



WPI



Development
Design Lab

GSAP
Global Sustainable Aid Project

Worcester Polytechnic Institute's

Akyem Dwenase Sanitation IQP 2021



Elaine Chen
Computer Science
Professional Writing

Ruchita Choksey
Mechanical Engineering

Casey Willis
Mechanical Engineering

Danielle Upton
Chemical Engineering

Using Vermicomposting Toilet Design to Develop Sustainable Living

Sanitation continues to improve over time with developing technologies and increasing world wide health standards. To those who are categorized as First World, hygiene and publicly available sanitation is something that is taken for granted. This is not the case for Third World countries where natural and economic resources hinder access to sanitation. As a result, members of this demographic practice open defecation when no form of restroom is available.

As the open defecation rate rises in Western Africa, the spread of feces-borne disease causes great health risks to the general population. Harmful diseases such as cholera, typhoid and dysentery are spreading and causing a public health crisis.¹ The average percent of the population in Ghana that practices open defecation (20%) may be lower than surrounding countries, but the data is skewed by urban areas in Ghana. Roughly 34% of rural Ghana practices open defecation.²

Many organizations such as UNICEF, GSAP, and WHO, have been working with communities in the Third World to come up with viable solutions to minimize open defecation practices. GSAP's work has been extensive in Western Africa, investigating the effectiveness of vermicomposting toilets as substitutions for latrines. Vermicomposting toilets are a sustainable and longer-lasting alternative. Latrines typically fail to over use, since waste can never be removed. This type of failure is not a problem with GSAP's design, which utilizes earthworms to decompose human waste and turn it into safe compost.³ After two years, the compost is harvested from the base of the toilet, dried, and can be used to fertilize crops. GSAP has installed around 2,000-3,000 of these toilets in Ghana, and have first hand accounts from farmers proving the fertilizer yields fruitful crops.

In the community of Akyem Dwenase, the citizens are already on their way to lower open defecation practices. The community has latrines installed by the schools to promote sanitary skills, however they were not intended for public communal use. Overuse of these latrines has led us to work with the people of Akyem Dwenase to help mitigate open defecation.

Collaborative Design in New Environments

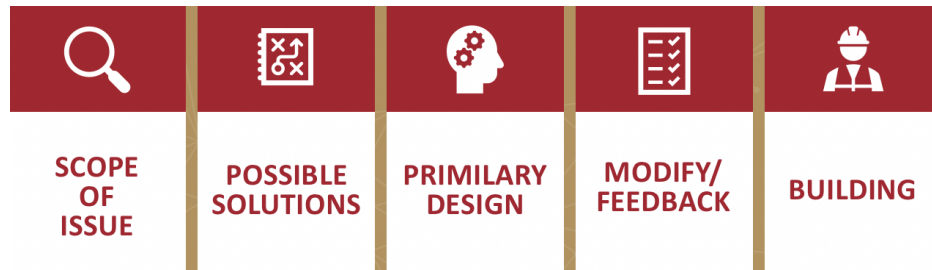
Due to the discrepancy between different nations' lifestyles and technological advancements, approaching development can look radically different depending on a countries' social and economic standing. Previously, development was recognized due to the awareness of poverty and social unrest in poor countries. First World nations saw these countries as a threat. This caused First World nations to interfere in these countries and address these differences as "problems" that needed to be fixed.⁴ Scientific and technological advances looked promising in First World countries, inciting the idea of superiority. This also displaced countries that did not have

advancements and caused them to be viewed as inferior.⁴ However, just because their advancements were not recorded or identical to those of the Western culture's, that does not suggest these other nations did not have their own form of development. Moreover, because of colonization and the process of development from First World countries, these nations' history was erased and ignored.⁴ Therefore, in order for good development in the future, engineers need to allow for collaboration from the communities they are interacting with. By allowing communities to share their knowledge, values, and experiences, the developer can recognize that the pace of development can vary. Understanding the development of a different location can be difficult, but it is important to acknowledge these differences and accept them. These understandings were the foundation of our design process.

