Cost-Effective Design of Latrine for Low Income Group

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ABSTRACT

Purpose: *Latrine is a symbol of cleanness. It is most to have a latrine even for getting basic government facilities. Though the country is declared ODF, in reality, it is difficult to maintain the status for long. There are pieces of evidence that the declared ODF zones have reverted to open defecation over time. It was in this context, that the study was carried out to explore appropriate latrines to be constructed in the case of Mahottari District, Nepal.*
Design/Methodology/Approach: *Two communities namely Khyarmara (of Bardibas Municipality wards no. 10 and 11) and Pipara (of Pipara rural municipality, wards no. 1 to 7) were selected for the study. Household surveys along with the observation of the latrines constructed in the homestead, focus group discussion with the local people and key informants with the local implementers are the main sources of data followed by secondary data.*
Findings/Result: *The study has identified three different types of latrines existing in the study areas including water seal offset type single pit latrine (SO), latrine with the septic tank (LST), and water seal offset type double pit latrine (DO). By and large, SO-type latrines exist in the study area. It was found that 87 % of the latrines are currently sustained (SL), whereas the rest fall under either the sustained but at risk (SAR) category or simply not sustained (NS). The study analysis showed that the water seal offset double pit latrine (DO) is more sustainable and cost-effective in comparison to other types of latrines that exist in the study area. This led to the recommendation for constructing DO types of latrines in the study areas. It is very challenging for people having low income to afford to construct the latrines. Therefore, it is worthwhile to provide certain support in terms of capital subsidy to construct the latrines for the weaker section of society.*
Originality/Value: *This is significant to policymakers and designers to overcome the issue of toilet construction.*
Paper Type: *Action Research*
Keywords: Types of Latrine, Cost, Suitability, Design, Income

1. INTRODUCTION :

Housing for the low-income groups seems difficult to be addressed although it is a fundamental right based on the constitution of Nepal [1] then toilet facilities would not be easy. Globally, several methods are found to be assessed for fulfilling housing needs. Nepal is also estimating and attempting to fulfill housing needs [2, 3, and 4]. For the holistic development of human civilization, the basic facilities should be focused on.
Mahottari district has been divided into 10 municipalities and 5 Rural Municipalities with 111,034 households (formerly 66 village development committees & 3 municipalities). As per the population census of 2068, the total population of the Mahottari district is 7, 01,037. Among them, the male is 3, 58,144, and the female is 3, 42,893(CBS, 2011 as cited in Jha and Jha, 2019) [5].
Like the majority of districts in the Terai region, the Mahottari district has also a record of poor hygiene and sanitation practices with concern to open defecation. The eradication of open defecation had not been the priority of the local population and it was rather accepted as social culture. People felt more comfortable defecating in the open public spaces than in latrines which used to be practiced in society with a supportive mindset and as a part of their culture. The situation was so poor that there used to be feces along the two sides of the road from Pipara to Vitthamod and Pipra to Janakpur for about

approximately 14 km and around 1-foot depth and it was even reported as the *"Longest Open Toilet"* in Nepal in a newspaper. However, the lack of spaces for individual household latrines, high population density in the society as well as poverty-driven economic problems for construction prevailed in the existence of the practice of open defecation in the study area. Moreover, there was no government subsidy to construct individual household latrines.

The Open Defecation Free (ODF) Zone declaration program was started by Government in 2010, followed by Sanitation and Hygiene Master Plan brought into action in 2011(MoU, 2069/070) [6]. Under this Khayaramara of Bardibas Municipality of Mahottari district had the opportunity to receive support from the government. At present, all the municipalities and rural municipalities have been declared ODF zone. Mahottari dwellers have been chanting an inspiring slogan *"Mahottari basi ko abhibhara, khulla disamukta banau gau sahar sara",* this means ODF is the responsibility of the public of the Mahottari district. This will be maintained to access affordable latrines to all; however, this kind of study has not been conducted yet.

2. OBJECTIVES :

The main objective of the study is to find out the convenient and cost-effective design of the latrine for Mahottari District, Nepal.

3. LITERATURE REVIEW :

3.1 Sanitation Target:

Sanitation is considered a milestone for public health, development, and prestige. Sanitation facility is the fundamental right of every citizen which is an approach that keeps places tidy, especially by managing human waste. Around the globe, helpless disinfection stays a significant danger to improvement, affecting the nation's progress in wellbeing, instruction, and sexual orientation value, social and monetary turn of events. Since sterilization joins with wellbeing, schooling, and destitution, so it is a significant supporter of the accomplishment of objective 7 of the Millennium Development Goals which states "By 2015, halve the proportion of people without sustainable access to safe drinking water and basic sanitation".

Nepal had targeted to achieve water supply coverage of 73 % and sanitation coverage of 53 % then at par with MDG Goal 7, which are already surpassed by the coverage of water and sanitation within Nepal [7].

Worldwide 2.5 billion individuals including 840 million kids don't utilize improved sterilization. 1.2 billion (right around one-fifth of the total populace) practice open poop in provincial zones, this is the situation of 1 out of 3 individuals (UNICEF, 2009) [8]. In Nepal, sanitation promotion was prioritized only after the declaration of the Sanitation Decade in 1981 by the United Nations. During the early days, only 6 % of the total households present in 1990 had latrine facilities which gradually increased in the subsequent years. In CBS 2011 [5], sanitation coverage is quoted at 62 %. Currently, the country's sanitation coverage has increased notably within the period of five years (2011-2016) after the enforcement of the Sanitation and Hygiene Master Plan (SHMP) and the massive expansion of the ODF campaign (NSHCC, 2011) [9]. This ODF campaign has significantly contributed to the vision of the Government of Nepal **'Prosperous Nepal, Happy Nepali'.** The current sanitation coverage in Nepal is 100 % (NMIP/DWSSMM, 2020) [10] which have access to latrine/sanitation. "With due respect to the declaration of 753 Rural Municipalities, Metro/Sub-Metro/Municipalities and 77 districts as open defecation free, *I declare Nepal as Open Defecation free Country besides I call upon people of Nepal to move towards total Sanitation country and achieve the target of sustainable development goal (SDG 6.2) by 2030"* stated by Honorable Prime Minister of Nepal on 30th September 2020 [7].

