisting of two cubicles, one for boys and one for girls, next to each other. Figure 13 presents the UDDTs next to the school ground. Water tank for hand washing is located next to the toilets and connected to the rain water harvesting system. Similar but a bit bigger tank that is further away, is used for storing the urine.

Figure 13, *Some of the UDDTs in Hope and Kindness school.*

According to the school manager and the head of the school, all the pupils are using the UDDTs, as there are no pit latrines in use anymore. The school in surrounded by fences so there is not possibility to "go to the bushes" anyhow.

Interviewed pupils found ecosan toilets very convenient to use, as there is no bad smell or flies. Pupils also think that UDDTs look nice. They were toughed about the importance of sanitation and benefits of ecosan and utilization of the product. Obliviously in this school there are no negative attitudes towards ecological sanitation or utilization of the product. Children study agriculture and are aware of the benefits of recycling the nutrients and fertilizing crops with UDDT products (it is free, urine is rich in nutrients and thus excellent fertilizer, and treated faeces good as soil conditioner). Evidence is visible on the farm as well where crops that are fertilized with treated faeces grow well.

One problematic issue is that also the very youngest pupils use the UDDTs. Considering the fact that the smallest children attending the baby school are only three years old, special arrangements for them would be required. According to the older pupils, toilet facilities are often misused and not clean after small children. Also, the size of squatting pan is too big for the very smallest pupils.

Hand washing has become a routine among the pupils and water tank is always filled with water. Children have been toughed and trained by a GTZ consultant in the beginning of the project, and after it by teachers. Every year new pupils are taught how to use the UDDTs correctly, including the hand washing. Teachers are responsible for their classes, but the majority of the teachers in the school are new, and did not attend the training a couple of years ago.

Sanitary pads are provided by the school, and girls dispose pads into the litter bins inside the toilet cubicles. But bins should be bigger and there should be lids to cover them, as also very young children use the same facilities.

4.2.4 Project implementation

The directors and sponsors of Hope and Kindness Trust Kenya have fully supported the ecosan project and thus this school is self-sponsored. The status of ownership is very clear as all is paid by the school itself.

All the teachers and pupils were trained by GTZ consultant. According to the head manager of the school, who is also in charge of sanitation, this education was very good, but more training would be needed to recall all the learned issues.

4.2.5 Operation and Maintenance

The facilities are cleaned three times per day. Every morning, before the pupils start their lessons, a male employee cleans the toilets, provides the ash and empties the urine tanks and litter bins if necessary. The same employee is in charge of small repairs and other operational tasks, such as unblocking the blocked pipes. When the vaults are full they are emptied to the bigger drying chambers. Separately collected un-decomposable material is burned. Toilets are cleaned twice more a day by a female employee, who is only in charge of the additional cleaning. The male employee is paid 4.300 KSh (approximately 40 €) a month, the female employee 50 KSh (approximately 0.45 €) a day.

Urine containers are emptied to a bigger storage tank every day. In storage tank urine is stored for one month before utilisation. Each vault for faeces is emptied directly after it is full, which means that the double vault aspect of the UDDTs is not fully understood and hygienic risk for handling faeces is higher. As only every second vault is in use, the others are transformed to storing closets. Faecial material is transformed from the vaults manually to bigger drying chambers, which are just next to the toilets. The material is stored for 10 months inside the chambers. After storage product is mixed with soil and piled next to the farm.

There have not been problems with operation and maintenance, except if the mail employee is sick or for some other reason not able to do his work. In those cases the female employee takes care of all daily operational tasks, but is not actually trained to do all those tasks.

4.2.6 Utilization of the ecosan products

Right next to the school there is a big school farm, where maize, beans and vegetables are grown. Dried faecial material is utilized to the farm after storage of 10 months, after which it is mixed with soil. Farmers are responsible for the implementation of the compost on the fields. Figure 14 shows treated and dry UDDT product that is mixed with soil and is waiting for utilisation. Fertilizer was completely odourless and locals did not hesitate to touch it with bare hands.

Figure 14, *Dried faecial matter was mixed with soil, and piled next to the farm to wait for utilization.*

Urine-water mixture was not implemented on the food farming, as farmers are sceptical of its usage. Urine-water mixture apparently still has some odours after storing which creates suspiciousness, but it was used for tree planting etc. But the product from dried faeces and soil, after storing, drying and mixing with the soil, is completely odourless and convenient to utilize. Farmers did not attend to the trainings on ecological sanitation or utilization of the products, which is most likely the reason for suspiciousness. The farmers should always be trained as well as all the other stakeholders.

On the maize fields there have been experimental tests and comparison between ecosan fertilizer (treated faeces), chemical fertilizer and blank-fertilizer. The results of this experimenting were just to be seen at the time of the school visit. In the beginning

maize field that was fertilized by chemicals grew faster than the others. But after a certain period of time ecosan crops reached the chemically fertilized ones in height. The drawback of chemical fertilizers is, beside the fact that they are expensive, that they also impoverish the soil. Opposite to this, ecosan fertilizer makes the soil richer in nutrients after each utilisation. As a comparison to the fertilized fields, the field without any fertilizers has also grown surprisingly well, but the reason for this is simply the fact that the same field was fertilized with ecosan only one year ago. Figure 15 shows maize fields of Hope and Kindness where different fertilizers were compared.

Figure 15, *Maize crops on the school farm.*

4.2.7 Benefits received

All the pit latrines had been closed and only UDDTs were in use. Ratio of the toilets per pupils is a bit too low (boys 1:45, girls 1:40) as the recommendations of Kenyan Ministry of Public Health and Sanitation (2005) guidelines suggest 1:30 and 1:25 for boys and girls respectively. Teachers and pupils both prefer these new ecosan toilet facilities to old pit latrines, as they are always clean, odourless, there are no flies and hand washing is easy. There have been accidents with old pit latrines as they have occasionally collapsed and sank. Especially during the rain seasons pit latrines were considered hazard and dangerous to use. After occurred accidents young pupils were afraid of using the pit latrines.

Ecosan products are utilized on the farm and these fertilizers are found to be better than chemical fertilizers, not only they are cheaper, but they also are much better for the soil in the long run. Crops maybe grow slower in the beginning, but in the end they reach the same height and produce as much food as chemically fertilized crops.

There has also been some observations that some weeds do not grow and hindrance the growth of the crops when ecosan fertilizers are used.

4.2.8 Main issues to be improved and recommendations on that

In school administration's opinion operation and maintenance would be easier if there was transformable buckets inside the vaults, which would make emptying and transforming much easier and safer. There are only few toilets for the pupils and vaults fill up quickly. This is the reason why the actual storing and drying is done in bigger chambers.

There was also concern among the school administration of how to be sure if the product has achieved sufficient hygiene. If there was an easy technology to ensure the complete pathogen reduction in the product, it would most likely convince everyone about safety to utilize the product.

When also small children use the same facilities, special attention is required. The youngest pupils need more instruction about the correct toilet usage and perhaps more regular reminding about it. Teachers and older pupils would be good supervisors on that.

There was also discussion about necessity of using the gloves when doing the ecosan fertilizer utilization on the fields. At the time of the fertilizing, the ecosan product should be completely free of pathogens and therefore safe to handle. If gloves and other health risk reduction measures are used, as recommend, an image that something hazardous is handled might be created which can cause suspiciousness. Another issue is, if gloves are provided by the project only in the beginning, later on if there is no resources to get more gloves problems and suspiciousness might emerge as well.

The main issues to develop in Hope and Kindness are:

- More training about the UDDT product fertilizing needed, as the farmers are suspicious.
- Pots for small children, therefore they would not cause extra mess in the UDDTs by misusing them.

4.2.9 Keys for the success?

Hope and Kindness was a very good example of well-functioning operation and maintenance system of UDDTs. Especially farming and exploitation of treated faeces as soil conditioner was superior. Even though some more knowledge would be needed to improve and enhance the system. School administration had innovative and interested attitude towards new projects, which of course affects how the things are prioritised. Remarkable issue is that this school is relatively well off due the funding from abroad and thus more has resources to put emphasis on things such as good hygiene, sanitation, clean water and farming in big scale.

The main factors affecting to the success of UDDTs in Hope and Kindness school:

- Two employed caretakers, facilities always tidy and well maintained.
- No bad smell or flies, pupils find ecosan toilets very convenient to use and nice looking.
- Crops that are fertilized with treated faecial material grow well, benefits of UDDTs in agriculture are remarkable.
- Rain water harvesting system has eased gaining hand washing water, hand washing and hygiene.
- No problems with financing and extending the sanitation system.

4.3 Kachan Primary School

4.3.1 School information

Kachan primary school is located at Pap Onditi in Kisumu County, Nyanza Province. It is mixed day school for approximately 400 pupils. Kachan Primary School was awarded by World Vision to be the best school concerning Health and Sanitation issues in 2009. To get all the relevant information, in addition to observations, the head teacher and the sanitary teacher were interviewed. Also one of the patrols of the Health Club was interviewed. Information about the school and sanitation is presented Table 9.

Table 7. Basic information of Kachan Primary School

Issue		**Comments**
Date	11.11.2011	
Pupils: total/ boys/ girls	400/197/204	
Age range of the pupils	3-16	*Primary School*
Teachers	12	
GPS coordinates	0°19'48.65"S, 34°57'17.68"E	
Number of UDDTs	4	
UDDTs for teachers, ratio	-	*No UDDTs for teachers*
UDDTs for boys, ratio	2, 1:100	*But only upper classes use UDDTs. UDDTs for boys were locked at the time of the evaluation.*
UDDTs for girls, ratio	2, 1:100	*Only upper classes use UDDTs, so the actual ratio is higher.*
Pit latrines in use	8	*4 for boys, 2 for girls, 2 for teachers*
Hand washing facilities	Yes	*But not connected to the rain water harvesting system.*
Soap available	No	
Ash available	Yes	
Bins in girls' toilets	Yes	

Toilet paper	No	
In charge of maintenance	Health Club	*Together with the teachers.*
A school garden	Yes	*Small.*

4.3.2 Condition of the UDDT Facilities

All UDDTs were in relatively good condition from outside. But only girls' UDDTs were in use. They were clean (floors and squatting pans), without smell and flies. Explanatory posters existed in each cubicle and rubbish bins in girls' units. Some small damages, such as cracks and small holes, were observed on the superstructure, for example on the chamber doors. Some urine tanks were full and about to overflow. Faeces in the containers were mixed to some extent with paper and plastic.

Both UDDT cubicles for male pupils were locked. Locked UDDTs are presented in Figure 16. As can be seen in the same figure, water harvesting system was not attached to the diverting pipe. According to the teachers pupils would first need more training on the correct usage of the UDDTs. Apparently there has been some problems and misuse. Training was planned to be held in the beginning of the next semester (January 2012).

Figure 16, *UDDTs for boys in Kachan Primary School.*

For hand washing there was a tippy tap near the toilets with a small 5 litres container. Tippy tap is a hygienic, simple and affordable device for hand washing with running water; a small (e.g. 5 liters) container has a hole near the cap, and is filled with water. Water runs out of the container when a stick and rope system, that is tied through a hole in the cap, is tipped with. At the time of the visit there was no water in the container. Next to the main buildings there was another possibility to wash hands, approxi-

mately 30 litre tank with a tap. A rain water harvesting system has been built to collect rain water from the roof of the main buildings. Rain water was directed to a big tank which is located behind the school. From this tank water is delivered manually to the hand washing containers.

