RAISED ECOSAN LATRINES GUIDELINE

Index

INTRODUCTION

The following guideline has the aim to propose a long term sanitation access through a more solid and sustainable toilette design.
Besides being a natural consequence on the need of responding the more frequent emergencies related to climate change, it is also a tool to propose in case the donor/project implementer would like to offer some solution against the chronic loop of poverty affecting the most vulnerable people; solutions to face the great lack of basic public health infrastructures (sewerages, grey water channelling, etc.); proposals for a new sustainable circular economy, with low environment impact.
In other words, despite it born just after to the floods related to the Cyclone Idai in Phalombe – Southern Region of Malawi (sanitation access Project 2019 – 2021), the present document is not to consider (only) as a tool for emergency contexts; it is actually proposed as a tool to take into considerations in any contexts where the high poverty and low access to natural/basic re- sources is affecting negatively the access to a long term sanitation.

1. Environmental – socio-economic aspects and target

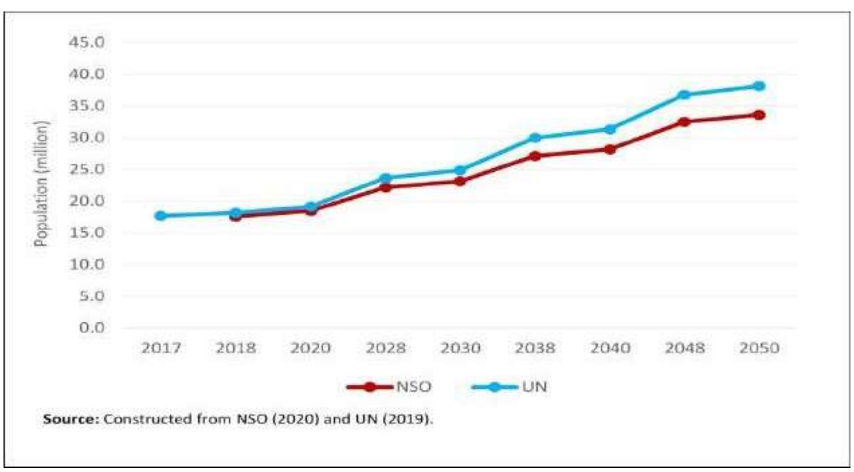
Environment and contextual aspect
As mentioned in the introduction, the environmental constraints related to both climate change and lack of preventive public health infrastructures in a high poverty context forced Inter Aide to brain storm different solutions in the sector of sanitation access for vulnerable communities. An episode of heavy rain for few days can unfortunately be easily considered as a "disaster", which is going to be more and more frequent and "routine" in the future.
In particular, the last Cyclone Idai 2019 affecting numerous Districts in Malawi caused a very big loss in terms of housing, sanitation and safe water access, transport and communication access. The consequent floods related to the cyclone or likewise related to the normal consecutive rainy days invited Inter Aide to reassess the appropriateness of pit latrines proposed until now in such kind of environment, taking into consideration all the contextual chronic problems not related to the global climate change, such as:

a. High rate of soil erosion due to natural composition of the land and great lack of trees;
b. Lack of wood for durable construction due to uncontrolled deforestation;
c. high population growth;
d. Low economic income combined with (more and more) high economic cost related to unfavourable weather (I.e. loss of harvest, rebuild of a cracked/collapsed building);

Analysing the context of Phalombe environment and sanitation access, (one of the poorest District in Malawi, according to the Malawian National Statistics) it was proposed the so called raised Ecosan toilette, using the technology already used in other countries.

Figure 1: a water point with an apron built about 10 years ago. The eroded soil under the apron is estimated about 50 cm; the erosion rate per year is there- fore estimated as 5cm/y.

Figure 2: a typical view of a village in the south of Malawi, after 3 days of rain. It is observable that there are very few trees protecting the soil from the erosion; the visible trees visible on the horizon are species that can be used only for fruit or for home cooking (so not for construction). In the picture it can be observed that the field and the crops are easily vulnerable during rain and drought episodes (ones the visible mud is dry, it will be very hard for crops roots).



Graph 1: Malawian Population growth prospection according to International Food Policy Research Institute and UN

Phalombe context (as other many Districts in Malawi) has the following characteristics:

- During/just after the rainy season, the water tables can be very shallow, even up to the level of the pit of the latrine. It can happen that the grey/black waters are spread to/from the pits, from/to the public areas of the village. This fact can also easily affect the drinkability of the water, in case the water point has a shallow water level and/or it is not well protected by a proper raised waterproof apron;

Figure 3: on the left, the pit of a traditional latrine provided with an IA concrete slab is full of sludge and rain water coming from the surface and the water table, after 2 days of rain; on the right, a temporary toilet has a collapsed pit, due to 2 days of rain, use of temporary material and absence of roofing.

- The timber necessary to cook the bricks is more and more scarce and expensive; nowadays is becoming not affordable for the poorest people, due to the distance of the last remaining forest areas;
- Due to the previous point, a relevant number of populations are still using/downgrading to the use of mud bricks or other temporary material (grass, low quality plastic paper), which are negatively affected by normal wheatear and environment conditions (heavy rain, termites, erosion, UV sun light etc.);
- The fragile materials used for the toilettes (and houses) can affect significantly the access of sanitation for a big part of the year. The rainy season corresponds with the lowest profitable season of the year (December – March), while the harvest income comes about 6 months later (around June/July); therefore the probability of the collapse of the toilette is higher when the family has no/very low income. Due to this fact, the families affected by a toilette collapse don't give any priority on building a new toilette; consequently there might be a gap of sanitation access between December/march up to June/July. Most of the affected families can go back to open defecation practices or temporary shelter.

Figure 4: a house build with mud bricks and temporary roofing is going to collapse, due to the melting of the bricks, after 2 days of rain. As deforestation progress, this kind of bricks are more and more used for “non-shelter” building such as toilets; the poorest class of the rural population use them even for houses.

- The mentioned points contribute on the poverty loop of the vulnerable people. In-fact, the rebuilding of new toilettes, even using temporary material, can cost about the equivalent of the lowest monthly income of the poorest families in the unfavourable season (source: Inter Aide Hydro economic survey – Phalombe 2019).
- The traditional single pit latrine, even if it doesn’t collapse, has to be rebuilt again once the pit is full (once each one or two years). This fact will affect economically the beneficiary family with the same magnitude of a latrine collapsing.
- The soil fertility and texture is extremely negatively affected by lost knowledge on basic agriculture technics (i.e. crop rotation, plantation of wheatear resistant plants, etc.), propaganda by media of artificial fertilizers and hybrid/GMO plants since long time, high erosion rate due to the absence of trees;

Due to the above listed points, the proposal of ecosan toilettes comes naturally, because:

- It doesn’t need an excavated pit; the sludge is collected in a flood proof and waterproof chamber above the soil level;

- As building block element it is proposed the SSB technology (Soil Stabilized Bricks - see below for details; for further details it is suggested the researchgate.net scientific platform, since there are many scientific publications about SSB applications and theory https://www.researchgate.net/search/publication?q=soil%20stabilized%20bricks).
  Any wood element is substituted by (low percentage) cement blocks and metallic elements (including doors and bars for roofing).
- The long lifespan of a cement base structure (approximately 20 years or more) and the fact that the chamber can be easily emptied, contribute to limit the poverty loop of the vulnerable population, avoiding to spend half/one monthly income to rebuild the structure (see below the chapters community approach + lifespan and maintenance for de- tails).
- According to the post survey (2 years after) done in the villages where they received an SSB toilette, it is noticed that other economic impact has affected the population in a positive way, mainly due to the saving of family funds previously spent for synthetic fertilisers and new temporary latrine rebuilding.

As per any other kind of technology, it doesn't exist any "perfect impact zero" solution. It is well known that each Kg of cement produce a Kg of carbon dioxide (gas/coal for cooking the minerals + chemical reaction products).

By the way, net of global impact due to the cement use, the environmental impact of the proposed raised ecosan is still considered positive due to the longer lifespan, if com- pared with the impact related to the cut of trees for building the same toilette once a year (either for pit filling or structure collapsing).

According to a "ballpark" estimation, a traditional toilette made by cooked bricks, would need about 600/700 "entire" bricks. By experience of Hydro Phalombe technicians, to cook properly a bulk of 5000/6000 traditional bricks, they are necessary "10/15 big trees with many branches", (at least 25/50 or more years old), which could correspond to:

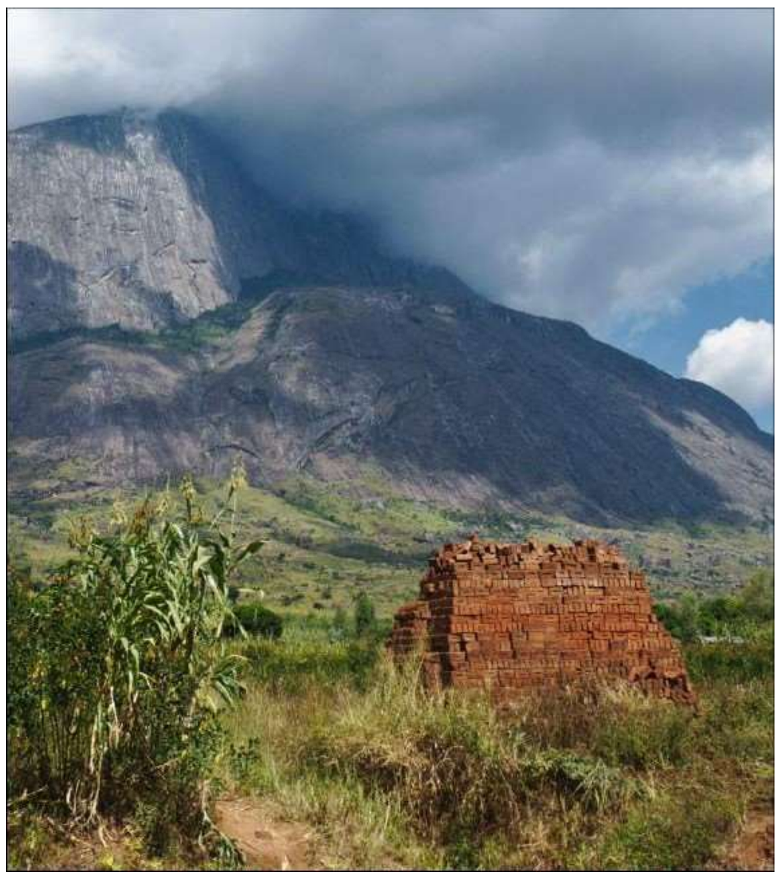


Figure 3: a typical stack of cooked traditional bricks. Behind the grass at the base of the stack, there are small tunnels created to insert the burning timbers. The heat of the fire is reaching properly only the first brick layers; the top and the external bricks are not well cooked and easily cracked

= (minimum) 10 trees X (at least) 5 tons of wood = 50 tons of wood, that is about 25 tons of Carbon.

In the ideal case where this carbon is fully efficiently converted in CO_2 (which actually never happens due to the low combustion temperature of the traditional cooking) the final CO_2 quantity is:

= Carbon quantity X CO_2 conversion coefficient = (minimum) 25 tons X 3.67 = about 91 tons of CO_2.

