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COMPARING COST DATA OF DIFFERENT TOILETS IN PERI URBAN AREAS OF DEVELOPING COUNTRIES (ETHIOPIA, KENYA, TANZANIA, UGANDA AND NEPAL)

Diploma Thesis
Awarding the Academic Title
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Abbreviations

ARB	Anaerobic Baffled Reactor
ARI	Acute Respiratory Tract Infection
BoQ	Bill of Quantity
CW	Constructed Wetland
DNA	Deoxyribonucleic Acid
DPC	Damp Proof Course
DWAF	Department Water Affairs and Forestry
DWSS	Department of Water Supply and Sewerage
Ecosan	Ecological Sanitation
ENPHO	Environment and Public Health Organization
E&T	Emptying and Transport
FWS CW	Free Water Surface Constructed wetland
HDPE	High Density Poly Ethylene
HSF CW	Horizontal Surface flow Constructed Wetland
IYS	International Year of Sanitation
MGD	Millennium Development Goal
O&M	Operation and Maintenance
PVC	polyvinyl chloride
RCC	Reinforced Cement Concrete
ROSA	Research- Oriented Sanitation concepts for peri-urban areas in Africa
SDC	Sewer Discharge Station
UASB	Up flow Anaerobic Sludge Blanket
UDDT	Urine Diverting Dry Toilet
UDFT	Urine Diverting Flush Toilet
UDPF	Urine Diverting Pour Flush
UN	United Nation
VF CW	Vertical Flow Constructed Wetland
VIP	Ventilated Improved Pit
WHO	World Health Organization
WSSCC	Water Supply and Sanitation Collaborative Council

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Zusammenfassung

Um Menschen ein gesundes Leben zu ermöglichen, ist die Entwicklung von funktionierenden Sanitärsystemen ist von größter Notwendigkeit für jedes Land. Außerdem kann dadurch das Risiko der Übertragung von Durchfall durch Dritte verringert werden.

Sanitäre Einrichtungen in einem Land beziehen sich auf verschiedene Aspekte. Einer der wichtigen Kennzahlen ist der Anteilder Gesamtbevölkerung, die Zugang zu WC-Anlagen hat. In Entwicklungsländern jedoch, bestehen viele Schwierigkeiten bei der ordnungsgemäßen Bewältigung menschlicher Ausscheidungen. Die Urscahen dafür sind unter anderem das geringe Pro-Kopf-Einkommen und der Mangel an Fachkenntnissen für die Errichtung angemessener Toiletten.

In dieser Studie werden verschiedene Toilettentypen in Äthiopien, Kenia, Tansania, Uganda und Nepal diskutiert. Die Errichtungskosten von verschiedenen Typen von Toiletten in allen Staaten werden auf Prozentbasis mit dem Pro-Kopf-Einkommen des Landes verglichen Bei der Klassifizeirung des Toiletten und bei der Entwicklung der Vorlagen zum Kostenvergleich wurde das von der EAWAG entwickelte “Compendium of sanitation systems and technologies“ (Tilley et al., 2008) verwendet.
Das Resultat dieser Arbeit zeigt, dass unter den verschiedenen Toilettentypen Urin-separierende Trockentoiletten (Urine-Diversion Dry Toilets, UDDTs) in allen Ländern verbreitet sind und als am Geeignetsten in den fünf Ländern befunden wird. In Äthiopien sind die Errichtungskosten für den Grundbau am niedrigsten (24,7 %) und für die Errichtung des Überbaus am höchsten (75,3 %). In Nepal ist das Verhältnis umgekehrt: Kosten des Unterbaus (73,3 %) bzw. Kosten des Überbaus (26,6 %). Auf Basis des Pro-Kopf-Einkommens, sind UDDTs in allen Ländern erschwinglich, da die Gesamtkosten für die Errichtung der Toiletten nicht höher als 45 % des Pro-Kopf-Einkommens sind.

Unter den verschiedenen Toilettentypen sind UDDTs nicht nur häufig in allen Ländern anzutreffen, sondern - wegen ihrer Erschwinglichkeit und Eignung für verschiedenste Bodenarten - auch zweckdienlich, günstig und praktisch. Folglich handelt es sich bei diesem Typ um eine ökologisch und hygienisch gut geeignete Toilette im Vergleich mit anderen Toilettentypen.

Abstract

Development of proper sanitation system is utmost necessary for any country in order to make the people healthy and prevent from being illness, diseased and control deaths. Similarly, it helps to control environment degradation.

In the study, different types of toilets in Ethiopia, Kenya, Tanzania, Uganda and Nepal are discussed. The costs of construction of common toilets in all countries are compared based on percentage and per capita income of country. According to the source of availability of costs data, various types of toilets in Nepal are discussed and the costs of other toilets in Nepal have been compared. System templates presented by TILLEY et al. (2008) were referred. Templates of BoQs of different types of toilets have been developed based on the list of technologies derived from EAWAG "Compendium of sanitation systems and technologies" (Tilley et al., 2008).

The results of this thesis show that among various types of toilets, UDDT is found as appropriate toilet in all five countries. UDDT is beneficial to all countries but percentagewise it is much benefited to Ethiopia in comparison to other four countries as the cost of construction of Substructure is lowest (24.7%) and highest (75.3%) in the construction of Superstructure in Ethiopia while highest in the construction of Substructure (73.3%) and lowest in the construction of Superstructure (26.6%) in Nepal. Based on per capita income, UDDT is affordable in all countries as the overall cost for the construction of the toilet does not exceed 45% of the per capita income.

Therefore among various types of toilets UDDT is not only common toilet in all countries but also appropriate, beneficial and convenient toilet because it is affordable, suitable in all soil condition, ecological sanitation and hygienic toilet in comparison to other toilets.

Keywords: Sanitation, types of toilets, developing countries, cost of construction, UDDT, Substructure , Superstructure

1. Introduction

'Proper Sanitation' plays a great role not only in the daily life of a man but to the existing environment also. Therefore governmental and non-governmental organizations of many developing countries are focusing to sustain proper sanitation either carrying out/supporting 'Hand Wash, Mosquito Net Programme or by initiating 'Counseling Programme' for the people to build toilet in their homes in order to reduce morbidity and mortality of all the age groups and to contribute to improved healthy growth and development. Sanitation has been prioritized in the Millennium Development Goal (MDG) also. 'Proper Sanitation' also has been proved as one of the most effective preventive measure of public health program of any country. Sanitation refers many things e.g. hand washing, cleanliness, water treatment etc. The study is dealt with the management of human excreta, technologies applied for construction, cost of construction of toilets and comparing costs of different toilets in five developing countries Ethiopia, Kenya, Tanzania, Uganda and Nepal.

The sanitation of a country indicates the total population with access to some kind of toilet facilities. The toilets constructed in some parts of a country really work well and some parts could fail to meet the required level of hygiene. So a toilet has to be technically constructed. It is necessary to increase the toilet coverage and its accessibility by the depth of understanding of community to ensure usage and sustained behavior. In developing countries, due to low per capita income people cannot construct a toilet of high cost. Toilets of low cost and hygienic are more appropriate in developing countries.

Poor management of human excreta is the main cause of poor sanitation. It has to be managed properly. The sanitation practices in developing countries promote the human excreta either hide and store in a deep pits or flush away or discharge or diluting them in rivers, lakes and sea. Though the hide and store of human excreta system costs low comparatively, it has many drawbacks. It is unhygienic as it produces odor and attract flies. It is not possible in high populated area, periodically flooded area, rocky area and the area where ground water level is high. It requires access to open area and digging of new pits once it is filled. The flush and discharge system requires large amount of water. It is not possible in the place where water scarcity has. In addition if it is discharged in river or lake, water resources will be contaminated. The discharging system of excreta requires pipe network. All municipalities cannot invest for pipe network and treatment plants. If human excreta are utilized in agriculture to enrich the soil after treatment, toilet will be environmentally friendly. This is a way by which we can complete the loop of nutrients cycle, conserve water and surrounding environment.

The importance of improved sanitation in safeguarding the health and wellbeing of human kind is well documented (WHO, 2001; Cairncross, 2003; WHO, 2004; Moe and Rheingans, (2006). The British Medical Journal (2007) reported that according to a survey of 11,000 global respondents, sanitation engineering represented a health breakthrough greater than the discoveries of antibiotics, anesthesia, vaccines and DNA, and public sanitation was the greatest medical breakthrough since 1840, giving sanitation recognition in saving human lives and reducing poverty. According to Vision 21, sanitation is a basic human right, and one of the major components of poverty eradication (WSSCC, 2000). Globally, at least 2.6 billion people lack access to basic sanitation (WHO, 2004) and more than 90% of the sewage in developing countries is discharged untreated (Esrey 2001; Lanergraber and Muellegger, 2005).

UN MGD was published in 2000. Among the eight main goals and several sub targets, there was target 10, which claims to halve the proportion of people without sustainable access to safe drinking water and basic sanitation supply by 2015 (UN Millennium Project 2005). According to the UN’s World Water Development Report 3 (2009), however, the portion of people without improved sanitation has only decreased by eight percent between 1990 and 2006. Based on current trends in 2015, around 2.4 billion people won't be served with adequate sanitation infrastructure. So, in order to achieve the target, immediate acceleration in progress is needed. Recognizing the risk that the MDG on sanitation may not be achieved and the fact that sanitation affects other MDGs directly and indirectly, the UN declared 2008 to be the International Year of Sanitation (IYS), in order to raise sanitation awareness amongst UN and other donor agencies, governments and civil society.

The lack of access to improved sanitation potentially contributes to environmental pollution together with its consequences to society. In situations where sanitation is lacking, human excreta may accumulate around homes, in nearby drains and in garbage dumps, leading to environmental pollution (Kulabako et al., 2007). The full range of technical options for providing adequate basic sanitation is still not widely known nor are the characteristics of the different options well understood. Particularly, there is little appreciation of long-term financial, environmental and institutional implications of operating and maintaining the various sanitation systems. As a result, in many cases, communities and local governments are choosing technical options that, in long term, are unaffordable and/or unsuitable.

According to DWAF (2007), challenges arise from the wide range of options available and the differing environments and conditions to which each is suited. On the base of experiences of some places, it is important to allow local involvement in the choice of solutions, with a full grasp of the requirements of each option. The options include the Ventilated Improved Pit (VIP) toilet in all its variations, Composting toilets, Dehydration type toilets, Onsite wet system such as Aqua privies and Septic Tanks, and a range of full water borne systems. The choice of technology is not only based on the technical aspects of each technology, but also on the factors as permanent of the settlement, financial costs and affordability, design life, expectations and preferences, institutional capacity, the potential for job creation and environmental consideration.

2. Objectives

The main objectives of this study are to collect and compare cost data for different toilets technologies applied in the four African pilot cities of the ROSA project (i.e. Arba Minch in Ethiopia, Nakuru in Kenya, Arusha in Tanzania, and Kitgum in Uganda) and in Nepal. Additionally templates for bill of quantities should be tested and adapted.
The other objective is to find an appropriate type of toilet in peri urban areas among the five developing counties (Ethiopia, Kenya, Tanzania, Uganda and Nepal).

3. Fundamentals

The choice of technology is very important factor for the construction of toilets because it directly affects in the cost and proper management of human excreta. Further to this, choice of technology also depends on the soil condition of that area and the economic condition of the community or people. The most important things to be considered are construction of 'Toilet' and the technology chosen by the people. However, the construction must be done in a way that could promote community ownership and create job.

3.1 Sustainability of Sanitation System

According to DWAF, the sustainability of Sanitation system refers to a proper Sanitation system which has to be developed in every house in order to live long healthy life and to protect environment. Therefore priority has to be given for the sustainability of proper sanitation by each individual, community and by the country. High priority has to be given in the most public health programmes e.g. Diarrhea, Acute Respiratory Tract Infection (ARI), and Immunization etc. According to DWAF (2007), the sustainability of a sanitation system is the most important consideration while selecting a specific technology option for a community. Sustainability refers not only the measures to minimize breakdowns and costs in the operation of a scheme, but also refers to measures to be taken to maximize its positive social impact while minimizing any negative environmental impacts. Some of the key requirements for promoting sustainability of sanitation systems and their relationship to choice of technology are as discussed in below.

3.1.1 User education and participation in technology choice

In the developing countries constructions are often done without consulting technical experts. This type of practices is huge in rural areas than in urban areas. The reasons beyond this may be the unavailability of technical person or the lack of knowledge of the people for consulting with expert. Therefore, government should make aware the people about proper sanitation and provide relevant assistance (technologies) and information. People have to be provided opportunities to take part in decision making in the development of their area. Then, people of the community will consult with the technical experts. The responsibility of a local authority is to provide a necessary level of user education on the proper use, care and maintenance of the selected sanitation technology. It could vary and depends on the system to be installed. The user education has to be extensive when the responsibility of a household or community for the operation and maintenance (O&M) is higher and the tarrifs and municipal O&M cost are lower. Likewise, when the institutional responsibility for the O&M is higher, the need of monitoring of the system by local authority is higher and the users have to provide necessary resources for O&M and effective cost recovery.

3.1.2 Health and hygiene promotion

Health and hygiene promotion is a public health concern. Therefore, line agencies relating to public health has to give priorities in their own policies and programmes for its promotion. At the local level also, it is the responsibility of local authorities to implement a health and hygiene programme. The factors need to address for the promotion of health and hygiene are safe disposal of human excreta along with composted wastes, practices of personal hygiene, importance of clean toilet, food hygiene, keeping stored water and clean and hygienic, safe disposal of wastewater and implications of inappropriate hygiene practices and associated diseases.

3.1.3 Operation and maintenance (O&M) tasks and plant equipment availability

Normally, households are responsible for the O&M of the sanitation system components located in their own area. The municipality/village development committees or units may provide support of undertaking bigger tasks such as pit or septic tank emptying, moving top structures or unblocking sewers. It is the responsibility of local authority for providing available equipment, handling sanitation wastes and ensures transport, treatment and disposable facilities. The emergency procedure is also the responsibility of local authority, so they have to address as the ongoing O&M requirements. For emptying pit or tank, some factors has to be considered such as availability of suitable emptying equipment, accessibility of pit or tank for emptying equipment, proximity to local treatment facility or suitable disposal arrangements, suitability of emptying strategy, provision for recurrent expenditure etc.

3.1.4 Cost Recovery

The recurrent costs for level of services to be identified and developed by concerned authorities at all levels. Budget should be allocated every year and priority has to be given for O&M during planning as a continuous activity. The O&M cost is itself a continuous activity which associated with other programmes e.g. education, hygiene and sanitation, environment etc. Issues regarding the cost recovery, awareness and the implications of non-payment must be addressed as an ongoing basis, then, it itself constitutes an O&M cost. The factor which is needed to be considered includes affordability in the medium to long term, willingness to pay, emergency sources of funding, subsidy policies (pensioners, disabled, etc.) and availability of equitable share for subsidy of the poor.

3.2 Sanitation System

A sanitation system does not consist of a single technology. According to the Compendium of Sanitation Systems and Technologies, 'Sanitation System' is a multistep process in which wastes are managed from the point of generation to the point of use or ultimate disposal. A complete sanitation system is comprised of wastes or products which travel through functional groups and contains a chain of technologies that can be selected according to the context. 'Sanitation System' includes management, operation and maintenance required by ensuring that the system functions safely and sustainably. A logical sanitation system can be designed by selecting an appropriate technology for each product from each applicable Functional Group.
Following TILLEY et al. (2008) and their Compendium on Sanitation, the following functional groups can be identified, with each representing one step within the sanitation process.
The Functional Groups presented in Sanitation technologies are

1. User Interface (Technologies U1-U6) : Red
2. Collection and Storage/Local Treatment (Technologies S1-S12) : Orange
3. Conveyance (Technologies C1-C8) : Yellow
4. (semi-) Centralized Treatment (Technologies T1-T15) : Green
5. Use of products/disposal (Technologies D1-D12) : Blue

1. User Interface (U) describes the type of toilet, pedestal, pan, or urinal that the user comes in contact with; it is the way that the user accesses the sanitation system. In many cases, the choice of User Interface will depend on the availability of water. It is to be noted that grey water and storm water do not originate at the User Interface, but may be treated along with the Products that originate at the User Interface. It includes Dry toilet, Urine Diverting Dry Toilet (UDDT), Urinal, Pour Flush Toilet, Cistern Flush Toilet, Urine Diverting Flush Toilet (UDFT) and Tippy Tap.

2. Collection and Storage/Local Treatment (S) describe the ways of collecting, storing, and sometimes treating the Products that are generated at the User Interface. Treatment that is provided by these Technologies is often a function of storage and usually passive (e.g. no energy inputs). Thus, Products that are 'treated' by these Technologies often require subsequent treatment before use or disposal. It includes Storage Tank, Single Pit, Single Ventilated Improved Pit (VIP), Double Ventilated Improved Pit, Fossa Alterna, and Twin Pits for Pour Flush, Dehydration Vaults, Composting Chamber Faecal Septic Tank, Anaerobic Baffled Reactor (ABR), Anaerobic Filter and Anaerobic Biogas Reactor.

3. Conveyance (C) describes the transport of Products from one Functional Group to another. Although Products may need to be transferred in various ways between Functional Groups, the longest, and most important gap is between Collection and Storage/Treatment and Semi- Centralized Treatment; thus, for simplicity, conveyance is limited to transporting Products at this point. It includes Jerrycan - tank, Human-Powered Emptying and Transport, Motorized Emptying and Transport Faecal Simplified Sewers, Solids-free Sewer, Conventional Gravity Sewer, Transfer Station (Underground Holding Tank) and Sewer Discharge Station (SDS).

4. (Semi-) Centralized Treatment (T) refers to treatment Technologies that are generally appropriate for large user groups (i.e. multiple households). The operation, maintenance, and energy requirements for Technologies within this Functional Group are more intensive. The Technologies are divided into 2 groups: Technologies T1–T10 is primarily for the treatment of black water, whereas Technologies T11–T15 is primarily for the treatment of sludge. It includes Semi centralized Anaerobic Baffled Reactor, (semi) centralized Anaerobic Filter Faecal Waste Stabilization Pond (WSPs), Aerated Pond, Free-Water Surface Constructed Wetland, Horizontal Subsurface Flow Constructed Wetland, Vertical Flow Constructed Wetland, Trickling Filter, Up flow Anaerobic Sludge Blanket Reactor (UASB), Activated Sludge, Sedimentation - Thickening Ponds, Unplanted Drying Beds, Planted Drying Beds, Co-composting, Anaerobic Biogas Reactor and Struvite Recovery.

5. Use of products/disposal (D) refers to the methods in which Products are ultimately returned to the environment, as either useful resources or reduced-risk materials. Furthermore, Products can also be cycled back into a system (e.g. the use of treated grey water for flushing). It includes Fill and Cover - Arborloo, Application of Urine: Application of Dehydrated Faeces, Application of Compost - Eco-Humus, Biogas for energy, Irrigation, Soak Pit, Leach Field, Aquaculture Ponds, Floating Plant (Macrophyte) Pond, Water Disposal - Groundwater Recharge, Land Application of Sludge and Surface Disposal.

3.3 System Template

A system template defines a suite of compatible Technology combinations from which a system can be designed. Each System Template is distinct in terms of the characteristics and the number of Products generated and processed. The System Templates present logical combinations of Technologies, but the planner must not lose a rational engineering perspective. It must also be noted that although the Compendium is thorough, it is not an exhaustive list of Technologies and associated systems. 'System Templates' are predefined and the compendium user has to select the appropriate Technology from the options. The choice should be based on the local environment, culture and resources, is a context specific. System Templates 1 to 8 range from simple with few choices of technology and products to complex with multiple choices of technology and products. According to the Compendium of sanitation, there are eight different System Templates. In the system templates, the bold line with arrow are lined with the most functional groups for a given Input or output whereas the thin lines indicate other possible flow streams.

System 1: Single Pit System
System 2: Waterless System with Alternating Pits
System 3: Pour Flush System with Twin Pits
System 4: Waterless System with Urine Diversion
System 5: Black water Treatment System with Infiltration
System 6: Black water Treatment System with Sewerage
System 7: (Semi-) Centralized Treatment System
System 8: Sewerage System with Urine Diversion

3.3.1 Single Pit System

The Single Pit System is suitable in the rural and peri-urban area where the soil condition is appropriate for digging and also the Effluents are absorbed. This system is chosen in the area where is enough space for further digging the pit continuously, once the pit is filled and disposes the Faecal Sludge. This is not possible in urban dense populated area. This system is suitable in the area where there is no prone of high rainfall and flooding as the excessive water may shorten the life of the pit and overflow the pit. This is a low cost technology system to construct and maintenance cost is considerable, that depends on the depth of the pit. It depends on how often the pit can be emptied which is related to the absorptive capacity of the soil of that area.

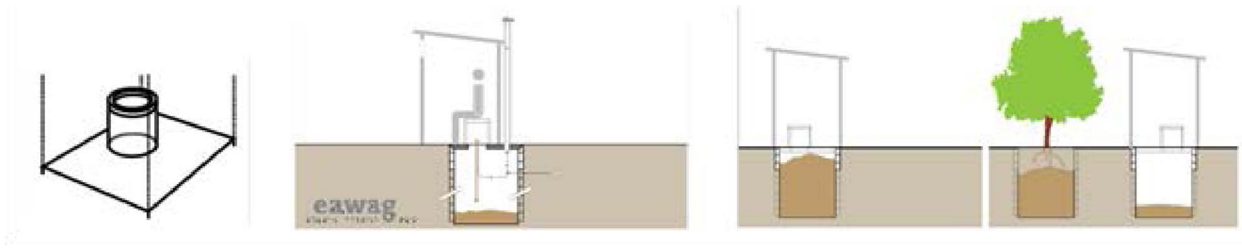

Figure 1 Single Pit System (TILLEY et al., 2008)

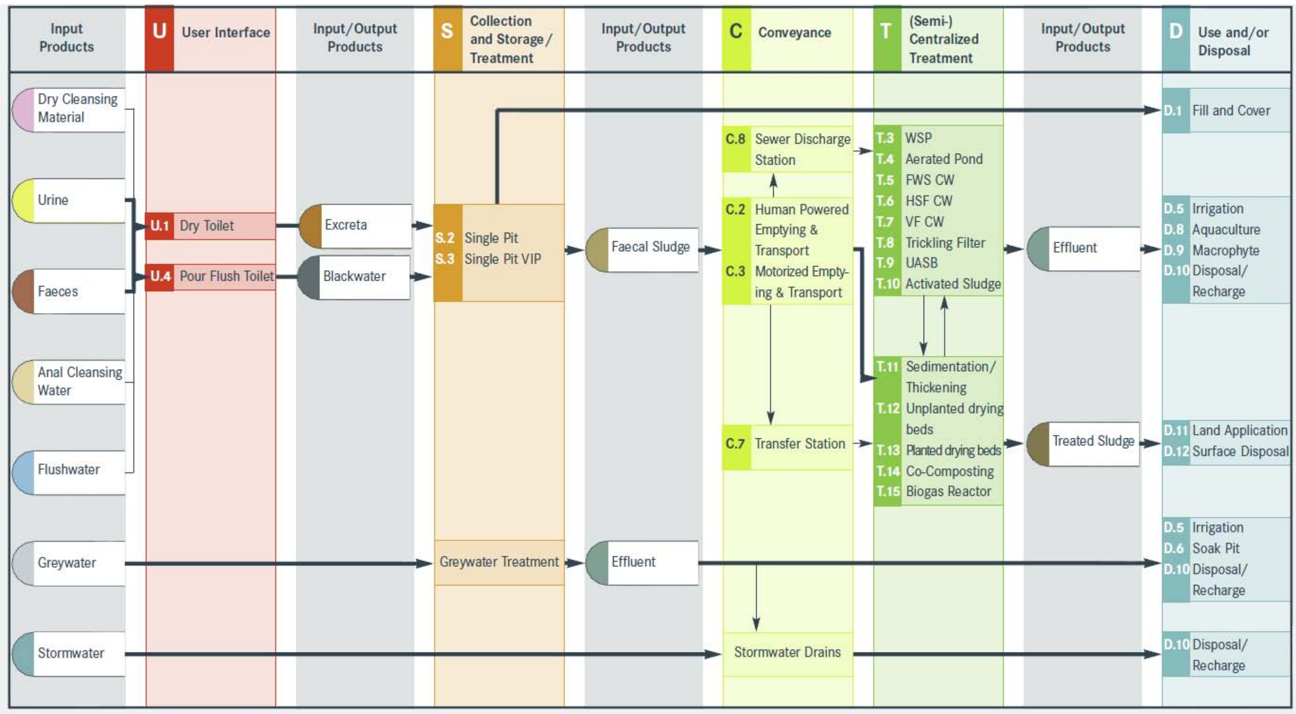

Figure 2 System Template 1: Single Pit System (TILLEY et al., 2008)

This system is based on the use of a Single Pit to collect and store the excreta depending on the User Interface. This system can be used with or without Flush water, Dry cleansing material, Urine, Faeces, Anal Cleansing water and Flush Water are the inputs of the system. The use of Flush water and/or Anal Cleansing water depends on the availability of water and the local habit. Dry Toilet and Power Flush Toilets are two User Interfaces of this system. They are directly connected to Collection and Storage/Treatment Technology (i.e. Single Pit or Single Pit VIP).When the Pit is full, there are several options. If there is space, the Pit can be filled with soil and planted with a tree as per the fill and cover and built a new Pit. Generally this is possible only when the Superstructure is mobile. Alternatively, the Faecal Sludge which is generated from the Collection and Storage/Treatment has to be removed and transported for further treatment.

Conveyance Technologies include Human Powered Emptying and Transport (E&T) for the solid sludge or Motorized E&T for liquid sludge. When the Faecal Sludge is thinner, it must be emptied with a vacuum truck because the Faecal Sludge is highly pathogenic prior to treatment and human contact and agricultural applications should be avoided as well. When it is not feasible to empty the full pit, (semi) Centralized Treatment can be omitted and the pit can be filled and covered with suitable material for decommissioning. The decommissioned Pit can be planted with a fruit or flowering tree since it will thrive in the nutrient rich environment.