4.3.3 Usage of the facilities

Four UDDTs were built by the EPP, two for girls and two for boys. Only the eldest pupils were using the UDDTs, classes 6, 7 and 8. According to the teachers, younger children seldom remember the right usage of the toilets, even they are taught. If all the pupils used the facilities, maintaining would be more challenging and UDDTs overloaded. For lower classes there are altogether 6 pit latrines in use; separated for girls and boys. Additionally for the teachers there are two pit latrines. At the boulders of the school plot there was a dumping site of old, abandoned pit latrines. These old pit latrines can create a health and environment hazard, as soil might be contaminated with pathogens that can drift further in soil with groundwater.

According to the teachers there were some negative attitudes among the pupils about the usage of the UDDTs and utilization of the products in the beginning of the project, as pupils were not used to this kind of system. But thanks to the trainings by the project implementation team pupils know now the importance and benefits of the ecological sanitation and the concept is accepted.

Annually all the new students are trained about the correct use of UDDTs by two teachers. There is a female teacher who is in charge of training the girls and a male teacher who is responsible for the boys. The drawback is that neither of these teachers attended to the project implementation trainings in 2009. So there would be a demand for another training.

According to the teachers all the pupils always aim to wash their hands after visiting the toilets. Water is the problem as it is not always available. Kachan Primary School has gained good reputation of their hygienic manners as it was awarded in 2009 for good prosperity in Health and Sanitation. Therefore for example hand washing is a well-known routine among the pupils. A Health club had been established in the school already before EPP. The club has 40 members who are responsible for operation and maintenance of the UDDTs.

The girls get once a year a sample package of sanitary towels from the school, but to cover the need of all the year, it is not enough. Girls dispose the sanitary towels in the litter bins inside the toilets. Bins are emptied to a pit on the school yard where all the garbage is burned.

4.3.4 Operation and Maintenance

Pupils themselves are responsible for operation and maintenance of the UDDTs. Classes 6, 7, and 8, who are using the UDDTs, are also in charge of cleaning the toilet facilities. This is arranged by the school’s Health club. Good reputation of the club is one driving

factor motivating the pupils to attend the action. As a member of the Health club, a pupil can learn for example about the utilization of ecosan products and gets responsibility. The gained award of Health and Sanitation by World Vision in 2009 also brings motivation and engagement. In addition, clean toilets are highly appreciated, as the pit latrines, which are used by younger pupils, are smelly and unhygienic. During the rain seasons due to wet and soft soil pit latrines have sank and collapsed.

UDDTs are cleaned every morning by the Health Club members, but according to the corresponsive teacher they should be cleaned more often, at least twice a day. The health club members are responsible for operation and maintenance of the toilets. Students are working in groups, one group is in charge of cleaning the toilets and taking care that there is ash and water for hand washing available. The Health Club is responsible also for empting the vaults and urine tanks, together with the teachers.

The most common problems have been blockages in the urine pipes and misuse of the facilities. If urine pipe gets blocked, teachers are in charge of unblocking it. During the experiment urine pipes have blocked few times. Unfortunately teachers do not particularly know the methods for unblocking them.

4.3.5 Utilization of the ecosan products

Both products from the UDDTs, urine and faeces, are utilized. Urine is stored for one month and then diluted with water in relation of 1:3. Urine-water mixture is used for fertilizing the vegetables, mainly onions, on the school farm. Treated faeces are stored and dried for the recommended six months and then utilised in tree planting. Part of the crop is usually sold to earn some money for the Health Club. Pupils together with the teachers are doing utilisation of ecosan products on the field as well as farming general.

4.3.6 Project implementation

The school was participating in the construction of UDDTs and provided material (e.g. bricks, sand and gravel) and labour. According to the head of the school the implementation was good but the project could have been longer. Also parents and community was involved to the project which might affect to its prosperity. More training is still needed.

4.3.7 Key messages and recommended actions for improving

There have been issues considering the right use of the UDD toilets. Teachers do not have actual preparedness to act for example if urine pipes get blocked. This is a consequence of frequent teacher mobility which is common in Kenya. If qualified teachers, in terms of ecological sanitation, leave the school the risk for total disappearance of the knowledge is high. In this sense it is important to involve the whole school and for example name several sanitary teachers. A simple manual of the basics of O&M should be provided for each school to ensure that there is a backup to e.g. check what to do in problem cases such as pipe blockages etc.

According to the interviewed pupils and teachers UDDTs have brought many benefits for the school. These benefits are motivating the school to continue maintaining the UDDT facilities well. The main motivation factors are:

- UDDTs are more comfortable to use compared to pit latrines, they look nicer, are more hygienic and environmentally friendly.
- In long run less space on the school yard needs to be used as one UDDT lasts for a long time (according to Rieck et al. (2012), under usual circumstances, more than 15 years).
- Free fertilizer for farming.
- Health Club has taken responsibility of maintaining the toilet facilities, which seems to be working well, via children knowledge of the importance of sanitation will be spread to parents and communities.
- Health and Sanitation Award has probably courage the school staff and pupils to continue improving the hygiene issues and to remain as a good example of the schools where hygiene and sanitation is well arranged and maintained.

Challenges related to the sanitation and needing improvement:

- Blockages in the urine pipes are an issue, more training needed for not blocking them, especially with ash, struvite is another case.
- Teachers do not particularly know the methods for unblocking pipes, they should also be trained more.
- Misuse of the facilities of frequent problem, mainly by visitors.
- Hand washing water is not always available, hand washing tanks should be filled up more often, soap also needed.

4.4 Siany Mixed Secondary School

4.4.1 School information

Siany Mixed Secondary School is a boarding school located in Nyakach area in Nyanza province. As Nyakach area is flat and swampy it has been a big challenge to find suitable solutions for safe and sustainable sanitation. UDDTs are a very good option for swampy areas like this. In Table 10 basic info about the school and sanitation is presented. Beside field observations the principal and sanitary teacher were interviewed.

Table 8. Basic information of Siany Mixed Secondary School

Issue		**Comments**
Date	14.11.2011	
Pupils: total/ boys/ girls	160 / 79 / 81	*Boarding School*
Age range of the pupils	14-20	
Teachers	10	
GPS Coordinates	0°22'59.97"S, 34°57'19.56"E	

Number of UDDTs	4	
UDDTs for teachers, ratio	2, 1:5	
UDDTs for boys, ratio	-	*No UDDTs for male pupils yet*
UDDTs for girls, ratio	2, 1: 40	
Pit latrines in use	2	
Hand washing facilities	Yes	*Rain water harvesting system*
Soap available	No	
Ash available	No	*Usually is, but at that time of the visit there were problems with unusually heavy rains and the kitchen, from where ash is usually delivered to the toilets*
Bins in girls' toilets	Yes	
Toilet paper	No	*Pupils bring their own paper with them*
In charge of maintenance	Grounds man	
A school garden	Yes	*Sukuma wiki, onions. Tree planting.*

4.4.2 Condition of the UDDT Superstructure

In Siany Mixed Secondary School UDDTs were well maintained and clean. Figure 17 provides a view inside a tidy UDDT cubicle. Tanks for hand washing were located next to the toilets and there was water inside, but the tank was not connected to the rain water harvesting system. Superstructure of the UDDTs was in relatively good shape. Paint was worn out at some spots. One upper beam was detached and doors were slightly in disorder, as seen Figure 18, but still functioning. As seen in the left corner of Figure 18, Nyakach area and the school yard are swampy and wet, thus special arrangements for proper sanitation are required. Trees on the left side of the figure have been fertilized with ecosan fertilizers.

Figure 17, *Floor, walls and the squatting pan were clean. The hole for the storing vault was closed with a brick.*

Figure 18, *UDDTs were relatively well maintained but some grievances were observed.*

But even well operated and maintained, the major difficulty in this area has always been the wet soil due to the heavy rains during the rain seasons. During the heavy rains clay soil gets wet and swampy and especially pit latrines can sink or collapse easily. But rains can also cause problems with UDDTs. In Siany Mixed Secondary School doors of the storing vaults in the back of the UDD toilets were not isolated well enough, and thus water has been leaking into the vaults. According to the principal wooden frames are isolating better than the metal ones. As a consequence vaults are leaking and

faeces cannot completely dry. Some insects, mainly worms, were observed in the vaults. Heavy rain has also caused some issues in the kitchen of the school which has hindered ash provision to the toilets.

4.4.3 Usage of the facilities

There are four UDDTs in this school, two for female pupils and two for teachers. According to the principal, everyone who is allowed to, uses UDDTs i.e. girls and teachers. Even the majority of the pupils are happy with the odourless and clean toilet facilities, some still have traditional believes and negatives attitudes about utilization of the products, as according to some believes only mentally disoriented persons are getting touched with human excreta. Training and awareness creation lessons have helped pupils to understand the benefits of ecosan system. One big issue for accepting the concept of ecological sanitation, including product utilization, is the visible confidence. In Siany school many trees on the school yard have been fertilized by dehydrated faeces and urine-water mixture. These ecosan fertilized trees have grown visibly better than the ones further away without fertilizing, even they all have been planted at the same time. The principal and the teachers seemed to be very happy and proud of this succeed, and for sure they spread this spirit to the students.

For male students there are no UDDTs yet, they have to use old pit latrines. But according to the principal more UDDTs will be built immediately when there is a financial possibility for that. Pit latrines on wet areas are collapsing even more easily than on drier ground. It is in general knowledge now among the school staff and the students that pit latrines are unecological and possibly spreading many diseases to the ground water. According to the principal it is also getting very expensive in long term to build new pit latrines after every rain season. This is one reason to invest more on UDDTs.

New pupils are annually trained by biology and agriculture teacher, who is in charge of ecological sanitation including awareness creation and utilization. Annual training for new pupils includes the right usages of three different holes, importance of using ash as well as importance of hand washing and benefits of utilization of the products.

4.4.4 Operation and Maintenance

The grounds man of the school is in charge of the maintenance of the whole school compound, also the toilet facilities. He cleans the toilets every day, provides the ash from the kitchen to the UDDTs, empties the urine containers and the vaults of faecial matter after the drying period. The grounds man is also responsible for small repairs of the toilet construction and unblocking the possible blockages in the urine pipes.

The main issues considering the operation and maintenance of the UDDT facilities are the problems caused by water leakages into the vaults and water mixing with faecial matter. One issue is also that there are too few toilets for the population of the pupils (girls) which causes overload of the facilities. At the time of the evaluation there

was no ash available in the toilets, as the heavy rains caused problems for delivering it from the school kitchen.

Urine containers are emptied every week by the grounds man. Vaults for solid waste are closed when they get full, which is quite rare, only approximately once a year. Then faeces are stored for half a year before utilizing for tree fertilizing.

4.4.5 Utilization of the ecosan products

Containers for urine in girls' toilets are filled up two or three times a week, after which the grounds man empties them, mixes together with water in ratio of 1:1. In teachers' UDDTs urine containers fill up rarer. Urine-water mixture is implemented for the trees on the school yard and also for the school garden, where vegetables, mainly *sukuma wiki* (local vegetable) and onions, are grown.