Again according to the experience of the staff, due to the low efficiency of the traditional bricks cooking, from the mentioned bulk, only 50% of the bricks will be really usable (the other part will result cracked in the middle or uncooked). This means that the related CO_2 emission is about double, which is about 180 tons of CO_2.
Scaling this quantity – (min) 180 tons for (max) 6000 bricks – with the amount of bricks necessary for one toilette – that is (min) 600 bricks, they are emitted 18 tons of CO_2 per latrine; in the very rare and unrealistic case in which a traditional latrine last 20 years as a SSB toilette, they are emitted 18 tons / 20 years = about 900 Kg of CO_2 per year at local level.

One SSB toilette needs about 500 Kg of cement (for blocks, finishes, plastering, slabs, steps; see below for details), so emitting about 500 Kg of CO_2 at global level. Considering a lifespan of 20 years, the "yearly" emission of CO_2 related to cement use is about 25 Kg.

In conclusion, even approximating down the necessary quantity of wood for traditional bricks as half (so producing 450 Kg of CO_2) and doubling the CO_2 emitted for a complete SSB toilette (reaching 50 Kg of CO_2, including into account also the moderate quantity of metals for roofing and the door), it is possible to consider the SSB solution as less impacting than the traditional buildings (in addition to having no impact on on-going deforestation).

Suggested beneficiary target of raised ecosan toilettes
The above described context characteristics, where Inter Aide is intervening in sanitation access, is suggesting to consider "only" the raised ecosan anywhere the latrines pits can be a dangerous public health problem. In areas where floods/heavy rains can affect the sanitation access, it is advisable to avoid any pit latrine technologies.

In other contexts, where the water table is enough distant from the pits (2 meters according to Sphere standards, even more to be prudent in fractured rocks/soil) the pit/double pit design can be considered as acceptable in terms of public health prevention. In terms of easy practice for emptying the sludge in the pits, the double pit is still acceptable but surely less easy than a raised ecosan.
By the way, it could be very appreciated if the project would take into consideration also other aspects, not strictly related to the climate emergencies but actually also related to high poverty and poor access to sustainable/natural resources; this in order to offer to the beneficiaries a

permanent solution that allow them to improve the global long term life quality. In order to allow this, it is advised to take into account also the building material and technics, in addition of the slab already offered until now in the pit sanitation villages.
In Phalombe sanitation program 2021, in some villages where the flood risk is low, it was proposed to build only double pit latrines (instead of giving the option of single pit too), providing to the beneficiaries only the slabs (without any support for the superstructure, as designed in the previous years); in terms of design it seems a well-accepted solution, due to the possibility to reuse the same pits in the future without building a new superstructure (if no structural is- sues happen).
Unfortunately a relevant part of the beneficiaries (about 25%) didn't manage to build any superstructure within one year of project, due to financial reasons related to the bricks.
This fact, likewise numerous examples happen before, in addiction of the latrines collapsing phenomenon in both flooded and non-flooded areas (source: latrine surveys report 2019 – post evaluation of toilettes built between 2016 and 2018), can be used as a reflection point for reassessing the resources offered to the beneficiaries.
Whatever is the offered toilette design (ecosan or double pit), besides the people living in a flood risk areas, the typical beneficiary that should receive some support for the building structures too, has mainly the following profile (having at least one point):

- He/she live in a village where durable construction materials are scarce at local level;
- He/she need unaffordable funds to collect reliable building materials from very far;
- He/she live in a District/Country where the deforestation is significantly contributing to the high poverty and high environmental damages;
- His/her area need to recover the fertility of the soil, (if he/she will be part of a following agriculture project once the manure is ready it could be a must);
- There are no cultural taboos on using/moving human manure;
- He/she followed the hygiene training (as per Inter Aide condition, see below the chapter "community approach");
- He/she doesn't have the labour energy or the funds to pay someone for emptying the fulfilled pit (this is valid also at public places like schools or health centres; see below the chapter "integrations with other sectors");

2. Community approach

The greatest "warranty" that can be offered by the beneficiaries as evidence of interest on the offered project is their contribution. Inter Aide Hydro Phalombe has a historical, solid and successful policy on this aspect. During the last years, the community contribution and participation has been a strong pillar on which every projects stand, limiting the phenomenon of unused facilities after few years.

Therefore, a clear policy on community motivation involvement, based on solid written principles is really essential. Inter Aide Hydro Phalombe has developed the following steps as guarantee of community motivation. Each of the following steps is "allowance free", that is without paying any benefits (allowances, cash, food, refreshments, etc.), to any stakeholder (Authorities, committees, and beneficiaries) at any phase (meeting with local/non local Authorities, PHAST, any other necessary training, civil works). This in order to have the warranty that the beneficiaries are participating to Inter Aide trainings and works due to their real motivation only, showing the interest on having a toilette and hygiene knowledge and not only on the offered meal/re-freshment/ cash. Other NGOs working in emergency sector in other districts, reported that the “allowance approach” did not gave good results in the long term. In some areas where the flood risk is very high, the mentioned approach directed the beneficiaries to build on purpose temporary buildings where the risk of losing the house and the toilette is higher (near by the rivers, sandy soil, on weak foundations, etc); this in order to receive a “cash emergency compensation” during the rain reason from emergency NGOs, agencies or government, knowing that the cash compensation will be higher than the temporary building.

In order to let the beneficiaries absorbing properly the training contents (it is considered more impacting a set of few hours training instead of one long day training), to allow them to go for their personal job, and to minimize the claiming of allowances, all the meeting and training activities are designed to last maximum half day. In the particular rare possibility where it is necessary to occupy more than 6 hours, Inter Aide Hydro Phalombe organizes a lunch paid directly at a restaurant /village house/take away catering, never giving cash.

The following steps are used also for the raised ecosan solution:

a. Inter Aide informs the catchment Area leaders at the very beginning that Inter Aide is around.
b. Knowing that Inter Aide is there, in case they are in need, the beneficiaries are invited to request a letter of support; it is not recommended to decide only at office level what the village need without their consciousness. It usually comes through a letter from the village chief or Village Health Committee.
c. After receiving a request, Inter Aide organizes a Hygiene awareness campaign using PHAST protocol. As an indicator of motivation, the community has to shows the presence of at least 50% of inhabitants (at least one family representative per household). The awareness campaign finishes when the beneficiaries identify the reasons that create the sanitation risks, which are lack of proper toilettes and lack of hygiene practices.
d. At this point, the mobilization of locally available material can start. The labour force beneficiaries (having the age above 18 years old), have to show their motivation, collecting all the necessary items (deep soil and river sand for the blocks and the slab, quarry stones for the slabs.
e. At the same time of the point d, Inter Aide field officers record all the beneficiaries that apply to receive a toilette, besides recording all the beneficiaries that will use a toilette owned by another family (see next point h). The registration process will help a lot for organizing the work, especially for the work phases where it is possible to proceed only one beneficiary by one (i.e. SSB press machine can produce only the blocks for 1 latrine per day).
f. As per working organization (see below next chapter), the beneficiary has to hire a local builder, monitored by Inter Aide technical staff (hired and/or internal). Before starting any civil work, Inter Aide staff negotiates the fixed price that will be paid by the beneficiaries with the local builders, in order to avoid any abuse or exaggerations. For the success of the project, it is really important to negotiate a reasonable fixed price, which is never higher than the one used for traditional latrines. The final financial involvement of the beneficiaries is designed in order to let the family pay what they would pay for a

traditional latrine. This will ensure the beneficiaries that the "new" toilette is affordable as well as the traditional toilette (despite is more durable).

g. The civil works can start; all the necessary labour, including the moulding of the blocks, the casting of the slabs, minor labours such as mixing of the mortar or water collection is required by the beneficiaries.
h. For vulnerable people that cannot work, it is settled an inclusion system through the involvement of a village committee and/or family members living nearby. Two options could give them the access to an ecosan sanitation:
    I. During the registration of the beneficiaries (see below), it is asked in advance by Inter Aide staff if any vulnerable households in the village is welcomed in the toilettes that will be built by an "healthy" family. Most of the time, the adult sons/daughter are very available to share the same ecosan toilette with the parents/grand-parents/uncles.
    II. The village committee can identify the "real" vulnerable lonely beneficiary (so excluding the ones not motivated), building the toilette for them, using the extra blocks produced by the other households.

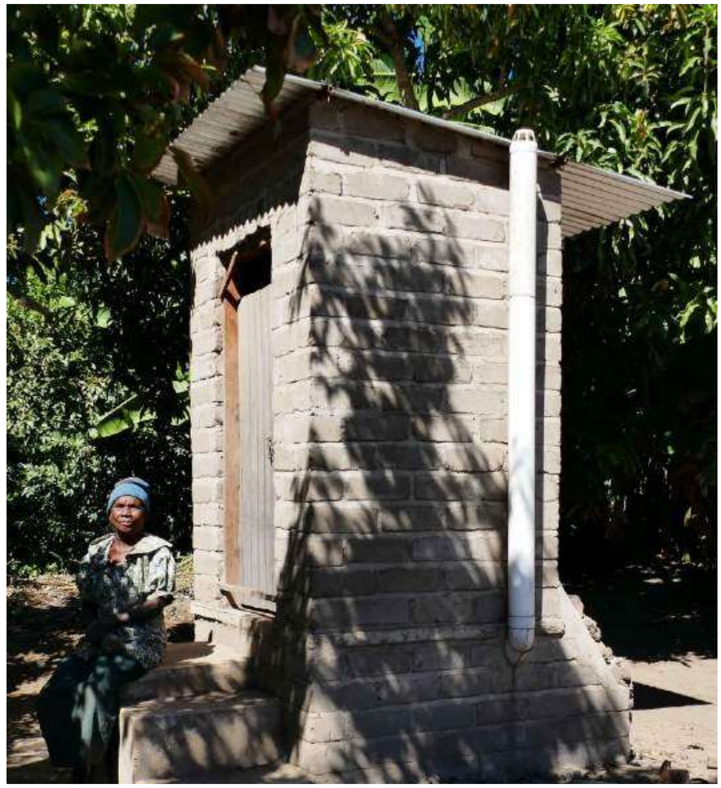
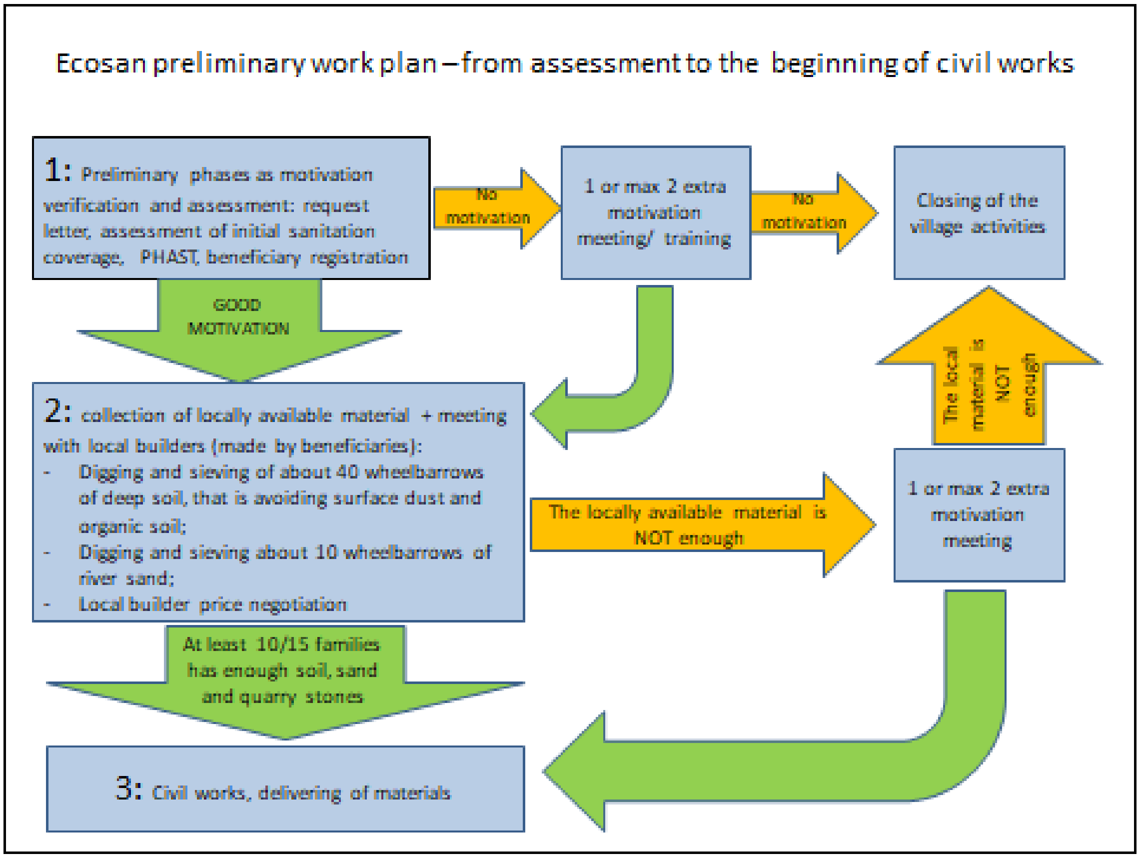