Cross country development for Open defecation free (ODF) is going on by Sanitation and Hygiene Master Plan in 2011. At present, the information delivered by the Environmental Sanitation Section (ESS) of the Department of Water Supply and Sewerage Management (DWSSM) shows those 7 areas, 77 Districts, 753 Municipalities/Rural regions have been pronounced open defecation free (ODF) zone (ESS/DWSSM, 2020) [11] with an expanding pattern of ODF affirmation of the most recent five years. The open defecation-free (ODF) movement is guided by the principle of community-wide total sanitation led by local bodies with flexibility in approach and technologies. The continuity of ODF and its advancement towards total sanitation depends on several factors like motivation, financial, technical, institutional, and political.

Nepal National Sanitation Policy, 1994, characterizes sterilization as all exercises which improve and continue cleanliness to raise personal satisfaction and the soundness of a person. It incorporates legitimate techniques for removal of human excreta, individual cleanliness, food cleanliness, appropriate dealing with, capacity and utilization of drinking water, appropriate strong and fluid garbage removal, and legitimate creature garbage removal as the vital parts of sterilization. The Urban Water Supply and Sanitation Policy – 2009 states that sterilization is the sheltered administration of human excreta, including the equipment (lavatories, and so on) and programming (guideline, cleanliness, advancement, and so on) expected to diminish fecal-oral sickness transmission. Hence, hygiene and sanitation are interlinked entities for public health and environmental sustainability.
Within ten municipalities and five Rural municipalities of Mahottari District, the total population benefitted from the water supply is 548,759 (87.71% of the total population) and the total number of households benefitted from latrine facilities is 111,034 (100%) of the total households [12]. With this coverage, Mahottari District stands at 73rd position among all the districts in water and sanitation coverage within Nepal.

3.2 Different Types of Existing Household latrine across the physiographic regions:

There are different types of Latrines for households as per the Environmental Sanitation Section of DWSSM (Source: DWSSM, 2011) [13].

- Water Seal Offset Type Single pit latrine
- Water Seal Direct Pit Latrine
- Ventilated Improved pit Latrine (Sulabh)
- Latrine for differently able people
- Latrine with septic tank & soak pit
- Eco-san Latrine (Dry -type)
- Eco-san Latrine (Wet -type)

Table 1 Shows different latrines being constructed across the physiographic regions of the country along with the cost of construction [14]. While investing in latrine construction, it is necessary to consider the local income level to provide sustainability to these latrines. The locally available construction materials also play an important role not only in construction but also in maintenance works.

Table 1: Types of Household Latrines Used

S. N.	Regions	Latrine Options	Costs (NRs.)		
			Local Material Cost	Non-Local Material Cost	Total Cost
1.	Mountain	Offset type Double pit Latrine (Wooden stick, bamboo Mats, dry stone wall)	10.034	3,000	13,034
		Direct Pit VIP latrine (Wooden stick, bamboo Mats, dry stone wall)	7,685	3,000	10,685
		Pour Flush Double pit Latrines (Wooden stick, bamboo Mats, dry stone Masonry)	10,054	3,000	13,054
2.	Hill	Offset Type, Double Pit Latrine (Dry stone Masonry)	9797	3,000	12,797
		Offset Type, Double Pit Latrine (Dry Stone Masonry)	8695	3,000	11,695
		Direct Pit, VIP latrine (Dry) Stone Masonry)	8585	3,000	11,585
		Offset Type, VIP latrine with attached Pit (Dry stone Masonry)	10,054	3,000	13,054

		SULAV Latrine in stone Masonry with pre-cast Rings	10.014	3,000	13,014
		Pour flush & stone masonry	10,014	3,000	13,014
3.	Terai	Offset Type VIP latrine with attached pit (Bricks Masonry)	10,014	3,000	13,014
		Sulabh Latrine in stone masonry with pre- cast Rings	10,860	3,000	13,860

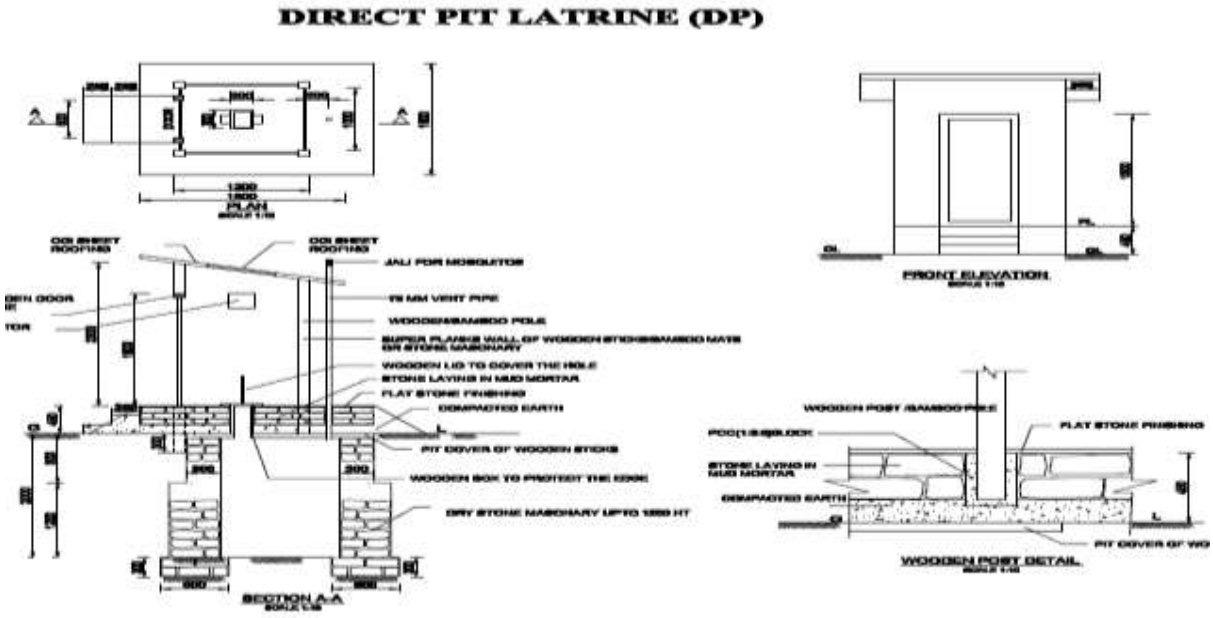
[14]