Faecal Sludge that is removed can be transported to a dedicated Faecal Sludge treatment. (Sedimentation/Thickening, Updating drying Beds, Planted drying Beds, Co-composting and Biogas Reactor). In the event that treatment facility is not accessible. The Faecal Sludge can be discharged in a Sewer Discharge Station or Transfer Station. From the Sewer Discharge Station, the Faecal Sludge is transported by the sewer and is co-treated with Black water in the sewer network (Technologies: Anaerobic Baffled Reactor, Anaerobic Filter, Waste Stabilization Pond, Aerated Pond, Free-Water Surface Constructed Wetland, Vertical Flow Constructed Wetland, Trickling Filter, Up flow Anaerobic Sludge Blanket Reactor, Activated Sludge).

The Faecal Sludge from the Sewer Discharge Station is released either directly into the sewer or at timed intervals. If sludge is introduced directly into a sewer, there must be enough water to adequately dilute and transport the sludge to the treatment facility. From the Transfer Station the Faecal Sludge must be transported to a dedicated Faecal Sludge treatment facility (Sedimentation/Thickening Ponds, Unplanted Drying Beds, Planted Drying Beds, Co-composting, Anaerobic Biogas Reactor) by a motorized vehicle.
All (Semi-) Centralized Treatment Technologies produce both Effluent and Faecal Sludge, which require further treatment prior to use and/or disposal. Technologies for the use and/or disposal of the treated effluent include Irrigation, Aquaculture Ponds, Macrophyte Pond or discharge to a water body or recharge to groundwater.

3.3.2 Waterless System with Alternating Pits

This system is used in the area where the space is limited as it is a permanent system and can be used in the dense area that do not have access to mechanical emptying/trucks. It is also appropriate to the water scarce areas and where is an opportunity to use humid material. The decomposition process in this system enhance if there is availability of soil, ash and organic matter as leaves, woodchips, husks etc. The Grey water should be collected separately as it makes the Pit moist and also less aerated which can maximize the storage Period. Too much moisture in the Pit fills the air-voids and deprives the microbes of oxygen which may impair the degradation process. Dry Cleansing material can be discarded into the pit/chamber, especially if they are carbonaceous (e.g. toilet paper, newsprint, corncobs, etc.) as this may help with degradation and airflow.

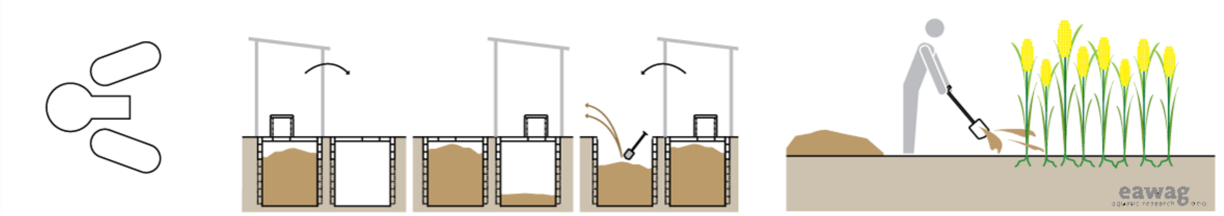

Figure 3 Waterless System with Alternating Pit (TILLEY et al., 2008)

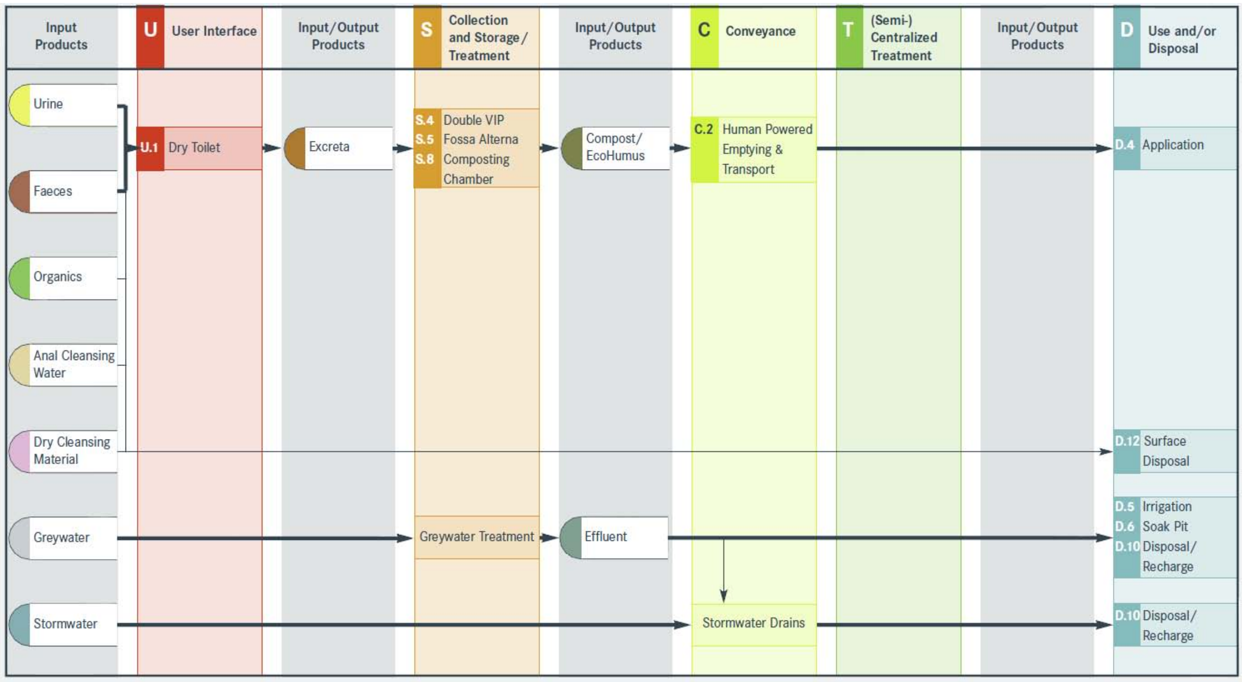

Figure 4 System Template 2: Waterless System with Alternating Pit (TILLEY et al., 2008)

In this system, alternating pits are used without the addition of flush water. Produce dense, the inputs of this system are Urine, Faeces, Organic, Anal Cleansing Water and Dry Cleansing Materials. The User Interface is only Dry Toilet which does not require water to function as water should not be input into the system. Anal Cleansing water should be kept to a minimum or excluded from the system if possible. Dry Cleaning material can be added to the Pit depending on the Collection and Storage/Treatment Technology; otherwise, it can be collected separately and transferred directly for disposal.

The Excreta is directly connected to collection and storage/Treatment technology; (Double VIP, Fossa Alterna and Composting Chamber). After the first pit is filled, it is covered and temporary taken out of service and second pit is used. And, when, the second one is filled, the drained and degraded excreta within the first pit are emptied and the pit is put back into the service and the cycle is repeated indefinitely. The Composting Chamber is not an alternating technology, however, it has multiple chambers and produces a safe, useable compost Product. Alternating the Pits gives the material an opportunity to drain, degrade and transform into a nutrient- rich, hygienically- improved humid material that can be used and disposed safely.

The Compost/Eco Humus generated from the Collection and Storage /Treatment Technology can be removed and transported for use and/or disposal by Conveyance Technology: (Human Powered E&T). Since it has undergone significant degradation, the humid material is quite safe to handle and use in agriculture. As concern about the quality, it can be further composted in a delicate composting facility, but there is no need to transport the Compost/Eco Humus to (Semi) Centralized treatment facility as decomposition of Excreta takes place onsite. For the use and /or Disposal of compost or Eco Humus the application of Compost/Eco Technology is utilized.

3.3.3 Pour Flush System with Twin Pits

Depending on the selection of collection and Storage/Treatment technology, the system will depend on different criteria. In case of double pits, the system will depend on the soil which can absorb adequate moisture so that the clay and dense packed soil is not appropriate. It is best suited in peri-urban and rural areas where source of organic waste and animal manures are used for household biogas. The piping system must be well maintained to prevent from the leakage of gas and water can be used for anal cleansing and in case of used of dry cleansing material, has to be collected separately to prevent from pit or reactor.

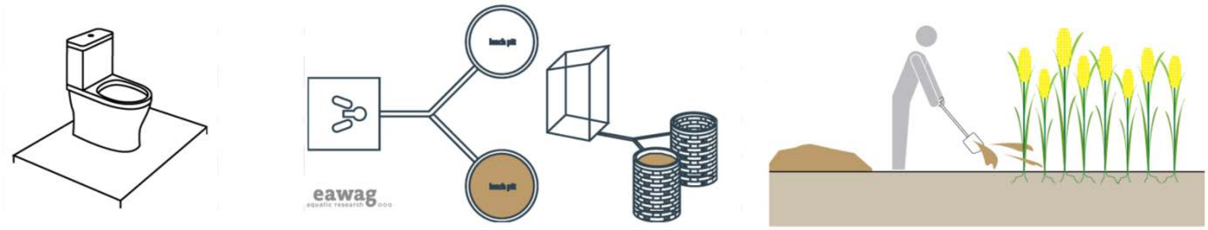

Figure 5 Pour Flus System with Twin Pit (TILLEY et al., 2008)

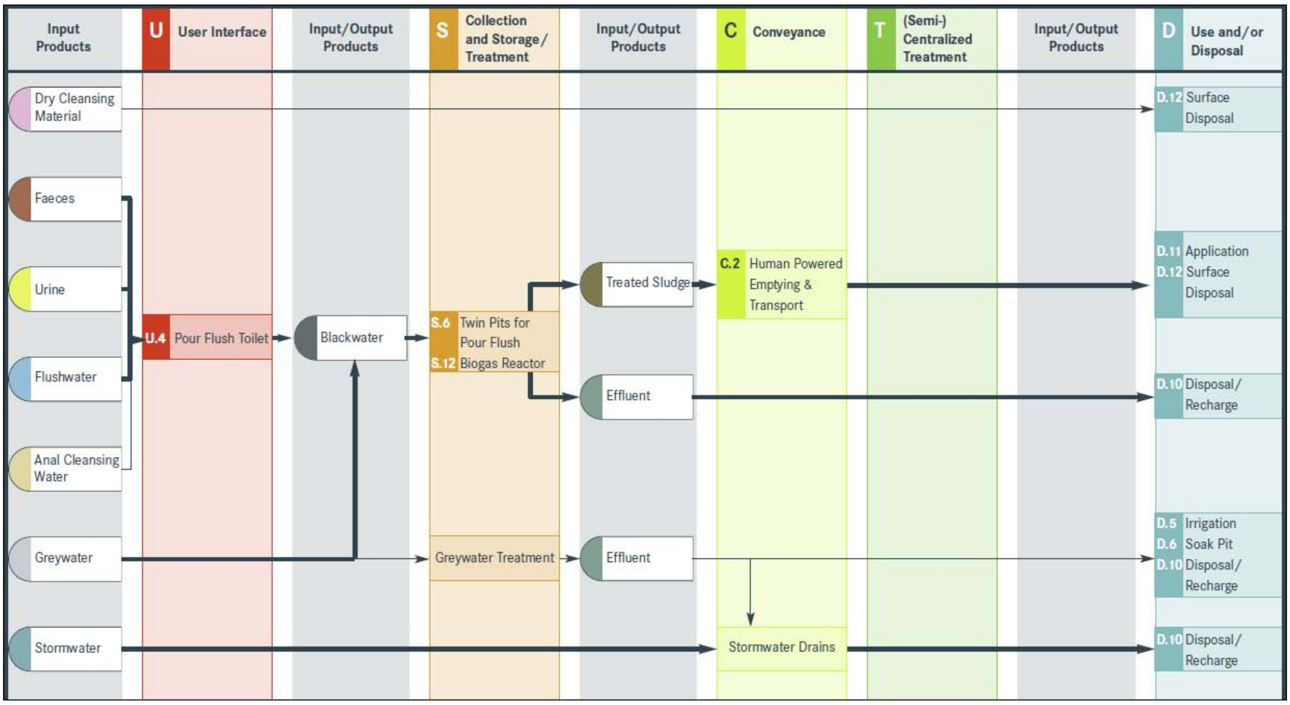

Figure 6 System Template 3: Pour Flus System with Twin Pit (TILLEY et al., 2008)

The Pour Flush Toilet can be of pedestal or squat pan which is used to produce partially digested humus like products that can be used as a soil amendment. This is water based system. Grey water can be used in this system and do not require separate treatment. Faeces, Urine Flush water, Anal Cleansing Water, Dry Cleansing materials and Grey water are the input products in the system. The Pour Flush Toilet is the User Interface technology. Urinal cannot replace Pour Flush. It can be used as additional option. Twin Pits for Pour Flush is one of the technologies used for the Collection and Storage/Treatment of Black water output from the User Interface.
The Twin Pits are linked with a porous material which allows the Effluent to infiltrate into the ground while the solids accumulate and degrade at the bottom of the Pit. When one Pit is filled with Black water, it is covered and temporarily taken out of service. A pit generally takes minimum 2 years to fill. While the first pit is filled, the second pit is out of service and it is used. When the second Pit is filled, the first Pit is ready to empty. The treated Sludge that is generated in a Pit after 2 years is removed and transported for use and/or dispose manually using Human Powered E&T Conveyance Technology. It is not needed to transport the Treated sludge to (Semi) Centralized Treatment facility as the treatment of Black water takes place onsite. Dry Cleansing material may clog the Pit and reactor and prevent water from infiltration into the soil so it should be collected separately and transferred for Surface Disposal. The alternative way for

the black water is that it can be directed towards an Anaerobic Biogas Reactor. The reactor functions better if organic waste and animal manure are added while the liquid inputs such as Greywater should be kept to a minimum. This biogas can be used in household and Treated Sludge can be used as soil amendment. The Sludge is not as pathogenic as raw and undigested as it has undergone significant degradation. For use and/or disposal component of the system template, Application of sludge technology is used. As the Effluent for the Twin Pits for Pour Flush is directly infiltrate into the soil onsite from each pit, this system should be installed in a place where groundwater table is low.

3.3.4 Waterless System with Urine Diversion

This system is designed to separate Urine and Faeces and allow Faeces to dehydrate and /or recover and the Urine for beneficial use. This system is especially in water scarcity regions. The success of the system depends on the efficient separation of Urine and Faeces. It depends on the use of suitable drying agent as well. Dry and hot climate can contribute the rapid dehydration of Faeces. Anal Cleansing water must be separated from Faeces though it can be mixed with Urine before it is transferred to Soak Pit. If Urine is used in agriculture, Anal Cleansing Water should be kept separate and treated along with Grey water.

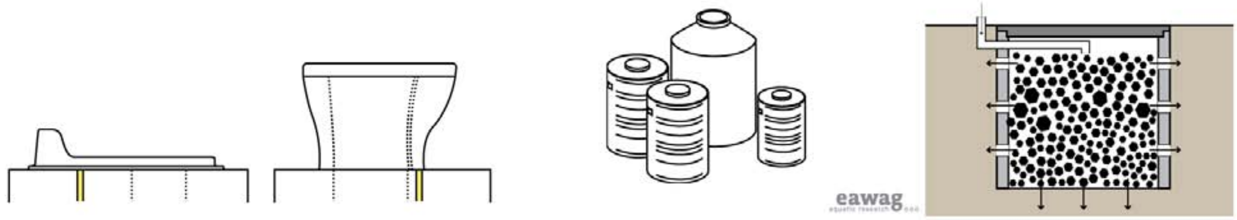

Figure 7 Waterless System with Urine Diversion (TILLEY et al., 2008)

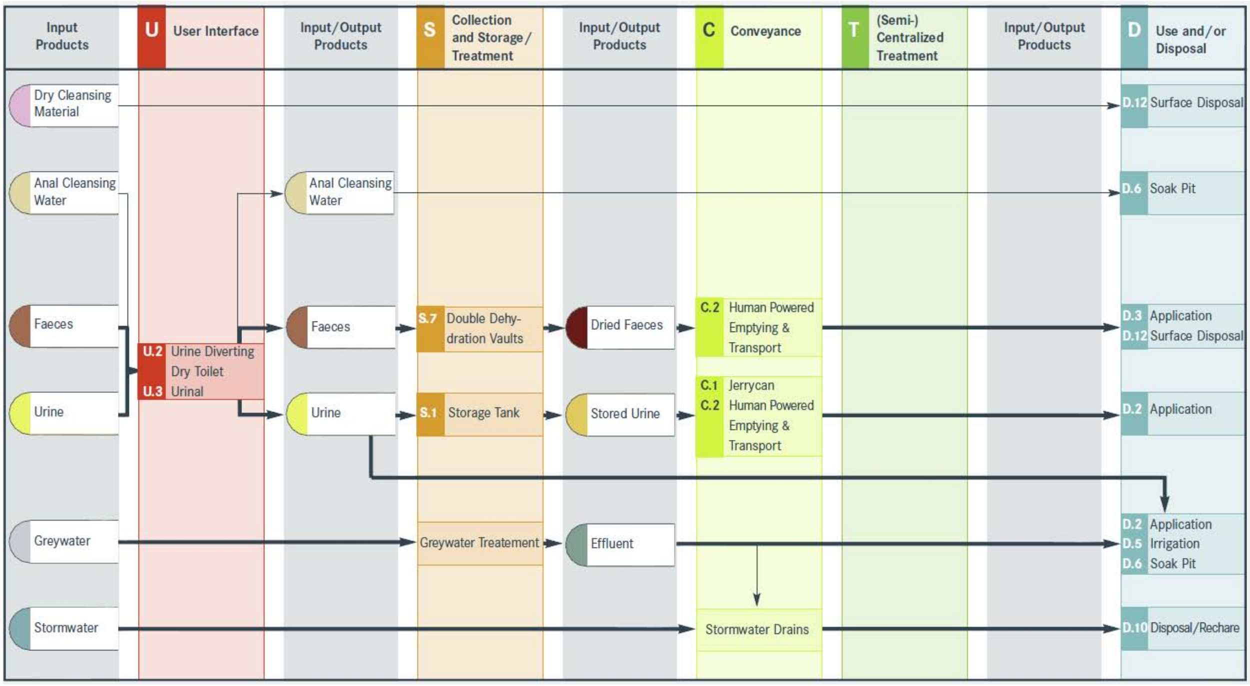

Figure 8 System Template 4: Waterless System with Urine Diversion (TILLEY et al., 2008)

In this system, the input products are Faeces, Urine, Anal Cleansing Water and Dry Cleansing Materials. Two User Interface technologies are used in this system they are Urine Diverting Dry Toilet (UDDT) and Urinal. UDDTs with a third diversion for Anal Cleansing Water are not common, but can be manufactured locally or ordered depending on local washing customs. Though the Dry cleansing materials will not harm the system, they should be collected separately from the UDDT and directly transferred for Surface Disposal. Double Dehydration Vaults are used for the collection and Storage /Treatment Technology for Faces. Anal Cleansing Water should not put into the Dehydration Vaults so it is diverted and put into a Soak Pit. In order to encourage dehydration and hygiene, the Faeces in the chambers should be kept as dry as possible. The chamber should be kept watertight and care should be taken during cleaning. To minimize the odor a constant supply of ash, lime or dry earth is important, the PH increase helps to kill organisms. A barrier between Faeces and potential vectors for example flies should be provided. A separate Greywater system is required since it should not be introduced into the Dehydration Vaults and preferably not into the pits. The Dried Faeces generated from the Collection and storage/treatment technology can be removed and transported for use and/or disposal. The Conveyance Technology that can be used is Human Powered E&T. The dried Faeces can be a little health risk.
Urine can be disposed of easily without any risk to the environment as it is generated in relatively a small volume and is nearly sterile. The Urine can be diverted directly to the ground for Use and /or Disposal as land Application, Irrigation of soil infiltration through Soak Pit. Storage tank can be used for Collection and storage/ treatment of Urine. The stored Urine can be transported for Use and/or Disposal using either Jerrycan or Motorized E&T Technology. This system can be used regardless of users, acceptance to Urine use; can be used in agriculture and cultural needs of the users.

3.3.5 Blackwater Treatment System with Infiltration

This system is appropriate in areas where desludging services are available and affordable and where there is appropriate way to dispose of the sludge. It is adapted for use in cold climates even there is ground frost. It requires a constant source of water. The capital investment for this system is considerable (excavation and installation of an onsite storage Technology), but the costs can be shared by a number of households if the system is designed for a larger number of users. This water-based system is suitable for Anal Cleansing Water, and since the solids are settled and digested onsite, easily degradable Dry Cleansing Materials can also be used.

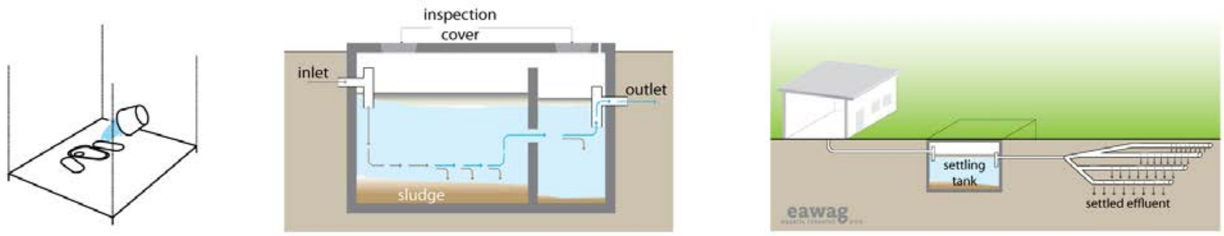

Figure 9 Black water Treatment system with Infiltration (TILLEY et al., 2008)

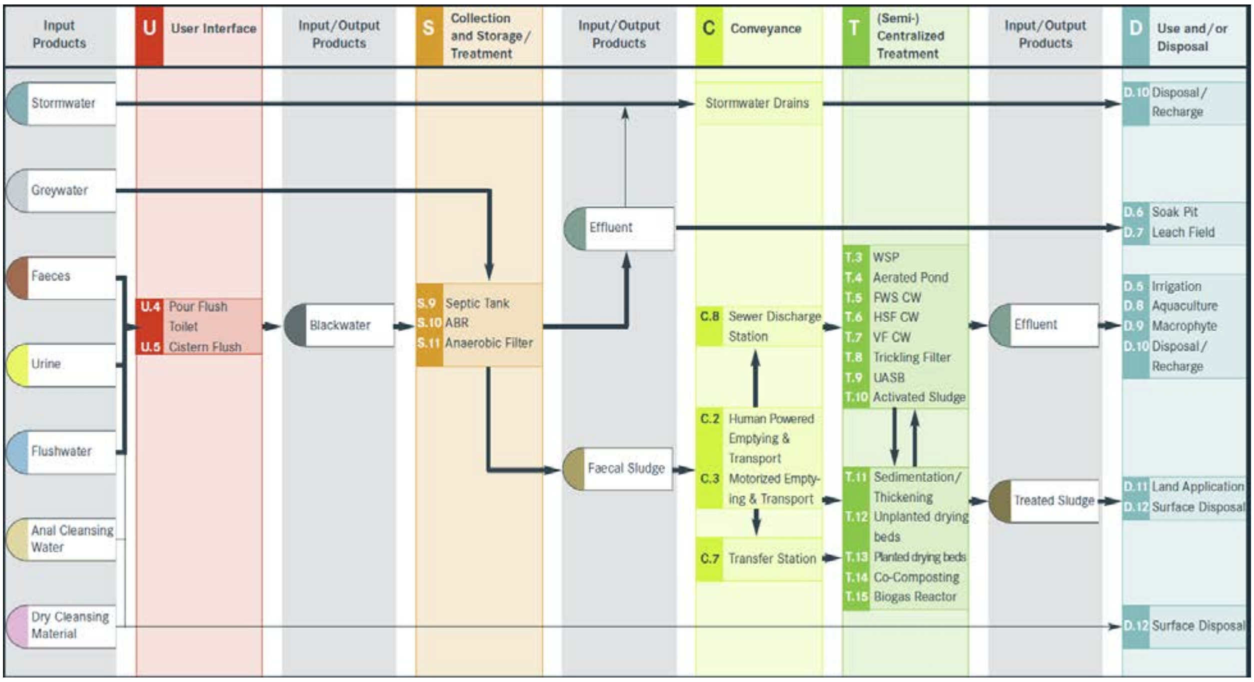

Figure 10 System Template 5: Blackwater Treatment System with Infiltration (TILLEY et al., 2008)

This is a water based system which requires a flush toilet. Collection and Storage/Treatment Technology should be able to store a large quantity of water. The input to the system includes Faeces, urine, Flush water, anal Cleansing Water, Dry Cleansing Materials and Grey water. The user Interface Technology of the system includes Power Flush Toilet and Cistern Toilet. In the event Dry Cleansing Materials are collected separately from Flush Toilets and can be directly transferred for Surface Disposal.

The User Interface Technology is directly connected to a Collection and storage/ Treatment Technology for the treatment of generated Black water, either in a Septic Tank or in an Anaerobic Baffled Reactor (ABR) or Anaerobic Filter. The Anaerobic process reduces the organic and pathogenic load but the Effluent is not suitable for the direct use. Grey water must be treated along with the Black water in the same Collection and Storage /Treatment Technology. In case of water recovery, this can be treated separately. Effluent generated from the Collection and Separated/ treatment Technology can be directly diverted to the ground for the Use and /or Disposal through Soak Pit or Leach Field. To work this, there must be sufficient space available and the soil must have capacity to absorb the Effluent. The Effluent can be also discharged into the Storm water Drainage network for use and /or Disposal as Groundwater Recharge when the amount of Effluent is very and have no capacity for the onsite infiltration or transportation offsite.