When one vault of faecial matter gets full, the hole is closed and the other vault is taken under usage. The product is stored and dehydrated for six months. After this the agriculture and biology teacher is in charge of implementing the product to the garden.

Success of ecosan fertilizing is visible as the fertilized trees have grown much faster compared to the ones without fertilizing. This kind of comparison has helped sceptical pupils to understand the possibilities and benefits of ecological sanitation and utilization of the products. Still, some have negative attitudes towards utilization of human excreta. Some UDDTs are applied to households in the surrounding communities, but with wider promotion, negative attitudes could be changed more effective.

4.4.6 Project implementation

According to the principal, the project implementation was good and the team did good work on training the teachers and pupils, and it enabled teachers and pupils to operate and maintain the facilities themselves, but still some annual training would be required to changing the attitudes.

The school participated to the construction offering materials such as bricks, sand, labour and also money. The status of the ownership is clear, the school owns the facilities and therefore wants to maintain them well. There are some key persons supporting the ecosan project, mainly teachers and individuals, and the teacher's club of the area is also involved.

4.4.7 Benefits received and factors for motivation

According to the principal the new sanitation system has brought several benefits for the school, including health-, environmental- and economic benefits. Besides the fact that UDDTs are cleaner and less smelly than pit latrines, they also don't create a risk for health. They are easier and cheaper to maintain. In wet areas and during the rains pit latrines can get very disgusting and uncomfortable to use if the faeces and urine get mixed with the water in the ground. One important health benefit is that the hand washing is nowadays a routine among the pupils. Above all, rich ecosan fertilizer has been

proofed to be effective on the trees and farm. The main factors for motivation and therefore reasons for maintaining the UDDT facilities are:

- Clean and odourless facilities, no flies.
- Nyakach area is, in terms of sanitation, very difficult due to the wet soil, and UDDTs are a good solution for wet areas for safe and sustainable sanitation.
- The fact that UDDTs are also a cheaper solution in long run, compared to the pit latrines, is well known among the school administration.
- Agricultural benefits, visible proofs of good fertilizing effects of urine and treated faeces in the tree planting.
- Teachers are motivated.
- The school gets support from the surrounding communities.

Tree planting has also further benefits on the wet land. As trees grow faster they suck more and more water from the soil, making it less wet and swampy. Ecosan fertilizing, mainly with urine-water mixture, has accelerated tree growing remarkably. Making the ground drier has further benefits, for example helps the fight against malaria. As the soil gets drier there are less puddles for mosquitoes to breed, which lowers the amount of these insects.

4.4.8 Main issues to be improved and recommendations on that

First of all, the biggest problem is that there are too few UDDTs for the pupils (and only for girls). Thus the toilets are occasionally too crowded and as the urine containers are small in volume they fill up quickly which strains the person in charge of empting them. Also as the population of the school is growing continuously, there is a need for more UDDTs.

The current conditions do not meet the needs of menstruating girls. Bins for sanitary pads are too small, even they are emptied and burned weekly. This is mainly because there are too few UDD toilets for 80 girls in the school. Additionally also male pupils would need UDDTs.

UDDTs have been applied to the surrounding communities to some extent, but with larger scale, negative attitudes among some pupils could be reduced better. Also more training from outside the school would be beneficial. In the principal's opinion larger scale awareness creation, e.g. at the national level, would be needed, i.e. government should make more effort creating knowledge about ecological sanitation and utilization of the products. The principal of Siany Mixed Secondary School suggested that some pilot gardens should be planted by the government to convince people especially about the benefits of the nutrient recycling. This would lead to higher acceptance and knowledge and thus benefit the gospel of ecosan.

The ecosan project has highly increased the knowledge about the benefits of ecological sanitation, and the school staff as well as the pupils have adapted the technology. There is urge and motivation to build more toilets, it is only the question of fi-

nancing, as usual. But on the other hand, it is known that in long run the UDDTs actually pay themselves back, as once UDDT is build it lasts for a long time, if well maintained. Besides this a good crop from the school garden can be harvested without a need for buying chemical fertilizers.

4.5 Radienya Primary School

4.5.1 School information

Radienya Primary School is located at South Nyakach in Kisumu County. It is a mixed day school for 330 pupils. The information about the school and its sanitation management was gained from the head teacher and the sanitary teacher. Table 11 presents the basic info and some statistics of the school.

Table 9, Basic information of Radienya Primary School

Issue		**Comments**
Date	15.11.2011	
Pupils: total/ boys/ girls	330/173 /153	
Age range of the pupils	7-16	*Primary school, no baby class*
Teachers	9	
GPS Coordinates	0°24'29.60"S, 34°58'8.21"E	
Number of UDDTs	4	
UDDTs for teachers, ratio	1:9	
UDDTs for boys, ratio	1:88	*Two UDDTs for boys*
UDDTs for girls, ratio	1:153	*One UDDT for girls*
Pit latrines in use	4	*Two for boys, two for girls. Also an urinal for boys.*
Hand washing facilities	Not functioning.	*Water tanks were stolen.*
Soap available	No	
Ash available	Yes	
Bins in girls' toilets	No	
Toilet paper	No	
In charge of maintenance	Health Club	*With help from the teachers.*
A school garden	Yes	

4.5.2 Condition of the Superstructure

In general UDDTs were sufficiently maintained. Partly facilities would need repairs and more maintenance such as cleaning and empting the overflowing urine containers. Some metal components were rusty as seen in Figure 19, which shows the vault doors behind the UDDTs. Isolation of the vault doors have been tried to improve with metal beams, but they suffer of getting rusty, as can be seen in the figure. One UDDT cubicle was

used for storing ash and had become untidy. There were some cracks and holes on the superstructure and no litter bins in girls' cubicles. Faeces in the vaults were mixed with some un-decomposable material. Despite the demand for some small improvements, the facilities were generally functioning well without odours or flies. There was a harvesting system for rain water and it was functioning, but there were no tanks to collect the water as they had been stolen. Therefore there was no possibility for hand washing. Tanks were not attached to the structure and were stolen as they were located near to the road.

Figure 19, *Vault doors behind the UDDT.*

4.5.3 Usage of the facilities

UDDTs are used only by the oldest pupils as the usage is considered too difficult for the youngest pupils i.e. classes 1 to 3. There are altogether 4 UDDTs, two for boys, one for girls and one for teachers. If all the pupils were using the UDDTs they would be overloaded. But according to the teachers the pupils who are allowed to use UDDTs, absolutely prefer them to the pit latrines. Problem with pit latrines have been, beside unhygienic conditions, sinking and collapsing of the toilets during the rain seasons.

There have been negative attitudes to some extent among the pupils towards utilization of the ecosan products, and also towards the regular cleaning to some extent, as the pupils are responsible of it. But on the other hand pupils value clean toilet facilities and they realise that someone has to clean them. Pupils also pay more attention on the correct usage of the facilities as they know that they are responsible of the maintenance themselves.

New pupils are trained each year by the teachers. But visitors from outside the school have caused some problems as they are not trained. If a visitor pays attention to the explanatory posters on the wall he will probably manage using a UDD toilet correctly, but risk for a misuse is high.

4.5.4 Operation and Maintenance

The Health Club of the school is in charge of toilet cleaning, maintaining, ash provision (ash brought from their homes) and also empting the tanks and vaults. Classes 4 to 6 are using UDDTs and also in charge of their maintenance. Teachers clean their own UDDTs. According to the teachers urine tanks in pupils UDDTs get full almost every day, so there is lots of work with empting the containers and utilizing urine and faeces. Utilization is done together with the teachers. A motivation for Health Club members to maintain their UDDT facilities well, is the earned money from selling a part of the crop that is fertilized by ecosan products. With this money Health Club members are allowed to buy for example magazines or books.

4.5.5 Utilization of ecosan products

Urine is, at least most often, utilized for fertilizing banana trees and sugar cane. Urine is not stored, due to lack of space and storing facilities. Urine is directly mixed with water (ratio 1:3) and utilized on the trees and canes.

4.5.6 Main issues to be improved and recommendations on that

Teachers highlighted few issues that should be improved with the system, first of all instead of stairs there should be ramps to able also disable pupils to reach the toilets. On the other hand usage of the toilet itself can be challenging for disable pupils, without any handgrip or handle. Teachers also suggested that urine tanks should be bigger and hand washing tanks should be fixed so they could not get stolen. In addition more training about the utilization would be required as e.g. more information about the differences between tree and vegetable fertilizing with ecosan products. Two issues that would need urgent action are:

- New water tanks to make hand washing possible, soap should also be provided.
- Misuse by visitors should be prevented.

4.5.7 Motivation for maintenance

The motivation factors for taking good care of the UDDT facilities are the usual ones:

- More comfortable facilities than the traditional pit latrines.
- Hygiene is better.
- Environment feels healthier.
- The pupils are motivated to maintain the facilities, the affecting factors are i.e. partnership of the Health Club, extra money from selling the crops fertilized by UDDT products.

4.6 Kakichuma Primary School

4.6.1 School information

Kakichuma primary school is located at Kibabi in Bungoma County, Western province of Kenya. It is mixed day school of nearly 900 pupils. The school is sponsored by a religious organisation. The area is very dry especially during the dry seasons and the shortage of water is a crucial problem. Table X offers basic information and some statistics about the school and its sanitation. The principal of the school was interviewed together with the sanitary teacher. Few pupils were also discussed with. Basic information of the school is provided in Table 12.

Table 10, Basic information of Kakichuma Primary School

Issue		**Comments**
Date	21.11.2011	
Pupils: total/ boys/ girls	899/453/446	
Age range of the pupils	4-20	*Classes 1 to 6, Primary School.*
Teachers	15	
GPS Coordinates	00°41'36.1"N, 034°32'04.5"E	
Number of UDDTs	4	
UDDTs for teachers, ratio	2, 1:8	
UDDTs for boys, ratio	2, 1:200	*Only male pupils have ecosan toilets.*
UDDTs for girls, ratio	-	
Pit latrines in use	4	*For girls.*
Hand washing facilities	Yes, but not in use	*Rain water harvesting system did exist but was not functioning*
Soap available	No	
Ash available	Yes	
Bins in girls' toilets	-	*No UDDTs for girls*
Toilet paper	No	
In charge of maintenance	-	*No one is clearly responsible of sanitation (O&M)*
A school garden	Yes	*Banana trees*

4.6.2 Condition of the Superstructure

There were altogether four constructed UDDTs at the school site, two for teachers and two for male pupils. All the UDDTs were mainly in good condition, clean and well maintained. Some small repairs would be required. For instance, the soil around the teachers' UDDTs had suffered from erosion and as a result the first step of the stairs was relatively high, and likely very hard to step on especially for older teachers. Figure 20 shows the result of the erosion. It also shows a lack of a valve on a tap of the hand washing tank, so harvested rain water is leaking onto the ground.

Figure 20, *UDDTs for the teachers were mainly in good condition.*

In pupils' UDDTs there was some ash on the urinating hole which might lead soon to a blockage in the urine pipe. Seemed like faecial matter was wet, so there has probably been some misuse of the facilities. Water harvesting system was not functioning as the pipe from the roof was missing. Seemed like facilities were not correctly used, but on the other hand there was no odour in the toilets. Figure 21 shows the UDDTs for pupils.