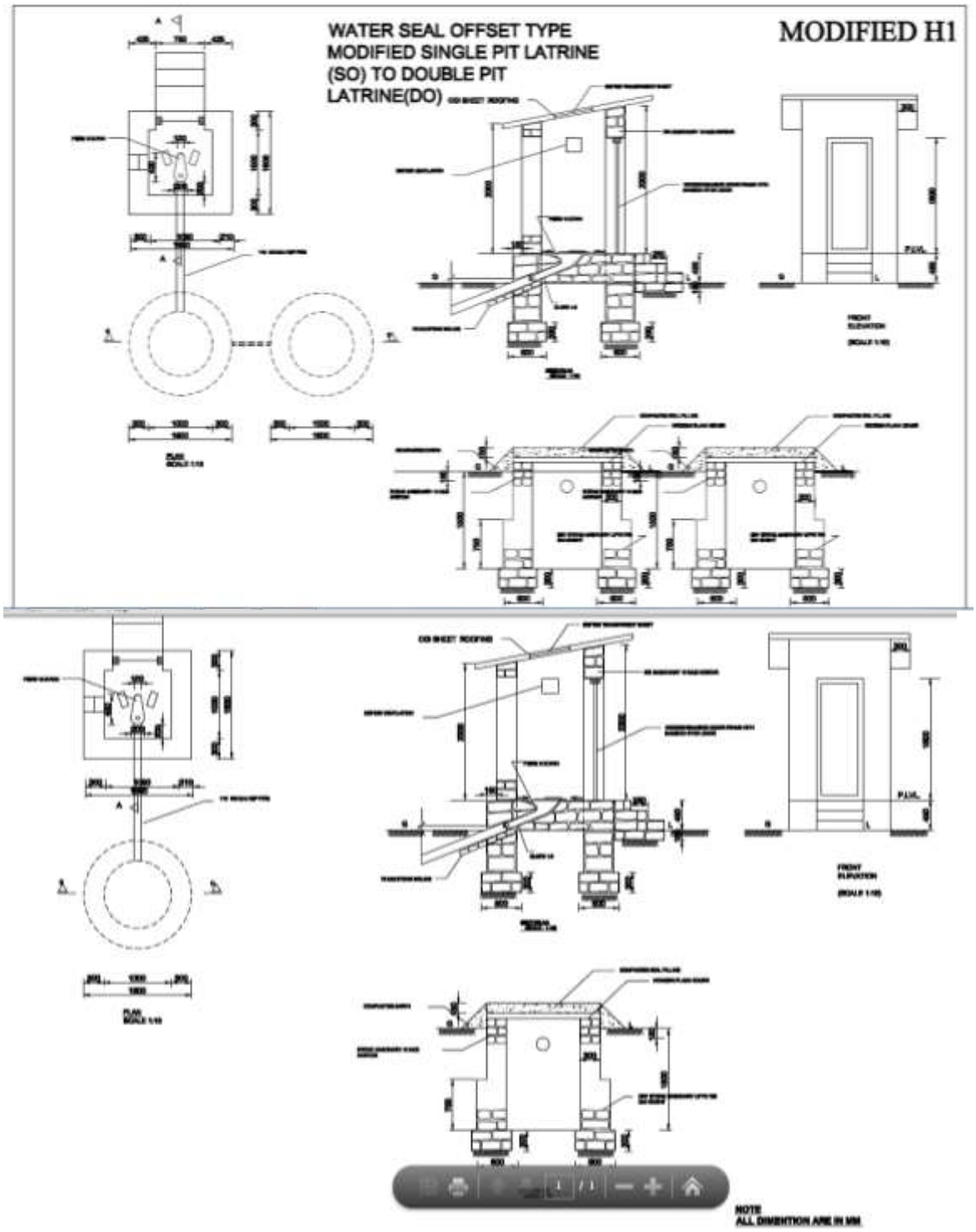
The National Water Plan Nepal 2005 has categorized sanitation service levels for rural and urban communities as (a) Pit latrines, (b) Ventilated Improved (VIP) Latrines, (c) pour-flush latrines for the rural communities, and d) latrines associated with individual septic tanks and toilets associated with sewer framework in center metropolitan territories where inhabitants can bear to share the capital venture just as the activity and upkeep cost. Proper consideration is needed to introduce various latrine options to suit the people, places, and princes in diverse socio-economic and ecological conditions such as for rural hill Single Direct Pit, Single Pit Offset Latrine, Double Pit Offset Latrine and VIP Latrine with Per capita Technology cost is $ 8, 16, 19 and 10 respectively. Similarly, for Rural Terai PF Single Pit, PF Double Pit, ECOSAN and Septic tank with soak pit with Per capita Technology cost are $ 36, 42, 36 and 97 respectively; Even for Semi-Urban and Urban same sanitation technology with an added cost in urban area Latrine with sewer connection was additional with Per capita Technology cost in $95 [15].