The Faecal sludge which is generated from the Collection and Storage/Treatment must be removed and transported for the further treatment. The Conveyance Technology can be used that include Human Powered E&T or motorized E&T. The Faecal Sludge is highly pathogenic prior to the treatment so that human contact and direct application to the agriculture should be avoided. Faecal Sludge that is removed is transported to a dedicated Faecal Sludge Treatment facility: Sedimentation/ Thickening ponds, Unplanted Drying Beds, Planted Drying Beds, Co-Composting and Bio-gas Reactor. In the event that the treatment facility is not easily accessible, the Faecal Sludge can be discharged either to Sewer Discharge station or Transfer Station.

From the Sewer Discharge Station, the Faecal Sludge is transported by sewer and is co-treated with the Black water flowing in the sewer network. Faecal Sludge from Sewer Discharge Station

is released either directly into the Sewer or at timed intervals (to optimize the performance of the (Semi) Centralized Treatment facility.) If sludge is introduced directly into the sewer, there must be enough water to dilute adequately and transport the sludge to treatment facility.
From Transfer Station, The Faecal Sludge must be transported to a dedicated faecal sludge Treatment facility by a motorized vehicle.
(Semi) Centralized treatment Technology produces both Effluent and Faecal Sludge which require further treatment prior to Use and/or disposal. Technologies for Use and/or Disposal of the Treated Sludge include Irrigation, Aquaculture, Macrophyte Pond, and Discharge to water body or Recharge to ground water. It also includes Land Application or Surface Disposal.

3.3.6 Blackwater Treatment System with Sewerage

The investment of cost of this system is moderate to considerable with the offsite transport of the Effluent to a (Semi) Centralized Treatment facility. The success of this system depends on higher user commitment to O&M of the sewer network; alternatively a person or organization can be made responsible on behalf of the user. An accessible, affordable and systematic method for the septic tanks must be there since one user's improperly kept tank could adversely impact the entire community. Well-functioning and properly managed Centralized Treatment facility is also important which is managed at municipality or regional level in some cases. There must be a well-defined structure for O&M in case of local solution for instance wetland. This system is especially appropriate for dense, urban settlement where there is little or no space for onsite storage technology or emptying. It is suitable in the area of high water because the sewer is shallow and watertight. The system is suitable for Anal Cleansing water inputs and degradable Dry Cleansing Material can be used but other material like leaves, rags should not be used as they can clog the system and cause the problem with emptying.

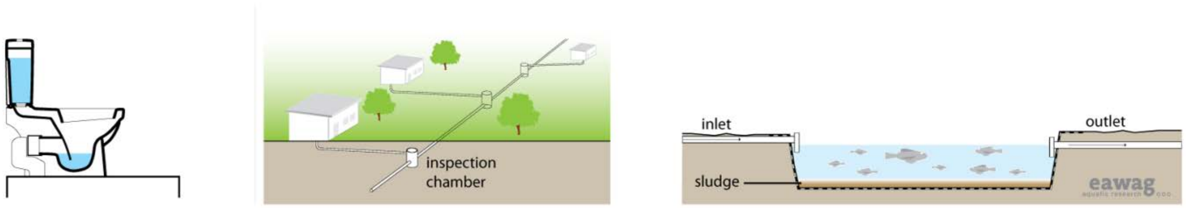

Figure 11 Blackwater Treatment system with Sewerage (TILLEY et al., 2008)

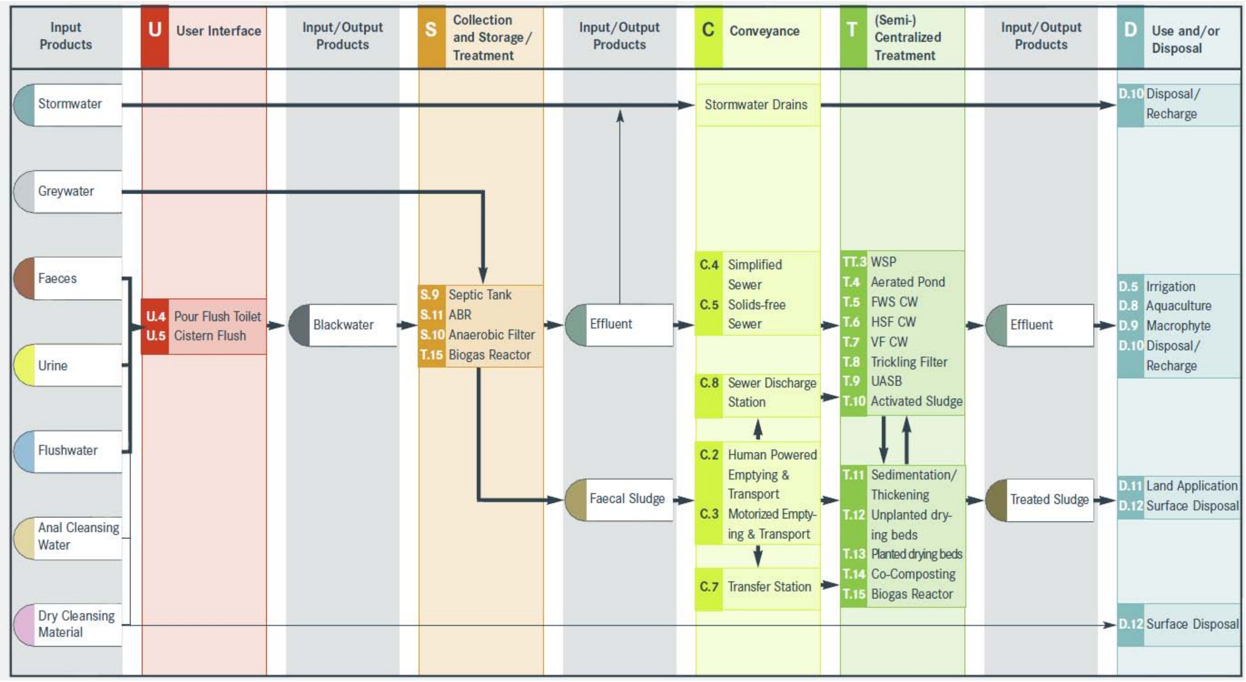

Figure 12 System Template 6: Blackwater System with Sewerage (TILLEY et al., 2008)

This system is used of a household level Technology to remove and digest settleable solids from Black water, and digest settleable solids from Black water, and a simplified or sewer system to transport the Effluent to a (Semi) centralized Treatment facility.

The input to the system includes Faeces, Urine, and Flush water, Anal Cleansing water, Dry Cleansing materials and Grey water. This system is similar to the Black water Treatment System with Infiltration except the management and processing of the Effluent generated during Collection and storage/ Treatment of the Black water.

There are two transport pathways for the Effluent generated from the Collection and Storage/Treatment of Black water. Effluent can be discharged into the Storm water Drainage network for Use and /or Disposal as groundwater Recharge. The Effluent should be transfer to a (Semi) Centralized Treatment Facility from the Collection and Storage/ Treatment via a Simplified Sewer network or a Solid Free network. An Interceptor or Septic tank is required before the Effluent enters the sewer. Alternatively, this system can be used as a way of upgrading underperforming onsite Technologies (e.g. Septic tank) by providing improved, (Semi) Centralized Treatment. Effluent transported to a (Semi) Centralized Treatment facility is treated using one of the technologies: ABR, Anaerobic Filter, WSP, Aerated Pond, FWS CW, HSF CW, VF CW, Trickling Filter, UASB and Activated Sludge.

All (Semi) Centralized treatment Technologies, produce both Effluent and Faecal Sludge which need further treatment prior to Use and /or Disposal of the treated Effluent include Irrigation, Aquaculture, Macrophyte Pond or Discharge to a water body or Recharge to Groundwater. Technology of Use and /or Disposal of the treated Faecal Sludge includes Land Application or Surface Disposal.

3.3.7 (Semi) Centralized Treatment System

This system is only appropriate when there is willingness to pay for the Capital investment and maintenance costs and where there is a pre-existing treatment facility that has the capacity to accept additional flow. The capital investment of this system is high as gravity sewer requires extensive excavation and installation can be expensive, whereas simplified Sewers are generally less expensive if the site conditions permit condominal design. Depending on the sewer used, the system can be adapted for both Urban and Peri-rural areas. It is not suitable in a rural area as a constant supply of water is needed to ensure that the sewer do not block. Depending on the sewer type and management structure (simplified vs. gravity, city-run vs. community operated) there are varying degrees of operation or maintenance responsibilities for the home owner.

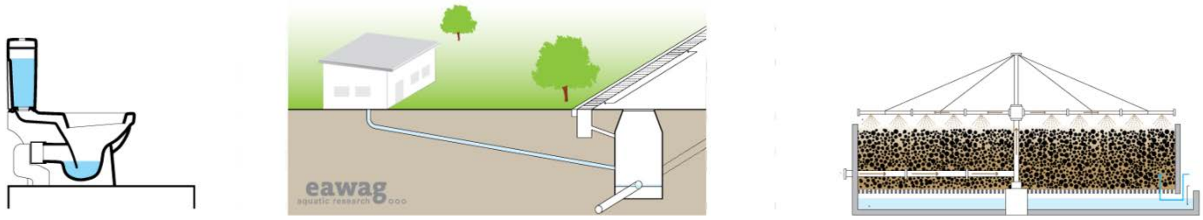

Figure 13 (Semi-) Centralized Treatment system (TILLEY et al., 2008)

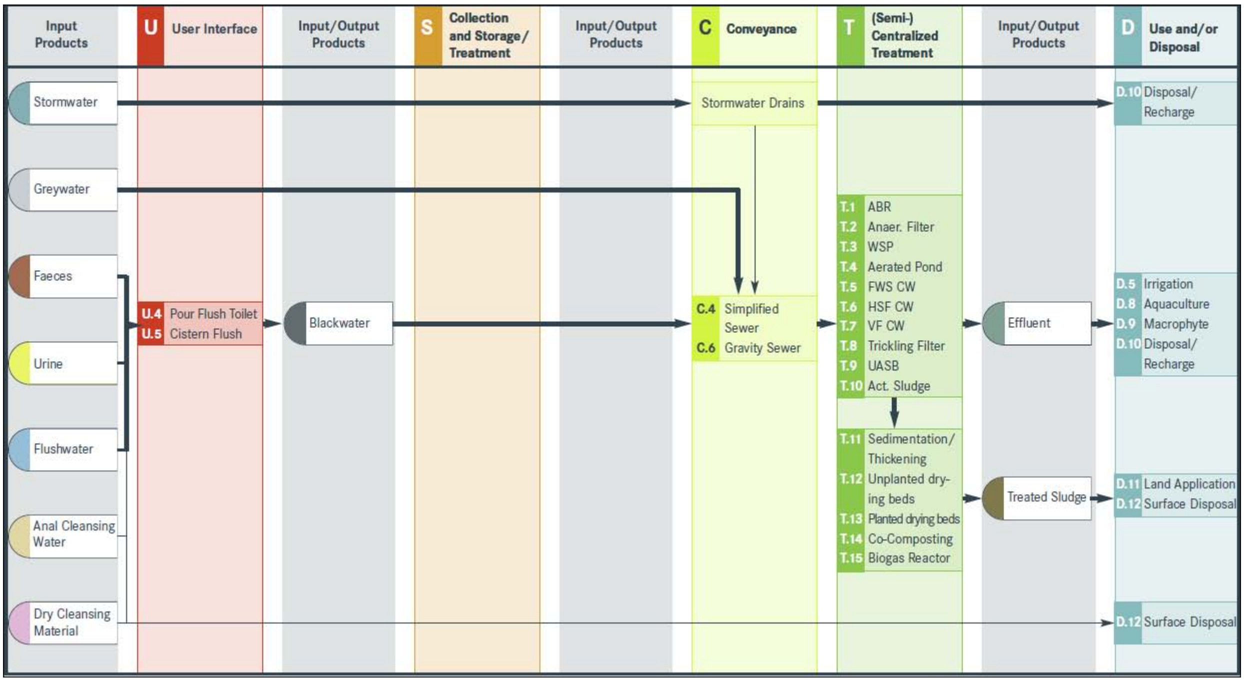

Figure 14 System Template 7: (Semi-) Centralized Treatment System (TILLEY et al., 2008)

This is a system where there is no Collection and Storage treatment. This is a water-based sewer system in which Black water is transported to a centralized treatment facility. The inputs includes Faeces, urine, Flush water, Anal Cleansing water, dry Cleansing Materials, Storm water and Grey water. Two User Interface Technologies are Cistern Flush Toilet and Pour Flush toilet. Dry Cleansing Material can be handled by the system or they can be collected separately and transferred for Surface Disposal. The Black water generated in User Interface is directly collected to a (Semi-) Centralized treatment facility by a Simplified Sewer or gravity Sewer network as there is no Collection and Storage/Treatment facility. Grey water is co-treated with the Black water. Storm water collected within the Storm water drains can be input to the Gravity Sewer Network, though Storm water overflow is required. The inclusion of Grey water in the Conveyance Technology helps to prevent solids from accumulating in the sewers. One of the technologies (ABR, Anaerobic Filter, WSP, and Aerated pond, FSW CW, HSF CW, VF CW Trickling Filter, UASB and activated Sludge) is required for the treatment of transported Black water. The Faecal Sludge which is generated from one of technology should be treated in a dedicated Faecal Sludge Treatment facility (Sedimentation/Thickening, unplanted drying beds, Planted drying beds, Co-composting Faecal Biogas Reactor) prior to Use and or Disposal. All (Semi-) Centralized technologies produced Effluent and Faecal Sludge. Use and/or Disposal Technologies include Irrigation, Aquaculture, Macrophyte Pond or Discharge to a water body or Recharge to groundwater. Technologies Use and /or Disposal of treated Sludge include Land Application or Surface Disposal.

3.3.8 Sewerage System with Urine Diversion

The capital cost of this system is high and is not common because in market there is limit competition and also high quality plumbing is required for the dual plumbing system. This is appropriate when there is a need for the separated Urine and/or when there is a desire to limit water consumption by collecting Urine without flushing water. This system requires a constant source of water and uses significantly more than a waterless system. This can be adapted in both peri-urban areas and dense urban areas depending on the types of sewer used, but not in rural areas. There must be a constant supply of water to ensure that the sewer do not block. This system is also appropriate when there is a need and desire to collect, transport and use Urine. If overloaded, there is a treatment of the plant and reduced nutrient load (by removing the Urine) could optimize treatment. If the plant is under loaded (The plant has been over designed), the system can further aggravated the problem. Depending on the sewer type and management structure, there will be varying degree of operations or maintenance responsibilities for the owner.

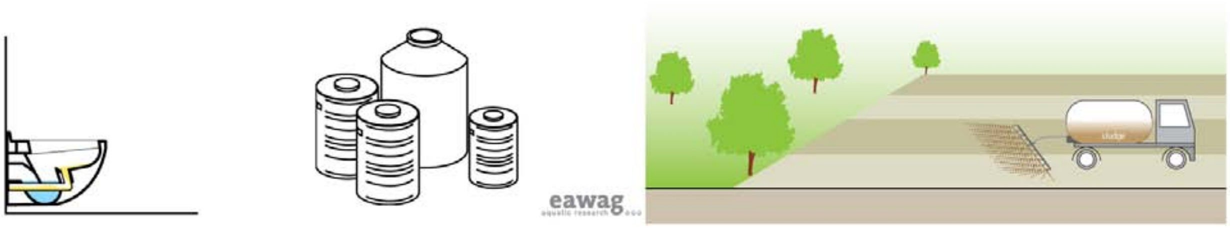

Figure 15 Sewerage System with Urine Diversion (TILLEY et al., 2008)

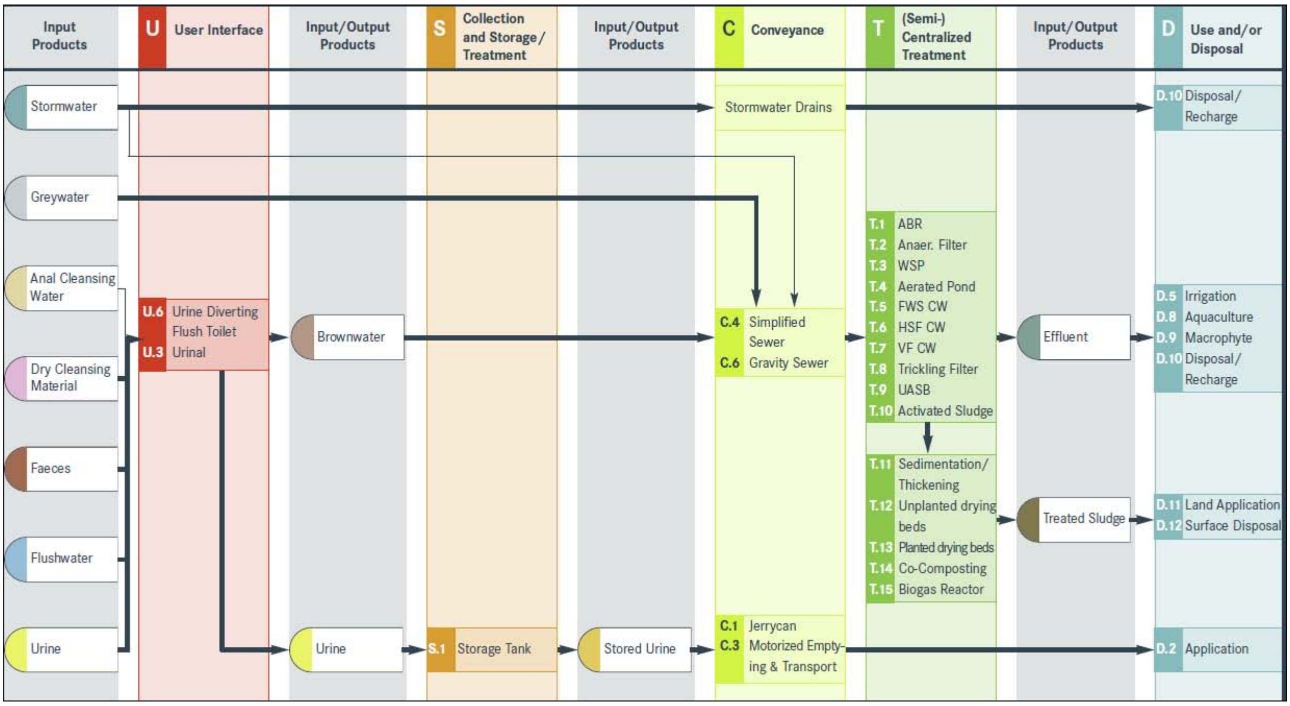

Figure 16 System Template 8: Sewerage System with Urine Diversion (TILLEY et al., 2008)

This is a water based system which requires a Urine Diverting Flush Toilet (UDFT). The UDFT is a special User Interface that allows for the separation and collection of Urine without water, but that also uses water to flush Faeces. The input to the system includes Faeces, Urine, Flush water, Anal Cleansing water, Dry Cleansing Material, Storm water and Grey water. User Interface technologies that can be used for this system are UDFT and Urinal. Urinal should be used in conjunction with the UDFT and as an alternative for men who do not want to sit on the pedestal. Both Brown water and Urine are separate in the User Interface. Brown water by passes a Collection and Storage/Treatment facility and is conveyed directly to a (Semi-) Centralized Treatment facility using Simplified Sewer network or Gravity Sewer network. Grey water is transported in the sewer and is not treated separately. Storm water can be connected to a Gravity Sewer network though Storm water overflows are required.
Urine separated in the User Interface is directly linked to a Storage Tank. The stored Urine is transferred for use and /or Disposal using Jerrycan or Motorized for E&T for application to an agricultural land.
Brown water is treated at a (Semi) centralized Treatment facility using from the treatment must be further treated in a dedicated Faecal Sludge treatment Facility by technologies (Sedimentation/ Thickening, Unplanted drying Beds, Planted Drying Beds, Co-composting and Biogas Reactor). The Treated Sludge is used in Land Application or Surface Disposal, Use and /or Disposal Technology. The Effluent collected can be used for Irrigation, Aquaculture, Macrophyte Pond or Discharge to a water body or Recharge to a Ground water.

3.4 Different Types of Toilets in Ethiopia, Kenya, Tanzania, Uganda and Nepal

3.4.1 UDDT in Ethiopia

According to ROSA (2010), Arba Minch, Ethiopia is characterized by floody type during rainy season with unstable soil conditions. The storage of water is all over the town. The head of the family had irrigation farm more than half hectare at the bank of the river kulfo and the river is flowing cutting the town into two. The UDDT is of household and has one vault where Faeces are collected in half cut 200 liter barrel while plastic water storage tanks are used for urine collection through PVC pipes. The slab was done by masonry and other Superstructure done with corrugated iron. It is designed in such a way that the operator can empty them from the near side of the toilet. The toilet has an elevated concrete floor with plastic squat seat. The squatting pan leads to a vault for dehydration along the anal cleansing material. Ash is applied on the Faeces after used and urine is led to subsurface tank which is situated behind the toilets in the vault. The collected urine and Faeces are reused as fertilizer in the farm. The floor plan of the toilet is shown in the Figure17.

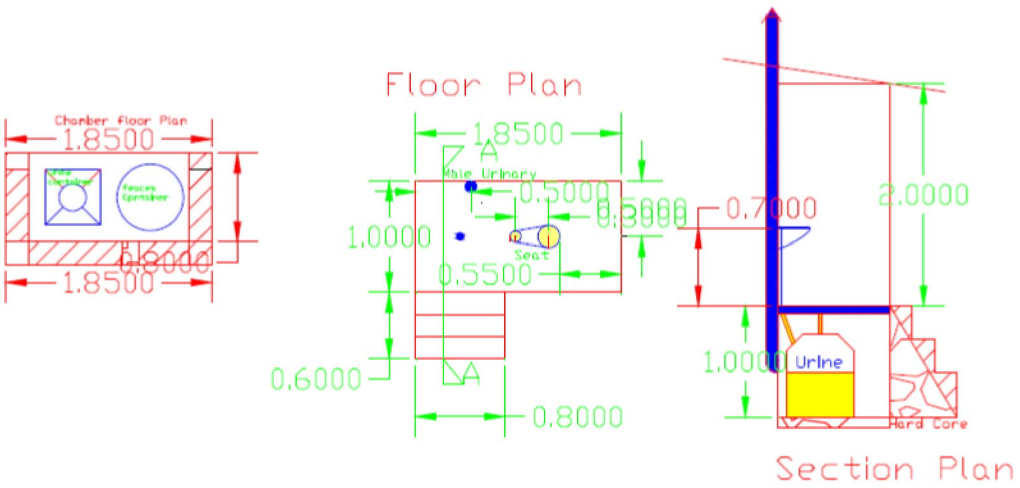

Figure 17 The floor and Section plan for Agafari's UDDT (ROSA Arba Minch; 2009)

3.4.2 UDDT in Kenya

In Kenya, the cost of UDDT has been taken in different places like Crater View Secondary School, Kaptembow Primary School, Residential area and house of fire ministries. The total number of toilets in Crater View Secondary school is 7, Kaptembow Primary School is 4, residential area is 3 and house of fire ministries is 3.

3.4.2.1 UDDT in Crater View Secondary School

According to ROSA (2010), the area of Crater View Secondary School of Kenya is a dense populated area where the type of soil is volcanic loose type ranging from moderate occurrence of surface rock to very shallow soil. The area has a problem of inadequate water supply. The UDDT is for school's students so masonry block consisting of eight stances of single vault UDDTs are constructed. Girls' toilet was provided with 5 cubicles, 4 urinal channels and space for changing clothes. For the boys 3 toilets and 9 waterless urinals bowls. To supply adequate amount of water, rain water is harvested from the roof into two 250 liter plastic tanks and the water is connected to the hand washing basins. Two hand washing basins are fixed. In the school, there was grey water treatment system which consists of a settlement tank of 250 liter and grey water collection tank of 750 liter. Grey water system receives grey water from the kitchen of the school and hand washing basins. Dying shedding was constructed to ensure a closed loop of sanitation system in the school where Faeces from UDDT will be received for further drying and treatment. The Faeces are collected in single vaults below 75mm suspended floor slab fixed with urine diversion eco plate. The vaults are 1.1m×0.9×0.75m (L×B×H) with enough space to hold three 5 liter containers and adequate room for the attendant to remove and replace the buckets and allows pathogens die of for at least 6 months (WHO, 2006). Once the container is filled, it is pushed aside and the place is occupied by another empty bucket. Vault doors are large enough to replace and removal of the container easily. The vault doors are of galvanized steel so that it is durable and are painted to prevent from rusting and are tightly fixed to prevent the entry of flies. The urine from 4 girl's urinals, 9 boy's urinal and from UDDTs is collected in a 2000 litter masonry underground tank. The tank is enough to hold urine only for approx. 2 months. The urine drain pipe is submerged into the collection tank with a basic water seal. The school has farm and the urine is used as fertilizer and the dried faecal matter as a soil conditioner.