Figure 4: a lady declared as vulnerable by the community and her ecosan toilet. She is a lonely grandmother, her 4 young grandsons are living with her; since she has no income sources, the community has decided to give her the necessary material and the remaining bricks to build her toilet.

If one or more of the listed conditions are not accepted (previously agreed with the village), Inter Aide is free to close the activities in that particular village, dedicating the resources in a more motivated village. Unfortunately it can happen that few non-vulnerable families are not interested, without caring about the public health risk (even one pit leakage can involve the full village), while the rest of the village is applying for the sanitation project. In this scenario, Inter

Aide staff could try to convince the last reluctant people organizing an extra motivation meeting or a discussion with the chief. By the way, during the last years where Inter Aide offered ecosan latrines, the sanitation access coverage reached 100% of the majority of the villages.

The described points are summarised in the graph below:



Graph 2: preliminary plan scheme finalized on preparation of local material from the beneficiaries

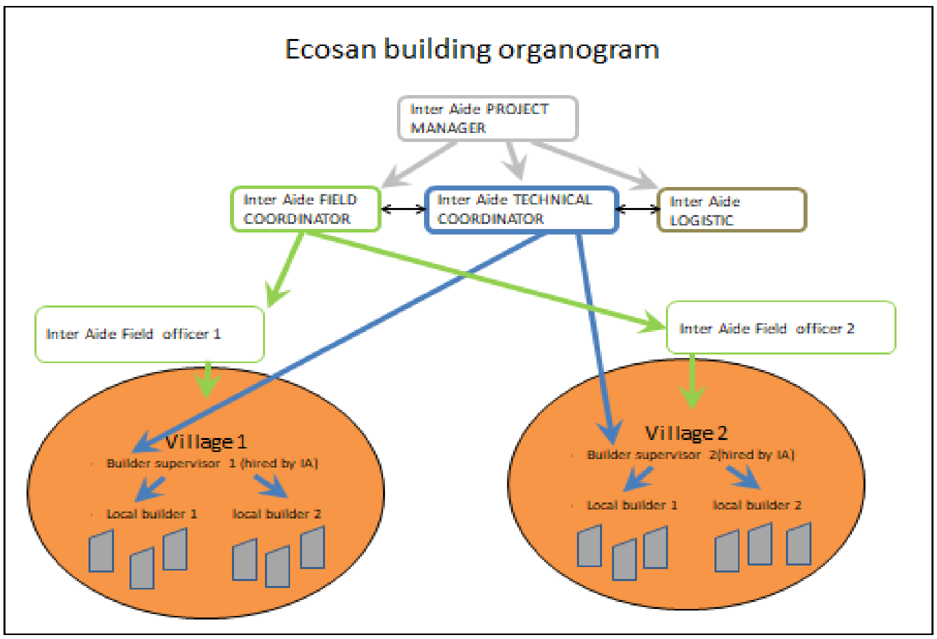
3. Work plan and staff organogram

The organogram used for ecosan toilettes is designed taking into consideration the already settled schemes used for other Inter Aide Hydro Phalombe activities (water points and pit latrines), the staff organogram already in place, the available skilled people based in the field. Compared to the other mentioned activities, the only additional level is the mentioned local builder at beneficiary level.

Once the targeted village has shown its interest, the civil works are organized in the way below described. The key persons managing the whole process are:

- Field Coordinator: he/she plan and follow-up the activities in the field (from the introduction meeting at local authorities' level up to the indicator data collection at the end); he/she plan extra meeting in case of extra motivation problems at village level.

- Technical coordinator: he/she manage all the technical civil works steps, following up the builder supervisors and interacting with the logistic sector.
- Field officer: he/she is part of Inter Aide staff, in charge for PHAST training, baseline and end-line surveys, collection of progress data, beneficiary registration.
- Builder supervisor: he/she is based in the beneficiary village; he/she is usually hired by Inter Aide as an external contractor with professional expertise as mason, in charge to warranty the quality of the works done by the beneficiaries (i.e. quality of blocks production) and the local builder (I.e. quality of raising the superstructure).
- Local builder: he/she is a local mason, usually not as expert as a builder supervisor but able to follow his/her technical directions. He/she is proposing him/herself to the community during the meeting about the labour cost per toilette (in the presence of Inter Aide staff); he/she is chosen and paid by the beneficiaries.



Graph 3: Inter Aide sanitation staff organogram

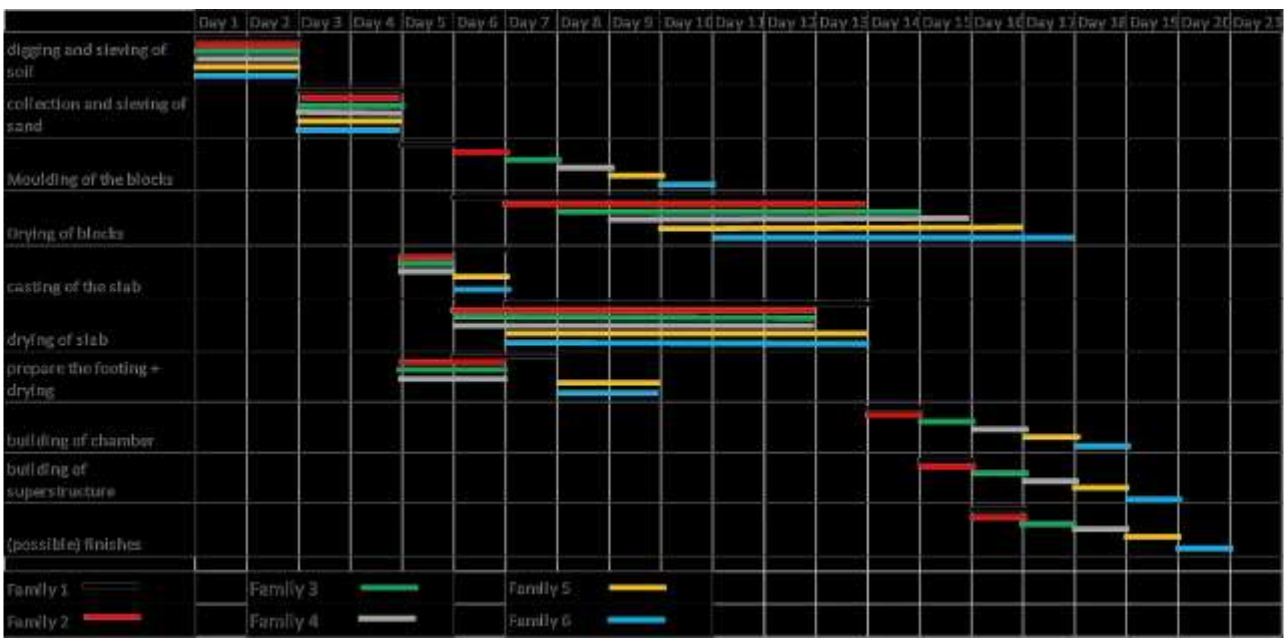
In order to hand-over the project to the community in a reasonable time, it is important to consider the timing of each phase. Taking into account only the "mathematic" aspects, it is necessary to consider that the SSB press is the most important limiting factor of the building rate; in- fact, one toilette needs about 400/450 SSB blocks, which is almost the equivalent of the daily blocks production rate (about 500 blocks per day). This means that with one machine it is possible to finish maximum one toilette per day, regardless of the number of builders. In particular, as shown in the graph below, each phase needs the following timeframe:

- Collection of 50 wheelbarrows of soil and 10 wheelbarrows of sand: about 2 days of work for each material, including sieving process. The final quantity to be used can be less but it is recommended to ask some more, to overcome problems of misunderstanding about the "volume" of available containers.
- Moulding of the 2 slabs: it can be done in 2 hours and need to dry slowly (7 days) and be

watered time to time the first days. It is suggested to make it before doing the blocks, in order to be ready to put them on top of the chamber just after it will be raised.
The quantity of quarry stones is about 4 buckets of 20 litres, collected of crashed by the beneficiaries. As per the soil and sand, the quantity asked to the community could be a bit more than necessary.

- Moulding of the blocks and drying: as introduced, with one SSB press it is possible to produce about 500 blocks per day. After moulding, they have to be dried slowly in a shady area (under leaves or a breathable fabric) for 7 days and be watered time to time.
- Preparation of the footing: it is a concrete pouring used as the base of the toilette. It needs few hours.
- Building of the chamber: it needs half day, from the footing up to the slab installation; after raising it, it has to dry for the rest of the day and night. The day after, it is possible to continue the building of the superstructure.
- Building of the superstructure and finishes: it takes another half day. If done by expert builders, a complete latrine can be fished within the end of the day.
  Note: since the majority of the phases need half day or less, the builders can organize themselves to follow more than one construction per day.

The following graph 3 is showing a possible work plan of 6 families, which started their local material collection at the same time:



Graph 4: timetable scheme of 6 hypothetic beneficiaries mobilized to build their own toilette.