(a) Simple Pit latrine:

A simple pit latrine does not require water. This could be constructed with local materials and a concrete slab. The pit should be well linked with stones, bricks, or concrete rings for durability. Although it is easier and cheaper to construct, there may be the presence of flies and insects, if it is not maintained properly. It is suitable for mountain and hill areas where water is scarce. A pit Latrine comprises of a physically worked top to cover the squat opening to make it fly tight and scent tight. These restrooms are reasonable for less thickly populated regions where space is accessible for moving the toilet when it is full. "The simple pit latrine is a failure model although it may help develop a habit of using latrine while permanent latrine increases the use level" [16].

Types of Latrines draw:




WATER SEAL OFFSET TYPE
MODIFIED SINGLE PIT LATRINE
(SO) TO DOUBLE PIT
LATRINE(DO)
MODIFIED H1
NOTE
ALL DIMENTION ARE IN MM

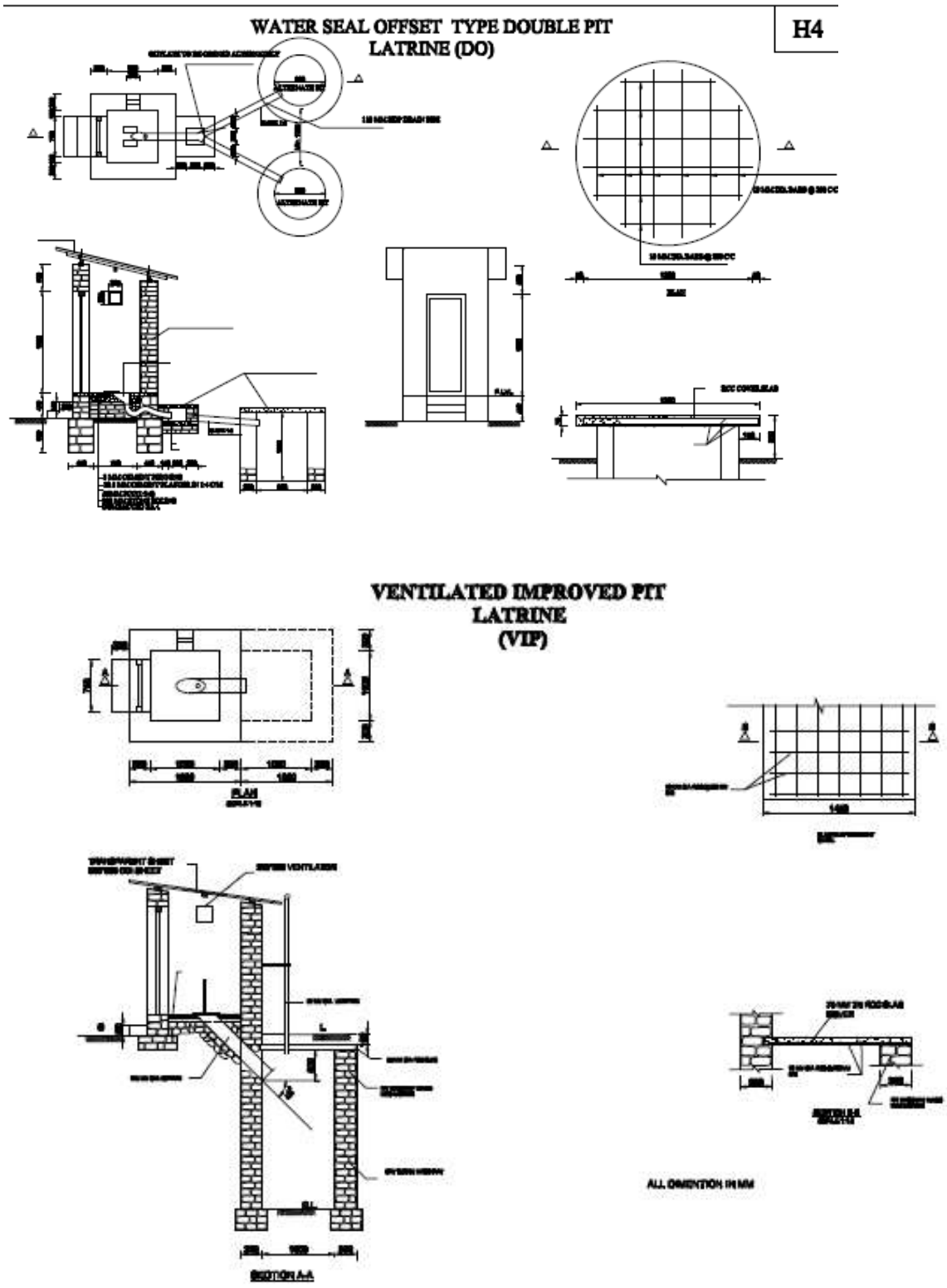


Fig. 1: Types of Latrines drawings

(b) Ventilated Improved Pit Latrine:

The Ventilated Improved pit (VIP) latrine is the improved simple pit latrine with the provision of a vent pipe. The VIP latrine is constructed with local materials and a concrete slab. There is less foul smell than in the simple pit latrine. This is generally suitable for hilly and mountainous areas and this is cheaper, easier to construct, and appropriate when adequate water is not available. VIP latrines may be constructed with a single pit or double pit as per the requirements and availability of land.