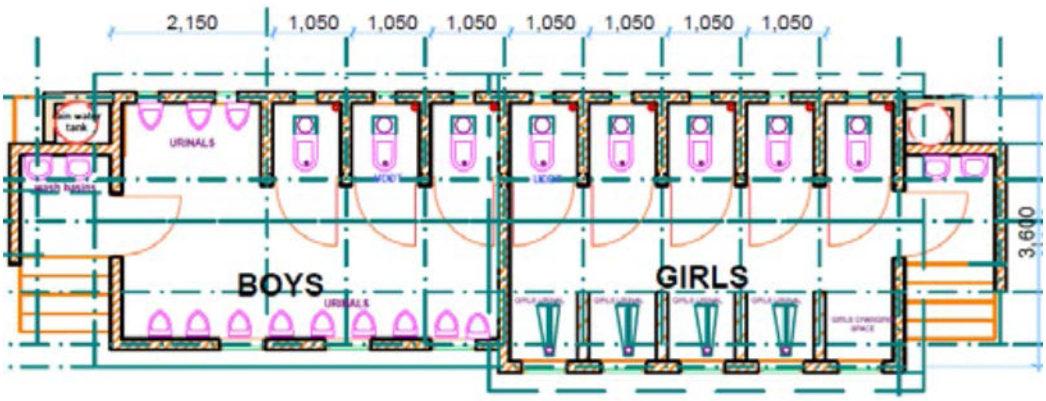

Figure 18 Floor plan for UDDT at Crater View Secondary School (ROSA Nakuru; 2009)

3.4.2.2 UDDT in Kaptembwo Primary School

According to ROSA (2010), the area of Kaptembwo Primary School is located in the loose type of soil and has the problem of inadequate water supply. The UDDT is constructed of masonry which consists of 7 single vaults UDDT as a whole. Among all toilets 4 for girls and 3 for boys and a urinal with ten urinals bowl. Each vault of (1.1m×0.9m×0.75m) holds two 30 liter containers for faecal matter storage and two 1000 litre containers for urine storage. When one container fills, it is left to stay inside the vault for a period not less than six months while the other is being used. Ash is sprinkled on fresh faeces in each toilet. As in the Crater View Secondary School, 200 liter water tank is used to collect the rain harvesting water and is directed into a hand water basin. Vault doors (0.8m×0.75m) are made up of metal with tightly fixed and gauge wires covered the vent space above the door to avoid flies. The human manure and urine are used in the agricultural field as reuse.

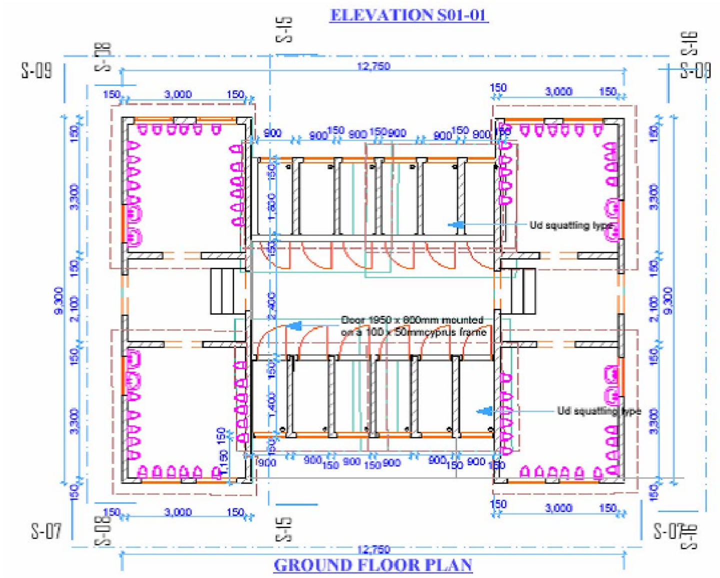

Figure 19 Ground floor plans of UDDTs in Kaptembwo Primary School. (ROSA Nakuru; 2009)

3.4.2.3 Residential UDDT

According to ROSA (2010), the UDDT which was constructed in residential area is characterized by shallow soil and hard rock. As it is expensive to dig on a rock, constructed raised pits are used by the residents. The total number of UDDTs for the people of residence is 3. One of the toilets is assigned to men and the rest are for children and women. Single vault UDDT was chosen instead of double vault. 70 to 100 liter of plastic containers is placed in the vault underneath the toilet chamber to collect the faeces. Once it is filled, it is pushed aside to place empty ones under the faeces hole. Urine is collected in 100 liter of plastic tank and the urine is discharged through an overflow pipe into a soak pit. The urine can be collected easily from the tank for agricultural use. 100 liter of tank is connected to the water basin as the tank is used to collect the harvested rainwater. A 100 mm thick base concrete slab was placed over the compacted stones and the Superstructure is constructed above this. The designed vault of 1100mm×900mm×750mm size can receive 600 litres of faecal matter. All 3 containers of 100 liter last for 4 and half months. The interior of the toilet is well ventilated and lighted by a vent space. A gauge wire is covered above the door to avoid flies and each vault has a vent pipe that rises 1m above the roof for effective air circulation from vaults to the atmosphere. As the area is covered with buildings, very less space is available for urban agriculture. The dried faeces emptied from the vaults are disposed at dumpsite which is only 50m from the plot and the excess urine goes to the soak pit.

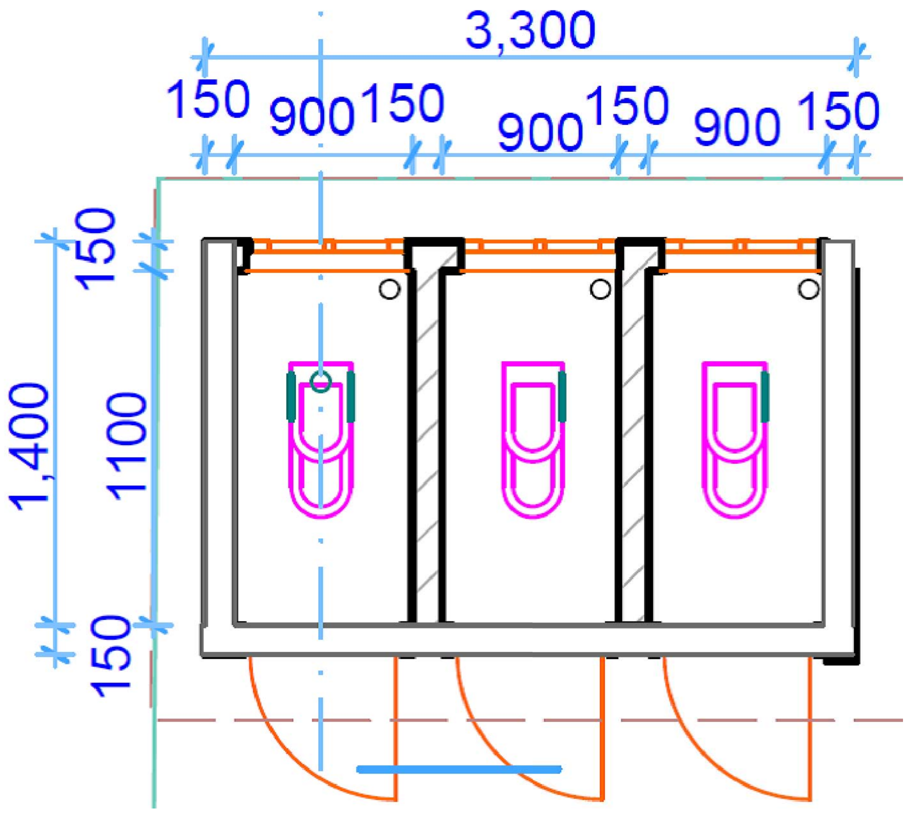

Figure 20 Floor plan of residential UDDTs (ROSA Nakuru; 2009)

3.4.2.4 UDDT in house of Fire Ministries

According to ROSA (2010), the house of fire ministry is a small community church which is located in an area where the type of soil is volcanic loose type of soil, ranging from moderate occurrence of surface rock to very shallow soils, there was a possibility of liquid content in the pit leaking to underground and transported to the lake along geological fault lines, that may cause contamination to the ground and surface water. For the ease of collection of the faeces, instead of making fall of faeces in a floor of chamber, the faeces are collected in a container. For female, a single vault UDDT and a double vault UDDT with solar dying cover at the back while for men single vault UDDT and a urinal cubical with five waterless urinal bowls. The two urinal bowl are of standard ceramic and the rest three are especially designed for children which are modified from 5 liter plastic containers and fitted lower to the floor level (300mm compared to standard level of 600mm). As in other places of Kenya mentioned above, rain water is harvested and is collected in 250 liter tank and is connected to a ceramic basin for hand wash. The faeces are collected in 50 liter plastic containers places in vault underneath the toilet chamber while 20-30 liters of small containers are placed in double vault chambers. Once the containers fill, they are transferred to solar drier in the double vault until they become completely dry and odor free before using them in the garden. Urine is collected in a 100 liter plastic tank and use in the agri-culture field.

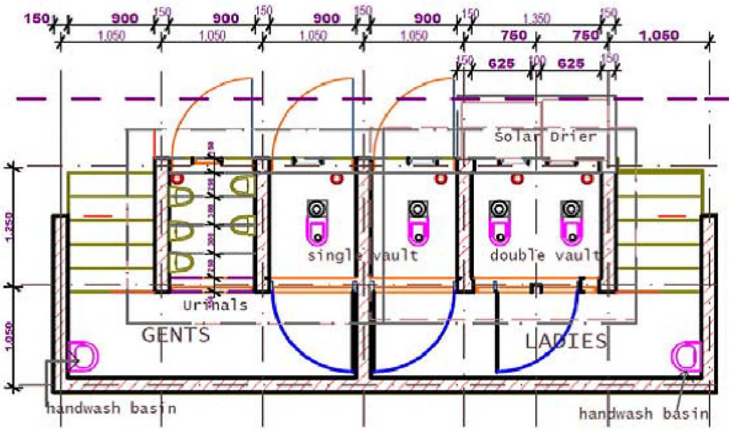

Figure 21 Floor plan of UDDTs of house of fire ministries (ROSA Nakuru; 2009)

3.4.3 UDDT in Uganda

According to ROSA Kitgum (2009), in Uganda, UDDT has been piloted at household level, prisons quarter and council offices of town. Here 2 stances UDDT and 1 stance UDDT have been piloted. The floor plans of these toilets have been shown in Figure 22 and Figure 23. The 2 stance UDDT has permanent Superstructure and has been piloted at council offices of the town and prison staff quarters. The 1 stance UDDT which has been piloted in Nyikinyiki (with permanent structure) while 1 stance UDDT at Acutomer (with temporary Superstructure).

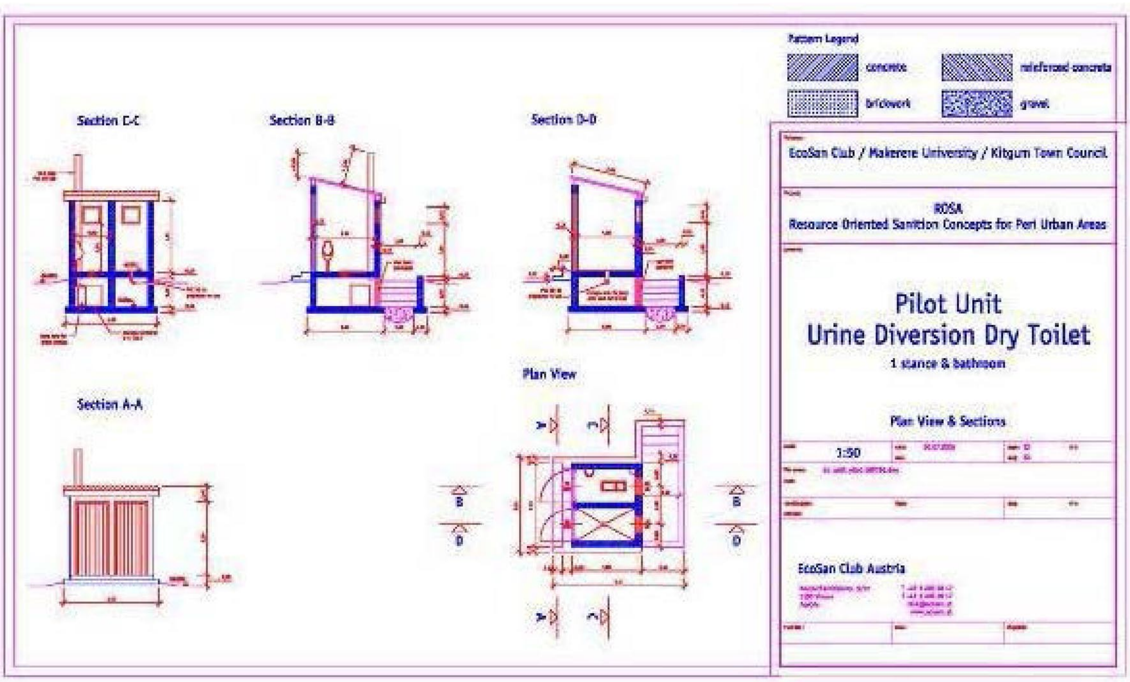

Figure 22 Floor plan of one stance UDDT (ROSA Kitgum, 2009)

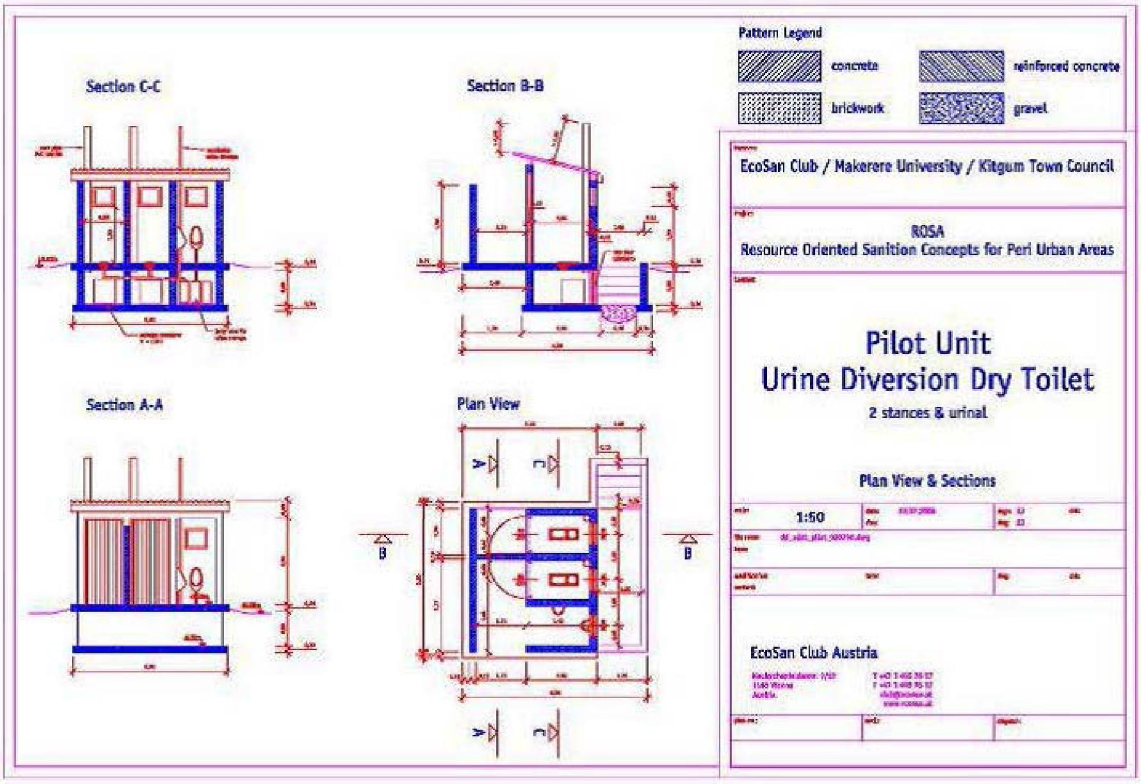

Figure 23 Floor plan of two stances UDDT (ROSA Kitgum, 2009)

3.4.4 UDDT in Tanzania

According to ROSA Arusha (2009), the UDDTs have constructed in different places in Tanzania. Double vault types of UDDT have been constructed in five households while single vaults for three households. The size of each vault is 1 m³. On the basis of the estimation, with 4-6 people per household, it will take 3-5 years for one vault to get full. In all UDDTs concrete blocks of 5 inches thickness were used as Substructure. The Superstructure is also built by concrete blocks and in a case timber has been used for walling. In other case 3 inches blocks were used instead of 5 inches blocks of Substructure. Some toilets are provided plastic squatting pans but majority are of concrete squatting pans. 20 liters plastic tanks are placed adjacent to the main door to one of the side wall. Due to the small size of the urine tank, it has to be emptied every 2 weeks and is directly used in the field followed by equal amount of water. When the double vaults types are full, the faeces will be dried and composted for improving soil or disposed to the municipal dumping area along with the solid waste.

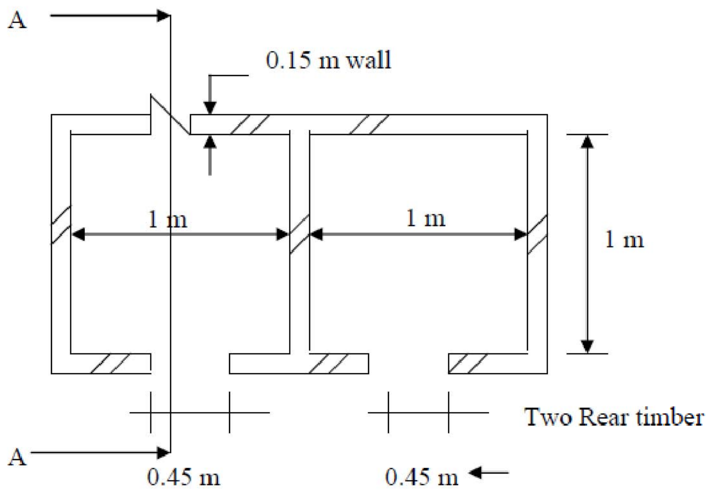

Figure 24 Floor plan of double vault UDDT (ROSA Arusha, 2009)

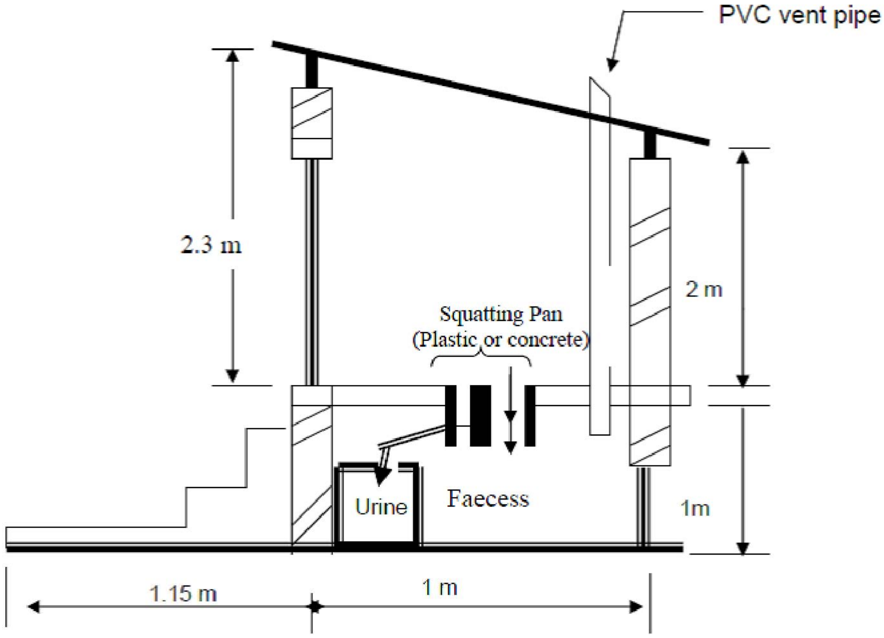

Figure 25 Cross section of double vault UDDT (ROSA Arusha, 2009)

3.4.5 UDDT in Nepal

In Nepal, majority of the UDDTs have been built in the peri-urban areas of Kathmandu Valley. Few toilets have been also constructed outside of the Kathmandu valley, ENPHO (2006). The UDDT which have been used in household are described below.

The most common type of urine diversion toilet in Nepal is based on Vietnamese model. However, several variations have been made to suit local conditions and requirement of users. The urine diversion toilets can have a single pan or double pan. The double pan version which has two vaults is the most common type and is usually constructed outdoors whereas single pan version is more suitable for indoor conditions or where space is constraint. The plan of vault and plan of UDDT have shown in Figure 26 and Figure 27.

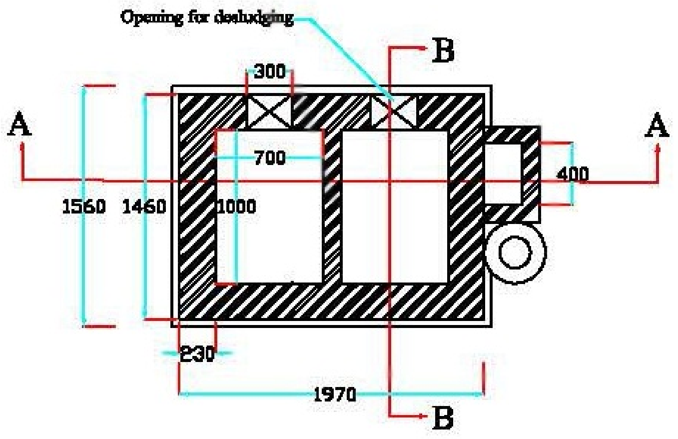

Figure 26 Plan of vault of UDDT, (Source: DWSS)

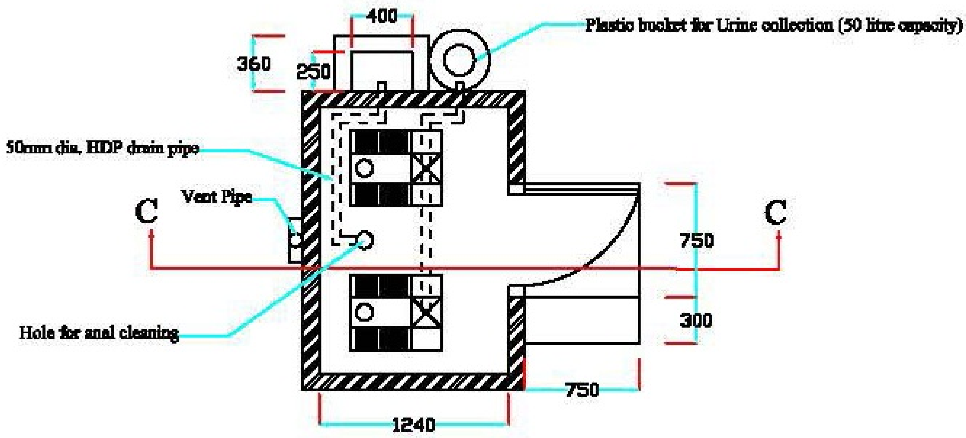

Figure 27 Plan of UDDT, (Source: DWSS)

In January 2002, ENPHO organized an interaction programme to raise awareness of UDDT and explore the potential for its application in Nepal. Later that year, DWSS, together with D-net, initiated a pilot project to construct ten UDDTs in the community of Siddhipur in Lalitpur district and ENPHO, with support from Water Aid Nepal, initiated a similar project in Khokana, Lalitpur. Since then UDDTs have been widely used of various designs have been established and there is growing interest in technology. There are some variations in the UDDT which have been made to suit local conditions and requirement of users. The UDDT is of a single vault and double vault type.

3.4.5.1 Double Vault UDDT

According to Water Aid (2011), the double vault toilet has two vaults and has the capacity of 0.3 m^3, above the ground level for faeces collection. Each vault has an opening of 30.5×30.5 cm in the back side for emptying the faeces. One vault is used for a period approximately 6 months. Once it is filled, the second one is used while the first one is left untouched for dehydration. Once the second vault is filled, the first vault is emptied and reused. The content of the first vault is further composted or applied directly in the fields. Thus the vaults are used alternatively in every six months. The vaults are constructed above the ground level to avoid ground water seepage and have a thick brick masonry wall of about 10.2 cm. The vaults are separated by 10.2 cm partition wall. Outside the toilet there is a tank for urine collection which is of usually 100 liter plastic tank and a small wetland for the treatment of anal cleaning water.

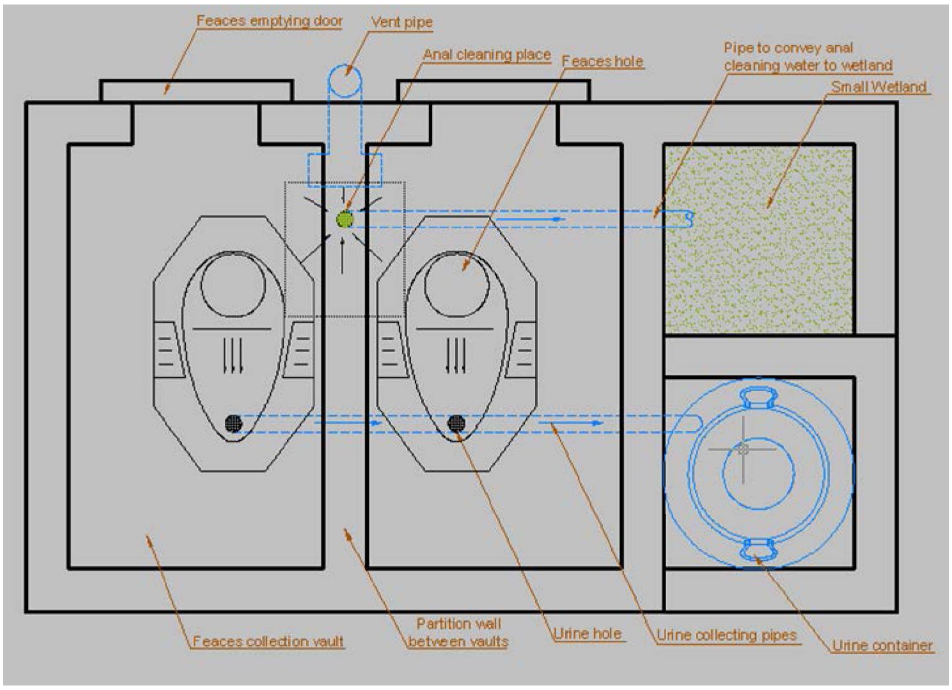

Figure 28 Double vault UDDT, (Source: ENPHO)

3.4.5.2 Single Vault UDDT

According to Water Aid (2011), Single vault UDDT is similar to the double vault UDDT, except it only has one pan and a single vault or bucket to collect faeces. This type of toilet is used where is not enough land to construct a double vault UDDT. The size also varies according to the available space. In this toilet, faeces are collected in a bucket placed on a trolley inside the vault. When the bucket is filled, it is replaced by new bucket. The bucket of faeces is covered and left for at least 6 months before it is used as a soil conditioner.