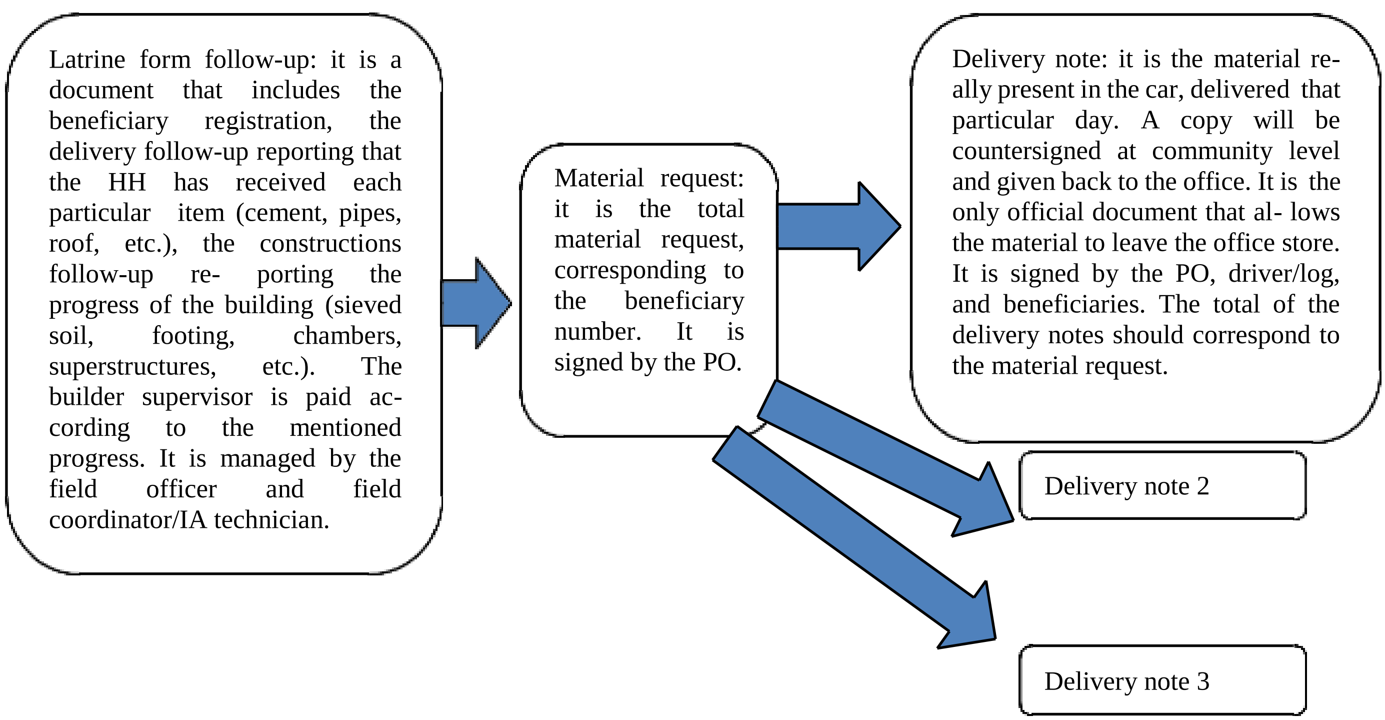
Unfortunately the proposed timetable can be easily affected by other factors; while on the paper a number of X toilettes can be finished within N drying/digging days + X days, in many cases in the field it can happen that the process is slowed down by absenteeism/delay of a local builders, other tasks affecting the beneficiary, a village meeting/funeral, etc.

In case Inter Aide project has in its equipment less SSB machines than opened villages, it is possible to plan in advance all the phases that doesn't need the press (i.e. digging, footing, slabs casting, some material delivering), in order to be ready once the press will be available. In case instead there are 2 (or more) presses in the same village, each builder supervisor can follow up 2 (or more) toilettes per day, due to the presence of double (or more) quantity of blocks (i.e. from the day 15 of the previous graph 2 families could proceed to the next step instead of 1).

It is advised to have a solid audit system for the entire logistic sector. Unfortunately the frauds of building material are a relevant and concrete risk. In Inter Aide Hydro Phalombe there is in place a consolidated logistic system of material request -> material delivery that can limit the fraud "temptations" by the beneficiaries, builders or staff. As introduced, the number of potential beneficiaries is registered at the beginning by the field officers; according to this number, a material request form has to report the total amount of material for each village and has to be approved by the Project Manager; once approved, they will be necessary a certain number of trips for delivering all the requested material, which is accompanied by a dedicated delivery note. The total of the delivery note should fit the initial request form. In the field, each beneficiary has to sign the receiving of each particular material once it is the time to build his/her toilette.

In case the beneficiary registration number is changing (increasing or decreasing), a new material request form has to be prepared (adding new material in a new form or avoiding to deliver the material for beneficiaries that has abandon the project).

In particular, in Phalombe project we are using the same procedure used for other project sectors as following:



4. Ecosan tools and design

Necessary tools to deliver to the community and/or to the builders supervisor

Shovels, picks (optional in case of hard soil and absence of a hoe from the beneficiary), wheel-barrows and sieves: they can be lent by the project to prepare the soil before the delivery of the SSB press. The sieves are really relevant to avoid clots of soil, holes and organic material during the moulding of the bricks. It has to be used for both soil and river sand.

Footing mould: it helps the builder to have a precise shape in a short time, avoiding the casting using temporary wood. It is made by interlocking metallic flat bars sized as: 160 X 170 cm (internal), 5 cm high, 3 mm thick (it is advisable to use a good thickness in or- der to avoid deformations and allowing an hard welding; it is kept straight by diagonal y10 bars inserted in metallic rings on each angles and by a vertical y10 bar in the middle.

Figure 5: footing mould used to build the base of the toilet.

The Builder tool box is made by the common building equipment: bucket shovels and picks for mixing; for the building itself: 2 size of spirit levels (about half meter and 1 meter), builder square, shining trowel, 5m tape, internal and external corner, builder rope, wire brush, sisal brush, wooden or plastic float, builder trowel, pointing trowel, brick jointer, hacksaw for metal, hacksaw for wood (the SSB blocks can be easily cut by an hacksaw), chisel, wooden straight edge, 4 pound hummer, rubber hummer, 6 wire jointer, gloves (the cement material is very alkaline), safety shoes, safety helmet, 2 work suit.

Scaffold: it is relevant to have at least one per village during the building of the superstructures; traditionally in Malawi they use makeshift means like an upside down drum or homemade temporary wooden stands, which are not safe and in contradiction with forest preservation. If it is not available in the market, it is easy to make it by a medium expert welder.

SSB press: It is the main tool producing the block units of the building, which gives the "production rate" of the building activities, especially if it is the only one provided to the village. In Malawi it is made in a professional historical factory in Blantyre since many years, it costs the equivalent of about 6 ecosan toilettes. A used and trained beneficiary group can produce about 500 blocks per day. There are different versions of engine

Figure 6: Phalombe WASH team is testing the use of the SSB press for the first time.

(electric, diesel, manual), making different shapes of blocks (simple parallelepiped, interlocking shapes, interlocking with holes, as in figures n 6, 7, 8). In Inter Aide Phalombe project it is chosen a manual one, in order to minimize the need of maintenance, the running costs and professional skills, besides letting the beneficiaries to participate easily in terms of labour.

Despite the interlocking shapes are very interesting, due to the fact that they don't need mortar to be joined among each other, Phalombe project has chosen a common block shape; this because in order to have solid homogeneous locking male/female shape without any crumbling, it is supposed that the mixture of the cement-soil-sand has to be "perfect", while the mixing at village level is done manually by non-expert volunteers, so with risk of non-homogenized mixture at the locking part of the brick; the interlocking shape could be ideal if a manual/engine cement mixer and precise measuring containers are present within the equipment; by the way, the interlocking shape can be very interesting In terms of budget saving due to the fact that a lot of mortar will be not necessary, at least for the superstructure parts. The shape with holes instead is made to let pass iron bars inside the columns of bricks; it is suggested for earthquake sites or unstable areas, where the structures need flexible metallic reinforcements.

Figure 7: Two classic interlocking blocks made using a SSB press**.** On the right a model of an interlocking block with a site for an iron bar passing inside. The both shape are designed to use zero/little quantity of mortar.

Figure 8: the very first block made in the first pilot village by the family of the lady in the picture, sanitation Phalombe program 2019-2020

Slab mould and hammers: In case the project need to verify the motivation of the beneficiaries through the preparation of quarry stones (starting from big stones crashed by the beneficiaries), the hammers should be provided. Two different sizes of hummers could be necessary in case the size of the original stones is very big (i.e. 1 weighting 4 pounds (1.8Kg) and one as 20 pounds (9Kg)). If instead the beneficiary purchase directly the crashed stones, the hummers are not necessary. As a third option, the quarry stones can be provided directly by the project like other materials.
The pre-casting of the slabs is considerably helping the builder/the beneficiary to finish the chamber part in an easy way; it avoid the need of "casting in situ", which needs temporary wooden moulding, funds and time. It measure as 120 X 75 cm, 5 cm high and 3 mm thick. As visible in the figure 9 (top right part), it has already the shape for the urine channel. The rounded hole mould in the centre has been designed to facilitate the urinal flowing outside the chamber, especially for the children and the women.

Figure 9: slab mould, with its welded urinal channel and hole-rounded mould

Door frame sample (optional but suggested): as introduced, wood is avoided in each component, including the door and the door frame. Therefore the door hinges are fixed directly in the mortar (see below for details). A Door frame sample could help the builder supervisor to know in advance where to fix the male part of the hinges.

Optional for the builders: heavy duty bicycle to move during work from/to/among beneficiaries, solar phone charger, phone, mosquito net/camping tent, mattress.

Bill of quantity and necessary material

N	ITEM	Quantity	Unit
1	Average cement bags for 450 blocks (standard: from 70 to 80 blocks per 50kg bags)	6	50 Kg bags
2	Average cement bags for mortar (brick laying + footing + internal chamber plastering)	3.5	50 Kg bags
3	Average bags for slabs	0.66	50 Kg bags
4	total cement bags	10.2	50 Kg bags
5	mesh wire	1.8	m^2
6	square tubes for roofing (20X20 mm, 1mm or less thick, 2 pieces of 1,75 m)	3.5	Meters
7	iron sheets (7 feet, about 0.5 m width)	3	Pc
8	bolts and nuts (size 10)	14/20	Pc
9	flat sheet for the chamber: 136 cm X 55 cm *	About 0.75	m^2
10	vent pipes	4	Meters
11	45 degree elbow	2	Pc
12	Air vent cover	2	Pc
13	Flat sheet for the door (78cm X 61cm X 2 sheets) *	About 1	m^2
14	Square tubes for the door (15 x 15 mm, at least 1 mm thick; frame size: 170 X (min) 61 cm)	4,6	Meters
15	Rivets	About 12/16	Pc
16	Hinges (welded with iron sticks that grab the mortar)	2	Pc
17	Mosquito net	About 0.2	m^2
18	Galvanized wire/ iron wire	Lump	Meters
19	Cut used pipe for urine exit	About 50	cm
20	Slab cover *	2	pc
*	Note on the material and time optimization: commercially the flat sheet is cut from a long roll, which has a fixed width (Phalombe project supplier supplied a sheet 78/80 cm width; therefore it is advisable to ask the supplier to cut it only according to the needed length (i.e. 61 cm for Phalombe doors, 55 cm for the chambers). Therefore, the door is covered by 2 sheets 78 X 61 cm, covering 155 X 61 cm of its area, out of 170 X 61 cm (the gap is covered by a mosquito net). The chamber cover is initially made joining 2 sheets of 78 X 55 cm; since the total length is more than necessary (78 cm X 2 = 156 cm), 20 cm are cut from one sheet. The cutting parts are not considered a scrap, they can actually be used as a slab cover.		