(c) Pour Flush water Seal Latrine:

The pour-flush (PF) water latrines are water-dependent latrines. In Nepal different local and non-local materials are used for preparing its superstructure communities have been using 6 'B' (Brick, Block, Boulder, Bamboo, Bush, and Bag) for constructing the superstructure of latrines depending on the availability of materials and community preferences.

The PF toilet is predominantly subject to the use of water. In this toilet, water flushes out the excreta from the bowl, which comprises of water - seal commonly known as a snare. The pour-flush toilet is uncommonly planned with a water seal underneath, which requires 1-2 liters of water for flushing the excreta, some water consistently stays at the lower part of the skillet after it has been utilized.

The SULABH latrine could be used for both households and schools. The SULABH latrine is adopted in the different ecological regions in Nepal. In India, the SULABH latrine has brought about a revolutionary change in liberating the scavenger from their traditional practice of manual handling of excreta.

(d) Ecological Sanitation Latrines:

The urine-diverting latrine is called eco-san latrines. Two types of latrines of eco-san latrines have been introduced in Nepal. These are Urine-Diverting Dry latrines (UDDT) and Urine Diverting Wet Latrine (UDWT).

- Double Vault Urine Diverting (DVUD) Latrines

This is the oldest type of eco-san latrines in Nepal. This is an advanced form of the Vietnamese double vault dry latrines. The basic component of these latrines is two separate watertight chambers with vent pipes for storage of feces and one urine collection vessel. The superstructure is made of a masonry wall.

- Two vaults solar model

The basic components of this model are also the same as that of the DVUD Latrine. The only difference is that the access hole -cover changes from vertical to inclined and a metal sheet painted with black color is used as the cover. The sheets are oriented toward sunlight so that the temperature inside the chamber rises. A few of these models have been installed in Siddhipur and Kathmandu valley. Another component of the latrines is the same as that of the DVUD latrines.

- Single vault movable container Type

This model is intended for the indoor sort of dry restroom. A plastic holder mounted on the metal box is set just underneath the crouching container of the lavatory. The appearances are put away in this holder. when the compartment is topped off, it is supplanted by the next compartment. This model is appropriate for those households who lack adequate space to build latrines. This type of latrine is used in Siddhipur of Lalitpur district.

- Urine Diverting Pour Flush latrines

The model is suited specifically for the Terai regions considering easily available water and communities are not traditionally accustomed to using excreta as a fertilizer. These are two pit flush latrines with urine diversion arrangements. As in the SULABH latrine, there are two RCC pits to be used alternatively. Water is used for cleaning and flushing and urine is collected separately. This model is used in Sabaithawa (Parsa District), Darechowk (Chitwan district), and Sunawal (Nawalparasi).

3.3 Overview of Sustainability Tools (Performance Indicators):

With regards to this exploration, supportability is best-characterized even-mindedly as 'whether something keeps on staying at work past 40 hours' (Abrams, 1998). All the more explicitly, it infers the capacity to recuperate from a specialized breakdown in the framework. Incorporated with the basic origination of the term are ideas of negligible outer help, town-level financing, and the continuation of valuable assistance over the long run [16].

Maintainability is a well-connected term in current improvement practices and talks and it's perceived from various perspectives as per the circumstance wherein it is applied, it has become a perplexing term that can be applied to pretty much every framework. The world's assets are restricted and all human movement should accentuate the maintainable utilization of it. As per the International Union for Conservation of Nature (IUCN), the United Nations Environment Program (UNEP), and the World Wildlife Fund (WWF), Sustainability comprises "improving the nature of human everyday routine while experiencing inside the conveying limit of supporting eco-framework" [17].

3.4 Key Sustainability Dimensions:

Key maintainability measurements: Dimensions are the most significant level of supportability observing pointers embraced by Water Aid in Nepal. For water flexibility and disinfection offices four checking measurements are utilized: specialized, socio-ecological, monetary, and institutional.

Center elements among other manageability factors: - Core factors are the main maintainability factors. Each center variable is considered as 'Center' to make its relating administration area supported or not continued. Water Aid in Nepal has recognized two central factors each for water and disinfection administrations.

Factors and sub-factors adding to key measurements: - Each manageability measurement is huge administered by numerous components and sub-factors for example 'specialized as one of the maintainability measurements of disinfection administrations is enormously administered by two key variables: working of sterile toilets and state of being.

Reviewing of Dimensions: - according to the standards of multi–rules drawing near, each set model is appraised relying on the possible commitment of its criticalness in putting forth the defense feasible. The similar loads given to measurements, factors, and sub-factors were resolved through participatory strategies including area experts and field laborers. Further, each factor and sub-factor is appraised considering its noteworthiness to present the defense practical.

Dynamic: - Sub-factors is the least level patrons, hence, the grouping, estimation, and positioning fundamentals are done physically at this level just for the dynamic. Depending upon the necessary attribution of the specific sub-factors, it is estimated through an estimation arrangement of evaluation focuses (5,4,3) as appeared in the table underneath. The enumerator arranges every single sub-factors as far as, phenomenal (E), Very good (VG), good (G), fair (F), and poor (P) in the field utilizing various devices, rules, and decisions. At the sub-factor level, the screen takes the choice or all in all, chooses the best other option, given various devices indicated in the field visit checklist.

3.5 Sustainability Ranking:

A Projects administrations are positioned as far as continued, supported yet in danger (Sustained danger), and not supported tasks. The target of this kind of positioning was to help choices for future ventures (Water Aid, 2010) [18]. The supposition will be that Water Aid doesn't have to offer any help for 'continued 'ventures, requirements to give some subsequent help to 'supported yet in danger activities', and necessities to give huge undertaking recovery uphold 'not supported 'ventures.