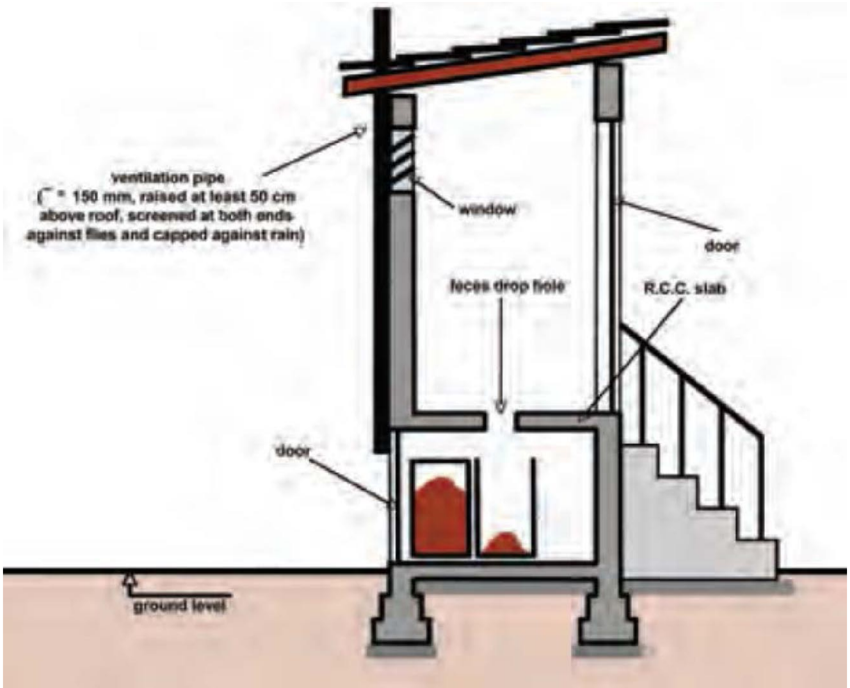

Figure 29 Single vault UDDT, (Source: ENPHO)

3.4.6 Other Types of Toilet in Nepal

3.4.6.1 Single Pit / Direct Pit

It is a simple and one of the most famous types of toilet in Nepal. According to compendium of sanitation and Technology, the toilet is System Template 1: Single Pit System. To construct the toilet a pit of about 1.5m in height and 1.2m in diameter is dug and covered with a slab depending upon the availability of materials. A hole is made in the slab and the excreta are stored in the pit until it is filled up. The pit may or may not be lined depending upon the type of soil. The lining material may be bricks, stone, concrete or some bamboo mat as in Figure 31 and plan of bamboo lining pit is shown in Figure 32. The cubical is made of any available local materials. Once the pit is filled, it is either emptied or buried and another pit is built for faeces collection. Single pit toilet is cheap to construct and less water consuming and suitable for scattered settlements however these types of toilet are unhygienic as they are built temporarily and produce odor problems, attracting flies and mosquitoes. But ash, wood dust, dry leaves can be used after defecation to reduce the odor. In addition these can cause ground water contamination from pits which do not have proper lining. Since pits tend to fill up quickly they have to be emptied regularly.

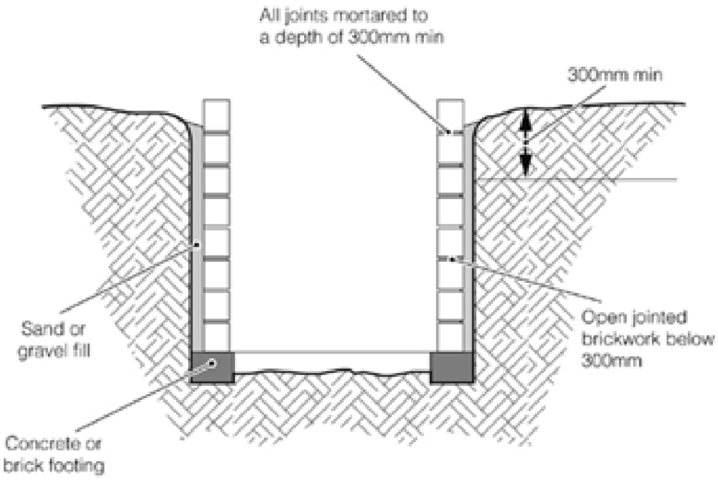

Figure 30 Single Pit (Source: website)

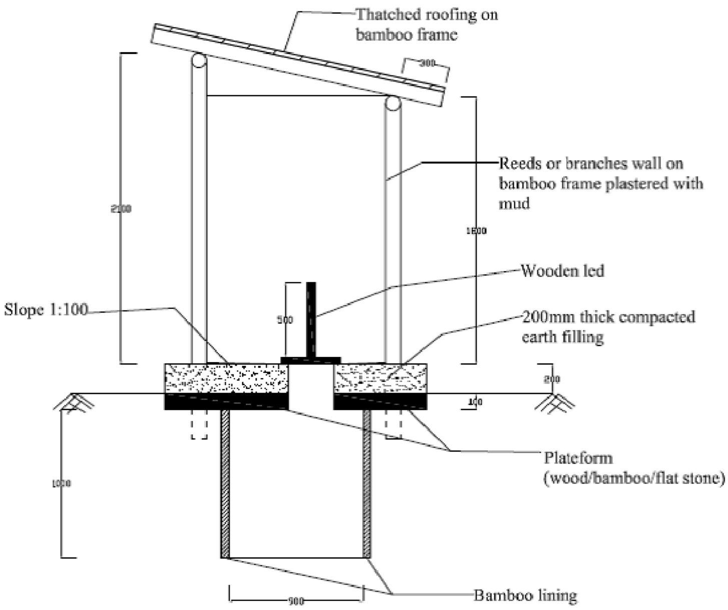

Figure 31 Direct pit of bamboo lining toilet (source: DWSS)

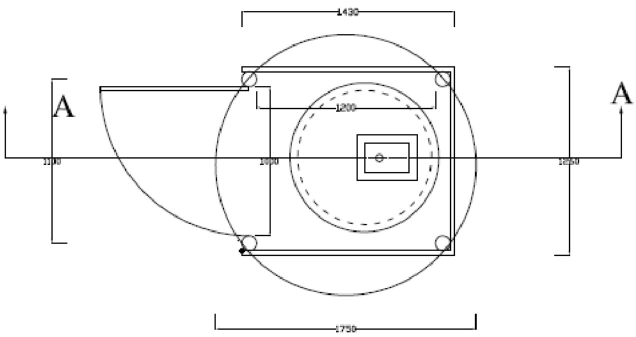

Figure 32 Plan of Direct pit of bamboo lining toilet (source: DWSS)

3.4.6.2 Double Pit Toilet

According to Compendium of Sanitation System and Technologies, the toilet is System Template 3: Pour Flush System with Twin Pits. In this toilet the pits are built a few meters away from the squatting pan or toilets. In between the pit and pan a pipe is laid. Water is used to transport the excreta to the pit from the pan. To use less water, the slope of the pipe of the pit from the pan is kept as high as possible and the distance between pit and slab kept as small as possible. It can be single or double pit toilet. In case of double pit, the pit is alternatively use. This type of toilet is good in the area where no sewerage system is and is not suitable in the area where the water table is high. In addition dislodging has to be done frequently and the construction cost is comparatively higher than other toilets

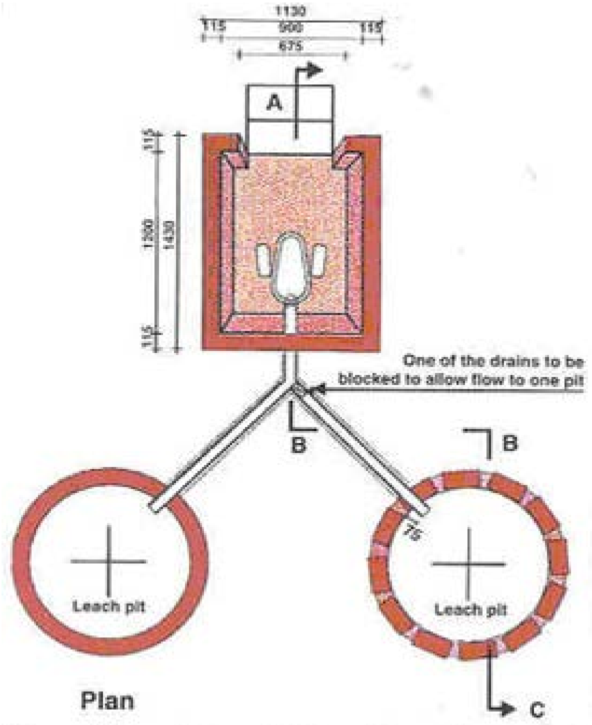

Figure 33 Double Pit Toilet (source: web site)

3.4.6.3 Ventilated Improved Pits (VIP)

VIP is also unhygienic like direct pit as they produce odor. However, the vent pipe provided from the pit allows fresh air flow and reduces the odor. Flies are attracted at the top of the vent pipe and have the chances of ground water pollution. VIP with bamboo lining, brick lining and RCC ring are widely used by the people of rural area. VIP with dry brick lining is suitable to a flood prone or water logged areas. VIP with bamboo lining is shown in Figure 34. According to Compendium of Sanitation System and Technologies, the toilet is System Template 1: Single Pit System.

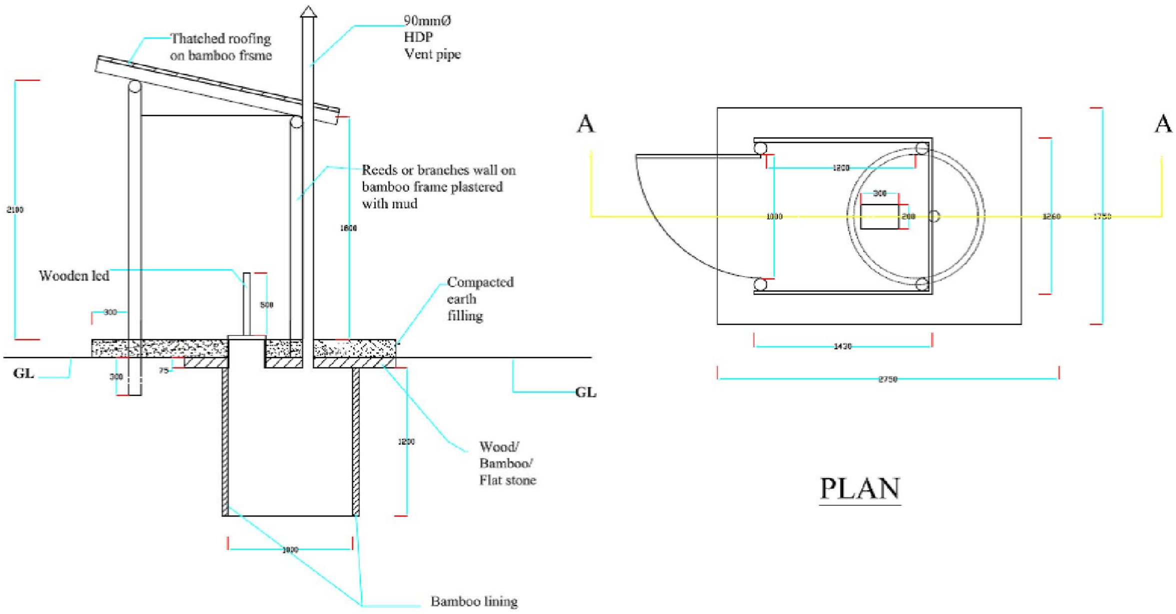

Figure 34 VIP bamboo lining toilet with floor plan (source: DWSS)

3.4.6.4 Waterseal Direct Pit

Water seal direct pit toilet is a pour flush direct pit toilet. According to Compendium of Sanitation System and Technologies, the toilet is System Template 5: Blackwater treatment system with infiltration. The toilet has a squatting hole in the cover slab. It has a shallow toilet pan with a U shaped water seal. It is used where there is sufficient amount of water so that chance of odor is very less. It can be constructed with low budget so it is very suitable in a low income group people. But, there is a chance of ground water contamination. This type of toilet has various types of pit lining. Water seal direct Pit of RCC lining is shown in Figure 35.

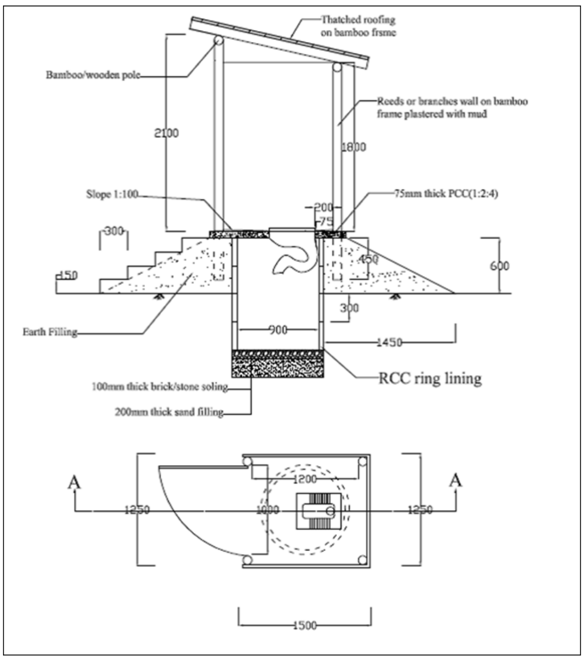

Figure 35 Water seal direct pit of RCC lining and plan (source: DWSS)

3.4.6.5 Water seal Offset Double Pit

According to Compendium of Sanitation System and Technologies, the toilet is System Template 3: Pour Flush System with Twin Pits. The pit of the toilet has different lining like RCC ring lining, dry brick lining and dry stone lining toilets which are mentioned as water seal offset double pit I, II and III in Table 11. Watreseal offset Double Pit of RCC lining shown in Figure 36.

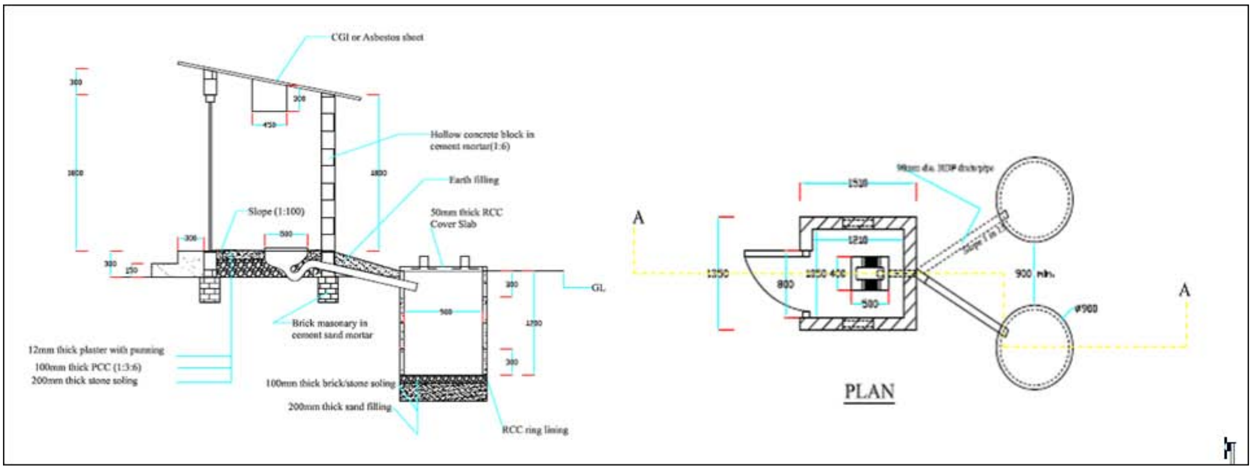

Figure 36 Water seal offset type double pit of RCC lining and plan (source: DWSS)

3.4.6.6 Urine Diversion Pour Flush (UDPF)

According to Compendium of Sanitation System and Technologies, the toilet is System Template 3: Pour Flush System with Twin Pits. As water is used to flush the faeces and anal cleaning purposes, it is called wet urine diversion toilet. UDPF is both of single vault and double vault. Special squatting pans made up of different materials like plastic, cement, fiber glass etc. are used like in UDPF. The squatting pans are shown in Figure 37 and Figure 38. It is more socially acceptable than UDDT in Nepal as use of water in toilet is common practice in Nepal. It is not much different than common toilet in Nepal as there is no need of handling faeces regularly. Therefore it utilizes as much as water that the water is used in common toilet. The use of faeces is difficult as it collected along with the flush water and anal cleansing water which are its disadvantages. If the faeces are used, they are collected in 2 pits which are used in alternation for about 2 years each. The water infiltrates into the soil and faeces are decomposed. The urine is collected separately and can be used as fertilizer. Usually a partition has been made in the toilet bowl for urine in the front and for faeces at the back. The flushing mechanism for urine part is designed in one of two ways; when urine pipe stays open, can receive certain amount of flushing water when the bowl is flushed and when the urine pipe is closed by a valve, the bowl will not receive flushing water. It can be constructed from locally available material so that it is affordable. However, it is not suitable in all difficult ground condition like hard rock soil, high ground water levels, area prone to flooding due to required excavation for pit and possibility contamination of groundwater and surface water.

Figure 37 UDPF Pan made from cement (source: ENPHO)

Figure 38 UDPF Pan made from fiber glass (source: ENPHO)

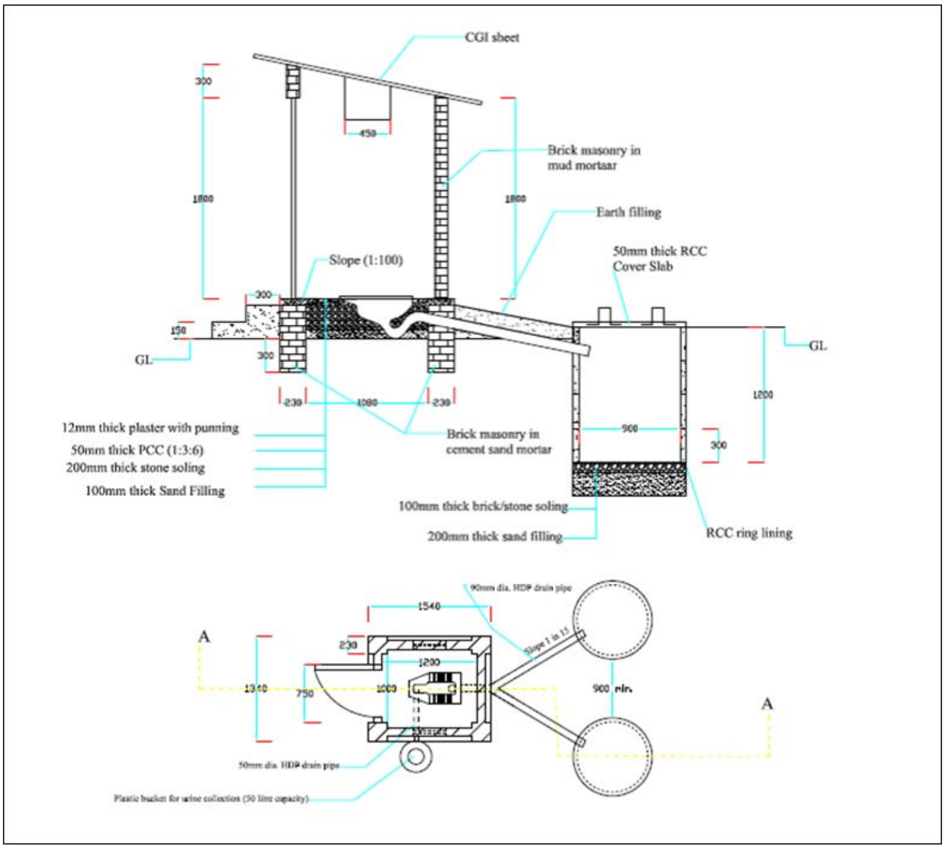

Figure 39 UDPF of pit RCC lining and plan (source: DWSS)

3.4.6.7 Toilet for Disable Person

This type of toilet is built for disable persons. According to Compendium of Sanitation System and Technologies, the toilet is System Template 3: Pour Flush System with Twin Pits. This toilet is designed for a person who is disabling. The Ramp with landing is provided at the door side and the door is made in a way of easily open during emergency.

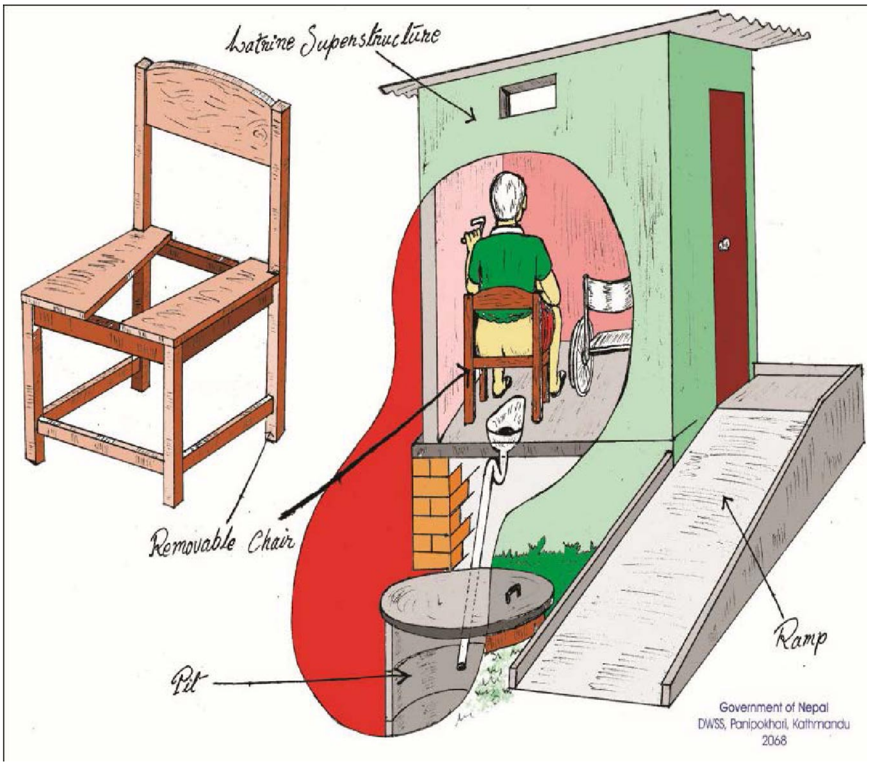

Figure 40 Toilet for disable person

3.4.6.8 Emergency Toilet

According to Compendium of Sanitation System and Technologies, the toilet is System Template 1: Single Pit System. Emergency toilet with its plan is shown in Figure 41 and Figure 42.

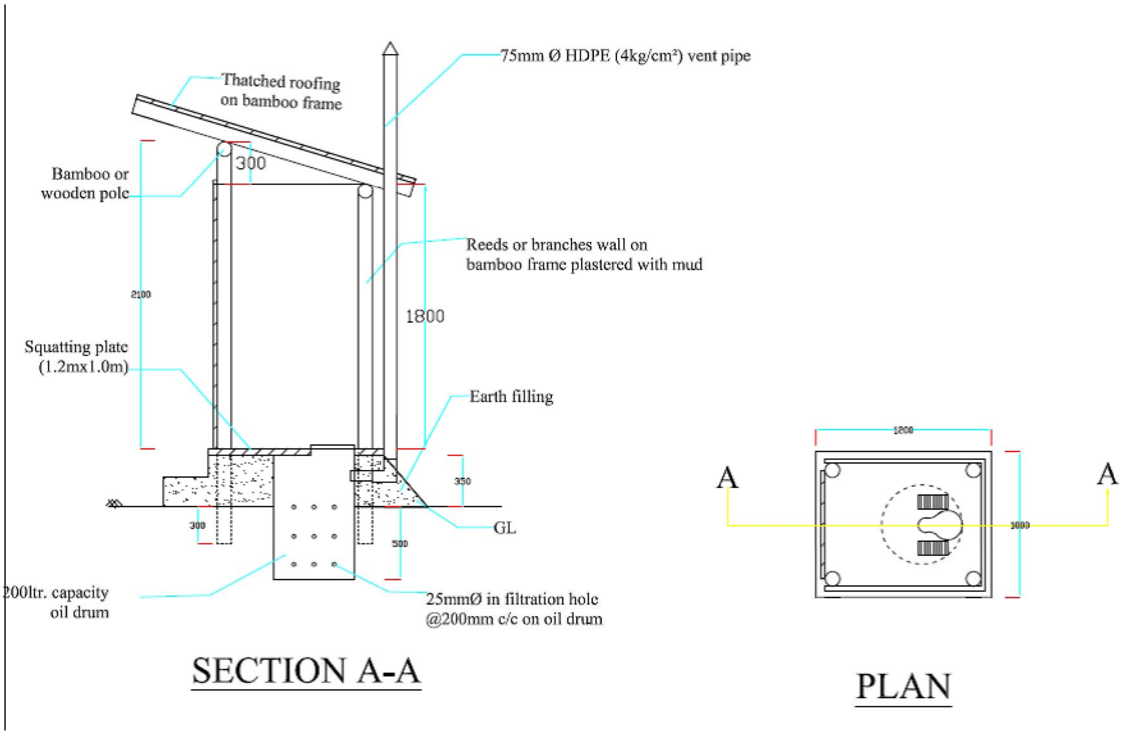

Figure 41 Emergency Toilet Type A and plan (source: DWSS)

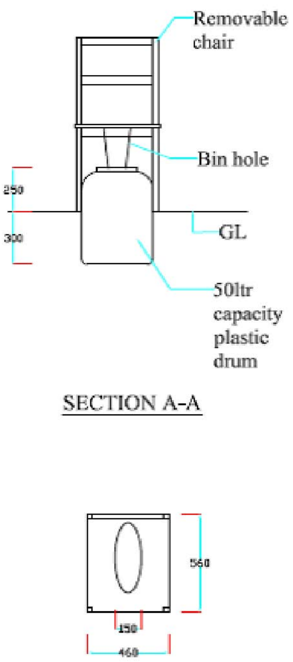

Figure 42 Emergency Toilet Type B and plan (source: DWSS)

3.4.6.9 Septic Tank with Soak Pit Toilet

According to Compendium of Sanitation System and Technologies, the toilet is System Template 5: Blackwater Treatment System with Infiltration. These types of toilets are used in the areas where there is no provision of sewerage facilities. These are similar with water seal offset double pit toilet which is attached with septic tank and soak pit. Septic tank is water tight structure that helps in separating and digestion the solid wastes. The effluent which harms human is collected in soak pit that helps infiltration of the effluent. For construction of the toilet, comparatively large space is required than other toilets and also more expensive as manpower is needed for the maintenance of the toilet.