Figure 21, *UDDTs for male pupils.*

4.6.3 Usage of the facilities

There are only two UDD toilets for 450 male pupils. For 450 female pupils there are four pit latrines. All together there are too few toilets to cover the need of 900 pupils. As a result of national Free Primary Education (FPE) program in 2003, the population in the school has risen rapidly but the facilities are the same.

Pupils found UDDT facilities comfortable to use as there is no smell or flies in the toilets. They were well aware of the ecological sanitation and its benefits. Also pupils had recognised the problems related to the shortage of the water. They were also concerned about the disable fellow pupils who cannot use the facilities due to the stairs. New pupils are not trained by teachers how to use UDD toilets. Pupils are supposed to learn from older pupils and posters that are hanging inside each cubicle.

Hand washing facility was not well maintained. At the pupils' UDDTs a pipe from the roof to the water tank was missing, so there was no possibility for hand washing. Shortage of the water at this area is a serious problem, as there are no rivers or other water sources nearby. During the dry seasons there would no possibility to fill the tanks in any case, probably this is the reason why there is a lack of interest to take care of the hand washing facilities. The only option for equivalent water resource would be a borehole. Hard rocky soil makes this kind of investment very expensive.

Menstruating girls are an issue that would require further discussion. Many of them do not come to school while their menstruation, and this leads to many days of absence from the school every month, and according to the principal often eventually to dropping out of the school.

4.6.4 Project implementation

There was a seminar held after the UDDT construction, which, according to the principal, was very good and enabled the teachers and students to use and maintain the facilities. But more training would be required as there are new teachers and pupils in the school. Training also convinced pupils about the new sanitation system and eliminated negative attitudes.

School administration assisted the implementation team to locate and build the facilities. The school also provided material, such as bricks, sand and water as well as additional labour for the constructions. The ownership is clear, the school owns the facilities.

4.6.5 Benefits received

Soil of the area is rocky and therefore digging pits is hard and expensive. But rocky soil does not prevent the pit latrines from sinking, which has happened, according to the principal, almost every rain season. The multifaceted benefits of ecological sanitation and UDDTs are realized and hopefully weighed seriously in the future decision making.

Teachers and pupils do like their UDDT facilities, but there are not particular lessons of good maintenance than could be learned from this school.

4.6.6 Operation and Maintenance

There is not a certain person in charge of the maintenance of the toilet facilities. Children are supposed to clean after themselves, and daily base cleaning is carried out by the teachers, who have a schedule for that. In the end, the head teacher is in charge of the facilities. Ash is provided from the kitchens of the head teacher and the pupils who carry it to the school with them. In case something needs to be prepared, the school management committee and the head teacher are responsible.

4.6.7 Utilization of the ecosan products

Sanitary teachers and pupils are responsible for empting the urine tanks and vaults as well as applying the fertilizer on the farm. Urine tanks are emptied when full, usually after four days. Containers for faecial matter have not been emptied or utilized yet as toilets are relatively new and vaults are not full yet. Urine is mixed with water and implemented immediately to the banana tree farm. Sanitary teacher is in charge of that together with pupils.

4.6.8 Main issues to be improved and recommendations on that

The problem is, as very often, the lack of finance. Even the ecosan facilities and the project itself is highly appreciated, many things are not functioning i.e. hand washing facilities and cleaning arrangements, mostly because they would require expensive investments, e.g. drilling a borehole to provide water. Also cleaning would require more attention.

There was some ash in the urine hole of the squatting pan, which can cause blockages in urine pipes. For new pupils there is no arranged training about the ecological sanitation and usage of the facilities, which is a significance flaw. Educating the users of UDDTs, especially new pupils, would help and reduce misuse. For new young pupils using a dry toilet might seem to be complicated, without any orientation. Usage of UDDTs and possible utilization of the product should be discussed openly. Recommendations for better success in future:

- Someone should be named to be in charge of sanitation, especially maintenance of the facilities.
- Small repairs needed, more attention to cleanliness.
- New pupils should be trained every year to make sure they know how to use the UDDT facilities correctly.
- In general more training needed, especially for the new teachers.

4.7 Eldoret Educational Centre

4.7.1 School information

Eldoret Educational Centre is a new school, it was built in the beginning of 2011. The school is private and supported by its South-Koran funders. At the moment there are 180 pupils in the school, but the population will grow in the near future. At the moment the school is self-financed as it gets incomes from selling the vegetables from the farm. There are also animal husbandry, cows, pigs and chicken producing goods for sale. Information and statistics about the school and its sanitation is collected in Table 13.

Table 11, Basic information of Eldoret Educational Centre

Issue		**Comments**
Date	22.11.2011	
Pupils: total/ boys/ girls	180/ 90 /90	
Age range of the pupils	3.5 – 14	
Teachers	15	
Number of UDDTs	4	
UDDTs for teachers, ratio	1	
UDDTs for boys, ratio	1, 1:90	*Boys also have urinals*
UDDTs for girls, ratio	2, 1:45	
Pit latrines in use	-	
Urinals for boys	1	
Hand washing facilities	Yes	*A tank with four taps*
Soap available	No	
Ash available	Yes	
Bins in girls' toilets	Yes	
Toilet paper	Yes	
In charge of maintenance	Sanitary person	
A school garden	Yes	

4.7.2 Condition of the UDDT Superstructure

UDDTs were new and very well maintained. Toilets were clean and there was no smell or flies, no complaints at all. Ash and toilet paper was provided in each cubicle and in girls' toilets there were rubbish bins for sanitary pads. There was no damage or cracks on the superstructure. These UDDTs were built by private project and the structure was different compared to the UDDTs built by EPP. Figure 22 shows the ecosan toilet unit in this school. Figure 23 shows the ventilation system into the vault. It is done with a pipe on the right of the picture, holes on the wall are for air ventilation for the cubicle itself. The other hole for the vault is closed using some stones for help. Ash is provided in a bucket in the corner, and also toilet paper is available.

Figure 22, *UDDTs in Eldoret Educational Centre are all built in one unit. There are two UDDTs for girls, one for teachers and one for boys. In addition there is a urinal for boys. On the left is the hand washing tank with four taps.*

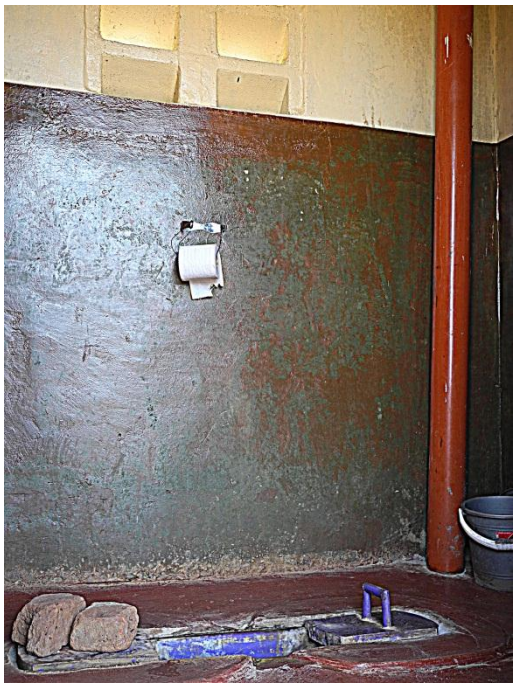

Figure 23, *A view inside the UDDT cubicle in Eldoret Educational Centre.*

4.7.3 Usage of the facilities

The original sanitation plan was to build pit latrines, but after consultancy the school administration decided to build UDDTs instead. And they were very pleased for that decision at the time of the evaluation.

All the pupils and teachers and other school staff were using the UDDTs as there was no other toilets. But under construction there are flush toilets that will be connected to biogas facilities. Interviewed pupils were pleased with the UDDTs, especially because there is no bad smell inside the cubicle and they look nice and are comfortable to

use. According to the school administration UDDTs are very suitable also for the smaller children, they are not scared for falling down as they usually are with pit latrines.

The toilet ratio for girls is 1: 45, which is less than recommendation 1:25. But more toilets will be built in the future. For boys there is only one UDDT (ratio 1:90), but also urinals, which improves the flow and shortens queues.

Toilet doors were lockable also from the inside, which is important thing for privacy. Girls bring they own sanitary pad and dispose them to the rubbish bins. All rubbish from the school centre is burned in a pit.

Pupils know how to use the three holes squatting pans as they were taught in the beginning of the semester. New pupils will be trained in the beginning of each semester. The sanitary employee is in charge of this. For recall, there are explanatory posters in each cubicle. In some cubicles there was a note not to throw ash in the urine whole. This is very simple but presumably effective way to prevent possible blockages in urine pipes.

For hand washing there was a tank with several taps (see Figure 22 above). Water for the tank is pumped ground water, and this far carried manually from the main tank. There is no rain water harvesting system on the roof of the UDDT unit. Future plan is to construct pipelines and also harvest the rain water for use.

4.7.4 Operation and Maintenance

One person is in charge of maintenance of toilet facilities. This person in charge of sanitary issues arranges cleaning of the toilets three times per day, is in charge of unblocking the possible blockages in pipes, empties the rubbish bins, provides toilet paper and ash to the cubicles. The school does not use fire wood in the kitchen so ash is collected from other schools and hotels around. In this case lime could be preferable substance to use (better to dry the faecical matter, and ash is not easily available, e.g. from the school kitchen).

Urine containers are removed and changed to new ones every evening. Containers are labelled with the date and stored in a closet beside the toilet for 14 days. Sometimes provision of ash has been a problem, as it is not provided from the school itself. According to the sanitary employee, lack of ash occasionally leads to spreading of flies inside the UDDTs. Few times urine pipes have been blocked as some ash has gone into the urine whole. If pipes would be shorter they would not get so easily blocked. Urine tanks should be situated close to each cubicle. Sanitary person is responsible for unblocking. In case something needs to repaired, a grounds man of the school takes care of it.

4.7.5 Utilization of the ecosan products

Urine has been widely utilized on the school farm. First it is stored in the containers for a period of 14 days. There is a closet by the UDDTs for urine storing, and each container is labelled by a date. After 14 days of storing, containers are delivered manually for

the farmers, who supply urine-water mixture on the field. Farmers are trained to handle urine with sufficient caution and to mix it with water in ratio 1:1. An irrigation system is used for fertilizing, which makes urine-water delivering easy and convenient. On the school farm vegetables (e.g. tomatoes, sukuma wiki and onions), trees and flowers are fertilized by urine-water mixture. According to the person in charge of sanitary issues especially passion fruits are very suitable for urine fertilizing. The benefits of utilizing ecosan products have been noticed: vegetables grow well and stay green, even during dry seasons, when fertilized with urine-water mixture. Figure 24 shows facilities for urine storing and Figure 25 the urine-water irrigation system.