Notes on logistic and prefabricated items: If possible, it is advisable to prepare in advance all the toilette components in advance, at office level. This logic will allow completing the toilettes in a reasonable time within the budget year and, above all, before possible weather issues as rainy season. In Phalombe Project, a watchman has been promoted as office support; among other tasks for other project sectors, he has been trained on the use of the welding machine and main metalworker tools. This staff figure could help a lot in terms of efficiency; in-fact, while this internal staff is fully concentrated on Inter Aide needs, an external metalworker could delay a lot the delivery of the order (even months) because he/she is busy also with other customers, besides electricity issues that at office level can be solved; besides, with an internal staff it is really much easier to request and modify the design of an item according to the needs, the possible arguments with an external worker on wrong specifications are avoided and the cost of each item is considerably cheaper.

It is also advisable to plan and organize a stock at Inter Aide store level. In Phalombe, most of the items are purchased directly at the production factories, at the beginning of the budget year (except cement, which could be spoiled by humidity).

It is advisable to prefabricate the following items:

- metallic door (using items n 13, 14, 15, 16, 17, 18):
  It is designed to be waterproof, long lifespan compared to wooden option, to provide sun light avoiding the window at the superstructure (for cost and time minimization of the builder), to minimize the waste and the costs. Therefore it was decided to weld a frame sized 170 X 61 cm, fixing 2 pieces of flat iron sheet using simple rivets (80% cheaper than bolts and nuts and resistant).
  The width size of the door is decided according to the dimension of the SSB blocks, precisely according to the minimization of blocks cutting sited on the sides of the entrance (figure 21).
- Roofing (using items 6, 7, 8): it is simply composed by 3 corrugated iron sheets sized 7 feet X 0.5m width, overlapping on each other, fixed on 2 square tubes 20X20 mm, long 1.75m using bolts and nuts size 10 (note: to avoid water droppings from the holes, the bolt should enter from the top part of the corrugated wave, not the downer).
- Chamber door (using item 9), as per the door, it was asked to the factory place to cut them directly long like the height of the chamber hole. Therefore the complete chamber cover is made by 2 pieces of flat sheets, jointed manually by a tinsmith.
- The pre-cut of mesh wire for the slabs (figure 15).
- The pre-cut of used pipes could facilitate the builders during the casting of the slabs and the urine outlet channel.

Important logistic/transport note: if it is very difficult to know the real weight of sand/soil/quarry stones sold on the street/river, so DON'T USE the project car! In fact, a Toyota Land Cruiser – single cabin, can carry a maximum of 1 ton of weight; on the back it has a volume of about 0.45m X 2.15m X 1.6m = 1.55 m^3 (up to the edge of the back door); since the density of half dried/wet sand is about 1750 Kg/m^3, the mentioned volume corresponds to about 2.7 tons, almost 3 times the affordable weight! Lack of care of this fact, the project car risks some expensive problems on suspensions systems, brake systems, clutch, etc.

Operational steps and design

Following the steps listed in the graph 3, in the present paragraph it is described each operational component. In general, it is advised to organize the work in order to have a sort of continuity, trying to minimize the downtime between two steps. Example 1: be sure that the brick machine will be active every day -> check in advance the presence of the soil and the beneficiary, using a SSB booking timetable done by a field officer; Example 2: be sure that once the chamber is raised, the slab is ready to put on top -> the slab casting should be implemented seven days before.

As introduced before and visible in the graph 3, the step related to the casting of the slab and the one for blocks moulding can be exchanged, according to the availability of the SSB press.

STEP 1: SOIL AND SAND PREPARATION

Necessary tools	Shovels, picks, sieves, wheelbarrow/standard container used for every material
Items to deliver	Not yet necessary

The proportions suggested by the Malawian company of the press is 5:1:1, that is 5 part of soil, 1 part of sand, 1 part of cement (plus some little quantity of water until the mixture looks like a plastic modelling clay).

The soil cannot be taken from the first visible surface, due to high presence of organic material (leaves, barks, etc) and high presence of fine dust. Therefore it is has to be dug under the first surface (indicatively from 20/40 cm downward). In order to have a homogenous mixture, it is necessary to dry and sieve all the excavated soil, beside the necessary sand.

Indicatively, one week is enough to dry all the necessary soil and sieve it.

Figure 10: a beneficiary family is sieving the necessary soil for the bricks.

STEP 2 (it can be exchanged with step 3): THE MOULDING OF THE BLOCKS

Necessary tools	Same of step 1 + SSB press, used oil for oiling the machine, shading fabrics
Items to deliver	Cement

Once the material is dried and sieved, it is ready to be mixed with cement and water. After mixing, it can be poured in the press. According to the suggestions of the press company and according to experience, for each bag of cement it is possible to mould 75 blocks, so in a range between 70 and 80 blocks. In order to preserve the pressure resistance, it is advisable to not exceed 80 blocks per 50 Kg cement bag. The standard blocks chosen in Malawi Project measure 9cm X 14 cm X 29 cm. According to the past experience, for each press machine it is possible to mould more than about 400 blocks (corresponding to about 1 latrine). For an efficient production, it is advisable to ask at least 6 volunteers/beneficiary people: 2 at the mixture phase, 2 for material transport, and 2 at the press. SSB doesn't need cooking phase, so all the labour and the costs related to tree cuttings, tree transport and bricks burning are eliminated. It is necessary to dry them under a shaded place or a shading fabric for about one week. NOTE: be sure that heavy rain is not affecting the fresh blocks.

The SSB press operation steps are the following:

a) Once 10/15 families are ready with the soil and sand, deliver the machine in the village; it has to be transported vertically and close, using the safety position, keeping close the two main movable parts with a metallic wire (orange arrow in the figure 12);
b) Dig a little pit (about 50 cm width, 180 cm long and 30/40 cm deep) in order to fix the stands in the soil; be sure that it is "centred the bubble" and the stands are covered with compacted soil, in order to avoid the shaking during the pressing (yellow arrow in the figure 12);
c) Remove the metallic wire only once the machine is fixed in the soil. Than insert the handle and open the machine until the plate in the mould is completely down; Security note: use the specific handle to accompany up and down the opening side (figure 12, green arrow), don't let it just fall down!
d) Insert the cement-soil-sand-water mixture in the mould and close the cover, which will remove away some surface material. As in the figure 13, the quantity of the mixture has to be appropriate, just enough to fill completely the mould with some little quantity emerging on top. In case the quantity is too few, the block will be weak and not pressed enough, if it is too much the pressing will be too hard (with damages risks on the bearing and welding parts). The mould cavity itself can be considered as the standard quantity.

Figure 11: an SSB press in a pressing phase. Blue arrow: the press handle is in correctly positioned in a diagonal position, not too vertical and not too horizontal, indicating that the amount of soil mixture in the mould is correct; Black arrow: upper lock of the plate. Green arrow: the volunteer is correctly accompanying the press handle system using the side handle by the left hand; Grey arrow: closing plate of the mould; Orange arrow: the 2 plates that should be tied by a wire during trans- port and non-working time; Yellow arrow: the press machine foots are dug in 30/40 cm below the ground level.

Figure 12: on the left, the mould is correctly filled up to the edge; on the right, the wrong overestimated quantity of material.

e) Close the cover putting on top the press pin and its lock (figure 12, arrows black and grey), press from the opposite side using the handle properly. The handle should be down enough to be accessible, not very vertical or too much down, as in figure 12, blue arrow. The pressing has to be a bit hard but fluid and easy, feasible even by a normal middle body size person. In case it is too hard or too easy, it means that there is too much or too low material in the mould accordingly.

f) Open the press and the cover moving in the opposite way, until the entire block is out. The opening phase will com- pletely press out the pressed block, as in figure 14. In case it is too hard to press it out, it could mean that there was too much soil mixture in the mould; so, correct the mixture amount.

g) Hold the block using well opened hands in a delicate way, in order to avoid breaking or scrambling the fresh block. Put the block in a flat area under the shade or covered by a shading fabric. In case the block is broken or cracked, put it again in the main mixture.

Figure 13: the SSB press in the open position. The block is completely out, ready to be hold and put outside the mould

Figure 14: on the left, a volunteer is removing the new block correctly putting the hands on the long side of the block; on the right, another volunteer is trying to remove a block using the short sides of the blocks, risking to brake it during the movements.

h) Repeat the steps from the point c). Security note: use the specific handle to accompany back the opening side, don't let it just fall down!

The SSB press use has to be supervised by a builder supervisor, just to train the beneficiaries to insert the correct quantity of soil mixture in the mould site. In-fact, in case the user put too much mixture in the mould, the bearing and some welded parts can be affected and broken. It can be useful to provide a container with a volume that fit exactly the volume of the SSB mould. Its basic maintenance is mainly consists on oiling the bearing sites and the block mould. The following video shows how the press is working https://www.youtube.com/watch?v=BYzsytWipjo

STEP 3 (it can be exchanged with step 2): THE SLAB CASTING

Necessary tools	Same of step 1, shading fabrics, slab moulds, wooden or plastic float
Items to deliver	Cement, mesh wire

The slab is dimensioned as small as possible in order to optimize the material use of the whole structure. It is considered enough big for one people in a squatting position.
It should be pre-casted before the building of the chamber, in order to fix it on the same day of the chamber building. The mixture proportions for the concrete are: 1:2:3 meaning 1 x 10 litres bucket of cement (corresponding of about 1/3 of cement bag) , 2 x 10 litres buckets of river sand, 3 x 10 litres buckets of quarry stones, surrounding a mesh wire (4 /4.5 mm thick, 75X120 cm as the slab mould). For each chamber are necessary 2 slabs, so at the end 2/3 of bag of cement are used. In order to facilitate the urine separation the slabs are provided by an open channel going to an outlet, as visible in the next fig 15:


Figure 15: slab casting phase, using the mould complete with urine channel and movable hole mould

STEP 4: FOOTING and POSITIONING

Necessary tools	Footing mould, builder tool box
Items to deliver	Cement

Since even the sludge chamber is raised, it is not necessary to excavate a pit. It is just needed to remove the first layers of soft soil, which is mixed with organic materials, sand and dust. Indicatively the base of the sludge chamber has to be placed on stable hard soil/rock layer, which could be at 20 cm under the ground zero (according to the field condition). The base require to be well levelled and with well-done borders. Professional builders are able to fix the borders using metallic sticks and ropes but needs some hours. In order to save time, as mentioned before, IA supplies a metallic mould to place directly on the area, just to refill with mortar.
A concrete layer of 5 cm X 174 cm X 159 cm has to be done using the footing mould, as the following figure 17:

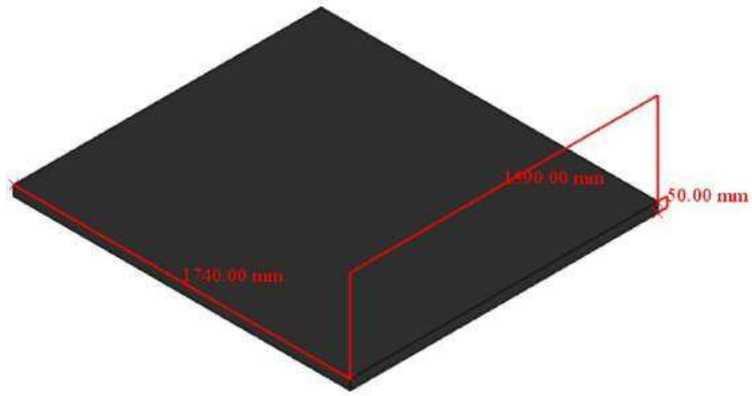


Figure 16: base of the sludge chamber. The dimensions are slightly bigger than the chamber area (about 5cm each side)

The location of the latrine is decided by the beneficiaries, after explaining them that the position should be possibly on a higher level than a downer ground level affected by rain water flow. As will be explained in the following paragraphs, the position should consider also a good compromise between the privacy and sun exposure, which are related to the position of the door and the chamber door (one on the opposite side of the other).