We began to reimagine and suppress the design process that engineers are typically taught. Here we came to value one particular aspect of design; codesign. Codesign allows for collaboration of knowledge and expertise. This is especially important in instances where the location of development is unfamiliar to the designer. Without communal input, lone designers can make decisions that may have valid reasoning, but contain subconscious bias. A prime example of a failed design was the PlayPump that was installed in South Africa. This product offered a new approach to solving the lack of water access in developing communities. Hypothetically, the pump provided a creative solution to the laborious hand pumping water system. It relied on the community's youth to play on a spinning wheel, which would then pump water into a storage tank. The creator, Trevor Fields, identified a problem and executed an idea with minimal research and community contact. When UNICEF analyzed why the PlayPump ultimately failed in their article titled *An Evaluation of the PlayPump® Water System as an Appropriate Technology for Water, Sanitation and Hygiene Programmes*, it concluded that a key step in the development phase was skipped. They explained that if the needs of the community were considered, they would have found that a PlayPump was only necessary if there was “no other type of water pumping system before”.⁵ It is crucial that the needs of the users are prioritized in the design process.

By learning from past mistakes, our team developed a design process that was focused on codesign. To identify the scope of the issue, we communicated with locals, researched open defecation and investigated why the preexisting latrines were failing. From here we began discussing possible solutions. A vermicomposting toilet was quickly identified as a sustainable solution that appealed to the community. We began by researching vermicomposting toilets in our preliminary design. We were quickly led to Global Sustainable Aid Project (GSAP), a nonprofit that has implemented thousands of vermicomposting toilets across Western Africa.³ Fortunately, our advisor had many connections to GSAP representatives who were very knowledgeable of the impact that culture has on development. In the next phase, we modified our design based on feedback from locals. On our calls with Chief Osabarima and Nana Attah, the Educational Chief, they emphasized the importance of putting the community first. As Chief

Osabarima said in one of our meetings, “I’m trying to give you guys the cultural perspective.” This perspective impacted many parts of our design. For example, we initially intended on distributing surveys to the community, which is something that is culturally normal at our college. However, we found it to be easier in Akyem Dwenase to get feedback through word of mouth from Nana Attah. The knowledge and opinions that were shared helped to ensure that the development was what the community wanted, needed, and deserved. Lastly, the final phase is building, which unfortunately we can not partake in. We look forward to maintaining communication with masons as they complete the structure and continue the codesign process.



Influences of Adaptive Codesign

Our project goal is to work with the community in Akyem Dwenase to improve public sanitation. To do this we plan to develop eight vermicomposting microflush toilets in convenient locations that would help tackle the issue of public defecation. Each location is placed strategically to distribute communal use. At each location there will be two toilets, one for men and one for women. Our main objective was to develop a manual outlining toilet fabrication because we are unable to participate in construction, as this project is being completed virtually. The manual and YouTube tutorial was sent to the masons for construction and clarification. The manual also includes research for suggestions about interchangeable aspects of the toilet, such as the superstructure or water mantle placement. The purpose of these sections was to ensure we left important decisions up to the community. We gave our suggestions and reasonings, but ultimately they are the experts of the area.

The characteristics of our preliminary initial design is for the toilets to be simple, easy to make and use, and sustainable. The toilet looked relatively industrial, as it was made out of bricks and concrete. We originally started our design with research on the process of making compost. After determining the earthworms’ capability to break down human feces, we made modifications to ensure that we would not use an invasive species. Following this, we looked into methods for water access. Originally, it was determined that a tap above the base of the toilet would be most efficient. After a quick call with Chief Osabarima, it was decided that a separate hand washing station should be used, as it is more user friendly to the community since it would minimize the risk of flooding the digester bed. Next, we estimated measurements and sizings of the toilets, and

developed an outline with steps. To better understand the construction process, we created different composite bricks to see how different materials would behave. This gave our group a more holistic understanding of the construction process.

Certain design features of our toilet were reshaped by our informal engagement with the people of Akyem Dwenase. Since we were unable to properly display our design to the community due to limited internet access, there were occasional misunderstandings. Our team would have loved to incorporate more community engagement, instead of just primarily speaking to government officials as contacts. However, we greatly appreciate all that Chief Osabarima and Nana Attah were able to provide for us and how they went out of their way to gauge local interest.

With codesign, there is always give and take in the design process. While the design of the toilet is sustainable and functional, there was a concern that the community would have wanted a porcelain toilet. Due to modernization and normalized Western culture using these toilets, it is understandable that visual appeal was a large concern. However, to minimize stress on water access, the original design of the toilets have a different internal structure than porcelain toilets and require significantly less cleaning. Additionally, the amount of pressure needed to use a porcelain toilet is not possible without plumbing. Meanwhile, the original design utilizes gravity to our advantage.