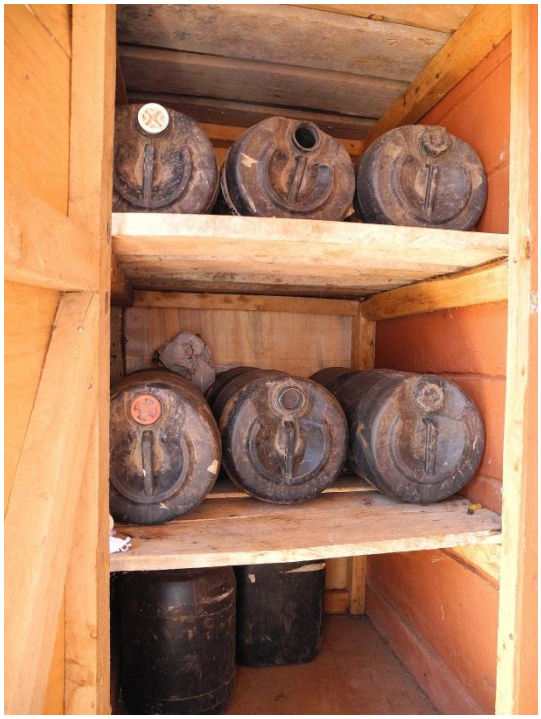

Figure 24, *Urine is stored in the containers in a closet by the UDDTs. Containers are labelled by the date and stored for 14 days of minimum before delivering to the farm.*

Figure 25, *Urine-water mixture is delivered to the farm via an irrigation system.*

The facilities were built in late 2010 and therefore being in use only one year at the time of the school visit. First vaults were almost full and ready for storing, after which seconds vaults will be taken under usage. Figure 26 shows the faeces at the time of the visit: the product was already looking good, dry and it didn't smell at all. Toilet paper and toilet rolls were mixed with the faeces. The vault was almost full, so the storing would be started soon and the other vault taken under usage. Some toilet paper and rolls were mixed with the product.

Figure 26, *Faeces in the vault before the actual storing period.*

4.7.6 Keys for the Success

It seemed that the key for success in this school was a sanitation expert, who is in charge of managing the maintenance of the UDDT facilities (and also other estate management issues) and arranging farming and educating on ecosan. The school farm is productive and thanks to that the school is self-financed. The school is fortunate being able to afford employing a person who is fully in charge of practicalities of sanitation and thus ensuring that things work. The whole system is functioning very well and will probably feed itself and create a positive vicious circle.

The school had gained good reputation with its success in linking sanitation and farming and being self-financed. Using urine as a fertilizer has raised interest around the school. Some stakeholders have even offered to buy the ecosan fertilizer!

4.8 Khaimba Primary School

4.8.1 School information

Khaimba Primary School is located in Mumias constituency in Isongo. The school is part of the Butere/Mumias district in the Western province of Kenya. Khaimba Primary is a mixed day school. The school is sponsored by The Central Government. Khaimba Primary School is an ecosan pioneer in the country, as it was the first school where

UDDTs were promoted by EPP and the head teacher of the school had the very first UDDT in the whole country. School information is presented in Table 14.

Table 12, Basic information of Khaimba Primary School

Issue		**Comments**
Date	25.11.2011 and 9.1.2012	*Two visits for this school*
Pupils: total	900	*Approximately 50% girls and 50 % boys*
Age range of the pupils	6-20	
Teachers	13	
GPS Coordinates	00˚19'56.6"N, 034˚36'49.1"E	
Number of UDDTs	4	
UDDTs for teachers, ratio	2, 1:7	
UDDTs for boys, ratio	1, 1:450	
UDDTs for girls, ratio	1, 1:450	
Pit latrines in use	10	*8 old ones and 2 relatively new*
Hand washing facilities	Yes	*Not functioning at each cubicle*
Soap available	No	
Ash available	Yes	
Bins in girls' toilets	Yes	*In female teachers' cubicle*
Toilet paper	No	
In charge of maintenance	Health Club	*Together with the teachers*
A school garden	Yes	*Banana trees*

4.8.2 Condition of the UDDT Facilities

UDDTs were built in 2008, but they had suffered from the time a little bit. Some damages such as broken doors and fainted paint were observed. One UDDT for boys was closed, the reason possibly was a blockage in urine pipe. Also the other toilet for teacher was closed as the door was damaged. Rain water was collected with a harvesting system from the roofs of the UDDTs. There was also rain water harvesting from the roofs of the main buildings, and this water was collected to a big tank presented in Figure 27. One of the hand washing water tanks next to the UDDTs was missing. Some of the urine tanks were about to overflow and would need quick empting. There was a litter bin in the UDDT for female teachers but none at the girls' UDDT. But, the UDDTs that were open and used were functioning well, there were no flies or odours and they were relatively clean. Figure 28 shows the UDDT unit for teachers. The figure shows damages on the superstructure, for example the doors were missing some boards. Rain water harvesting facilities and hand washing facilities were functioning, but some tanks were missing (from the other unit).

Figure 27, *A big water tank for harvested water from the roofs of the main buildings in Khaimba Primary Schoool.*

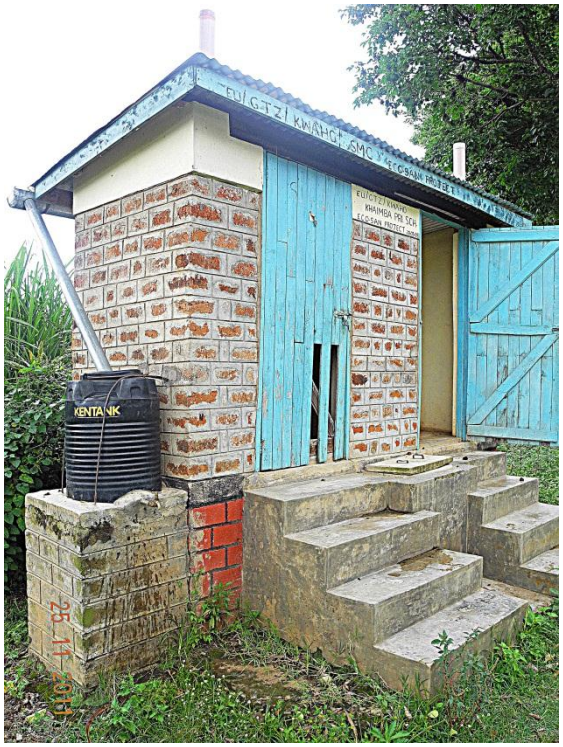

Figure 28, *UDDTs were clean and functioning, but a bit damaged.*

4.8.3 Usage of the UDDTs

The school was one of the best ones dealing with their sanitation system until year 2010. Back then, the facilities were very well maintained, and the products were utilized on the school farm. But in 2010 the teacher in charge of the sanitation left the school, and unfortunately after that school did not manage as well as earlier, even new sanitary teacher was named.

Only the top classes, 7 and 8, use the UDDTs. With this practice toilets are not over loaded or misused by young pupils. Pupils starting 7th class each year are trained by the sanitary teacher and also by fellow students. Training by the teacher mainly contains information of how to keep facilities clean, importance of usage of the ash, how faecial matter is processed to decomposed organic material as well as about the utilization of it.

There were two UDDTs for 13 teachers, but looked like these toilets were mainly used for urinating. Only girls' UDDT was open and in use by the time of the visit, UDDT for the boys was closed. Beside the UDDTs there are several pit latrines, altogether 10. These are used by younger pupils, and in case UDDTs are closed or busy.

4.8.4 Operation and Maintenance

Sanitary teacher together with the school's Health Club is responsible for operation and maintenance of the facilities as well as utilization of urine and faeces. Toilets are cleaned every morning by the members of the Health Club and they also provide ash to the toilets. In case something is broken the school employs someone to repair it. Teachers are responsible for opening possible blockages in the pipes. According to the head teacher urine containers are emptied once in four days. Figure 29 shows the system, tanks and pipes for urine collection in a closet next to the toilet. Urine is diluted with water in ratio of 1:3 or 1:4 and utilized on the school farm to enhance growth of banana trees, vegetables and maize. Occasionally vegetables are sold for locals. Community members are every now and then attending to utilization of the UDDT products on the farm in terms of learning about ecological sanitation and especially possibility of utilizing urine and faeces on the field.

Figure 29, *Urine tanks for collecting the yellow gold.*

4.8.5 Success and Challenges

According to the head teacher UDDTs have brought more value to the school. It has also made school proud as it gets visitors from other schools to see and learn about ecological sanitation. He hoped that the project can be sustained in future, but monitoring tools need to be improved. Unfortunately when the teacher in charge of sanitation changed the school lost its very good management of the UDDTs. But the goal is to get back to that position. Simple school based monitoring would help not to drop the quality again.

- The principal of the school is motivated, and wants to make an effort for better sanitation and hygiene.
- UDDTs have brought more value to the school.
- School is proud of their UDDT system, and they get visitors from other schools to see and learn about ecological sanitation.

The main challenges with UDDTs are blockages in the urine pipes. Challenges that are already crossed are cultural issues and fear to use the UDDTs. With regular training attitudes were changed. Teacher exchange and therefore disappearance of motivation and knowledge from the school is also a problem.

According to the head teacher one surprising challenge has been that fertilizer products have been occasionally stolen from the vaults by people living in the surrounding areas. On one hand this is lamentable, but on the other hand it proofs that there are no negative attitudes towards utilization of the fertilizer. But uncontrolled transporting and handling of the urine and faeces without knowledge of the possible risks is not recommended.

In this school, as also in several other cases, schools feel dependent on the implementation team and are waiting for support and help in case of any problems. They should be encouraged to take full responsibility of their sanitation system and independently sustain it and even develop it further.

4.9 Mumias Muslim Primary School

Mumias Muslim Primary School is a big day school in the centre of Mumias town. Basic information of the school is provided in Table 15.

Table 13, Basic information of Mumias Primary School

Issue		**Comments**
Date	9.1.2012	
Pupils: total	1400	*Approximately 50% girls and 50 % boys*
Age range of the pupils	4-18	
Teachers	38	
GPS Coordinates	00˚20'17.2"N, 034˚29'21.8"E	

Number of UDDTs	4	*2 for boys, 2 for teachers, no UDDTs for girls*
UDDTs for teachers, ratio	1:18	
UDDTs for boys, ratio	1: 350	
Pit latrines in use	20	
Hand washing facilities	Yes	*Water pump*
Soap available	No	
Ash available	Partly	*Ash was available in teachers' toilets but not in pupils' toilets*
Bins in girls' toilets	-	*No UDDTs for girls*
Toilet paper	No	
In charge of maintenance	Health Club	*Pupils together with*
A school garden	Yes	*At the time of the visit no plants were growing, but it was the very beginning of the semester and activities were not yet fully going on*

4.9.1 UDDT Superstructure and Usage

UDDTs in Mumias Muslim Primary School were not in the best condition, but the head teacher blamed it on the beginning of the semester. There were altogether four UDDTs, two for teachers and two for boys, but only older pupils were allowed to use these cubicles. UDDT for female teachers seemed not to be in use. In addition to UDDTs there were 20 pit latrines in use.

There was no ash in some of the toilets and there was some odour and flies. Ash was only available in male teachers' cubicle, so in one of four UDDTs. In two of the toilets urine hole was blocked by ash and faecial matter seemed to be mixed with urine. Vault doors behind the UDDTs were damaged as well as urine tank closets, and some plants were growing inside the vaults as seen in Figure 30.

Figure 30, *Vault door behind the UDDTs were disordered and some weeds were growing inside the vaults.*

For hand washing pupils use water pumps, as rain water harvesting system exist only on the teachers' UDDT, but at the time of the visit there was no water in the tank. Currently only the boys have UDDTs but also the girls have asked the head teacher for the same facilities. There has been interest towards the toilets also from the parents. According to the principal some teachers were planning to build similar UDDTs to their homes. UDDTs were built in 2008 and according to the principal they have made a big difference to the sanitary condition in the school. So, even there are too few UDDTs in school, and they are not so well maintained, the message has gone through, which was the idea of EPP.