STEP 5: THE DOUBLE CHAMBER BUILDING

Necessary tools	Builder tool box
Items to deliver	Cement, pipe elbows, cut used pipes

The sludge is poured in one of the two chambers, as ecosan style. Each chamber is sized for about 8-10 people, considering the volume of 40 litres per people per year of faeces as per SPHERE standards. Considering the standard yearly volume per person and a 10 household members, the necessary theoretical volume is 40 L/p/y X 10 people = 400 Litres/year, equivalent to 0.4 m^3/year. Since the use of ecosan latrine requires the use of ashes and/or some dry soil, beside the presence of air, (necessary for aerobic bacteria digestion), the final total volume should be about double (800 Litres per year). In other words, each 6 months is produced a volume of about 300/350 Litres of sludge (200 of faeces + 50% volume of ashes/dry material). Therefore the total volume for each of the two chamber has to be 300/350 litres. As visible in the fig 6, the dimensions of the fillable part are 0.49 m X 0.53m X 1.35 m, for a volume of 0.36m^3 (excluding the last 2 lines of bricks, which they can be considered as volume for the air). For both the chambers the volume is therefore 0.72 m^3. During the estimations of the 3 dimensions, we considered that the height from the ground cannot be less than half meter, due to the risk of possible floods; the width measure is also slightly forced due to the minimum space necessary for the internal superstructure. So, the only variable dimension is the length, which is 1,35m in the current design.

The sludge, as per common bibliography on ecosan, has to be as dry as possible. Therefore the urine has to be separated as much as possible. In-fact, if we have to consider even the volume of daily production of urine, it is necessary a huge chamber, like 1 litre per day per person X 10 persons X 365 days, equal to 3.65 cubic meters, which is 10 times bigger than the one proposed

in this document. Another reason of urine separation is the fact that dry sludge at the end of the maturation is safe in terms of sanitation risk.
In real cases, after 6 months the real use of volume could be different, according to different factors. For example, it could be less in case the family is smaller, or, unfortunately, the beneficiaries are eating less than 2 meals per day. It could be higher in case for example in the reality more than 10 people are using the same toilette.
By the way, the post-survey done by Inter Aide WASH Phalombe team is reporting that the dimensioning of the designed volume is appropriate; in particular, the beneficiaries reported that the common period for filling one side of the chamber is normally 6 months.

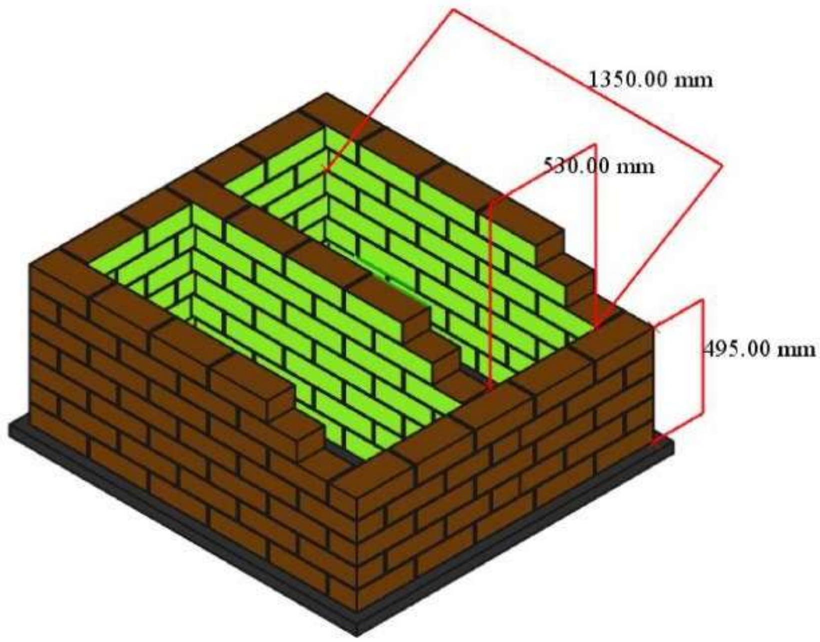


Figure 17: internal dimensions of each chamber's side, equivalent of about 0.36 cubic meters, equivalent of the volume necessary for about 8-10 people.

The building of the double chamber needs about half day, including internal plastering and placing of the slabs on top; as visible in the fig 6, they are necessary about 24 blocks per each complete layer, plus 2 uncompleted, making about 154 blocks (about 2 bags of cement).
The proportions for the mortar commonly used for other buildings is the same for SSB building, which is 1 cement part with 5 part of sand. A layer of 1 cm of mortar between the blocks is considered enough.

IMPORTANT NOTES:

- In order to safeguard the budget, it is suggested to pay attention on the thickness of the mortar, since local builders and supervisors could be prone to add unnecessary mortar among each layer (using the same habit for the traditional bricks).

Figure 18: SSB bricks lined in an internal part of a toilet chamber. The red arrow represent the wrong amount of mortar, corresponding to about 3 cm; the green arrow represent the correct amount of mortar, about 1 cm.

- It is very important to centre the bubble for each dimension. A part the obvious verticality of the structure, it is important to be sure that the slab is perfectly horizontal and the urine channel is tilted outwards!
- In general, where it is necessary to include an item in the mortar (i.e. pipe elbow, wires for roofing, hinges, etc.) in order to save time and budget, it is suggested to fix them directly while raising the chamber/stricture; if not, it will be necessary to make a hole and prepare a new mortar.

Figure 19: the chamber building with its two slabs

The SSB technology doesn’t need plastering. Anyway, for precautionary measure, the internal side of the chambers is plastered as well, due to possible acidity of the sludge (PH around 6).

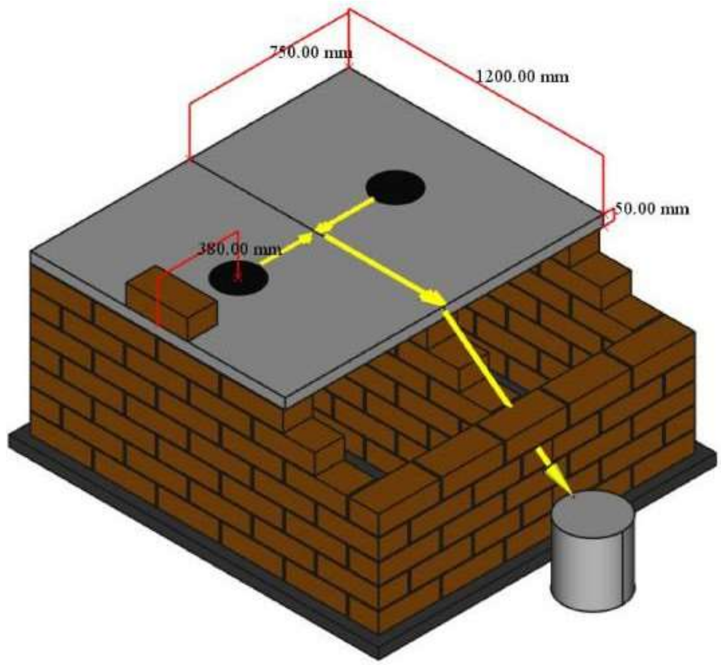


Figure 20: dimensions and position of the slabs with urine channels diversion, outlet to an external bucket

STEP 6: THE SUPERSTRUCTURE and FINISHES

Necessary tools	Builder tool box, scaffold, door frame sample
Items to deliver	Cement, male part of the hinges, roofing, chamber door, prefabricated door, vent pipes, vent covers, galvanized wire

The basic main purpose of the superstructure is to guarantee the privacy of the user, to keep dry the room and to avoid the entrance of flying insects attracted by odours. Therefore is designed in a minimal concept way, just for basic and fast use, guaranteeing resistance to rain for many years. It needs a maximum of 235/240 blocks, equivalent to a bit more than 3 bags of cement, in addiction of the necessary mortar. In order to limit the presence of flies, the structure doesn't have windows and it is sealed under to roof. A window with mosquito net is designed directly on the door. According to the available hinges in the Country, the fixing of the door can be different. In Malawi, until 2020, only fixed hinges were available, without any possibility of dis- mantling them. Since we avoided the use of wooden frame per policy, it means that the full door complete with hinges welded on it has to be ready and available during the superstructure building. If the door was not ready from the office for logistic issues, the door was fixed after, but breaking again part of the entrance and fixing them using new mortar (time and resources issue). With the arrival in the market of detachable hinges, it was finally easily possible to fix in advance the male part of the hinges directly on the entrance, while the door welded with the fe- male part could be installed in a different time.

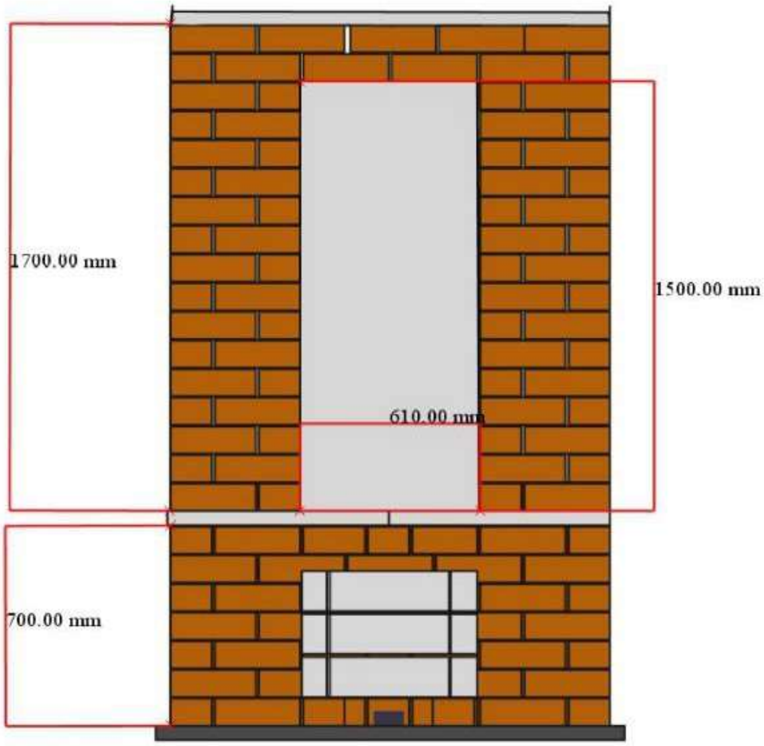


Figure 21: the door side view. The height could slightly change according to the mortar between the lined bricks. The borders of the stairs are bricks; the middle is just refilled with normal soil and then covered by plastering.