However, this functional design generated public concerns, which were voiced to us through Nana Attah. Eventually, we came to the understanding that they desired a product that looked modern and aesthetically appealing. In order to accommodate their desire for style, while maintaining our original design of the toilet, we are planning to use tile to line the floors and base of the toilet. This will ensure that the toilet does not look industrialized, but modernized and comfortable. Additionally, we had originally intended to incorporate plastic bricks because of their increased durability. However, there was hesitation to use the new bricks because they are more accustomed to designing with their own materials. After some discussion, they are more open to using the plastic bricks for projects in the future. This back and forth of conflicting design ideas taught us that we have to account for differing opinions and bias, but to keep an open mind and be collaborative.



Feedback Drives Improvement

With the year bringing new challenges to IQP projects our community engagement looked a little different than in the past. With Zoom, WhatsApp, and email being our main methods of communication, we powered through the digital world and used this new approach to our advantage. Our IQP team reached out to people who had experience working on creating sustainable vermicomposting toilets. Jermoh Kamara and Tedla Tamene are both members of GSAP. Jermoh was able to give us her personal advice and perspective when it came to implementing the toilets in towns in Ghana. Tedla, who is currently working on implementing the toilets in Ethiopia, gave us input on how long certain construction methods take and the different costs associated with them. Their input, both for the engineering and the cultural expectations, were a cornerstone to our project.

Once our project began we started to establish a relationship by utilizing a WhatsApp group with Chief Osabarima, Nana Attah Asante, Nana Kwasi Asare. They were our three primary contacts with the community and their job was critical in being our voice to the community and vice versa.

After various consultations with the community, we were able to better understand the expectations and intentions that the locals were anticipating. This caused us to change some of our original plans and helped us acknowledge their cultural norms. For example, we had originally anticipated implementing the toilets near a school to ensure that they would be cleaned daily. However, after speaking with Chief Osabarima, we realized their original intention was to prevent people from accessing the school and using their toilets. With this knowledge, we understood their target and we became more open to the other locations they had suggested. Additionally, we had anticipated to place a toilet near a local stream to simplify water collection. But after various consultations with Chief Osabarima and Nana Attah, we learned that during monsoon season the stream could overflow, flood our toilet, and kill the earthworms. Logistically, we had anticipated only constructing four toilets, one placed in each specified location. However, we were then informed that this would not be accepted in the community because of societal norms, and decided to build two separate gendered toilets in each location. We also learned that the users would be charged a small fee per use, in order to cover cleaning and maintenance fees. Additionally, they wanted to install locks on both the inside and the outside. While the standard lock on the inside is for privacy, the lock on the outside is to prevent users from accessing the toilet at night or during closed hours. Lastly, through our calls with Libby Gladding, another GSAP representative, we learned what the challenges were that she had to overcome after the implementation of the toilets. She had mentioned that there was pushback from people using the human waste compost. This is because people felt that the compost was dirty and unclean. She suggested that a farmer visit and showcase his crops grown from compost to combat this issue. After they were able to see the positive results of the compost, the pushback subsided.

The underlying cultural norms of the community of Akyem Dwenase determined how things were done and what path the project followed. While sharing a digester bed would have been less work and materials, due to the cultural norm of men and women having separate bathroom facilities, the toilets have to be put in separate locations. While we might have considered it to be a mere cost analysis reasoning, they opened our eyes to factors we were not previously considering. The expectations of the residents were also quite high, because they are people who take pride in their community. They want to see technological advancements depicted in Western culture. However, it is not necessarily the most realistic or sustainable, and it requires there to be a medium between what they want and what might be the most logical solution.



Coping With Long Distance Codesign

Codesign is essential to the success of any cross-cultural development. Recognizing this, our group planned for our design process to rely heavily on communicating with others. Unfortunately, completing this project remotely prevented us from having direct conversation with the individuals most likely to use the toilet. These interactions would have provided opportunities to learn more about the community's wants and knowledge in regards to the design. Each step of our design process faced different obstacles, challenging us to remain flexible.

When determining the scope of the issue, it was important to understand the fundamental problem. The best way to determine this, as Professor Krueger said, is to “speak to those living it”. Unfortunately, at this stage, we had minimal communication with locals. Instead, we learned about the impact of the open defecation issue from Chief Osabarima on behalf of the others. While this was still very helpful, hearing personal accounts would have allowed for a more accurate and defined scope of the problem.

The early stages of our design process may have been stunted by a lack of frequent communication with the Akyem Dwenase community. Utilizing the knowledge and expertise of GSAP helped us form a true collaborative relationship with Libby Gladding. This is when our group realized how important codesign was, since we were so heavily reliant on it when writing the manual. While communication with Libby was incredibly helpful, critiques from masons would have influenced our writing more directly. They would have better knowledge of the materials in the area and ways of construction. To combat this lack of additional codesign, we strategically left a lot of ‘wobble room’ in our manual. Many sections encourage the builders to use their expertise to create the superstructure and other portions in the way they see best fit.