There is five diverse sustainability Assessment Tool (SAT) that are right now being used for program observing of WASH mediations. Those instruments are as follows;

- AGUASAN- Sustainability Assessment Tool (SAT)
- Dutch WASH Alliance (DWA)
- Sustainability Factors (FIETS)
- USAID International Sustainability Index Tool (SIT)
- Sustainability (ToPPES)

(i) AGUASAN- Sustainability Assessment Tool (SAT):

AGUASAN Sustainability Assessment Tool (SAT) was created by the Swiss people group of training AGUASAN for auditing existing intercession of progressing and finished projects to help future Water, Sanitation and Hygiene (WASH) program arranging. There is no merged controlling archive for the particular system for applying the apparatus yet answered to be actualized by the executing organizations in Haiti, Nepal, and Mali [19]. Social, Economic, Environmental, Institutional, Technological, and Knowledge are manageability Factors

(ii) Sustainability Monitoring Framework (SMF):

The sustainability Monitoring Framework was developed by International Research Center (IRC) and Dutch WASH Alliance (DWA) and other partners. SMF links the theory of the change process and the outcome mapping. UNICEF Mozambique has executed five rounds of manageability checks under its 1,000,000 activities (OMI) program namely Institutional, Technical, Social, Financial, and Environmental.

(iii) USAID International: sustainability Index Tool (SIT):
In 2009, United States Agency for International Development (USAID) and Rotary International went into the key association. The supportability Index Tool (SIT) was created in 2012 [20]. Institutional, Management, Financial, Technical, and Environmental are sustainability Factors.
(iv) Sustainability (ToPPES):
ToPPES was created by water and sterilization for Africa (WSA) - as a choice emotionally supportive network to examine and foresee administration conveyance manageability for WSA venture administrators. Socio-monetary Context, Service Delivery Water assets, ecological necessities, Technical, Financial, Operation and support Institutional are supportability Factors.

4. RESEARCH METHODOLOGY :

4.1 Study Area:

Mahottari District lies in Province No. 2 of Nepal with an area of 1,002 km² and a population of 625,652 (MNIP/DWSSM-2020) [7, 20]. It was declared ODF under the supervision of D-WASH-CC with the slogan "Mahotari habitats responsibility to declare all rural municipality & municipality free from open Defecation."
The two ODF zones of two local levels of Mahottari District i.e., Khairamara of Bardibas Municipality and Pipara of Pipara Rural Municipality were selected for the study. The local levels were formed in 2073. Pipara Rural Municipality consists of 7 wards with a total population of 35524 and total households are 6490 according to the census of 2011. The total area of the rural municipality is 39.98 sq. km. The Bardibas municipality consists of 14 wards with a total population of 66358 according to the population census of 2011 [5]. The total area of the municipality is 315.6 sq. km (Figure 2). The study site was selected purposively which included wards number 1 to 7 of Pipara Rural Municipality where the total household number was 1275 and Khairamara community wards no. 10 and 11 had household numbers 1522.

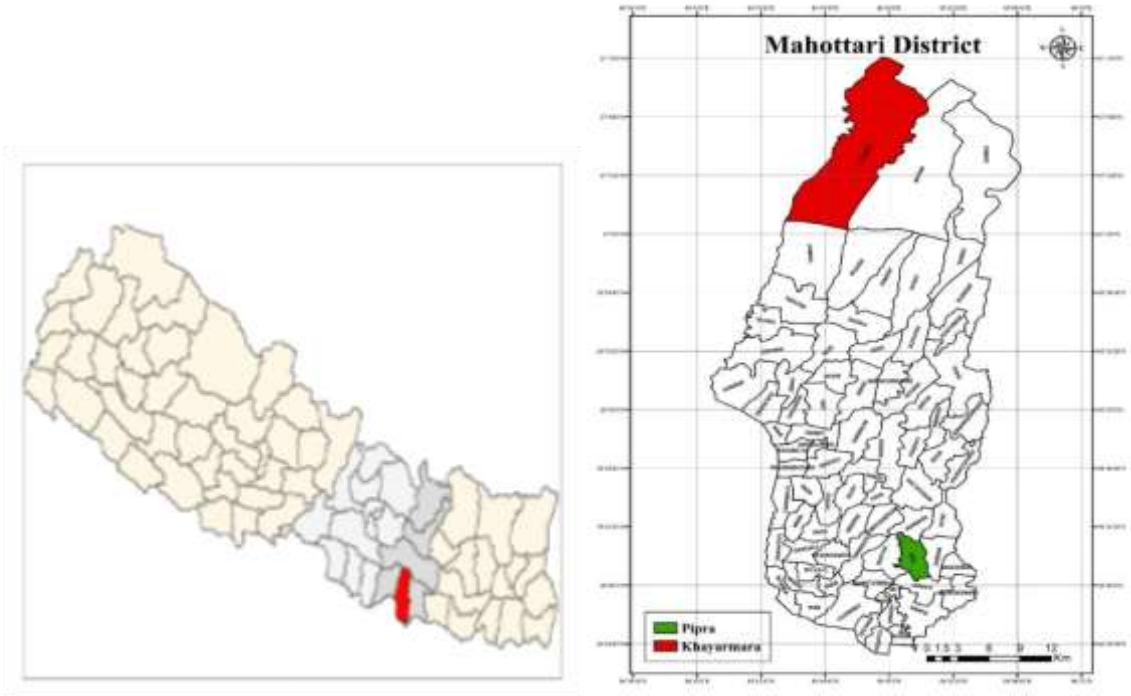


Fig. 2: Selected Municipalities of Mahottari District for the Study Purpose

4.2 Primary Data Collection:

Key Informant Interview
Interviews with local level implementers and the DWSSM were conducted to collect the information required for the study with a help of a checklist. A total of 18 key informant interviews were conducted.