4.9.2 Operation and Maintenance

Health Club of the school together with the sanitary teacher take care of the O&M of the toilet facilities. According to the principal this is mostly empting urine tanks, they get full in four days approximately. According to the principal urine from the UDDTs is stored for 14 days and then utilized on the maize field. Facilities are only cleaned when necessary. Members of the Health Club bring ash from their homes and provide it in the UDDTs.

4.9.3 The main challenges

In Mumias Muslim Primary School, the main issues to improve with UDDTs are the regular maintenance: general cleaning, opening the blockages of urine pipes and providing ash in each cubicle. As the schools is located in very central place near Mumias town, many happenings take place at the school site. This is a problem as visitors usually do not know how to correctly use UDDTs. On the other hand, there would be great potential to introduce UDDTs and spread the knowledge about ecological sanitation for the visitors, but special arrangements from the teachers or other school staff are required.

5 DISCUSSION

In total UDDTs were built in 73 primary and secondary schools throughout Western part of Kenya during the promotion project (Ecosan Network Kenya, 2009). According to the former EPP implementing officers, who now work as ecosan entrepreneurs, only very few schools are managing ideally. The set of the schools selected for this research (in the end nine schools) were all performing relatively well, but were almost the only ones doing so, and therefore the average is worse. In addition, even though all these schools were selected on the basis of good practise, considering especially O&M, there were still several shortcomings on their performance.

5.1 Comparison of the Main Results

Table 16 summarises the results of monitoring and evaluation of the schools. In the beginning of the project each school had four UDDT units, usually two for teachers, one for boys and one for girls, or one for teachers, two for girls, one for boys etc. The amount of UDDT cubicles was insufficient in all the cases. The recommended ratio of the toilets, according to the guidelines by the Ministry of Public Health and Sanitation (2005), is 1:25 for girls and 1:30 for boys. This was not reached in the monitored schools. The general condition of the UDDT facilities is categorized in Table 16 by good / ok / poor, according to the cleanliness, condition of the superstructure and necessity for repairs. Existence of the required equipment and hand washing facilities are dealt separately. A refers to ash, LB for litter bins, TP for toilet paper, S for soap. Minus marks are referring to some kind of shortcomings e.g. not available in all UDD toilets of the school. Asterisked schools are self-sponsored and get donations from abroad.

Some conclusions can be drawn from Table 16. In most of the schools at least one UDDT was locked. Obliviously schools have problems maintaining the UDDTs correctly and keeping them functioning. Often the reason for closing the facilities was blockage in a urine pipe. Two schools had built more UDDTs, indicating that they preferred them to pit latrines, even more effort to maintain UDDTs is needed.

Condition of the UDDTs between the schools varied a lot, even all the schools were classified as well-performing according to the pre-evaluation. Some conclusions can be drawn on the major factors affecting the good performance:

- The size of the school, small schools were performing better than big ones.
- Self-sponsored ones are managing better, money and fundings are affecting a lot.

- Employed grounds man/ cleaner seems to be leading to better general condition of the facilities.
- Schools that have only UDDTs in the school and not old existing pit latrines are doing well.

The characteristics connecting the well performing schools are also indicating well managed utilization of urine and faeces in practise. This connection probably holds true in rural places where farming, even in schools, is common, and fertilizers need for improving the crops.

Table 14, *Comparison the monitored schools*

School	Size of the school (pupils)	the amount of functioning UDDTs	General condition of the UDDT facilities	additional pit latrines	Equipment of the UDDT facilities	Functioning hand washing?	In charge of O&M	Proofed utilization of urine or faeces?
Kendu Muslim Secondary	400	5	ok	yes (8)	A	Yes, but not next to the UDDTs	Employed caretaker	No
Hope and Kindness*	170	5	very good	no	A, LB, TP, S	Yes, the only one with soap	Two employees	Yes, treated faeces for agriculture
Kachan Primary	400	2	ok	yes (8)	A, LB	Water tanks, no rain water harvesting	Health Club	No
Siany Mixed Secondary	160	4 (for girls and teachers)	good	yes (2 for boys)	LB	Yes, a rainwater harvesting system	Employed grounds man	Yes, urine for tree planting
Radienya Primary	330	4	poor	yes (4)	A, LB	No, water tank was stolen	Health Club	Yes, vegetables
Kakichuma Primary	900	4 (for teachers and boys)	poor	yes (4)	A	No	No one	No, but banana trees
Eldoret Educational Centre*	180	4	very good	no	A, LB, TP	Yes, but no rainwater harvesting	Employed caretakers	yes, urine for agriculture
Khaimba Primary	900	2	ok	yes (10)	LB-	Yes, but	Health Club	yes, tree planting
Mumias Muslim Primary	1400	3	poor	yes (20)	A-	Yes, a water pump	Health Club	no

5.2 Acceptance, Social and Cultural Aspects

Acceptance and popularity of the UDDTs was high. Interviewed users, i.e. teachers and pupils, appreciated the design of the UDDTs, convenience of usage and absence of odours and flies. In general pupils prefer using UDDTs to pit latrines, as they are much more comfortable and not smelly. They are also safer and more reliable to use as there is no danger of collapsing or sinking, as have happened in some cases with pit latrines, especially during the rain seasons. Cultural issues did not seem to be affecting acceptance or implementation of the UDDTs. Some pupils were sceptical in the beginning of the implementation, about the whole concept and especially about utilization of urine and faeces. But in the end of the project they were convinced about the benefits relating to ecological sanitation and accepted even the utilization of urine and faeces. As people are facing notable problems with poor hygiene and sanitation in general, cultural issues seemed to have minor importance.

5.3 The Main Challenges

Despite high acceptance and popularity of UDDTs, also problems were observed. Main issues were blockages in urine pipes and absence of hand washing facilities or water. Also according to many researches a common problem related to O&M of UDDTs are blockages in urine pipes, overflow of urine tanks and misuse by visitors and/or men (Wakala and Wycliffe, 2010). If no ash is available or used on solid waste odours may occur. All these problems were also observed in the schools covered by this research.

In some cases of this study UDDTs in schools were closed, as there were some problems, caused by e.g. blockages or misuse, and which the school stuff could not solve. Minor worn outs on the superstructures were observed, e.g. fainted paint as well as broken or disordered doors and vault doors.

Soap was hardly available in any of the visited schools. Only Hope and Kindness, which gets donations from abroad, had soap mixed with hand washing water. In other schools soap was not available. The problem with a loose piece of soap is that it easily gets stolen. The importance of proper hand washing facility aside the built toilet facilities is shown for example in the impact evaluation of SWASH+ Kenya. The evaluation study found out that schools receiving new latrines had a higher risk for children to contaminate their hands with faecal matter, and therefore absence of proper hand washing facilities with soap leads to higher disease load of children compared to children in schools without sanitation facilities. If there are no sanitation facilities at the school, kids rather defecate at home with higher chances for washing hands at some point. This indicates that hand washing is highly important issue and more emphasis should be laid to take care of the hand washing facilities and availability of soap.

In this study all the schools had too few UDDTs to cover the recommended ratio i.e. for girls 1 UDDT for 25 pupils and for boys 1:30. But, the aim of Ecosan Promotion Project was to introduce and promote ecological sanitation in many schools in different

areas, not to provide them the required capacity. As there are only four UDDT units built for each school, and only few schools have built more, there were too few toilets in ratio to population of the pupils. Therefore most of the schools had pit latrines in use, in addition to the UDDTs. Some of the small schools had only UDD toilets. Too few UDDTs for pupils, leads to overload of the facilities, as most of the pupils prefer using UDDTs to smelly and unhygienic pit latrines. Further, overload of UDDTs possibly leads to quicker untidiness and unsoundness of the facilities. Urine containers fulfil very quickly as well as rubbish bins (if existing). Some schools had limited the amount of UDDT users by allowing only the oldest pupils use them. In some cases small pupils were reported having difficulties to use UDDTs correctly. One solution for the overload and misuse of the UDDTs would be investing waterless urinals. This was considered to be a good solution also by von Münch & Dahm (2009). This would lower the risk of male urinating into the faeces hole, or behind the UDDT cubicles, as well as shorten the queues. In some schools where queues to the UDDTs were long, boys went urinating behind the toilets, which might lead to premature weathering of the construction.

The need for sufficient amount of UDDTs for pupils is much more urgent than for teachers, as in most of the monitored schools there were hundreds of pupils but only few UDDTs for them. Building UDDTs also for teachers has been considered as a good way to introduce the ecosan systems and their benefits, as well as engaging the teachers to maintain the systems and probably extend them as well. For instance according to Deegener et al. (2009) this is one of the guiding principles of implementing ecological school sanitation. The issue that has not been considered, is the slow filling up of the containers due to few teachers that use the teacher's UDDTs and often mainly for urinating. This is wasting of capacity and not so rewarding. Perhaps one UDDT for all the teachers would be a good option instead of constructing two units for a dozen teachers, one for males and one for females. Few of the schools had a shared UDDT for both genders and there were no problems reported with that. One possibility could be that teachers and pupils use the same facilities, when teachers would also be better updated on the condition of the pupils' toilets.

Misuse was often caused by visitors, who were not trained to use UDDTs correctly. If many people, attending e.g. some big event, use school's UDDT facilities and for example urinate into the faeces hole, might the whole system be ruined. Therefore special arrangements for guests and visitors are required. There would be great potential to introduce UDDTs for visitors, and spread the knowledge of importance of hygiene and proper sanitation as well as about ecological sanitation in general. But this would need special arrangements and extra work load from the teachers or other school staff.

Several schools found the stairs of UDDTs the major design problem, as small or disable children, and also old teachers, find it hard to enter the toilets. In some cases the first step was higher than it was supposed to be as heavy rains have caused erosion which had drift soil away around the toilet constructions. One school (Kendu Muslim Secondary School) had applied a ramp system instead of the stairs for their new UDDTs

that were built after the EPP. In the same school UDDTs at the ground level with underground faecal chambers were under constructions.

Keeping gained ecosan and hygiene knowledge in the school despite the exchange of pupils and teachers is one challenging issue. It was observed to be one of the major problems in the monitored schools in Nyanza and Western provinces, as disappearance of the motivation and knowledge with the teachers was common. This often happened when the person in charge of sanitation, i.e. sanitary teacher, leaves the school. Teacher exchange is common in Kenya, and due to this it is not unusual that the person who has taken responsibility of the sanitation, and has the valuable knowledge, leaves the school. Disappearance of the knowledge could be prevented by engaging several persons from the school administration for taking responsibility of the sanitation.

Often schools were depending or relying on the GIZ implementation team also after the project. So, even they felt strong ownership of their UDDTs, they were still waiting for support and help in any case of problems. The schools should be encouraged to take full responsibility of their sanitation systems and independently sustain them and even develop the systems further. UDDT monitoring could be arranged also at the school level. The person who cleans the toilets, empties urine tanks or faeces vault, repairs a blockage, fills hand washing water tanks, utilizes ecosan products on the farm etc. could mark all the tasks in a maintenance list for instance, which would work as monitoring sheet for the UDDTs.