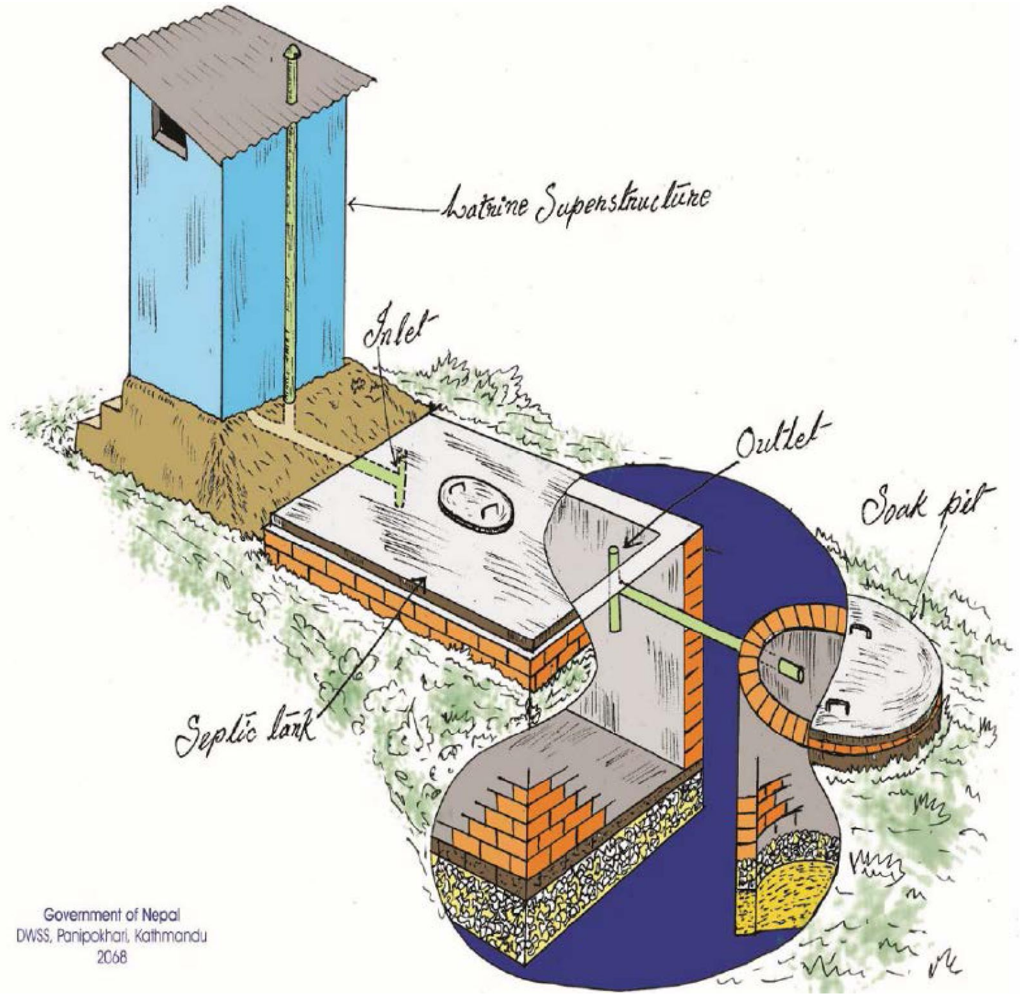

Figure 43 Toilet with septic tank and soak pit (source: DWSS)

4. Materials and Methodology

The Sources from where the data have been collected are

- The Bill of Quantities (BoQs) of different types of toilets in peri urban areas of Ethiopia, Uganda, Tanzania and Kenya are collected from the cost data available from Research-Oriented Sanitation concepts for peri-urban areas in Africa (ROSA) project. (http://rosa.boku.ac.at/).
- The cost data of different types of toilets in peri urban areas of Nepal is provided by Environment and Public Health Organization (ENPHO) from the Fiscal year 2011/12 of Government of Nepal, and by Department of Water Supply and Sewerage (DWSS) from "Technical Options of latrines for Large Scale promotion in Rural and Semi-Urban Communities of Nepal (volume II) October 2011''.

The developed templates for BoQs are based on the list of technologies derived from EAWAG *"Compendium of sanitation systems and technologies''* (Tilley et al., 2008).

Table 1 summarizes the data that have been used in the thesis regarding source, country and toilet types.

Table 1 Different type of toilets in Ethiopia, Kenya, Tanzania, Uganda and Nepal

Source	Country	Type of Toilets
ROSA	Arba Minch, Ethiopia	UDDT
		Fossa Alterna
		Arborloo
	Nakuru, Kenya	UDDT
	Arusha, Tanzania	UDDT
	Kitgum, Uganda	UDDT
ENPHO	Nepal	Single Pit
		Double Pit
		UDDT (Single Pit and Double Pit)
		UDPF (Single Pit and Double Pit)
DWSS	Nepal	Single Pit/ Direct Pit
		VIP
		Waterseal Direct Pit
		Waterseal offeset Double Pit
		UDPF (Single Pit and Double Pit)
		Toilet for Disable Person
		Emergency Toilet
		Septic Tank with Soak Pit Toilet
		UDDT

Within the ROSA project different types of toilets have been constructed in four Pilot cities Arba Minch in Ethiopia, Nakuru in Kenya, Arusha in Tanzania, and Kitgum in Uganda. The ROSA provided cost data of Urine Diversion Dry Toilet (UDDT) in all 4 pilot cities of African countries. In Ethiopia, along with BoQ of UDDT, BoQs of Fossa Alterna and Arborloo have been provided. ENPHO provided cost data of Single Pit Toilet, Double Pit Toilet, UDDT of Single Pit and Double Pit and Urine Diversion Pour Flush (UDPF) of Single Pit and Double Pit. DWSS provided cost data of Single Pit or Direct Pit Toilet, VIP, Water seal Direct Pit, Water seal Offset

Double Pit, UDPF of Single Pit and Double Pit, Toilet for Disable Person, Emergency Toilet, Septic Tank with Soak Pit toilet and UDDT.

The BoQ includes separate data for Substructure and Superstructure of different types of toilets which are prepared from the cost data. Before preparing BoQs a detail study of different types of toilets are carried out. Then, templates for BoQ of each toilet are prepared on the basis of developed templates from EAWAG Compendium of sanitation system and technologies (Tilley et al., 2008). The templates for BoQ of each toilet include Substructure and Superstructure. The Substructure of similar toilets is same in different places whereas the Superstructure of similar toilets can be various in different places. Both Substructure and Superstructure include Material Cost and Labor Cost which is shown in the templates of BoQ in Appendix. The Material cost of Substructure includes cost of Slab and Cost of Pedestal and the Labor cost includes cost paid to the worker or labor (skilled or unskilled) for any work required for the Substructure. The Material cost of Superstructure includes cost required for the construction of wall, door, window, roof, hand wash, trolley, vent pipe etc. The Labor cost includes the cost paid to the worker or labor for the construction of Superstructure. The currency of all five countries is converted into Euro on the basis of exchange rate on 15 January 2013 which is shown in Table 2. Total cost of Substructure is calculated, total cost of Superstructure is also calculated and at last the summation of total cost of Substructure and total cost of Superstructure is calculated as Overall cost of the toilet.

Table 2 Currencies in Euro according to the exchange rate on 15.01.2013

Name of Country	Currency	Euro
Ethiopia (Birr)	24.37	1.00
Kenya (KSH)	115.80	1.00
Uganda (USH)	3560.99	1.00
Tanzania (TSH)	2141.71	1.00
Nepal (Rs.)	116.78	1.00

As shown in Table 1, UDDTs are available in all five countries so that cost of UDDTs of Ethiopia, Kenya, Uganda, Tanzania and Nepal are compared below.

5. Results

All BoQs developed are available as separate files on the attached CD. An example of the BoQs of UDDT in Ethiopia and its templates are presented in the Appendix. Here, only a summary of the costs is presented.

5.1 Cost of UDDT in Ethiopia

In Ethiopia, UDDT is of a household. For Substructure of the toilet, material cost is the sum of the cost of Slab and Pedestal. Cost require for concrete work is the cost of Slab. The sum of cost of half cut fecal matter collecting barrel, squatting pan, PVC pipe, elbow, PVC vent cap, PVC pipe and vent cap, wires, male urinal and plastic jerry is the cost of Pedestal. These materials are required for the purpose of connection, ventilation, reinforcement and urine collection. Cost paid to the labor for the excavation purpose of Substructure of the toilet is the Labor cost of Substructure. The sum of the costs of Materials and Labor for Substructure is total cost of Substructure. Materials like doors, window, wall, roof, hand wash, trolley, Aisle are used for the construction of Superstructure of the toilet. The cost of these materials is the material cost of Superstructure. For construction of Superstructure labors are paid which is Labor cost of Superstructure. The sum of the costs of the materials and labor is the total cost of Superstructure. The summation of the total costs of the Substructure and Superstructure is the overall cost of the toilet. The cost of a household UDDT in Ethiopia is presented in Table 3.

Table 3 Cost of UDDT in Ethiopia

			ETHIOPIA UDDT in Euro
Number of Toilets			**1**
Substructure	**Materials**	**Slab**	**5.23**
		Pedestal	**32.83**
	Labor		**0.80**
Total cost of Substructure			**38.86**
Superstructure	**Materials**	**Doors and windows**	**16.78**
		Wall	**12.30**
		Roof	**16.39**
		Hand wash	**0.06**
		Trolley	
		Aisle	
	Labor		**73.01**
Total cost of Superstructure			**118.55**
Overall total Cost			**157.41**

In Table 3, costs of Slab, Pedestal and Labor are Euro 5.23, Euro 32.83 and Euro 0.80 respectively. The total cost of Substructure is Euro 38.86. The sum of material costs and labor costs of Superstructure is Euro 118.55. The overall total cost of the UDDT in Ethiopia is Euro 157.41.

5.2 Cost of UDDT in Kenya

In Kenya, cost of UDDT has been taken in different places like Crater View Secondary School, Kaptembow Primary School, Residential area and house of fire ministries. The total number of toilets in Crater View Secondary school is 7, Kaptembow Primary School is 4, residential area is

3 and house of fire ministries is 3. Average cost of UDDT of each place is calculated and at last Average cost of UDDT of Kenya is calculated below.

Table 4 Cost of UDDTs in Kenya

			KENYA								
			UDDT a	Average a	UDDT b	Average b	UDDT c	Average c	UDDT d	Average d	Average
			Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
Number of Toilets			7	1	4	1	3	1	3	1	
Substructure	Materials	Slab	86.36		153.57		57.16		107.53		
		Pedestal	89.77		235.32		58.96		64.04		
	Labor		141.96		171.57		74.97		79.07		
Total cost of Substructure			318.10	45.44	560.45	140.11	191.09	63.70	250.65	83.55	83.20
Superstructure	Materials	Doors and windows	124.93		361.40		72.62		65.72		
		Wall	81.15		84.26		21.38		22.59		
		Roof	96.88		157.72		48.39		48.39		
		Hand wash	12.34		43.18		7.20		11.51		
		Trolly									
		Aisle									
	Labor		141.57		395.87		131.02		136.14		
Total cost of Superstructure			456.86	65.27	1042.43	260.61	280.60	93.53	284.35	94.78	128.55
Overall total Cost			774.96	110.71	1602.88	400.72	471.69	157.23	534.99	178.33	211.75

UDDT in Crater View Secondary School = UDDT a
UDDT in Kaptembow Primary School = UDDT b
Residental = UDDTc
UDDT in house of fire ministries=UDDT d

In Table 4, UDDTs in Crater View Secondary School, Katembow Primary school, Residence and House of Fire Ministries are represented by UDDT a, UDDT b, UDDT c and UDDT d respectively.

In Crater View Secondary School, cost of slab is the cost of mass concrete and reinforced concrete is Euro 86.36. Cost of pedestal of UDDTs is the sum of the cost of DPC polythene, binding wires, Squatting pedestal, urine bowl, plastic containers for faeces and urine collection, plastic tank, vent pipe and uPVC pipe is Euro 89.77. Labors are needed for the work like excavation of the top soil, planking, strutting etc. The cost required for the labor of Substructure is Euro 141.96. The total cost of Substructure is the sum of costs of materials and labor of 7 UDDTs is Euro 318.10 and average cost of the UDDT is Euro 45.44. The materials required for the super structure of UDDTs are timber, mesh net, butt hinges, door latch for door and window; paint, external wall for walling; wall plate, purlin, facial board, nails, roof sheet, ridge cap gauge, gutter holder, rain water storage tank for roofing; hand wash basin to wash hand. For Superstructure, labors are needed for dressing wall and finishing wall. The total cost for the Superstructure of 7 UDDTs is Euro 456.86 and average cost is Euro 65.27.The overall total cost of 7 UDDTs is Euro 774.96 and average cost is Euro 110.71.

In Kaptembow Primary School, the cost of slab is the cost of mass concrete and the reinforced concrete for strip foundation and suspend floor, is Euro 153.57. The cost of pedestal is the total sum of the cost of DPC polythene, binding wires, UD squatting pedestal, plastic containers, plastic tank, vent pipe, uPVC bend, uPVC tee and uPVC pipe, is Euro 235.32. Labors are hired for work like excavation of the top soil, extract of water, extract of loose soil, planking and strutting and steel work. The cost of labor for the Substructure is Euro 171.57. The total cost of the Substructure is the total sum of the cost of slab, pedestal and labor of 4 UDDTs is Euro 560.45 and average UDDT is Euro 140.11. The materials used for the construction of Superstructures of UDDTs are Cyprus timber, mesh net, and butt hinges for door and window of UDDTs. Paint and plaster are required for wall. Wall plate, purlin, facial board, nails, roof sheet, gutter holder for roofing. Storage tank is for collecting rain water and hand wash basin for washing hand. Labors are used for the work like internal plaster of the wall, dressing wall and finishing wall and wooden surfaces of the Superstructure. The cost of labors of Superstructure of 4 UDDTs is Euro 395.87. The total cost of Superstructure is the sum of the cost of the materials and labor, is Euro 1042.43 while cost of average UDDT is Euro 260.61. The overall cost of the UDDTs is Euro 1602.88 and average is Euro 400.72.

In residential UDDTs, the cost of slab is the cost of mass concrete, reinforced concrete for the strip foundation, suspended floor and floor of the slab, is Euro 57.16. The cost of the pedestal is the sum of the cost of binding wires, DPC polythene, UD squatting pedestal, urine bowl, plastic containers, vent pipe, uPVC pipe and uPVC bend, is Euro 58.96. The labor required for the work like removal of top soil, planking and strutting, underdressed walling of Substructure and fixing and plumbing. The cost paid for these work is labor cost which is Euro 74.97. The total cost of Substructure of 3 UDDTs is Euro 191.09 and average cost is Euro 63.70. The Superstructure of the UDDTs include materials like timber, mesh net, butt hinges, latch door for door and window; oil paint, plaster for wall; wall plate, purlin, facial board, nails, roof sheet, ridge cap gauge, gutter holder for roofing; storage tank to store rain water and hand wash basin for hand wash. The labors are required for the work like internal plaster, smooth trowel, finishing wooden surfaces, finishing wall, undress walling of Superstructure. The labor cost of Superstructure is Euro 131.02. The total cost of the Superstructure of 3 UDDTs is Euro 280.60 and average cost is Euro 93.53. The overall cost for 3 UDDTs is Euro 471.69 and cost of each UDDT is 157.23.

In house of Fire Ministries the total number of UDDTs is 3. The cost of the slab is the cost of mass concrete and reinforced concrete for the strip foundation and suspended floor as in other UDDTs in Kenya. The cost for the slab is Euro 107.53. The total cost of the pedestal is the cost of DPC polythene, binding wires, UD squatting pedestal, urine bowls, plastic urinal set, plastic container, plastic tank, vent pipe with cup and net and uPVC pipe for draining urine, is Euro 64.04. The labor cost is the total cost required for the work done by labors like removal of top soil, undress walling of Substructure and floor slab, planking and strutting, is Euro 79.09. The total cost of the Substructure of UDDTs is Euro 250.65 and average cost is Euro 83.55. The materials used for the Superstructure are timber, mesh net, butt hinges, door latch for door and window; oil paint and plasters are used for wall; wall plate, purlin, facial board, nails, roof sheet, ridge and gauge, gutter holder are used for roof; storage tank to store rain water and wash basin with tap fitting is for hand wash. For the construction of Superstructure, the labors are needed for work like wall dressing, finishing wall and wooden surfaces of the Superstructure. The labor cost is Euro 136.14. The total cost of the Superstructure is Euro 284.35 and average cost is Euro 94.78. The overall cost of 3 UDDTs is Euro 534.99 and overall average cost is Euro 178, 33.

The average costs of Substructure, Superstructure and overall cost of UDDT in Kenya are Euro 83.20, Euro 128.55 and Euro 211.75 respectively.

5.3 Cost of UDDT in Uganda

In Uganda, the cost of UDDT has been taken from 1 Stance and Bathroom and 2 Stance and Urinal. The average cost of UDDT of Uganda is calculated below in Table 5.

Table 5 Cost of UDDs in Uganda

			UGANDA		
			UDDT e	UDDT f	Average
			Euro	Euro	Euro
Number of Toilets			**1**	**1**	
Substructure	**Materials**	**Slab**	**71.52**	**81.35**	
		Pedestal	**27.97**	**56.50**	
	Labor				
Total cost of Substructure			**99.49**	**137.85**	**118.67**
Superstructure	**Materials**	**Doors and windows**	**8.29**	**8.29**	
		Wall	**27.87**	**37.24**	
		Roof	**48.83**	**66.14**	
		Hand wash			
		Trolly			
		Aisle		**26.45**	
	Labor				
Total cost of Supertructure			**84.99**	**138.11**	**111.55**
Overall total Cost			**184.47**	**275.97**	**230.22**

UDDT-1 Stance & Bathroom=UDDT e
UDDT-2 Stance &Urinal=UDDT f

In Table 5, UDDT- 1 stance & Bathroom is represented by UDDT e and UDDDT-2 stances & Urinal is represented by UDDT f. In UDDT e, cost of slab is the sum of the cost of cement, sand and aggregate mass concrete for the bottom of the slab and reinforced concrete for squatting slab which is Euro 71.52. Cost of pedestal is the cost of PVC DN 150 pipe, PVC DN 50 pipe and PVC DN 50 elbows, is Euro 27.97. The total cost of the Substructure of UDDTe is Euro 99.49. In the construction of Superstructure, cost of materials is the cost of the cement, sand and aggregate for reinforced door beams; cement, sand and aggregate for the plaster of walls and pre painted facial board and iron sheet for roofing, is Euro 84.99. The overall cost of the UDDTe is Euro 184.47. In UDDT f, cost of slab is the cost of cement, sand and aggregate, is Euro 81.35. The cost of pedestal is the cost of PVC DN 150 Pipe, PVC DN 50 pipe, PVC DN 50 elbows and PVC DN 50 T pieces, is Euro 56.50. The total cost of Substructure is Euro 137.85. For the Superstructure of UDDT f, the cost of materials is the total cost of Superstructure, is Euro 138.11. For the construction of Superstructure, materials used are cement, sand and aggregate for reinforced the door beams; cement, sand and aggregate for the plaster of the wall, cement sand and aggregate for reinforced concrete aisle; pre painted iron sheet and facial board for roofing. The overall cost of UDDT f is Euro 275.97. For the construction of Substructure and Superstructure of UDDT e and UDDT f, labors are not used.
In Uganda, average costs of Substructure, Superstructure and overall cost of UDDTs are Euro 118.67, Euro 111.55 and Euro 230.22 respectively.

5.4 Cost of UDDT in Tanzania

In Tanzania, out of 17 wards the site selected for the implementation of UDDT is chosen in 3 wards (Lemara, Sokon I and Daraja II) because these wards account for 26% of Municipal population. UDDTs are of household. The UDDTs of concrete block and wooden wall are of double vault. The average cost of UDDT in Tanzania is also calculated below in Table 6.

Table 6 Cost of UDDTs in Tanzania

			TANZANIA		
			UDDT g	UDDT h	Average
			Euro	Euro	Euro
Number of Toilets			**1**	**1**	
Substructure	**Materials**	**Slab**	**63.27**	**69.34**	
		Pedestal	**78.63**	**69.29**	
	Labor		**7.00**	**7.00**	
Total cost of Substructure			**148.90**	**145.63**	**147.27**
Superstructure	**Materials**	**Doors and windows**	**48.65**	**48.65**	
		Wall	**60.70**	**28.01**	
		Roof	**16.06**	**16.06**	
		Hand wash			
		Trolly			
		Aisle			
	Labor		**35.02**	**28.01**	
Total cost of Superstructure			**160.43**	**120.74**	**140.59**
Overall total Cost			**309.33**	**266.38**	**287.85**

UDDT of concrete block=UDDT g
UDDT of wooden wall= UDDT h

In Table 6, UDDTs of concrete block and wooden wall are represented as UDDT g and UDDT h respectively. In UDDT g, cost of slab is the cost of cement, sand, aggregate and blocks for the pit, is Euro 63.27. Cost of pedestal is the cost of UD squatting pan, wire net, baskets, wet mesh, pipe, vent pipe, nails and elbow, is Euro 78.63. Labor cost is Euro 7. The total cost of Substructure is Euro 148.90. Materials used for the construction of Superstructure are doors, timber, nails for door; blocks, sand and cement for wall; corrugated iron sheets for roofing. Labor cost for Superstructure is Euro 35.02. The total cost of Superstructure is Euro 160.43. The overall cost of UDDT g in household is Euro 309.33. In UDDT h, cost of slab is the cost of cement, sand, aggregate and blocks for the pit, is Euro 69.34. Cost of pedestal is the cost of wire mesh, PVC pipe, and Vent pipe of 6m, elbow PVC, cap, timber, nails, squatting pan and wire net, is Euro 69.29. Labor charge is Euro 7. The total cost of Substructure is Euro 145.63. The total cost of the Superstructure is Euro 120.74. The materials used in the Superstructure are door, timber and nails for door and walling, is Euro 266.38. .
In Tanzania, the average costs of Substructure, Superstructure and overall UDDT are Euro147.27, Euro 140.59 and Euro 287.85 respectively.

5.5 Cost of UDDT in Nepal

In Nepal, UDDT is of single and double vault. The BoQs of UDDTs are of household. The average cost of UDDT is calculated below in Table 7.

Table 7 Cost of different UDDTs in Nepal

			ENPHO				DWSS	
			UDDT	UDDT i	UDDT j	UDDT k	UDDT	Average
			Euro	Euro	Euro	Euro	Euro	Euro
Number of Toilets			**1**	**1**	**1**	**1**	**1**	
Substructure	**Materials**	**Slab**	**140.78**	**84.91**	**56.00**	**30.28**	**119.98**	
		Pedestal	**18.96**	**19.38**	**24.73**	**20.45**	**18.46**	
	Labor		**35.97**	**20.55**	**15.41**	**15.41**	**20.47**	
Total cost of Substructure			**195.71**	**124.84**	**96.15**	**66.14**	**158.91**	**128.35**
Superstructure	**Materials**	**Doors and windows**	**29.97**		**29.97**	**3.43**	**25.86**	
		Wall						
		Roof	**2.57**	**2.57**			**20.55**	
		Hand wash	**0.21**	**0.21**	**0.13**	**0.13**	**0.69**	
		Trolley				**5.99**		
		Aisle						
	Labor		**52.24**	**20.55**	**4.71**	**6.42**	**26.40**	
Total cost of Superstructure			**84.99**	**23.34**	**34.81**	**15.97**	**73.49**	**46.52**
Overall total Cost			**280.70**	**148.18**	**130.96**	**82.11**	**232.40**	**174.87**

UDDT up to pan level = UDDT i
UDDT in House up to pan level I = UDDT j
UDDT in House up to pan level II =UDDT k

In Table 7, UDDT up to pan level, UDDT household up to pan level I and UDDT household up to pan level II are represented by UDDT i, UDDT j and UDDT k respectively. According to the BoQ of the UDDT from ENPHO, cost of slab is cost of bricks, cement, sand, aggregate and MS bar which is Euro 140.78. Cost of pedestal includes cost of 2 UDDT pans, poly bend of 3'' and 11/2", poly tee of 3'' and 11/2'', poly cowl, poly pipe, PVC net cap, PVC pipe, GI nipple (6"), GI socket and plastic container, is Euro 18.96. Labor cost is Euro 35.97. Total cost of Substructure is Euro 195.71. For the construction of Superstructure, materials used are door, window, slate for roofing, and plastic tap for hand wash. The labors are needed for the work like roofing and 9 labors are used for the construction of Superstructure. Labor cost of Superstructure is Euro 52.24. The total cost of Superstructure is Euro 84.99. The overall cost of the UDDT is Euro 280.70.

The UDDT up to pan level is taken in different places. Cost of the slab is the cost of bricks, cement, sand, aggregate and MS bar, is Euro 84.91. Cost of pedestal includes the cost of 2 UDDT pans, poly bend of 3" and 11/2", poly tee of 3" and 11/2", poly cowl, poly pipe, PVC net cap, PVC pipe, GI nipple (4"), GI socket and plastic container, is Euro 19.38. The number of mason used is 4. Labor cost is Euro 20.55. The total cost of Substructure is Euro 124.84. The materials used in the Superstructure are slate for roofing and plastic tap for hand wash. The number of labors used for the construction of Superstructure is 6. Labor cost for costruction of Superstructure is Euro 20.55. The total cost of the Superstructure is Euro 23.34. The overall cost for the construction of UDDT up to pan level is Euro 148.18.