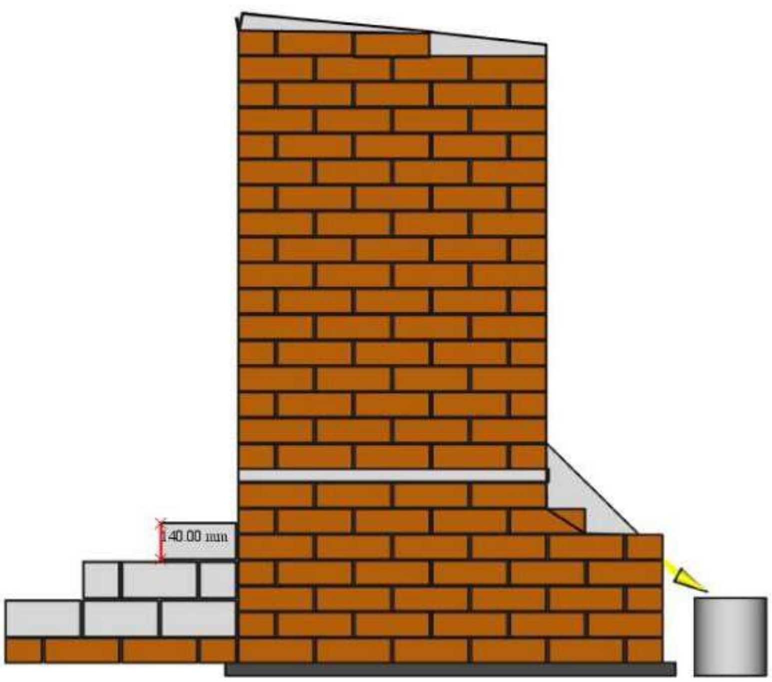


Figure 22: side view with stair steps. The height of each step corresponds to a block put sideway.

Since the rain water can negatively affect the sludge, the roof, the door and the chamber door have to be waterproof. For this reason IA team opted to propose a metallic roof and a metallic chamber door (painted at the factory). The roof support is not made by traditional timbers but it is fixed with 2 pieces of squared tube 20 X 20 mm using bolts and nuts. This because nowadays, for the mentioned item, the cost of metallic alternative is equivalent to the “rare” wood but it last more years, is not affected by termites (very common in Malawi) and no need of local deforestation. The roof itself is simple corrugated iron sheet (28g, which is 0.28mm thick). The chamber cover is the same material but not corrugated. As visible in the next figure 24, the roof is a bit exceeding the dimension of the superstructure; this because it is necessary to avoid high dropped rain on the chamber door below.
The sun exposure in southern hemisphere is oriented to the north, so the metallic chamber door should be in a northerly direction in order to warm as much as possible the content. Once it is vaporizing, the hot air containing the smelly gases and vapours are forced to move upwards (obviously on the hole of the slab must be resent a cover!). For the same reason even the ventilation pipes are placed outside the latrine under the sun exposure. On top of the pipe there is a vent cover, finalized to increase the outlet speed of the air.
The superstructure, according to the pilot experience, could be finished in 1 day.

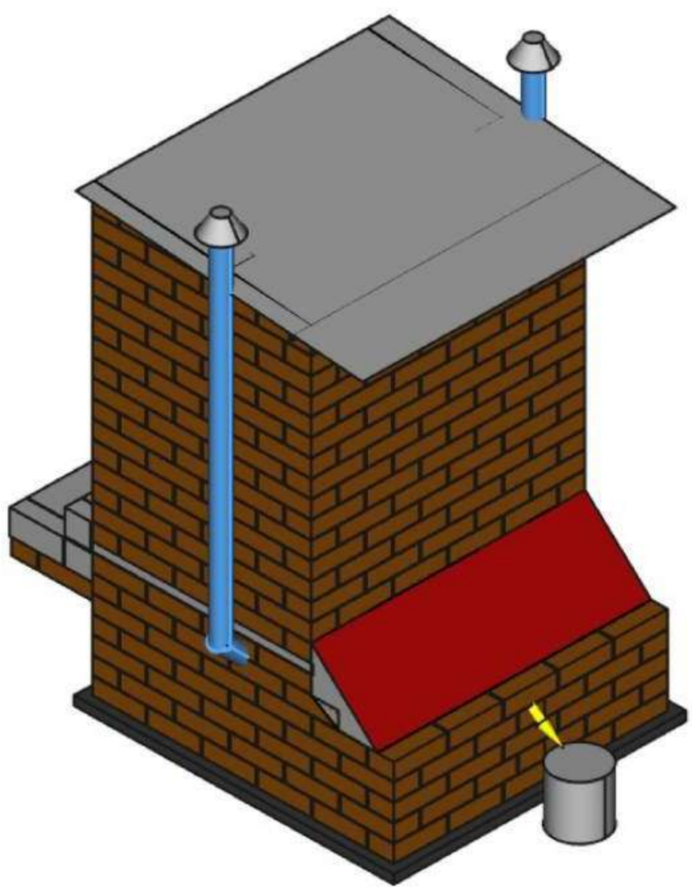


Figure 23: complete ecosan latrine. The sun exposure should be on the side of the red chamber door.

5. Lifespan, economical aspects and maintenance

Being a cement base design, the Ecosan toilette can be compared with any other normal cement base building. In this document it is mentioned a lifespan of 20 years as a preventive measure but actually it can be longer, like schools and health centres already built using SSB technics. The limit caused by the risk of rusting of metallic elements can be limited by using appropriate thick and rustproof iron sheets and/or waterproof paint (painted at the factory level using professional methodologies).

By the way it is recommended to invest some time to cross check the quality of the soil-cement-sand mixture in time, to avoid any solidity issue in the future. If the proportions are respected, SSB technology is waterproof, doesn't need any plastering, and the compression values are comparable with other materials (cement blocks, cooked clay bricks, etc.).

The factory selling the SSB pressing machine in Blantyre, is declaring a compression strength resistance between 2 and 7 N/mm^2. During the last year they were tested 4 samples from the villages where Inter Aide was operating, at Blantyre polytechnic, where it is present a standardized compression machine. It was reported that 3 samples had values between 2.1 and 2.7 N/mm^2, while one sample has been discarded, due to a testing procedure mistake.

Figure 24: compression test on a SSB block taken in a targeted village at the final breaking phase. The breaking point shown in this picture is at 2.2 N/mm^2.

At the polytechnic it was recommended to use blocks with compression value range between the ones mentioned by the SSB machine factory, paying attention on the proportions used by builders at the field level.

Concerning the daily maintenance, as trained by the field officers, it is recommended to use a cover for the slab hole and to drop some ashes and/or dry material each time the toilette is used. This is considered essential to avoid bad smells and to facilitate the emptying of the chamber in a safe way, simply using a shovel. Note: don't use ashes coming from plastic/rubber/other toxic waste, since the future manure could be used for food production.

ECONOMIC ASPECTS: A COMPARISON AMONG LOCAL ALTERNATIVES

As per the environment impact described before, in this paragraph they will be compared the economic aspects of the available alternatives in terms of constructions material. In particular they will be put on the same level one square meter of local cooked bricks, SSB blocks and perforated cement blocks.

Material cost of single bricks (exchange rate at the document time writing is 1 euro = 925 mwk)

The production cost of traditional bricks should include the whole process of moulding, timbers fuel for cooking, transport for timbers from the forests to the cooking place (and possibly from the cooking place to the building place), all related labour for each mentioned phases and production waste (like unusable bricks due to cracks). The price tendency of traditional bricks is increasing, mainly due to the increasing scarcity of wood in the remaining forests. Unfortunately, currently there is also the tendency of cooking the bricks using less wood, compromising significantly the solidity of the bricks and the productivity (less usable bricks at the end of the pro- cess). In this document it will be considered only the best cooking scenario.

According to the Phalombe team, the market is offering the traditional bricks at 25-35 mwk each, so 30 mwk as average, at final cooking stage ready to use, with dimensions of L = 23cm X W= 9 cm X H= 6 cm. on top of this cost there is the cost of the broke bricks, damaged during the transport or because sited at the external layer of the bulk, which are paid as well but unusable. According to different opinion collected among the team, a range between 10 and 50% of the bricks will be unusable. Therefore, using a percentage sited in between, we could estimate an extra cost of 20% on top of 30 mwk, = 36 mwk per usable brick.

This dimension is related to a medium size commonly used in Malawi but there are also other sizes with longer length up to 25/26 cm.

The SSB brick cost is mainly dependant by cement cost. At the moment of writing this document, each 50 Kg of cement bag cost 7900 mwk. Since each bag can produce about 75 units, each bricks costs 105.3 mwk, for a dimension of L= 29cm, W= 14cm, H= 9cm. In case of need of harder bricks for more advanced building foundation the cement proportion should be double but it will be not considered in this document.

The perforated cement block needs a cement-sand proportion of 1-3. The size of the blocks is variable, it depends of the wooden mould. In Phalombe program there are a mould sized as L= 31cm, W= 14cm, H=11cm. For this size of mould it is possible to produce 40 blocks, with a cost of 7900 mwk : 40 blocks = 197.5 mwk each. In the market there are available also blocks with double H; so the cost per block can be double (but covering a double surface).

	Traditional brick	SSB brick	Single mould perforated cement brick	Double height perforated cement brick
Dimensions	L = 23cm X W= 9 cm X H= 6 cm.	L= 29cm, W= 14cm, H= 9cm	L= 31cm, W= 14cm, H=11cm	L= 31cm, W= 14cm, H=22cm
Cost	36 mwk	105.3 mwk	197.5 mwk	395 mwk

Table 1: dimensions and price per brick in comparison

Price per vertical square meter

The quantity estimation and related cost for one square meter of surface depends by the size of the single brick, by the regularity of the surface shape of the brick and the thickness of the mortar.

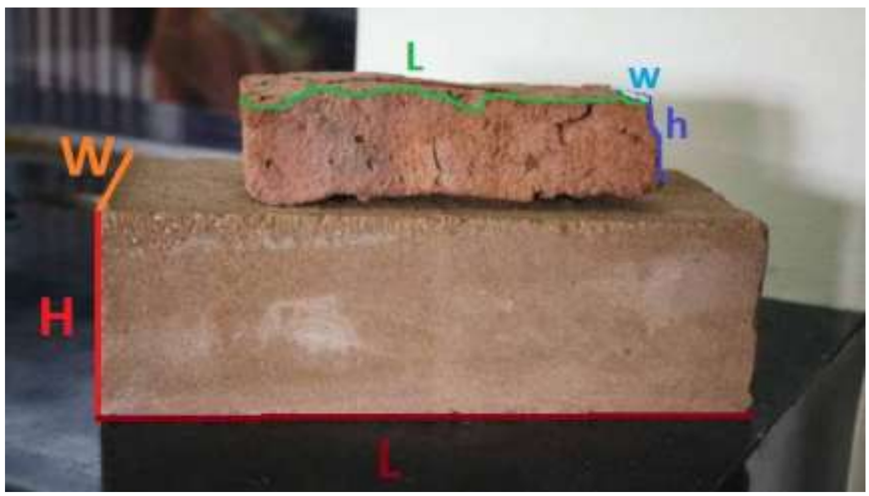


Figure 25: comparison among traditional brick (on top) and a SSB. They are visible the differences of material homogeneity, potential cracks, the irregular shape and the size.

In the present evaluation it is considered a theoretical mortar thickness of 2 cm for traditional bricks, due to irregular concave/convex/ wavy shape of the top surface and the presence of a rectangular hole in the middle;
For SSB it is considered 1cm of necessary mortar, due to the regularity of the surfaces and absence of holes;
For perforated cement blocks it is considered 2 cm of mortar, due to the fact that some mortar is falling inside the holes.