Figure 31 presents an impact chain of the main observed challenges and their relations.

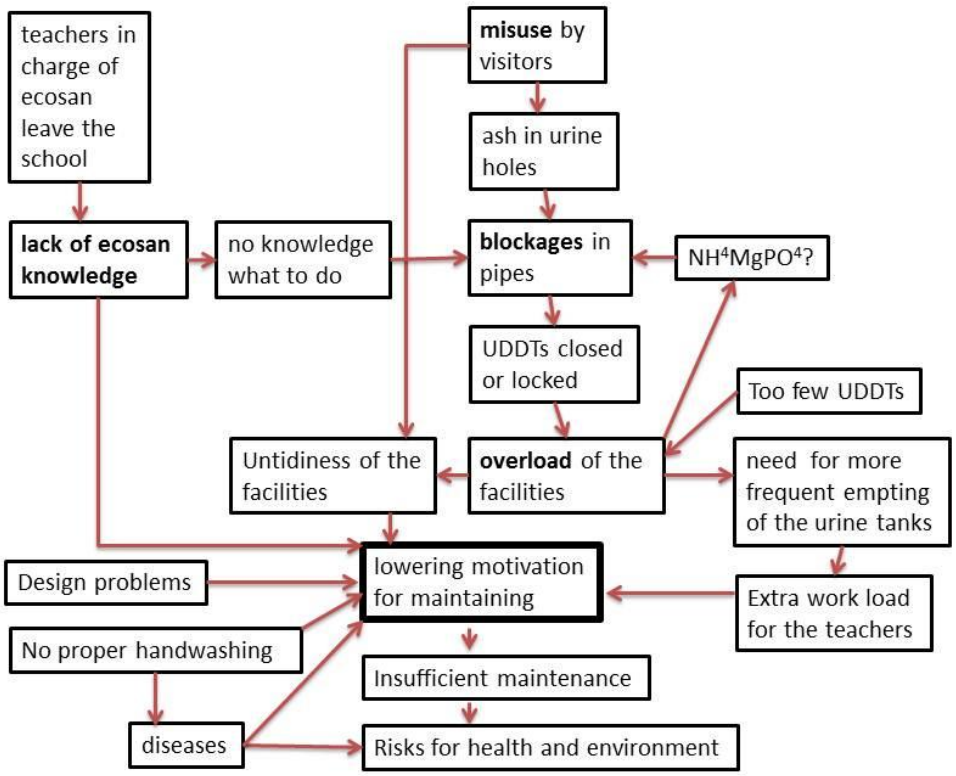

Figure 31, *Challenges of UDDts in a chain diagram.*

As a summary the main challenges and therefore the things needing improving:

- Blockages in urine pipes.
- Minor worn outs on the superstructures, e.g. fainted paint as well as broken or disordered doors and vault doors.
- Hand washing facilities, soap and availability of water.
- Amount of UDDTs was not sufficient. To cover the recommendations, 1 UDDT for every 25 girls, and equally for 30 boys, should be provided.
- Stairs of UDDTs were considered as a major design problem, as small or disable children, and also old teachers, find it hard to enter the toilets.
- Misuse was often caused by visitors, who were not trained to use UDDTs correctly.
- Keeping gained ecosan and hygiene knowledge and motivation in the school despite the exchange of pupils and teachers is one of the main challenges, as teachers exchange is common.
- Schools relying on the GIZ implementation team also after the project.

5.4 Operation and Maintenance

One of the main objectives under evaluation in this research was operation and maintenance of the UDDT facilities, as it is often the stumbling stone of the project sustaina-

bility. Common challenge is to create sufficient methods, incentives and motivation for maintaining the facilities, keeping them clean and functioning, managing and especially sustaining the systems well. Two different options for organizing O&M were observed; either an employed caretaker (grounds man, cleaner) or students together with help of their teachers were in charge of cleaning, litter disposal, small repairs, unblocking the pipes in case of blockages, provision of ash and possibly other items, emptying the containers and vaults, and utilizing fertilizers on the field.

According to Deegener et al. (2009) the best results are usually reported when at least one full-time-caretaker is responsible for the facilities. Good examples are also experienced with a team of caretakers cleaning in shifts. For bigger schools, minimum of two trained caretakers should be available, e.g. in case of illness or a holiday. A plan or a strategy for cleaning and maintaining is needed for the caretakers and cleaning staff to carry out regularly all the needed tasks. One option is that pupils clean the toilets (partly) themselves, but special care, training and monitoring are needed to secure the success. These same issues were also observed in this research, for instance the very best performing schools had an employed caretaker responsible for O&M. But all the schools cannot afford this, and on the other hand involving pupils (e.g. via Health Clubs) in the sanitation projects has several benefits, for example teaches them to take responsibility and involves them into important issues of hygiene and sanitation.

Schools should create a sustainable system for appointing and training persons who are responsible for operation and maintenance of the UDDT systems. In case the person in charge is about to leave the school, the knowledge should be transformed and responsibility named for another person. Ideal situation would be that there were several teachers who are in charge of sanitation (as for example in Kachan Primary School) so the system would be more secured and information stays more likely in the school. Also a manual or a simple handbook about ecological sanitation should be handed out in each school were ecosan facilities are constructed. This handbook could also include material and methods for training pupils and other teachers.

If the teachers are responsible for UDDT maintenance, they might have more work load than they want or can carry. In some cases, especially if UDDT products are not utilized, infiltering urine might be a good option. Particularly if toilets are overloaded and urine tanks should be emptied more frequently, teachers do not necessary have time to do that, and maintenance might suffer from neglecting. According to Tilley et al. (2009) soil infiltration of urine through a soak pit is a suitable option for UDDTs. This would mean no fertilizer production. On one hand fertilizer production was seen as a very important advantage of the UDDTs, in theory, but on the other hand in practise it often was not utilized.

5.5 Keys for the Success

Actual benefits received from ecological sanitation seemed to be important factors for motivating and engaging the schools into the ecosan and maintaining their UDDTs. One

important benefit seemed to be produced fertilizers, and therefore benefits for agriculture. But this was often perhaps only the idea in theory, and in practice other factors such as more convenient and hygienic toilets, healthier environment and saved space on the school yard, were the driving factors for motivation. Figure 32 presents the main success keys and their relations.

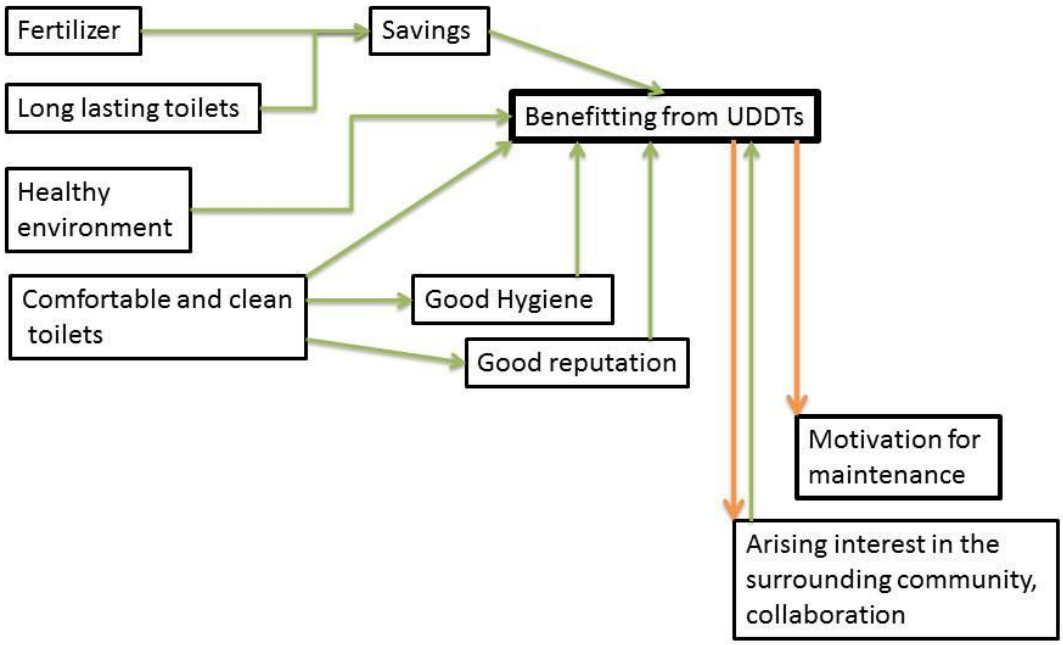

Figure 32, *Factors leading to benefits of UDDTs*

This research has identified a wide range of success and motivating factors leading to good performance of school sanitation. Below is a list of key success factors that uses the indicators of the toilet guideline by WHO/UNICEF (WHO, 2009) as a structure.

1. Sufficient toilets are available (according to the Kenyan standards)

- It was observed that in bigger schools the 4 toilets were exposed to an overload of users due to the low total numbers of toilets available in the school. Additionally pupils were interested to use new facilities instead of existing ones. The overload of facilities lead to quicker untidiness and unsoundness of the facilities e.g. blockages of urine pipes. On the contrary the two self-sponsored smaller schools of “Hope and Kindness” and “Eldoret” have a ratio of UDDTs to pupils of about 1: 40 which is close to the recommended standards. Here the overload of facilities was rarely observed. In addition to the Kenyan standards the authors recommends to implement also girls urinals.

2. Toilets are easily accessible
    - The access to the toilets was in general sufficient, even though smaller kids and older persons had problems with climbing the stairs.

3. Toilets provide privacy and security
    - Doors had functional locks inside providing privacy, were gender separated and located appropriately.

4. Toilets are appropriate to local conditions
    - UDDTs are clearly a better solution considering the local environment with (e.g. flooding or rocky soil)
    - Saved space on the school yard due to permanent toilets.
    - Clean communication and high expectations on the benefits of utilization of UDDT fertilizer in agriculture since subsistence agriculture is the main income source.
    - Involvement of surrounding communities

5. Toilets are hygienic to use and easy to clean
    - UDDT facilities are more comfortable (no odors, flies, no risks of collapsing) compared to e.g. pit latrines.
    - Hygiene has improved thanks to UDDTs, hand washing facilities are better.

6. Toilets must have convenient hand washing facilities nearby
    - Hand washing facilities must be firmly fixed to avoid stealing or misplacement and be flanked by an O&M that can mobilize resources for repair and purchase of soap in time (only witnessed in one school).

7. O&M - A cleaning and maintenance routine is in operation
    - Employed caretakers have provided the best results.

With regard to the shortcomings and challenges in the EPP supported schools there are additional factors that seem to have great importance for the success of school sanitation:

8. Affordability of facilities
    - Some schools had built more UDDT facilities, and many would like to, but the question is finding funding for that. The provided design by EPP was meant to promote the technology with attractive features and high quality. However for schools to replicate the technology it is necessary to showcase low-cost options that are more affordable to schools and their communities.
    - All schools that have constructed their UDDTs themselves, thus were toilets could be afforded, the ownership was high and the performance was comparatively the best. In the GIZ supported schools with no contribution by the school or parents-teachers association the performance was comparatively poor.

9. Keeping the knowledge of O&M in the school despite teacher exchange
    - Several teachers should be trained and in charge of sanitation
    - Provision of a manual or a simple handbook about ecological sanitation and operation and maintenance routines should be easily available in the schools – this was lacking in the all schools, but was frequently demanded.