The UDDT in house up to pan level I and II are designed in a similar way as the materials used for the construction of Substructure and Superstructure are same. Costs of slab of UDDT in house up to pan level I and II are the sum of the cost of bricks, cement, sand, aggregate and MS bar, are Euro 56.00 and Euro 30.28 respectively. Costs of pedestal is the sum of the cost of 1 UDDT pan, bucket, poly bend, poly tee, poly cowl, poly pipe, PVC tee, PVC bend, PVC net cap,

PVC pipe, GI nipple(1/2"), GI socket and plastic container, are Euro 24.73 and Euro 20.45 respectively. 3 masons are required for the work of Substructure. Labor costs for Substructure of toilets are Euro 15.41 and Euro 15.41 respectively. The total cost of Substructure is Euro 96.15 and 66.14 respectively. The materials required for the Superstructure of UDDTs in house up to pan level I and II are shutters for door and window; plastic tap for hand wash and trolley. Only one mason is needed for the construction of Superstructure in UDDT household up to pan level I and 3 masons are needed the for Superstructure work of UDDT household upset pan level II. The labor costs are Euro 4.71 and Euro 6.42 respectively. The total cost of Superstructure of UDDTs is Euro 34.81 and Euro 15.97 respectively. The overall cost of the both UDDTs is Euro 130.96 and Euro 82.11 respectively.
According to BoQ of the UDDT from DWSS, Cost of slab is the cost of bricks, cement, sand, aggregate and reinforcement is Euro 119.98. Cost of pedestal is the cost of binding wire, plastic drum, HDPE (4kg/cm2) vent pipe, HDPE (4kg/cm2) drain pipe, HDPE Tee (90mm dia.), L-drop, J-hook, Nut & bolt and Bitumen washer, is Euro 18.46. Skilled workers are used for the Substructure work of UDDT. The labor cost is Euro 20.47. The total cost of the Substructure is Euro 158.91. The materials used for the construction of Superstructure are door hinge, MS nail, GI plain sheet for door and Wood for door and window; CGI sheet (24 SWG 2.5' x 7') for roofing; bucket and jug for hand wash. The unskilled workers are used as labors. The labor cost is Euro 26.40. The total cost of the Superstructure is Euro 73.49. The overall total cost for the construction of the UDDT is Euro 232.40.
While calculating the average cost of UDDTs, it is found that the average costs of Substructure, Superstructure and overall are Euro 128.35, Euro 46.52 and Euro 174.87 respectively.

5.6 Comparing cost of other toilet types in Nepal

In the study, sources of Cost data of different toilet types in Nepal are ENPHO and DWSS. BoQs of Single Pit Toilet or Direct pit (sulav toilet), Urine Diversion Pour Flush (UDPF) of Single and Double pit and UDDT are received from ENPHO which are shown in Table 8. BoQs of Direct Pit, VIP with different lining like (bamboo, RCC, brick, stone, built up), Water seal Direct Pit, Water Seal offset Double Pit, UDPF, Toilet for Disable person, Emergency toilet and Septic tank with Soak Pit Toilet are received from DWSS which are shown in Table 9.

Table 8 Cost of other toilets type in Nepal (ENPHO)

			NEPAL (ENPHO)				
			Single pit	Double pit	UDPF (single pit)	UDPF (double pit)	Average UDPF
			Euro	Euro	Euro	Euro	Euro
Number of Toilets			**1**	**1**	**1**	**1**	
Substructure	**Materials**	**Slab**	**96.47**	**96.47**	**96.47**	**92.19**	
		Pedestal	**66.56**	**30.56**	**98.90**	**106.14**	
	Labor		**49.67**	**135.30**	**66.79**	**66.79**	
Total cost of Substructure			**212.70**	**262.33**	**262.16**	**265.12**	**263.64**
Superstructure	**Materials**	**Wall**					
		Door and Window					
		Roof					
		Handwash			**2.44**	**2.44**	
		Vent Pipe					
	Labor		**51.38**	**51.38**	**51.38**	**51.38**	
Total cost of Superstructure			**51.38**	**51.38**	**53.82**	**53.82**	**53.82**
Overall total Cost			**264.08**	**313.71**	**315.98**	**318.94**	**317.46**

In Single Pit toilet, cost of slab is the cost of bricks, cements, sand, and aggregate, is Euro 96.47. Cost of pedestal is the sum of the cost of pan, concrete rings, ring cover, pipe and fittings, poly cowl, poly tee, poly pipe of 3” and 4”, is Euro 66.56. The labors are required for the work like excavation of top soil and brick lining. Labor cost for Substructure construction is Euro 49.67. The total cost of the Substructure is Euro 212.70. For the construction of Superstructure, the materials required are found in surroundings so there is no cost for the materials. Labors are needed for the construction of Superstructure like to build door, window and roof. Labor cost of Superstructure is Euro 51.38. The total cost of Superstructure is Euro 51.38 and overall cost of Single Pit toilet is Euro 264.08.

In Double Pit toilet, cost of slab is the cost of bricks, cement, and sand and the aggregate which is Euro 96.47. Cost of pedestal is the cost of the pan, concrete ring, poly cowl, poly tee and poly pipe of 3” and 4” is Euro 30.56. Some helpers are used for excavation of top soil and some masons are used for brick laying, pipe laying, casting pit cover and concrete work. The labor cost of Substructure is Euro 135.30. The total cost of the Substructure is Euro 262.33. As in single pit only labors are required for roofing, door and window construction. The cost required for labor work is Euro 51.38. The overall total cost of Double Pit toilet is Euro 313.71.

The costs of slab of UDPF of Single Pit and Double Pit are Euro 96.47 and Euro 92.19 respectively. The Pedestal costs of the toilets are Euro 98.90 and Euro 106.14 respectively. The Labor costs of Substructure of the toilets are Euro 66.79 and Euro 66.79 respectively. The total cost of Substructure of the toilets are Euro 262.16 and Euro 265.12 respectively. For the construction of Superstucure of the toilets materials found on surroundings are used so that the costs of matrials are not needed in both types of toilets. In both toilets,, costs for hand wash and Labors are Euro 2.44 and Euro 51.38 respectively.

The average cost of Substructures, Superstructures and overall cost of UDPFs are Euro 263.64, Euro 53.82 and Euro 317.46 respectively.

Table 9 Cost of other toilet types in Nepal (DWSS)

			NEPAL (DWSS)																					
			Single Pit	VIP (I)	VIP (II)	VIP (III)	VIP (IV)	VIP (V)	Average VIP	WSDP A	WSDP B	WSDP C	WSDP D	Average WSDP	WSODP (I)	WSODP (II)	WSODP (III)	Average WSODP	UDPF	Disable	Eergency A	Emergency B	Average Emergency	STSP
			Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
Number of Toilets			1	1	1	1	1	1		1	1	1	1		1	1	1		1	1	1	1		1
Substructure	Materials	Slab	7.58	4.15	8.07	13.12	21.14	20.75	13.45	5.66	10.01	28.97	5.66	12.58	24.98	31.39	24.81	27.06	26.39	152.45	33.40	6.85	20.12	14.79
		Pedestal								28.72	21.72	24.49	28.72	25.91	183.43	66.46	87.00	112.30	40.05	34.73	4.69		4.69	25.28
		Septic tank																						166.27
	Labor		6.56	6.85	2.56	8.72	25.51	9.58	10.64	0.81	2.94	9.53	0.81	3.52	5.52	26.43	51.02	27.66	18.46	28.38	0.30	0.06	0.18	59.12
Total cost of Substructure			14.13	11.00	10.63	21.85	46.65	30.33	24.09	35.19	34.67	62.99	35.19	42.01	213.94	124.28	162.83	167.01	84.91	215.56	38.39	6.91	22.65	265.46
Superstructure	Materials	Wall	5.74	7.45	3.04	3.04	3.04	3.04	3.92	7.42	7.42	7.42	7.42	6.01	8.99	8.99	8.99	8.99	14.56	21.41	9.42			14.56
		Door and Window	0.35	0.35	0.35	0.35	0.35	0.35	0.35	1.80	0.86	1.80	1.80	1.57	1.80	1.80	1.80	1.80	9.69	45.16	0.35			28.06
		Roof			5.14	5.14	5.14	5.14	5.14	0.86	1.80	0.86	0.86	1.09	0.86	0.86	0.86	0.86	18.37		0.86			
		Handwash	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69			0.69
		Vent Pipe		7.96	7.96	7.96	7.96	7.96	7.96															
	Labor									2.53	6.55	21.70	10.90	10.42	7.89	18.43	38.76	21.69	11.00	55.41	3.90			29.47
Total cost of Superstructure			6.77	16.45	17.17	17.17	17.17	17.17	18.06	13.29	17.31	32.46	21.66	19.78	20.23	30.76	51.10	34.03	54.31	122.66	15.20		15.20	72.77
Overall total Cost			20.90	27.45	27.80	39.02	63.83	47.51	42.15	48.48	51.98	95.45	56.85	61.79	234.17	155.04	213.93	201.04	139.21	338.22	53.59	6.91	37.85	338.23

VIP (I) = VIP in Bmboo lining
VIP (II) = VIP in RCC lining
VIP (III) = VIP in Brick lining
VIP (IV) = VIP in Stone lining
VIP (V) = VIP in Build up(dry brick lining)

WSDP(A)=Waterseal Direct Pit in RCCC lining
WSDP(B)=Waterseal Direct Pit in dry brick lining
WSDP(C)=Waterseal Direct Pit in dry stone lining
WSDP(D)=Waterseal Direct Pit indry brick (build up)

WSODP (I)= Waterseal offset Double Pit in RCC lining
WSODP (II)= Waterseal offset Double Pit in dry brick lining
WSODP (III)= Waterseal offset Double Pit in dry stone lining
STSP= Septic Tank with Soak Pit

On the basis of cost data of DWSS, in Single Pit toilet, the cost of slab is Euro 7.58. Masons are used for bamboo laying and helper did the excavation work. The cost paid to masons and helpers is labor cost which is Euro 6.56. The total cost of Substructure is Euro 14.13. For the Superstructure, plastic sheeting are used for door and window; reeds or branches, nylon, MS nail are used to construct wall and bucket and jug are used to wash hand. The total cost of Superstructure is Euro 6.77. The overall cost of Single Pit toilet is Euro 20.90.

VIP (I), VIP (II), VIP (III), VIP (IV) and VIP (V) represent VIP toilets of pit lining with bamboo, Reinforced Cement Concrete (RCC), brick, stone and dry brick or built up respectively. Cost of slab is sum of cost of bricks, sand and bamboo in VIP of bamboo lining which is Euro 4.15. In VIP (II), cost of slab is sum of the cost of bricks, sand, cement, aggregate and bamboo, is Euro 8.07. In VIP (III), cost of slab is sum of the cost of bricks, sand, cement, aggregate and bamboo, is Euro 13.12. In VIP (IV), cost of slab is sum of the cost of stone, sand, cement, aggregate and bamboo, is Euro 21.14. In VIP (V), cost of slab is sum of the cost of bricks, sand, cement, aggregate and bamboo, is Euro 20.75. Labors are required for the work like excavation of soil, bamboo lining and brick lining. Cost of labor in VIP (I), VIP (II), VIP (III), VIP (IV) and VIP (V) are Euro 6.85, Euro 2.56, Euro 8.72, Euro 25.51 and Euro 9.58 respectively. The total costs of the construction of the Substructure are Euro 11, Euro 10.63, Euro 21.85, Euro 46.65 and Euro 30.33 respectively. Labors are not used in the construction of Superstructure of toilets. So, sum of the cost of materials is the total cost of Superstructure.The materials used in VIP (I) are plastic sheeting for door and window, reeds or branches for wall, bucket and jug for hand wash, vent pipe for ventilation. The materials like plastic sheets for door and window; jute or plastic rope, MS nail, wood led for wall; reeds or branches for roofing; bucket and jug for hand wash and vent pipe for ventilation are used in VIP (II). The materials like plastic sheeting for door and window; nylon, MS nail and wood led for wall; bucket and jug for hand wash and vent pipe for ventilation are used in VIP (III), VIP (IV) andVIP (V). The total costs of construction of Superstructure of VIP (I), VIP (II), VIP (III), VIP (IV) and VIP (V) are Euro 16.45, Euro 17.17, Euro 17.17, Euro 17.17 and Euro 17.17 respectively. The overall costs for the construction of toilets are Euro 27.45, Euro 27.80, Euro 39.02, Euro 63.83 and Euro 47.51 respectively. The average cost of Substructures, Superstructures and overall costs of Ventileted Improved Pit toilets are Euro 24.09, Euro 18.06 and Euro 42.15 respectively.

WSDP (A), WSDP (B), WSDP (C) and WSDP (D) represent Water seal Direct Pit Toilets with pits in RCC lining, dry brick lining, pit in dry stone lining and pit in dry brick (built up) respectively. Cost of slab is sum of cost of cement, sand brick and aggregate in WSDP (A), WSDP (B), WSDP (C) and WSDP (D). Costs of pedestals are costs of materials like steel bars, binding wires, squatting pan with water seal, Pre cast RCC ring and RCC cover in WSDP (A). Materials like steel bars, binding wires and squatting pan with water seal are used in WSDP (B), binding wires, squatting pan with water seal and reinforcement are used in WSDP (C) and binding wires, squatting pan with water seal, reinforcement, pre cast ring and RCC manhole cover are used in WSDP (D). Costs of pedestals of WSDP(A), WSDP (B), WSDP (C) and WSDP (D) are Euro 28.72, Euro 21.72, Euro 24.49 and Euro 28.72 respectively. The skilled labor is hired for the construction of Substructure of the toilets. The labor costs of the toilets are Euro 0.81, Euro 2.94, Euro 9.53 and Euro 0.81 respectively. The total costs of Substructures are Euro 35.19, Euro 34.67, Euro 62.99 and Euro 35.19 respectively. The materials required for the construction of Superstructure of the toilets are bamboo, reeds or branches and MS nail for wall, thatched roof for roofing; plastic sheeting and nylon for door and window; bucket and jug for hand wash. Unskilled workers are used to construct the Superstructure of the toilets. The labor costs of Superstructure are Euro 2.53, Euro 6.55, Euro 21.70 and Euro 10.90 respectively. The total costs of the Superstructure of the toilets are Euro 13.29, Euro 17.31, Euro 32.46 and Euro 21.66 respectively. The overall costs of the toilets are Euro 48.48, Euro 51.98, Euro 95.45 and Euro 56.85 respectively. The average cost of Substructures, Superstructures and overall costs of Water seal Direct pit Toilets are Euro 42.01, Euro 19.78 and Euro 61.79 respectively.

WSODP (I), WSODP (II) and WSODP (III) represent Water seal offset Double Pit in RCC lining, Water seal offset Double Pit in dry brick lining and Water seal offset Double Pit in dry stone lining respectively. Cost of slabs is the cost of bricks, cement, sand and aggregate in WSODP (I) and WSODP (II) and stone, cement , sand and aggregate in WSODP (III). The slabs costs are Euro 24.98, Euro 31.39 Euro 24.81 respectively. The cost of pedestal is the cost of HDPE pipe of 90mm diameter, HDPE elbow, squatting pan with water seal, pre cast ring and ring cover in WSDOP (I), is Euro 183.43. The cost of pedestal is the cost of HDPE pipe of 90mm diameter, HDPE elbow, squatting pan with water seal, bricks, cement, sand, reinforcement and binding wires in WSODP (II) is Euro 66.46. The cost of pedestal is the cost of HDPE pipe of 90mm diameter, HDPE elbow, squatting pan with water seal, stone, cement, sand, reinforcement and binding wires in WSDOP (III) is Euro 87. Masson and helpers are Labors. The labors for the construction of the Substructure of the toilets are Euro 5.52, Euro 26.43 and Euro 51.02 respectively. The total cosst of the Substructure of toilets are Euro 213.94, Euro 124.28 and 162.83 respectively. Materials used for the Superstructure of the toilets are reed and branches for wall; thatched roof; plastic sheeting and nylon rope for door and window, bucket and jug for hand wash. Labor costs for Superstructure of toilets are Euro 7.89, Euro 18.43 and Euro 38.76 respectively. The total costs of the Superstructure of the toilets are Euro 20.23, Euro 30.76 and Euro 51.10 respectively. The overall costs of the toilets are Euro 234.17, Euro 155.04 and Euro 213.93 respectively. The average total cost of Substructures , Superstructures and overall costs of Water seal offset Double Pit toilets are Euro 167.01, Euro 34.03 and Euro 201.04 respectively.

In UDPF toilet, cost of slab is cost of bricks, cement, sand, reinforcement and binding wires, is Euro 26.39. Cost of pedestal is cost of HDPE pipe, HDPE tee, squatting pan with U trap, brick, cement, sand, reinforcement and binding wires, is Euro 40.05. The masons are used for the work like brick laying, pipe laying casting pit cover. Labor cost for the construction of Substructure is Euro18.46. The total cost of the Substructure is Euro 84.91. The materials required for the construction of Superstructure are CGI sheet, MS nail for wall; bitumen washer and wood work for roof, GI plain sheet, J-hook, L-drop and door hinge for door and window and bucket and jug for hand wash. The helpers are labors. The labor cost is Euro 11. The total cost of the Superstructure of the toilet is Euro 54.31. The overall cost of the toilet is Euro 139.21.

In toilet for disable person, cost of slab is cost of the materials like bricks, cements sand and aggregate is Euro 152.45. Cost of pedestal is cost HDPE pipe, HDPE tee, squatting pan with U trap, brick, sand, pre cast RCC ring, RCC ring cover and removable chair, is Euro 34.73. Labor cost is Euro 28.38. The total cost of Substructure of the toilet is Euro 215.56. The materials used for the Superstructure are CGI sheet, MS nail for wall; wood work, nut and bolt, bitumen washer, J hook, L-drop, GI plain sheet for door and door hinge for door and window; bucket and jug for hand wash. Helpers are labors and the labor cost is Euro 55.41. The total cost of the Superstructure is Euro 122.66. The overall cost of the toilet is Euro 338.22.

In Emergency Toilet A, cost of slab is the cost of squatting plate and oil drum which is Euro 33.40. Cost of pedestal is cost of HDPE elbow and HDPE vent pipe, is Euro 4.69. The masons are used for block laying. The labor cost is Euro 0.30. The total cost of the Substructure is Euro 38.39. The materials cost for Superstructure of the toilet is the cost of materials like bamboo and reed or branches for wall construction; thatched roof for roofing; plastic sheeting for door and window and bucket and jug for hand wash. The labor cost is Euro 3.90. The total cost of Superstructure is Euro 15.20. The overall cost of the toilet is Euro 53.59. In Emergency Toilet B, the total cost of Substructure is the overall cost of the toilet. The cost of slab is the cost of plastic drum, bin hole and removable chair, is Euro 6.85. The labor cost is Euro 0.06. The overall cost

of the toilet is Euro 6.91. The average cost of Substructures, Superstructures and overall costs of the Emergency toilets are Euro 22.65, Euro 15.20 and Euro 37.85 respectively.
STSP stands for Septic Tank with Soak Pit. For this toilet, cost of slab is the cost of bricks, cement and sand, is Euro 14.79. Cost of pedestal is cost of steel bars, binding wires, squatting pan, HDPE pipe and HDPE tee, is Euro 25.28. The cost of septic tank is the cost required to construct septic tank which includes the cost of brick, cement, sand, aggregate, reinforcement, binding wires, HDPE pipe, HDPE tee and manhole cover frame, is Euro 166.27. Both skilled and unskilled workers are used to construct the Substructure of the toilet. The skilled and unskilled workers are used for pit masonry work and septic tank. The labor cost is Euro 59.12. The total cost of the Substructure is Euro 265.46. The materials used for Superstructure are CGI sheet and MS nail for wall; GI plain sheet, J-hook, bitumen washer, wood, L-drop and door hinge for door and window; bucket and jug for hand wash. The skilled and unskilled workers are used to construct the permanent structure of the toilet. The Labor cost is Euro 29.47. The total cost of the Superstructure of the toilet is Euro 72.77. The overall cost of the toilet is Euro 338.23.

5.7 Comparing costs of a UDDT in different countries

Costs of a UDDT in different countries are compared on the basis of percentage and per capita income of the country.

Table 10 Comparing costs of a UDDT on the basis of Percentage in Ethiopia, Kenya, Uganda, Tanzania and Nepal

	Ethiopia	Kenya	Uganda	Tanzania	Nepal
Total cost of Substructure of UDDT in Euro	38.86	83.20	118.67	147.27	128.35
Total cost of Superstructure of UDDT in Euro	118.55	128.55	111.55	140.59	46.52
Overall cost of UDDT in Euro	157.41	211.75	230.22	287.86	174.87
Total cost of Substructure of UDDT in Percentage	24.69	39.29	51.55	51.16	73.40
Total cost of Superstructure of UDDT in Percentage	75.31	60.71	48.45	48.84	26.60
Overall cost of UDDT in Percentage	100.00	100.00	100.00	100.00	100.00

In Table 10, the average cost of UDDTs of Kenya, Tanzania,Uganda and Nepal are derived from above Table 4, Table 5, Table 6 and Table 7 respectively and cost of a UDDT of Ethiopia is derived from Table3.
Among all five countries, percentagewise cost of Substructure of UDDT is found lowest in Ethiopia (24.69%) while highest is in Nepal (73.40%) and cost of Superstructure of UDDT is found highest in Ethiopia (75.31%) while lowest is in Nepal (26.60%). In Ethiopia for the construction of Substructure of a UDDT only cement is used in the concrete work of slab while various materials like bricks, cement and sand are used in the concrete work in Nepal. In addition to average cost of a slab in Nepal is higher (Euro 86.39) than in Ethiopia (Euro 5.23). It could be because of the soil condition in Ethiopia as it is characterized by flood and unstable type of soil. They have to reconstruct the slab after each flooding; they might use only cement for the concrete work of slab. In Ethiopia pedestal is of a single vault and a plastic squatting pan is used while in Nepal some UDDTs are of single vault and some are of double vault. The average cost of the pedestal in Nepal (Euro 20.40) is comparatively lower than the cost of pedestal in Ethiopia (Euro 32.83). The labor charge in Ethiopia is very low (Euro 0.80) while the labor charge in Nepal is very high Euro 21.56. The labors are used only for the excavation of top soil; trench excavation; backfill

under trench and backfill to level ground and compact with layer. The labors are unskilled labor. So the overall cost of Substructure of Ethiopia is very less (Euro 38.86).
On the contrary, for the construction of Superstructure in Ethiopia, materials like corrugated iron sheets and Eucalyptus wood are used for the construction of doors. The wall is made of bamboo and canvas cover which is cemented internally and externally as well. The roof is made of iron sheet. Hand wash depot with fix tap is used for hand wash. All the cement work for the construction of Superstructure is done by labors so that the labor cost is high (Euro 73.01). Skilled labors are used in the construction of Superstructure of the toilet. In Nepal, for Superstructure of toilet, door and window are usually made of wood, roof is of slate or CGI sheet and simple plastic bucket with plastic tap and jug are used for hand wash. Labors are needed for the work like fixing of roof, doors and windows. Unskilled labors are used for the construction of Superstructure. So the average Superstructure labor cost is low in Nepal (Euro 22.06). The cost of Substructure and Superstructure of UDDT in Uganda and Tanzania is more or less same. Similarly, Ethiopia and Kenya also accounts more or less same.

Table 11 Per Capita income of Ethiopia, Tanzania, Uganda and Nepal on basis of report of World Bank 2014

Countries	**GDP in million US Dollar**	**Total Population in Million**	**Per capita income in US Dollar**	**Per capita income in Euro**
Ethiopia	47527	94	505.61	480.33
Kenya	55243	44	1255.52	1192.75
Uganda	21494	38	565.63	537.35
Tanzania	33225	49	678.06	644.16
Nepal	19294	28	689.07	654.62

To find the per Capita Income of a country, Gross Domestic Product (GDP) of a country is divided by total population of the country. It is important to know the per capita income of a country in order to decide whether the people of the country are able to afford it or not. In Table 11, Per Capita income of all five countries in Million US dollar is calculated and then is converted in Euro on the basis of exchange rate of 10.03.2015.

Table 12 Cost of UDDTs in comparison to per capita income in Percentage

	Ethiopia	**Kenya**	**Uganda**	**Tanzania**	**Nepal**
Total cost of Substructure	8.10	7.03	21.84	22.98	19.47
Total cost of Superstructure	24.71	10.86	20.53	21.94	7.06
Overall cost of UDDT in Euro	32.81	17.90	42.37	44.92	26.52

In Table 12, on the basis of per capita income of all 5 countries, it is found that for the construction of Substructure it costs in an ascending order of total income of country are 7.03% in Kenya, 8.10% in Ethiopia, 19.47% in Nepal, 21.84% in Uganda and 22.98% in Tanzania Similarly, for the construction of Superstructure it costs in an ascending order of the total income of country are 7.06% in Nepal, 10.86% in Kenya , 20.53% in Uganda, 21.94% in Tanzania and 24.71% in Ethiopia. Among all countries, it costs least 32.81% of the total income in Kenya to construct UDDT including Substructure and Superstructure and highest 44.92% of the total income to construct UDDT including Substructure and Superstructure in Tanzania.

6. Interpretation and Discussion

While comparing different types of toilets in different five countries (Ethiopia, Kenya, Tanzania, Uganda and Nepal), only UDDT is found common in all 5 countries but the cost of construction is different in all five countries. In UDDTs, the template of the Substructure of the toilet is similar in all countries, however; the different in cost of the Substructure could be due to the different choice of user interface, applied technology, location and design. The cost of Superstructure could vary significantly due the different materials applied in the construction of walling and roofing. The Superstructure can be constructed according to the will of person.