The following table 2 is showing the minimum quantity of mortar necessary for lining the different type of bricks, taking into account their dimensions (W=width, H= height, L= length in fig 26).
The mortar volume put at the side of the block is given by W x H x thickness, while the volume put at the top is (L + side thickness) x W x thickness. In the following table it is also shown the number of bricks necessary to cover 1m^2. Note: building components like load-bearing walls, pillars, foundations and toilette chambers would need a double parallel layer of traditional bricks, due to their smaller dimension and solidity.

	Traditional brick	SSB brick	Single mould perforated cement brick	Double height perforated cement brick
Volume of mortar per m^2	6.51 Litres	5.04 Litres	8.97 Litres	6.64 Litres
Volume of mortar per m^2 for load-bearing walls and pillars	13.02 litres	5.04 Litres	8.97 Litres	6.64 Litres
Necessary mortar thickness	2 cm	1 cm	2 cm	2 cm
N of bricks per m^2	50	33.3	23.3	12.6
Number of bricks for load-bearing walls or pillars	100	33.3	23.3	12.6

Table 2: mortar quantity, minimum thickness and number of bricks for covering 1 m^2 of surface

Knowing the bill of quantity of material per square meter, now it is possible to estimate the final cost for the same surface, taking into consideration that:

- The common mortar is made with 1 part of cement and 4 parts of sand; consequently, in 1000 litres (1 m^3) or mortar, there are 200 litres of cement.
- Sand and water are costless, in case they are provided by the community;
- The density of powder cement is about 3000 Kg/m^3 = 3 Kg/L. Consequently, 200 litres of cement contained in 1 m^3 of mortar, there are 200 litres X 3 Kg/L = 600 Kg of cement.
- The price per 50 Kg of cement is 7900 mwk, corresponding to 158 mwk/Kg. Consequently, the mentioned 600 kg of cement contained in 1m^3 of mortar costs 158 mwk/Kg X 600 Kg = 94800 mwk per m^3 of mortar. Converted in mwk per litre, one litre of mortar costs about 95 mwk / L.

The final cost per square meter of surface, according to the brick materials, is:

- For 1m^2 of traditional bricks surface, they are necessary 50 bricks and 6.51 litres of mortar, for a cost of 50 X 36 mwk = 1800 mwk for the bricks and 6.51 L X 95 mwk/L = 620 mwk, for a total of 2420 mwk/m^2.
  For the load-bearing building components the cost is 3600 mwk for the bricks + 13.02 Litres X 95mwk/L = 1237 mwk for the mortar, making a total of **4837 mwk/m^2**.
- For 1m^2 of SSB surface, they are necessary 33.3 X 105.3 mwk = 3506 mwk for the bricks and 5.04 litres X 95 mwk/L = 479 mwk for the mortar, making a total of **3985 mwk/m^2**.
- For 1m^2 of perforated cement blocks height 11cm they are necessary 23.3 X 197.5 mwk = 4601 mwk for the bricks and 8.97 litres X 95 mwk/L = 852 mwk for the mortar, making a total of **5453 mwk/m^2**; while if the height is 22cm, they are necessary **5608 mwk/m^2**.

In conclusion, economically speaking, the single layers of traditional bricks seems the cheapest option, but technically speaking, in terms of structural strength, it cannot be used for load-bearing components (perimeter walls, foundations, etc.); therefore the most fair comparison is actually between the double layers traditional bricks – SSB – cement blocks. Using this comparison, SSB solution is 17.6% cheaper than traditional bricks and 27.5% less than cement blocks.

6. Direct and indirect benefits

In January 2022, it was conducted a dedicated survey with the aim to evaluate the direct and the indirect impacts related to the use of the Ecosan for the 2 last years.
All the results are described in details in a specific document called "primary and secondary impact ecosan impact".

In the present document they are reported only few general results:

- The presence of hand washing facilities has been grown from 43% to 60% (in the best village from 37% to 87%), while soap presence from about 0 to 25%, due to PHAST training accompanying the toilets constructions;
- The persons declaring to have a weekly diarrheal symptoms during the rainy season has been decreased from 26% to 0%, while the ones declaring to have the symptom at monthly basis has been decreased from 16% to 1%;
- The majority of the beneficiaries (more than 90% in each aspect) are managing the toilets properly, that is having some ready to use ashes in the room and having a dry, odourless, soil colour and without parasites sludge;
- The following percentage of people reported the following life quality improved aspects:

Which aspects of your life quality are changed? List of benefits spontaneously mentioned by the beneficiaries (more than one each)		
diarrhea reduction	24	35%
no need to build a new one every year	24	35%
better hygiene	23	34%
availability of manure	22	32%
budget saving	20	29%
it last long	15	22%
better privacy	9	13%
it is not smelling	8	12%
usable during rainy season too	6	9%
easy to clean	5	7%
no need to do long distance (in a place where there is no rain water)	4	6%
they are not afraid of a child falling in the pit or collapsing on them	3	4%
saving of land space	3	4%
It looks nice	2	3%
the harvest is better	2	3%

Table 3: list of spontaneous benefits reported by the beneficiaries that have received an Ecosan toilette

- After testing the effects of the manure, some beneficiaries decided to reduce the purchasing of synthetic fertilizers;

- According to the observations of the interviewed people, it has been notices a significant improved quality and quantity of crops, especially of maize;
- Summing the saving from the toilets and the saving coming from the manure, each family saved about 11500 mwk, which corresponds to a whole monthly income of a poor family during an unfavourable season (source: economic survey 2019);
- The mentioned saving are used for different purposes, in support of other needs. According to the survey, the saved amount is used for hygiene items, food, school fees, farmer's equipment, house needs, clothes, animals.

7. Relevance and integration with other sectors

Since the benefits are also covering some aspects that are not related to sanitation access, as mentioned above in the paragraph describing the "suggested beneficiary target", it is advised to design in advance an holistic approach, in collaboration with other Projects and partners, in support of other programs such as agriculture, school education, health, nutrition, etc.

A similar design of toilets was implemented for the first time in Phalombe at a primary school. The head teacher of the school approached Inter Aide WASH program delivering a letter that mentions the precarious conditions of the full pit toilette at the school, the financial difficulties related to their emptying and the fact that some girls are not coming to school because of lack of hygiene access.
In terms of contributions, the school committee promised one group of village members per day for the necessary labour (digging the soil, moulding the blocks, etc), while Inter Aide hired a builder supervisor and offered the necessary material.
Despite the mentioned promises, actually some villages members didn't came at all to support the constructions; the civil works delayed due to some absenteeism. At the end, about 75% of the bricks were moulded by motivated villages (especially by the ones that received a personal toilette from Inter Aide in their village in the last year), while the remaining 25% were made by masonry adult students coming for an official internship planned for their school diploma.

In case the public works involves the participation of the beneficiaries, it is therefore recommended to plan a strategy that let them understand the importance of a toilette in the school, besides a written agreement with the Authority. For example, the expectation of a personal toilette at home, promised by Inter Aide, can help the Project to have easily available volunteers at the school; at the same time, an agreement signed with each targeted village mentioning that "after receiving a personal toilette they should offer also one working day at the school" can help too.

The design of the toilette was almost the same, only the size of the chamber has been in- creased, due to the high number of users. In order to optimize the space and the costs, they were built in line instead of single spots.

Figure 26: six ecosan toilettes built in a line, under construction in a primary school.

Figure 27: door side of a line of 6 ecosan toilets in working progress for a primary school in Phalombe District

Figure 28: chamber side of a line of 6 toilets in a primary school in Phalombe District

Another small difference is regarding the management. At school level it is necessary to have the possibility to close the doors and the slab covers by keys, in order to keep under control the time of using and the chamber side in use/in maturation.
In the near future it could be interesting to analyse if the new toilettes are really emptied by the school committee and if the dropping out of the female students will be reduced. Since the mentioned school has internal activities regarding school the environment and agriculture topics, the head teacher has also announced to use the future manure for the school garden.

At the handover of the building to the school, Inter Aide implemented training for trainers on the use of the toilet, delivering simple manuals for student target regarding the hygiene and the future use of the manure (here below linked).
At the same hand over moment, Inter Aide facilitated and agreed with the school all the aspects of the common management. At the end an agreement mentioning the responsible departments in charge for each aspect of the maintenance has been signed: cleaning, provision of water and soap at the toilets site, budget for running cost, opening/closing of doors and chamber doors, emptying of the chambers, ownership of the manure, holding of the keys, etc.

https://washresources.cawst.org/en/resources/da701e40/cover
From CAWST organization: in the website page called "wash education and training resources" there are a lot of material for school educational training, open sources and ready to use, in many languages, officially declared free by CAWST.

https://huussi.net/wp-content/uploads/2013/06/Manual-2_ENGLISH.pdf
https://huussi.net/wp-content/uploads/2013/06/Manual-3_ENGLISH.pdf
From Global Dry Toilets Association of Finland, specialized in hygiene access solutions in development countries.

Unfortunately, in many countries, including Malawi, the public belongings can easily be considered as “ownerless”; as consequence of this believes, the vandalism episodes can be frequent and lack of care can be considered as a “normal agenda” of the school head teacher. Therefore, at the mentioned school, some precautions have been taken, even knowing that a perfect security and management level cannot exist. The following figures can show some of the mentioned precautions:

Figure 29: on the chamber sheet covered they were made some holes; in this way, the metallic sheet has no/low value, it is very less attractive at the black market and the risk of theft is much minimized.

Figure 30: the door has been installed with internal hinges, not visible to the public, in order to make possible theft/vandalism more difficult. (The visible hinge at the wall is not any-more relevant).

Figure 31: the two holes of the slabs are provided by a lock, in order to allow the students to use only the correct side of the chamber, letting the teachers to choose when it will be the right moment to shift the chamber side.

Figure 32: each door is provided with a lock, in order to don't allow external people during night/school closure.

The same design of toilettes could be tested in any public place where the emptying of pit latrines is a relevant financial challenge for the Authority in charge (health centres, markets, etc.) and the management responsibilities are clear (as any other facilities, whatever the design is).

As mentioned in the paragraph called "direct and indirect benefits", an obvious integration could be with agriculture programs. Since some challenges faced by agriculture programs are not directly depending by internal strategies (such as water point presence, distance with animal manure production), a WASH program in the same targeted area can be considered as an integration help in support of agro programs.

For each targeted village and school, in collaboration with agro program (which trained Hydro staff about the correct use of solid and liquid manure) it was implemented a training on the use of urea and solid manure. The final training is summarized in a simple booklet called "manure use booklet", (attached).

As conclusion, here below some pictures related to the first agriculture impacts and aspects (described in a dedicated separated report):

Figure 33: Mpiru vegetables growing with manure collected from the Ecosan toilette (in the bag on top of the picture). The beneficiary is reporting that the leaves are remaining greener for longer time. The portion of the garden in the picture is an area where before was not possible to grow any- thing, due the soil fertility.

Figure 34: Inter Aide hydro staff are showing that manure with fibres behave like a sponge (on the hand of the staff member), it is able to keep moisture and releasing water and nutrients little by little; a soluble artificial fertilizer is instead melted almost immediately once it rains.

Figure 35: the aspect of the manure collected from the chamber reached the proper standard: dry, without insects and any smell.

Figure 36: the beneficiary is showing the toilette of his house, the new 5 bags of manure collected from the first chamber, and the date of closing the first chamber written inside the toilette.

Figure 37: the beneficiary is showing his 3 tangerine trees, fertilized by the manure collected from he Ecosan toilette.