10. Keep additional work load of the teachers low
    - Reducing O&M tasks of UDDTs by e.g. , infiltrateringng urine might be a good option.
    - Employed caretakers take over responsibility (see point on O&M)

11. Modification of technical design to reduce urine pipe blockages

Involving community was observed as an important factor for example in Siany Mixed Secondary School, where teachers' committee of the community was supporting the school and their ecosan project and therefore the surrounding community was also linked to the ecological sanitation issues, and good results were observed. Besides teachers and pupils all the other stakeholders (caretakers, parents, and community members) should attend to trainings and be involved into ecological sanitation. To result in good maintenance and correct treatment and utilization of the UDDT products, groundskeepers, cleaners, farmers or other employees should always be trained.

Importance of community involving and was also stated by Müllegger and Freiberger (2010b) and their experiences on the field. According to their results the success of the UDDT projects can be explained by two main reasons. First of all, the important stakeholders should be involved in the planning of the projects from the very beginning. In this manner the systems will be designed as wished by the institutions and a strong feeling of ownership and responsibility for the facilities will be created. Secondly, benefits from the system, i.e. incomes via producing fertilizer, are a remarkable issue.

The main economic benefits in long run should be underlined for school administration, as many principals and head teachers considered UDDTs as an expensive option compared to traditional sanitation methods, i.e. pit latrines, which do have lower expenses in the beginning, but, as they last only a relatively short time, the total costs will be higher compared to UDDTs.

Utilization of the UDDT products varied a lot among the schools. Some schools utilized urine for tree planting, some for large scale farming. Some schools preferred using treated faeces as soil conditioner for fields. According to many interviewed teachers UDDT products were used on the school farm, but in practise it did not always seemed to be true. The very best performing schools had large scale agricultural activities (Hope and Kindness, Eldoret Educational Centre, both self-sponsored), or were utilizing UDDT products in tree planting (Siany Mixed Secondary School). These schools valued naturally produced and free fertilizer highly and considered it as a very important benefit of the UDDTs. These schools proved that good results in practice lead to

good motivation, which leads to deeper engagement and to continuity. These schools also had a possibility and capacity to employ one or more persons for managing O&M.

The success factors lead to the appreciation of UDDTs and their superiority to pit latrines which in turn generates extra motivation to maintain toilets well. This has also lead to the situation that schools have gained a good reputation on ecosan in surrounding communities which they want to preserve It was also observed that some teachers and Health Clubs were highly motivated by the fact that they could take over responsibility of ecological sanitation. The prospect of benefitting UDDT fertilizers in school farms and surrounding agriculture has initially lead to a high motivation but did not show a long-term effect. Most of the 73 schools have not implemented the reuse of human excreta from UDDTs even though this was the primary interest at the outset of the project.

The factors mentioned above are listed in a table in Appendix 4 which summarizes the main factors for motivation underlined in each school.

5.6 Reliability of the Results

Field researches based only on few interviews and observations have some difficulties concerning the data collection. First of all, the results from the interviews should be concerned with a hint of caution. Teachers wanted perhaps to give a pit too positive picture about functioning of their ecosan systems. For example utilization of urine and faeces was not probably as large scale as teachers often claimed. Also condition of the UDDT facilities did not always support the statements that the interviewed teachers gave about the maintenance. Therefore, the statements that this research is relying on, are not 100% liable. To get more realistic overview about the actual situation on the field, even more accurate research and detective work should be done. More specified and detailed questions, preferably for several persons, should be carried out.

6 CONCLUSIONS

The aim of this research was to monitor and evaluate EPP UDDTs, their condition, acceptance and use, O&M, utilization of urine and faeces as well as figure out the existing challenges and keys for success. In general only a small portion of the constructed UDDTs in 73 schools are performing well. Not even all of the monitored 10 schools that were expected to manage well were doing such a good job in practise. The main challenges originate from problems with the exchange of teachers leading to disappearance of the ecosan knowledge from the schools, overload of the facilities, and incorrect use. The research has also shown that certain success factors play vital role for the sustainability of a school sanitation project in rural Kenya. These are (a) sufficient amount of toilets for pupils, (b) self-financing of toilet construction by the school (ownership) and (c) the employment of grounds man / cleaners for regular daily cleaning and operation of the facilities.

All the involved stakeholders such as schools, pupils, teachers, parents and other community members as well as local administration have heard and also seen in practise how ecological sanitation works and are convinced about its goodness. Few schools have built more UDDT facilities, and many would like to, but the question of funding remains due to insufficient financial capacities by the schools. As the aim of the Ecosan Promotion Project was to promote and introduce ecological sanitation, and not to upscale, there is a lack of an enabling environment to enable interested households, schools and public institutions to venture into ecosan. In general schools are a challenge for sanitation but ecological sanitation can provide a good solution if schools are enabled to build affordable designs and get assistance in training on the management of sanitation facilities.

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APPENDIX 1

Monitoring Sheet – Field Observations

School	**Date**

1. Hygiene

1.1 Are there facilities for hand washing? What is the water source? Is water available? How about soap?

1.2 What is the condition of hand washing facilities?

2. Sanitation

	Girls	**Boys**	
2.1 Number of toilet cubicles in use			Enough? Ratio 1:25/ 1:30
2.2 Number of urinals in use			
2.3 Number of toilet cubicles **not** in use			*blocked/locked/damaged*
2.4 Number of urinals **not** in use			*blocked/locked/damaged*
2.5 Number of pit latrines in use?			

	Good	**Bad**
2.6 Condition of superstructure		*Holes, cracks, vandalism*
2.7 Conditions of the floor		*Cracked, uneven, poor drainage*
2.8 Conditions of the doors		
2.9 Conditions of drying chambers		*Damaged doors, cracks, no container for faeces*
2.10 Conditions of the urine tanks		*damaged, not in place, leaking/overflowing*
2.11 Condition of the hand washing		
2.12 Cleanliness		

2.13 Are additives available? *Ash / Sawdust / Soil? Available in each toilet cubicle?*

2.14 Are the doors lockable?

2.15 Is the design appropriate for children? *(Small children: the size of the drop hole and squatting pan; children with disabilities)*

2.16 Smell in the toilet: *Tolerable / Intolerable? Flies around?*

2.17 Faeces in the container

Dry / Wet / Mixed with not degradable material (plastic…)

2.18 Urine tank

How full? / Smell? / Flies?

2.19 Blockages in urine pipes?

2.20 Obvious improvements needed? (Cleaning, emptying, unblocking, repairs, other)

3 Reuse of urine and faeces

3.1 Have the urine containers been emptied? And urine utilized?

3.2 Have the faeces vaults been emptied? Is one of the vaults of the double system in use and the other one storing?

3.3 Is there a school garden?

APPENDIX 2

Questionnaire – Teachers

School	**Date**
Interviewed teacher	**email**

1.1 Number of pupils: total / girls / boys
1.2 Age range of students

2 Usage of the Ecosan toilets, social and cultural issues
2.1 Describe the toilet conditions before and after the Ecosan project. What has changed?

2.2 Do the students use the toilets? If they don't, what are the possible reasons?

2.3 Are there negative attitudes among the students towards the usage of UDDTs? Why?

2.4 Are there some cultural or tribal issues that possibly hinder students from using UDDTs?

2.5 Do the students know the importance of the new toilets and hygiene?

2.6 Were the students trained / informed about the right usage of the toilets? How were they trained?

2.7 When new students come, how are they informed about the usage of the toilets?

2.8 Do the students wash their hands after using the toilet? Why/ why not?

2.9 In your opinion, do you think that the toilet facility brought some health benefits to your school?

2.10 What recommendations would you make to improve the toilets?

3 Girls
3.1 What do the girls do when they have their menstrual periods?

3.2 Do the current conditions meet the needs of the girls who are menstruating?

3.3 Where do the girls dispose their menstrual pads?

4 Questions on operation and maintenance

4.1 Who is responsible for maintenance of the toilet facilities?

4.2 Payment / motivation?

4.3 What are the maintenance duties and how often are they carried out? (Cleaning, ash provision, small repairs, unblocking pipes, empting urine tanks etc.)

4.4 How are dispose sanitary pads and other non-decomposing material removed? (Burned / thrown in pit / buried)

4.5 How Is the hand washing arranged if there is no rain water available?

4.14 What have been the major problems with operation and maintenance?

5 Questions on utilization of urine and treated faeces

5.1 How and for how long is urine stored? What happens after the storing?

5.2 If urine used as fertilizer, for what is it utilized?

5.3 How and for how long is faecal material stored? What happens after that? (*Further treated? Utilized as soil conditioner or fertilizer?)*

5.4 Who is doing implementation of the fertilizers on the field? Are health-reduction measures used?

5.8 What have been the major problems considering utilization of urine and faeces?

6 Questions on project implementation

6.1 Are you satisfied with the support you got by the project implementation team? Has there been enough trainings and information?

6.2 Did the school participate in the:

a) Selection and design?
b) Construction of the facilities?

6.3 Was there any contribution to the construction costs by the school (in cash and/or in kind of...?)

6.4 Were there any subsidies paid? (Was Water Services Trust Fund involved?)

6.5 What is the status of the ownership? Who owns the toilets?

6.6 Is there still contact with the project implementation team? When was their last visit?

APPENDIX 3

Questionnaire – Pupils

School	**Date**

1 General Data

1.1 Gender: □ female □ male
1.2 Age:

2 Questions on the toilet facility

2.1 How important do you find the issues below? Please cross.

	Important	*Not so important*	*I don't know*
Toilets are clean.			
Toilets don't smell bad.			
There are no flies in the toilets.			
Toilets are easy to use.			
There is privacy to use the toilet.			
Hand washing is possible.			
There is soap available.			

2.2 Which toilet do you like better, the old pit latrines or the new Ecosan toilets (UDDT)? Please give reasons why?
2.3 Are there any problems with the Ecosan toilets concerning the issues below? Please write yes/no:
2.4 Do you use the UDDT toilets? Please give reasons: Why, or why not?
2.5 Do you ever wait to go to the toilet until you are home? Why?
2.6 Do you wash your hands after using the toilet? Why/ why not?
2.7 What do you think about using products from the toilets (for example urine) as fertilizer?
2.8 Do you believe that urine and treated feaces are **good** fertilizers?
2.9 Do you think there is a health risk to use treated faeces and urine as fertilizer? Why?
2.10 Would you be interested to join a student club that would take care of the operation of the toilets?

APPENDIX 4

Motivating factors that were found important in each of the monitored schools.

	Kendu Muslim	Hope and Kindness*	Kachan	Siany	Radienya	Kakichuma	Eldoret *	Khaimba	Mumias
Comfortable facilities	X	X	X	X	X	X	X	X	X
Appreciation towards UDDTs	X							X	
Maintaining the good reputation	X		X					X	
Fertilizer		X		X			X		
Possibility to use fertilizer	X		X		X				
Improved hygiene, better hand washing facilities		X			X				
Saved space in the long run			X				X		
Motivated Health Club					X				
UDDTs clearly better solution considering the local environment				X		X			
Motivated teachers.				X			X	X	
Support from the communities				X					
Equality for girls / disable children	X								
No financing difficulties		X					X		
Financial benefits				X					