Focus Group Discussion

A total of two Focus Group Discussions (FGDs) were carried out in two selected communities. The number of participants in total who conducted FGDs was 90. The FGDs were mainly focused on the factors associated with the achievement of the ODF zone and were facilitated with a help of a checklist and the members presented in each FGD along with the names of the places are provided.

Households Questionnaire Survey

A household questionnaire survey was conducted amongst the selected households of the two selected sites (*Pipara and Khairamara*) of the Pipara Rural Municipality and Bardibas Municipality with the help of a pre-administered set of questionnaires. The household survey was conducted to assess the condition of the exiting latrines which could help to ascertain the sustainability of the household's latrines. Physical observation of the latrines was also done simultaneously with the household survey. The total numbers of respondents were 97.

Study Population and Sample Size

Yamane's formula was used to determine the sample size to best represent the total households of the selected VDCs. The total number of households from the selected VDCs is 2797 as cited in Mishra and Sharestha, 2017 [21].

$$n = N/ \{1+N*(e^2)\} \quad \text{..... (i)}$$

Where: n = Sample Size
N= Total population
e = Margin of error (10 %)

Table 2: Total Number of Households and Sampled households

S. N.	ODF RM/M	Total Households	Sample Households
1	Bardibas municipality	-	-
a	Khayarmara community (ward no. 10 and 11)	1522	54
2	Pipara Rural Municipality	-	-
a	Pipara ward no. 1 to 9	1275	43
	Total	**2797**	**97**

Here, we know N= 2797 HHs

The sample size (n) derived for the above calculation is 97 households. The calculated sample size (97 households) was distributed proportionately amongst the total number of households in the selected VDCs; the distribution of sample size proportionate to the present households of the VDC is shown in table 2.

Research Matrix

The matrix illustrating the research objectives, data collection tools, data sources, and analysis methods is shown in table 3.

Table 3: Research Matrix

Objective	Data Collection Tools	Data source	Analysis Method
To find out the convenient and cost-effective design of the latrine for the study area	The questionnaire, Interview with checklist marks analysis with local implementers, household alongside field observations, FGD, KII	Household Level & Local Implementers like D/M/V-WASH-CC, WSSSDO, and other stakeholders	Descriptive Qualitative analysis Cost analysis for construction latrines, C-B analysis

5. RESULTS AND DISCUSSION :

5.1 Existing Latrine Types and their Sustainability:

It is important to identify what types of latrines are being constructed in the study area, are the latrines being constructed just for the namesake? Simple digging a trench also serves as a latrine but its sustainability is the greatest concern. During the household survey, detailed observation of the latrines

was also carried out, it was found that altogether three different types of latrines are existing in the study area. Those types are (i). Water Seal Offset type (SO), (ii). Latrine with a septic tank, (iii). Water Seal Offset Type Double Pit Latrine (DO). Among the total sampled households, 81 % of the latrines were Water Seal Offset Single Pit Latrine, 12 % of latrines are of Latrines with Septic Tank and 7% were Water Seal Offset Type Double Pit Latrine. Inhabitants have constructed Water seal offset single pit latrines (H1) in all the selected study sites which is the most dominating type of latrine in the study area followed by latrines with a septic tank and water seal offset type double pit latrine (Field Visit, 2020). The percentage distribution of the types of latrines in the two studied sites is shown in Table 4.

Table 4: Types of Household Latrines

Name of Study Sites	Water seal offset type Single Pit Latrine		Septic Tank		Water seal offset type Double Pit Latrine		Total
	SO	%-age	ST	%-age	DO	%-age	
Khayarmara	43	80%	7	13%	4	7%	54
Pipara	35	81%	5	12%	3	7%	43
Total	78	81%	12	12%	7	7%	97

(Source: Field Survey, 2020)

The study also tried to assess the sustainability of these constructed latrines of different types in the study sites through multi-criteria analysis which considered technical, social-environmental, financial, and institutional aspects of sustainability. The values of sustainability as mentioned under methodology were compared with the criteria proposed by Water Aid in 2010. It was found that 84 out of 97 constructed latrines fall under the sustainable category, 7 latrines come under the sustained but risk category and the remaining 6 latrines are not sustained. Out of 97 sampled latrines in Khayarmara, 47 latrines fall under sustained latrines, 4 latrines fall under sustained but at risk while the remaining 3 latrines are not sustained. Similarly, 37, 3, and 3 latrines of Pipara fall under sustained latrines sustained but at-risk latrines, and non-sustained latrines respectively. The sustainability status of the latrines in the study area is shown in table 5.

Table 5: Sustainability Status of the Latrine

Name of Study Sites	Sustained Latrine		Sustained but at Risk Latrine		Not sustained		Total
	SL	%	SAR	%	NS	%	
Khayarmara	47	87%	4	7%	3	6%	54
Pipara	37	86%	3	7%	3	7%	43
Total	84	87%	7	7%	6	6%	97

5.2 Cost and Benefits of Different Latrine Types Existed in Mahottari District:

From table 6, it was observed that around 87 % of the latrines constructed in the community are sustainable latrines whereas the remaining 13 % of the sampled latrines are either at risk or not sustained (Field Visit, 2020); the assessment of major causes of their non-sustainability here becomes important. Therefore, a cost-benefit analysis of different latrine types existing in the study area was carried out to find out the appropriate latrine type for the local inhabitants of the Mahottari district depending on their socio-economic conditions.

The total cost of construction of different types of latrines was also calculated based on the required material for the construction and the prevailing district rate of the materials. Direct Pit (DP) latrine construction was found to be cheaper as no significant work is needed; work is limited to digging a trench on the ground and establishing the latrines. The cost of construction of a Latrine with a Septic tank (LST) was NRs 28,700; similarly, the cost of construction of a Water Seal Offset type Single Pit (SO) Latrine was NRs. 13,500; and the cost of construction for Water Seal Offset type Double Pit Latrine (DO) was found to be NRs. 16,180.