The user interface of the UDDT can be made up of various materials. It can be ceramic or plastic or stone. The operation of all the user interface of UDDT is to separate and collect faeces and urine separately. The household UDDT costs comparatively lower price than that of the church, residential and schools. The cost also depends on the place where it is constructed. If the soil of that place is of rocky type, it's difficult to dig the pit, consequently requires more cost for labor. The constructed material and design (dimensions) of slab and pedestal is not similar in UDDTs.

The Substructure of UDDT of Arba Minch, Ethiopia costs comparatively less than other UDDTs of all 5 countries. The slab is made of cement and masons are used to construct it. It is of household so that it is constructed in a very simple way. The toilet has plastic squatting pan and is of a single vault. A half cut barrel is used to collect the faeces and plastic tank is used to collect urine through PVC pipe. Ash is applied after used. It is designed in such a way that makes the operator easy to empty dry excreta from near side of the toilet. The collected faeces and urine are used in farm as a fertilizer.

The cost of each Substructure of UDDT of Crater View Secondary (CV) School is less than that of Katembow Primary (KP) School, residential area and house of Fire Ministries but more than that of Arba Minch, Ethiopia. In UDDTs of Kenya, due to the lack of sufficient water, water is collected from rain water harvesting and used for hand wash. In schools, residential area and church the number of people used the toilet is more than that of in household. In CV School, single vault UDDT is constructed. The vault is constructed in such a way that has enough space to hold containers and adequate room for attendant to remove and replace the bucket. Vault door is of galvanized steel and is painted so that it is durable and is tightly fixed to prevent flies. The urine is collected in underground tank. The cost of Substructure of UDDT in KP school is more than that of CV school. In KP school also single vault UDDT is constructed but with urinal bowls and each vault holds two faecal matter storage containers of 30 liter and two urine storage containers of 1000 liter. The residential areas where the UDDT are constructed, the soil type is of shallow and hard rock type. It requires more cost to dig a pit so that people used constructed raised pit. The urine and faeces are collected in plastic tanks containers as in other UDDT. A 100mm thick base concrete slab was placed over the compacted stones and the super structure is constructed. As there is very less space for urban agriculture, the dried faeces are disposed in the dumpsite and have to carry to a 50m distance. The urine goes to the soak pit. The cost of UDDT of church or house of fire ministries is comparatively more than that of the UDDT of CV School and residential area. The type of soil in the area of church is of volcanic loose type, ranging from moderate occurrence of surface rock to very shallow soil. There is a possibility of leaking of liquid from the pit to the underground which may cause contamination to the ground water and surface water. So that, for the ease of collection of faeces, a container is used on which the faeces is directly collected instead of falling in a floor of chamber. For female single vault as well as double vault UDDT with solar drying cover at the back is used. For men single vault UDDT and a urinal cubical with five waterless urinal bowl of standard ceramic is used. UDDT for the children is also constructed which contain 5 liter plastic container and fitted lower to the floor level. Once the container of the faeces is filled they are transferred to the solar drier in double vault till they become completely dry and odor free. Urine is collected and used in agriculture as in other places of Kenya

The cost for the construction of the Substructure of UDDT in Uganda is more than that of the Ethiopia and Kenya except the toilet of KP school. In Uganda the UDDT is of 1 stance with bathroom and 2 stances with urinal. The soil is of poorly drained type and water logging type. Both 1 and 2 stances toilet have similar technology i.e. each stance contains a vault underneath and a urinal. While using the toilet, the faeces are directly dropped in a vault underneath. As the urine and faeces are not recommended to use in agriculture directly, once the container is filled, it is stored to undergo sanitization.

The cost for the construction of Substructure of UDDT in Tanzania is comparatively more than that of all UDDT in all 5 countries. Though it is of household with the estimation of 4 to 6 users, it is more expensive than the above UDDT of other African countries. Some toilets are of double vault and some are of single vault. In UDDT concrete blocks of 5 inches thickness are constructed and both plastic and (mostly) ceramic squatting pans are used. To fill the vault, it requires several years that is 3-5 years and the urinal plastic tank has to be empty every 2 weeks because of its small size.

The most common type of UDDT in Nepal is of Vietnamese model. Double vault UDDT is comparatively more expensive than that of single vault. The double vault is usually constructed outside whereas the single vault is more suitable inside. As in the above African countries, in double vault, once a vault is filled, the other one is used and the first one is left for the dehydration and is used later in agriculture. While in case of single vault, once it is filled, it is parted and other container replaced the first one and it is left for dehydration. The cost of Substructure of UDDT in Nepal is higher than other African countries except Tanzania. It could be due to the cost of the materials and labor charge is expensive in Nepal in comparison to other countries.

Besides UDDT, other toilets are also used in Nepal like single pit, double pit, VIP, Water seal direct pit, Water seal offset double pit, UDPF, Disable toilet, Emergency toilet and toilet with septic tank with soak pit. Among all these, Emergency toilet is the lowest cost toilet as squatting plate or bin hole, oil drum or a bin and a removable chair are used. The template is of single pit toilet. The single pit toilet (from DWSS) is also of low cost as for the construction of this toilet a pit is constructed where the faeces is received directly and the lining is constructed on the basis of the soil type and local material like bamboo and wooden led are used for the construction of slab and the pedestal is not constructed. But, the single pit toilet (from ENPHO) is more expensive because the slab is constructed with cement, bricks, sand and aggregate. The local materials are not used. Concrete rings, Ring cover, some pipe fittings, pipes are used in the construction for pedestal. In the same way VIP is also of low cost toilet and the template is of single pit toilet type, only the difference is a vent pipe which is provided from the pit to allow fresh air to reduce the odor. The cost of VIP varies due to vary in the lining. Among VIP toilets, the lowest cost of VIP is of RCC lining and the highest is the VIP of stone lining. Water seal direct pit toilets cost more than the single pit and VIP but still the people of low income can afford this type of toilet. . Pedestal is constructed and the template is completely different than that of VIP and single pit. The lining of this toilet is lined by various materials and the cost among the Water seal direct pit differs due to varies types of lining. The least cost is the Water seal direct pit of dry brick lining. The cost of RCC lining and stone lining are of same but a bit more cost is of built-up lining. The Waterfall offset double is of different template toilet. It is twin pits pour flush toilet. It cost more than single, VIP and water seal offset direct pit and emergency toilet. The different in the cost is due to the same reason as above, the lining of the toilet. The lining of RCC of this toilet is more expensive than the toilet of dry brick lining and dry stone lining. The cost of UDPF (from ENPHO) of single and double vault is more than UDPF (from DWSS). The template is same. It is Twin pit for pour flush toilet. The difference in cost of the Substructure is due to the materials like concrete ring and ring cover are used in the pedestal of UDPF (from ENPHO). The cost of Disable toilet is more than other toilets except the toilet with septic tank with soak pit (from DWSS). It is designed in such a way that it makes easy for disabling person. A ramp is made in the side of the door and the door is set in a way of easily open. A removable chair is also placed over the squatting pan. The cost of toilet of Septic tank with soak pit is the most expensive toilet among all toilets. It is similar to Water seal offset double pit toilet but it is attached with septic tank and soak pit. Beside the toilet a septic tank has to be constructed which requires an area and for soak pit as well Manpower is needed for the maintenance of the toilet.

Among different types of toilets in peri urban areas of Ethiopia, Uganda, Kenya, Tanzania and Nepal, UDDT is found as a common toilet in all countries. UDDT is affordable in all countries as the overall cost for the construction of the toilet is less than 45% of per capita income. It keeps the nutrient and water cycle in a closed loop sanitation process with a low energy approach that uses a complete natural process. It is applicable in both dense and thin populated areas and the place where scarcity of water is and the excreta can be used as a fertilizer in farm. Thus, it is found as a toilet with appropriate technology and convenient in all countries However, some toilets like Single Pit, VIP, Water seal direct Pit are found less cost than UDDT in Nepal, they are not appropriate in all soil condition and unhygienic.

7. Summary

The cost of various types of toilets of peri urban areas of developing countries (Ethiopia, Kenya, Tanzania, Uganda and Nepal) are collected from ROSA project, ENPHO and DWSS and compared by using standard template of EAWAG Compendium of Sanitation systems and technologies. While comparing different types of toilets, UDDT is found common in all counties. The UDDT takes the principle of environment sanitation. It keeps the nutrient and water cycle in a closed loop sanitation process with a low energy approach that uses a complete natural process. The cost of the toilet is compared on the basis of the Substructure of the toilet as technically the template of the Substructure of the toilet is similar. The Superstructure of the toilet varies as it can be constructed as per the will of the owner of the toilet. So that the cost of the Superstructure of toilet could vary significantly due to the different materials applied in the construction of walling, roofing, windows, doors etc. In Tanzania, the UDDT is of concrete block wall and wooden wall are constructed. The cost of the Substructure of concrete block UDDT and wooden Block UDDT has no big difference than that of the difference in cost of the Superstructure of the toilet. UDDT in all countries is more or less of similar design with a little bit modification in construction. There are double vault and single vault UDDT on the base of the principle of its operation. It can be constructed in and outside of the house. It is applicable in both dense and thin populated areas from household to residential areas, schools, church, prisons quarter and council offices. The UDDT is affordable and highly accepted by society of all countries. It is suitable in a place where there is scarcity of water as faeces is collected in dry state and urine is collected separately. Water is not required because ashes saw dusts and husks are used to cover the faeces instead of flushing it down. In order to prevent the flies, the above door is covered with a gauge wire. Each vault is provided with a vent pipe that rises 1 m above the roof for the circulation of air from vaults to atmosphere so that there will be no odor. In Crater View Secondary School, Kaptembow Primary School, residential area and the house of Ministers of Kenya, rain water is harvested and is used for hand wash. Water is not required so that it is a suitable toilet in dry areas or where there is scarcity of water. In some places where UDDT is applied, water is consumed and also produced waste water. It is during the process of anal cleaning which requires approximately 1 liter of water per use. The waste water coming from anal cleansing is collected separately in a soak pit or a small wetland is constructed outside of the toilet which prevents underground water contamination. It is considered as a toilet which can be constructed in a difficult ground condition. However, it can cause contamination of ground water and surface if it is constructed in an area of high groundwater level and in an area prone to flooding. Despite of this, UDDT is constructed in Arba Minch, Ethiopia; the place is characterized by flood type during rainy season with unsuitable soil condition. If the place where the toilet has to be constructed is characterized by hard rock type and shallow soil, constructed raised pits can be used like in the residential UDDT of Kenya. In addition, the type of soil of house of fire ministries is loose ranging from moderate occurrence of surface rock to very shallow soil and has the possibility of liquid content in the pit leaking to underground and transported to the lake along geological fault lines which may cause contamination to ground and surface water. In this case, the faeces can be collected in a container instead of letting fall in a floor of chamber so that the faeces can be easily collected. It can be constructed with the locally available material so that it is affordable. The urine and faeces collected are used as fertilizer in farm, however, sometimes applied only after secondary treatment.

While comparing costs of a UDDT in all five countries, it is found that UDDT is beneficial to all countries but it is much benefited to Ethiopia in comparison to other four countries. Percentage-wise it is found that the cost of Substructure is lowest in Ethiopia (24.69%) while the cost of Superstructure is highest (75.31%) amongst the five countries. On the contrary, the highest cost for

the Substructure (73.40%) and lowest cost (26.60%) is seen in Nepal. The highest cost of Supe structure in Ethiopia can make low as the Superstructure of the toilet can be made as per the will of the user. In Ethiopia while constructing the Substructure, the slab is constructed of cement. It could be due to the floody and unstable soil type of Ethiopia. While in Nepal for the construction of slab various materials like bricks, cement and sand are used in the concrete work. The average cost of slab in Nepal is higher (Euro 86.39) than in Ethiopia (Euro 5.23).
On the basis of per capita income, UDDT is affordable in all countries as the overall cost for the construction of the toilet does not exceed 45% of the per capita income. Percentagewise of the per capita income, the overall cost for the construction of UDDT is 17.90% in Kenya, 26.52% in Nepal, 32.81% in Ethiopia, 42.37% in Uganda and 44.92% in Tanzania.
Different designs of UDDT in Nepal have been illustrated. The most common UDDT in Nepal is based on Vietnamese model. There is variation in design of UDDT in Nepal. This is made to suit the local conditions and requirement of the users. A single pan and double pan versions are used. The double pan version, which is the most common in Nepal, is usually constructed outside and a single version is suitable for indoors where space is constraint. Different types of toilet are illustrated from the source ENPHO and DWSS. The different types of toilet in Nepal are single pit or direct pit, UDPF of single pit and UDPF of double pit, UDDT, VIP, water seal direct pit, water seal offset double pit, Disable toilet, emergency toilet and septic tank toilet with soak pit. Among all these toilets, acceptable by society, affordable, practical, hygienic, use the principle of sanitation, use of excreta and can be constructed in all type of soil and for large number of people is only UDDT. The UDPF is also socially acceptable by the people of Nepal as water is used for flushing and anal cleansing. However it is not suitable in all ground condition. UDPF is designed and used in the areas where compost from human faeces is not accepted locally. It is a twin pit pour flush toilet in which a special urine separating squatting pan is used and urine is collected separately while the faeces is collected with anal cleaning water.
There are some toilets like single pit toilet or direct pit toilet, VIP, emergency toilet, water seal direct pit and UDPF which cost less to construct than UDDT. Single or direct pit toilet is very simple, famous and low cost toilet with lots of cons like less hygienic, not useful in all places. Only a pit is constructed with lining of RCC or brick or stone or bamboo and in some places without lining and excreta is directly fall in the pit. VIP varies because of their different lining such as bamboo lining, RCC lining, brick lining, stone lining and dry brick lining. These are also unhygienic but produce fewer odors than single pit due to the vent pipe provided from the pit that allows fresh air flow and reduces the odor. Emergency toilet is built for emergency condition so it cannot be used in a daily life. Water seal direct pit is a pour flush toilet. In spite of being hygienic and low cost, it is not applicable everywhere especially in a region of water scarcity as it need lots of water. Some toilets cost more than UDDT like toilet with septic tank and soak pit, water seal off set double pit and disable toilet. Water seal offset double pit toilet and disable toilets are twin pits pour flush toilet. The water seal offset double pit toilet costs more or less, depends on the pit lining of the toilet. Normally the pit lining of RCC is more expensive than that of the dry brick and dry stone lining. The disable toilet is also twin pits pour flush toilet. It costs more to construct as it is designed especially for disable person. Required a bit more area to construct as a ramp has to make with extra removable special designed chair and should have enough space to move wheel chair. Toilet with septic tank and soak pit is pour flush toilet. The toilet costs more and suitable only those place where there is no provision of sewerage facilities. In addition, an extra septic tank and soak pit has to construct and extra place is required to place it. The toilet requires more manpower to maintain as the excreta have to remove to make the septic tank empty once it is full.
Various types of toilets are used in peri urban areas of Ethiopia, Kenya, Uganda, Tanzania and Nepal. Among them UDDT is found as the common toilet in all five countries. It is found as an

appropriate, much beneficial and convenient toilet among all types of toilets in the five countries. It is affordable, suitable in soil condition, ecological sanitation and hygienic toilet in comparison to other toilets.

8. Outlook

This work is based on secondary data. Different types of toilet have been used in all five countries. The work is done only on the available type of toilet in the countries. In the study, UDDT is found to be a common, applicable, beneficial, convenient and appropriate technology toilet in all five countries. The UDDT takes the principle of environment sanitation as it keeps the nutrient and water cycle in a closed loop sanitation process with a low energy approach that uses a complete natural process so that the technology of UDDT has to be widely expanded. Some changes can be made in the template of the toilet so that cost of the toilet will be lower. If the local people or the users know well about the operation and maintenance task and the plant equipment of the toilet; and are taught about the technology of the construction of UDDT, the cost for the construction of the toilet can be decreased by decreasing in labor cost and slab cost. As the UDDT can be constructed in all type of soil, the technology of UDDT has to apply in other places as well.

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10. Appendices

APPENDIX A: BoQ of UDDT in Ethiopia

it. No	Description	Unit	Quantity	Unit Price	Amount
	A. Substructure				
1	***Excavation and Earth Work***				
1.1	Clear the site to remove top soil to an average depth of 20 cm.	m^2	5.7	2.50	14.25
1.2	Back fill to level the ground and	m^3	0.31	3.50	1.09
1.3	compact with layer not exceeding 15	m^3	0.31	2.50	2.81
1.4	Back fill to level the ground and compact with layer not exceeding 15cm	m^3	1.31	2.50	3.28
	B. Super Structure				
2	***Masonry work***				
	Supply and Construct 20 cm thick Hollow concrete block wall bedded in				
2.1	Cement Mortar 1:4 both sides left for Plastering	m^2	4.25	315.00	1338.75
	20 CM Hollow concrete wall bedded in cement mortar 1:4 mix ratio and all				
2.2	external surfaces are plastered	m^3	1	315.00	315.00
3	***Concrete Work***				
	Lean concrete with minimum cement content of 150kg/m3 filled in to a				
3.1	formwork and vibrated in 5cm thick	m^3	0.17	750.00	127.50
3.2	Provide, cut and fix sawn Zigba wood form work	m^2	1.93	65.00	125.45
3.3	Provide and cut hexagonal chicken wire mesh	m^3	1.85	20.00	37.00
4	***Carpentary and Joinery***				
	Supply and fix Door Made from Corrugated Iron Sheet of Size 2 m by				
4.1	0.60m braced by Eucalyptus wood, including nailing accessories	pcs	1	1.05	1.05
4.2	Supply and fix Door Made from Corrugated Iron Sheet of Size 0.720m by				
	0.80m braced by Eucalyptus wood, including nailing accesoties	pcs	1	80.00	80.00
4.3	Fixing of Eucalyptus wood of:-				
	a. dia 80 mm	m	22.35	4.00	89.40
	b. dia 100mm	m	13.58	6.00	81.48
	c. dia 120 mm	m	15.8	10.00	158.00
	Supply and fix wooven Bamboo locally called 'karta' for walling including				
4.4	nailing accessories	m^2	8.1	7.01	56.78
4.5	Canvas cover for wall	m^2	8.1	30.00	243.00
5	***Rooffing***				
	Supply and fix corrugated iron SheetG-32 for roof cover including all				
5.1	nailing and fixing accessories	m^2	4.9	81.52	399.45
6	***Sanitary Fixtures***				
6.1	Squatting type toilet made of wood plastered by mortor	pcs	1	60.00	60.00
	Supply and fix a size of 110 mm thick pvc pipe and its vent cap for				
6.2	ventilation purpose and apply two coats of black paint	ml	3.5	25.00	87.50
6.3	50mm pvc pipe	ml	3	18.53	55.59
6.4	Elbow (90 degree) diameter 110mm	pcs	3	10.00	30.00
6.5	110 mm dia Pvc Vent cap	pcs	1	45.00	45.00
6.6	Hand wash depot fixed with tap	pcs	1	1.50	1.50
6.7	Half cut fecal matter collecting barrel	pcs	2	150.00	300.00
6.8	Male urinal pcs 1 35.00 35.00	pcs	1	35.00	35.00
6.9	Urine collecting tank(100 liter plastic jerry can)	pcs	1	150.00	150.00
	TOTAL				**3835.78**

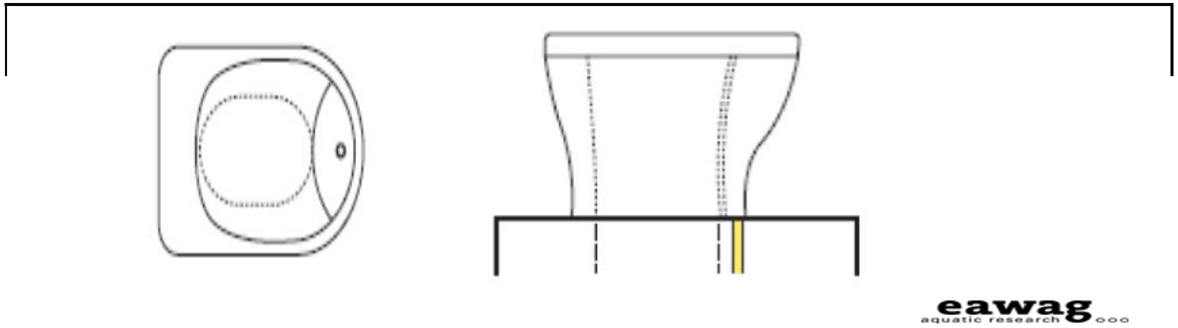
APPENDIX B: Tempaltes of UDDT in Ethiopia

URINE DIVERTING DRY TOILET (UDDT) -SINGLE VAULT | **U.2**

Bill of Quantities for single vault UDDT

REMARKS:
 * Cement mortar should be thoroughly mixed
 * Slab should be always wet while curing

Design of slab	Dimension:	
square		
Length	1	m
Width	1	m



1	SUBSTRUCTURE						
A	MATERIAL						
Description	Slab					Currency:	Birr
	Items	For :	Specification	Unit	Qty	Price/Unit	Cost
	Cement	filled into form work(CONCRETE WORK)	min.150kg/m³ ; 5cm thick	m³	0.17	750.00	127.50
	TOTAL						127.50
	Pedestal					Currency:	Birr
	Half cut fecal matter collecting barrel			pcs	2	150.00	300.00
	Squating pan		made of wood plaster by mortor	Pcs	1	60.00	60.00
	pvc pipe		50mm	pcs	3	18.53	55.59
	Elbow	connection	(90 degree) diameter 110mm	pcs	3	10.00	30.00
	Pvc Vent cap		110 mm dia	pcs	1	45.00	45.00
	PVc pipe and vent pipe	ventilation purpose	110mm thick	ml	3.5	25.00	87.50
	wires	reinforcement		m³	1.85	20.00	37.00
	Male urinal			pcs	1	35.00	35.00
	plastic jerry can	urine collection	100 liter	pcs	1	150.00	150.00
	TOTAL						800.09

B	LABOUR					Currency:	Birr
	remove top soil	Excavation	depth 20cm	m^2	5.7	2.50	14.25
	trench excavation		depth 30 cm	m^3	0.31	3.50	1.09
	backfill under trench		thickness 10cm	m^3	0.31	2.50	0.78
	backfill to level ground and compact with layer			m^3	1.31	2.50	3.28
	TOTAL						19.39
	Total (substructure)						946.98
2	SUPERSTRUCTURE						
A	MATERIAL						
	Door					Currency:	Birr
	Corrugated Iron sheet (0.72m×0.80m)	fixing door		pcs	1	80.00	80.00
	Eucalyptus wood of:-	fix					
	a. dia 80 mm			m	22.35	4.00	89.40
	b. dia 100mm			m	13.58	6.00	81.48
	c. dia 120 mm			m	15.8	10.00	158.00
	TOTAL						408.88
	Wall					Currency:	Birr
	Bamboo ' karta'	fixing wall		m^2	8.1	7.01	56.78
	canvas cover	fixing wall		m^2	8.1	30.00	243.00
	TOTAL						299.78
	Roof					Currency:	Birr
	Iron sheet	roofing		m^2	4.9	81.52	399.45
	TOTAL						399.45
	Hand Wash					Currency:	Birr
	Hand wash depot fixed with tap	washing hand		pcs	1	1.50	1.50
	TOTAL						1.50
B	LABOUR						
	Cement motor(1:4)	construction wall	hollow concrete block	m^2	4.25	315.00	1338.75
	Cement motor(1:4)	plastering external surface		m^3	1	315.00	315.00
	zigba wood form	provide, cut and fix		m^2	1.93	65.00	125.45
	TOTAL						1779.20
	Total (superstructure)						2888.81
	GRAND TOTAL						3835.78

Thickness	0.2	m
Concrete mix	1:4	

Observations

***In the source ,fixing door is given twice with different size so here it is mentioned only one door**
***door of size 0.72m by 0.8m of price 8o Birr is not mentioned**
***Squatting type toilet made of wood plastered by mortor cost Birr 60 per pcs**

APPENDIX C: List of Figures

APPENDIX D: List of Tables

11. Curriculum Vitae

Sujeeta Selalik Bimali
Born in Kathmandu, Nepal

EDUCATION

09/2012– 09/2015	**University of Natural Resources and Life Sciences, Vienna** Individual Master's Programme: Natural Resources Management and Ecological Engineering (NARMEE) with specialization on Ecological Engineering & Risk Management **Title of Master Thesis** Comparing Cost Data of different Toilets in Peri Urban Areas of Developing Countries (Ethiopia, Kenya, Uganda, Tanzania and Nepal) Institute of Sanitary Engineering and Water Pollution Control (SIG), Priv.-Doz. DI Dr. Günter Langergraber
08/2002 – 08/2005	**Tribhuvan University, Kathmandu, Nepal** Master of Arts (M.A.) with specialization on Sustainable Rural Deveopment & Rural Technology and Skill Development of Use of Chemical Fertilizer to Land Degradation (A Case Study of Anaikot VDC, Kavre District) CentralDepartment of Rural development , Prof. Dr. Bhesh Nath Sapkota
10/1999 – 10/2002	**Tribhuvan University, Trichandra Multiple Campus, Kathmandu, Nepal** Bachelor of Science (B.Sc.) in Environmental Science

WORK EXPERIENCE

10/2012 – 12/2012	**University of Natural Resources and Life Sciences, Vienna** Institute of Sanitary Engineering and Water Pollution Control (SIG) Mandatory Practice (literature research, compiling information and report on specific items, they are design and planning of waste water systems and costruction and management of abstraction wells for drinking water supply
02/2004 – 02/2005	**Brihaspati Vidyasadan, Kathmandu, Nepal** Teacher of Health and Environmental Science in secondary level
10/2001– 01/2003	**Golden Good Sherpa Construction Pvt. Ltd, Nepal** Environment assistant to Bio- (Protection of the landslide, planning for Vegetative plants)