As we received feedback from our work, we faced similar issues. After video calls with Nana Attah, he surveyed the community for us. However, due to his social involvement and busy schedule, it took exponentially longer than it would have if we conducted the survey ourselves. Additionally the information we got was generalized and not user specific. The virtual atmosphere made general communication more difficult. For example, the connection was poor, making it harder to understand each other's questions and responses. This barrier was challenging, but the resilience of all participants prevented it from becoming a detrimental issue.

As for the actual construction of the toilets, it has yet to be completed. We were eager to help with construction and learn from the masons in the community, and hope they will continue to communicate with us throughout the process.

Not being in Ghana made incorporating codesign into our project more difficult, but all the more necessary. The impact that our partners had on us was as strong as we had hoped and we learned so much from those we were able to design alongside. Technology is remarkable, and can be credited with making our project possible. With this appreciation for technology, we can still acknowledge that being onsite would have given this project an even larger opportunity for success. Regardless, we are still proud of the outcome and look forward to the actual implementation of the design.



The Future of Sanitation in Akyem Dweanse

Our project was designed to be an evolving endeavor that the community in Akyem Dweanse and future IQP students would be improving and maintaining over time. Below is a graphic, showing six of the next routes that our project could be taken. To ensure long term success and utilization of the facilities we build, a financial maintenance plan is necessary. For upkeep of the toilets, a hired community member is responsible for repairs and daily cleaning. Typically, a community buy-in-model called *susu* is used, but the money from the investment we secured

during our project could be distributed over time, making *susu* unnecessary. Aside from this, the co-design aspect of our project can be further expanded upon by investigating alternatives to superstructure fabrications. This aspect of our design is very fluid and is up to the community's needs and interests.

The next two options for the expansion of our project were brought to our attention from Libby Gladding. She informed us that in Ethiopia, GSAP developed a business model for earthworm farms. Having earthworms readily available in case of toilet flooding or overuse would aid in maintenance of our design. Owners of earthworm farms have had lucrative businesses and have been able to sell to composting toilet owners, farmers, and fishermen. Furthermore, an additional feature for a male urine capturing device can be added to our design. Urine can be collected and dried to form crystalized fertilizer for farming.

The last two options for expansion would be based on the results of how well our toilets worked. After two years of use, the compost harvesting process can be a project of its own. The compost can be collected, dried and quality checked. This portion of our design has the most community push back, because there are negative connotations surrounding the concept of using compost made from human feces. Our group believes a social impact campaign would be an excellent future IQP. Lastly, our design could be adapted to have a step flush, preventing contamination of touching the flushing handle.

Whatever route is pursued next year, there is one aspect that is the most important for future students to keep in mind: the community comes first. At the end of the day, we are just an aid to improving life in Akyem Dwenase. This project center challenges students to leave First World bias behind, and reimagine the design process. This truly is an opportunity to engineer for the better of humanity.

Future Projects



**Financial
Maintenance
Plan**



**Superstructure
Modification**



**Earthworm
Farming**



Urine Fertilizer



**Compost
Harvesting**



Step Flush



Worcester Polytechnic Institute

Acknowledgements

Our group would like to express our gratitude to the following partners. Through this process we have learned tremendously about reimagining development to implement codesign practices and the realities of virtual project management. Working with the community in Akyem Dwenase opened our eyes to the influence of cultural differences and immense benefits that collaboration has on projects.

Thank You!

Professor Robert Krueger
Professor Mustapha S. Fofana
Chief Osabarima Owusu Baafi Aboagye III
Chief Attah Asante
Chief Kwasi Asare
Libby Gladding
Jermoh Kamara
Tedla Tamene
Charlie Lord
Nelson Boateng

Sincerely,
Casey Willis
Elaine Chen
Danielle Upton
Ruchita Choksey

Bibliography

1. Ending Open Defecation. (2021). Unicef West and Central Africa.
2. WHO/UNICEF. (2011). A Snapshot of Sanitation and Open Defecation in Africa. Joint Monitoring Program for Water Supply and Sanitation.
3. Global Sustainable Aid Project (GSAP), <http://www.globalsustainableaid.org>
4. Escobar, A. (2017). Designs for the Pluriverse. Durham, NC: Duke University Press.
5. UNICEF. (2007, October). *An Evaluation of the PlayPump® Water System as an Appropriate Technology for Water, Sanitation and Hygiene Programmes.*