Table 6: Sustainability of construction of different types of latrines

S. N.	Particulars	SO	LST	DO
1	Technical	72.06	88	81.15
2	Social /Environment	71.12	100	75.35
3	Financial	72.41	65	73.16
4	Institutional	72.23	60	75.14

Similarly, the benefits of having each of these latrines were also reviewed through secondary sources, which are shown in table 8. The benefits of these latrines are compared based on various evaluation criteria such as suitability, construction cost, and other benefits.
The yearly income from the manure obtained from both pits was analyzed. The income of DO is Rs.3000 per year while the income of SO is Rs 1500 per year. It implies that DO is better than SO.

Table 7: Cost of Construction of Different Types of Latrines

S.N.	Particulars	SO	LST	DO
5	Cost in NRs	13,500	28,700	16,180

From calculation and observation, both SO and DO were found to be sustainable. However, SO is observed to be more suitable for small families and DO for a larger family. From economic benefit analysis, DO was found to be more sustainable compared to SO. The direct observation also reveals that DO was more sustainable than SO. Overall, it was concluded that DO was liked better locally and also more sustainable than SO.

As per the sustainability status of ODF through multi-criteria analysis consisting of technical, socio-environmental, financial, and institutional aspects, the water seal offset type double pit latrines (DO) are the appropriate design of the latrine because it has too many benefits/advantages over another type of latrine in Terai areas of Nepal like Mahottari District.

Table 8: Comparative Assessment of Existing Different Types of Latrines

Factors	Single Pit Latrine (SO)	Latrine with septic tank	Double Pit Latrines (DO)
Suitability	Suitable for small family members.	The latrine with a septic tank is the best type of latrine with the provision of a septic tank to digest black water anaerobic process and waste the effluent through a soak pit.	Suitable for a big family. When the first pit gets filled up, the flow of excreta has to be diverted to the second pit
	It is suitable to model for all.	It is also an offset type.	Two leach pits are connected to one single pour-flush latrine.
Construction Cost	Low cost.	High cost-environment friendly construct.	Twin–pit latrines are a high convenience.
Other factors	1-2 liters of water for flushing the excreta.	Latrine with septic tank needs a properly designed septic tank along with a soak pit to soak away effluent	The twin pit may be the RCC ring or honeycombed brick masonry wall, there is no concrete in the bottom twin pit, it works as the soak pit. the cover is used as an RCC cover

	Some water always remains at the bottom of the pan after it has been used.	It is generally suitable for Terai areas where there is no sewerage system.	The pipe is constructed in the shape of "Y" from the chamber of HDPE.
	Different Local and Non Local materials are used for preparing its superstructure	It works for years before the septic tank needs to be cleared.	The advantage is that when the first pit is filled, use another pit, when the first pit human excreta is used as compost manure.
	Communities have been using 6" B" (Brick, Block, Boulder, Bamboo, Bush & Bag for constructing the superstructure of the Latrine.	-	This type of latrine is hygienic for foul smell, flies, insects
	In this type of Latrine, water flushes out the Excreta from the bowl, which consist of a water seal generally known as a trap	-	-

5.3 Possibility of Modification of Existing Latrines to make them Sustainable:

Based on the above discussion the possibility of changing the existing latrine types considering the cost and benefits of the latrines with due consideration of the economic conditions of Mahottari District was also carried out in the study. As most of the sampled households of the two studied sites cater to Water Seal Offset Type Single Pit Latrine, the cost of a possible modification to convert into a double pit was carried out. The existing Water Seal Offset Type Single Pit Latrine (SO) consists of only one chamber for collecting feces which can be extended in two ways as shown in the drawing to make it a Water Seal Offset Type Double Pit Latrines (DO) types, which demand small amount for extension of the existing types. The cost of converting Water Seal Offset Type Single Pit Latrine into Water seal offset type Double Pit Latrine as proposed earlier came out to be NRs. 4,492. It was found out that while constructing new latrines in Mahottari District, Water Seal Offset Type Double Pit Latrine is preferred and recommended, as the cost of construction associated with it comes out to be nominal with more associated benefits. However, if the present latrine type has to be modified into Water Seal Offset Type Double Pit Latrine as far as possible to harness the benefits of the latrines.

6. CONCLUSION :

Mahottari District has been maintaining the ODF status and it has been oriented to achieve the state of total sanitation. Mostly water seal offset type single pit latrine (SO) dominates the study areas followed by latrine with a septic tank and others. More than 85 % of the existing latrines (N=97) fall under sustained latrines (SL) while the remaining percent fall under sustained but at risk (SAR) and not sustained (NS) categories.

The dominating Water Seal Offset Type single pit latrine (SO) needs to be converted into Water Seal Offset Type Double Pit Latrine (DO) for its longevity. This is because while constructing a new latrine in Mahottari District, the Water Seal Offset Type Double Pit Latrine (DO) is preferred and recommended as the most appropriate one due to various benefits. The study also tried to calculate the cost of converting Water Seal Offset Type Single Pit Latrine (SO) into Water Seal Offset Type Double Pit Latrine. The modification cost is slightly higher than the cost of constructing new DO-type latrines. So, constructing Water Seal Offset Type Double Pit Latrine (DO) is cheaper than modifying Water Seal Offset Type Single Pit Latrine (SO).

7. RECOMMENDATIONS :

Promote DO-type latrines in the study areas as it possesses multiple benefits. The most prevalent present SO type latrine in the study area should be converted into DO type to ensure ODF sustainability. Fecal Sludge Management (FSM) needs to be focused to achieve the sanitation goal set in the 15th Plan of the Government of Nepal and SDG 6.2.

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