Point of Use Water Treatment: *MadiDrop* and Copper Mesh Development
(Technical Paper)

How the United States Fails to Competitively Invest in Sub-Saharan African Development: A Technological Barrier
(STS Paper)

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Prospectus

Introduction

The world will only become more interconnected over time as powerful states continue to sponsor movements for advancement and development across the globe through foreign aid (Davis & O'Hallaran, 2018). Through one such example, China's Belt and Road Initiative (BRI), Chinese firms have funded over 31% of all infrastructure projects in Africa valued at $50 million or more FY2020 alone. Comparatively, western construction firms were directly responsible for approximately 12% in FY2020 of all African infrastructure projects of similar value, a decrease from 37% in FY2013. Thereby, indicating a staggering relative decrease in developmental investments from the West and a waning regional influence (The Economist, 2022). Through the BRI, immediate Sino-African relations have been bolstered by consistent short-term economic growth and entanglement (Wilson-Andoh, 2022). As a response, the efficacy of Western development practices, particularly the United States, have been drawn into contention.

American foreign development policy has primarily centered around localized projects meant to improve the quality of life in individual communities. Following this development style, the US attempts to implement small-scale systems and technologies it can leave behind in order promote a "self-reliant" African continent (USAID, 2021). However, this focus can cause severe barriers to technology use caused by varying perspectives on how these technologies and systems should be applied. American development projects struggle in comparison to the large infrastructure projects supported by the Chinese government (Wilson-Andoh, 2022). An STS analysis of how the US fails to competitively invest in Sub-Saharan Africa is needed to identify how technology is creating barriers to successful development and to strategize ways to improve and outcompete rivals such as China.

Access to clean water worldwide is specifically a challenge in Sub-Saharan Africa, where only 24% of the population has access to clean drinking water; as defined by the United Nations, drinking water should be "sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic use" (United Nations Water, 2019). Using these objectives as targets for technological innovation, the final technical deliverable will take the form of a water purification tablet known as the *MadiDrop*, a copper mesh, and a case that will deploy these two components in a simple and efficient manner. The research is supported by Silivhere Technologies Incorporated, a Charlottesville-based organization bringing needed point-of-use water treatment technologies to the public. Past research with silver-infused ceramic filters led to the development of the *MadiDrop*, a submersible tablet that effectively eliminates a vast array of water-based organisms (Smith, 2016). The technical deliverable will also seek to implement current research conducted by University of Virginia Professor James A. Smith on using a copper mesh for additional water treatment and organism elimination for drinking water. The *MadiDrop* and copper mesh work in tandem to release silver and copper ions into contaminated water, these ions then purify the water of bacteria, viruses, and suspended mosquito larva (Smith, 2016). The purpose of the technical research is to design, prototype, and construct a case for the *MadiDrop* and copper mesh that will not impede its ability to release the needed ions for water purification while avoiding the risk of overdesigning.

Technical

Contaminated household water is causing public health concerns through direct consumption leading to increased disease transmission. Globally, over 2 billion people lack access to safely managed drinking water at home (Centers for Disease Control and Prevention, 2022). Point-of-use water treatment methods can be used to effectively mitigate the

contamination issue and the associated risks. Technologies, such as the *MadiDrop* developed by Silivhere Technologies Incorporated, remove contaminates from water that has often been stored for long periods of time in unsafe containers prior to use (DePeiza, 2022). As it currently stands, one of the greatest struggles Silivhere Technologies Incorporated is having with the *MadiDrop* continue to satisfy primary drinking water standards, contaminant limits, without negatively impacting secondary drinking water standards such as turbidity, smell, or taste (Environmental Protection Agency, 2022). Introducing a copper mesh may further reduce contaminate levels. The mesh would be submerged alongside the *MadiDrop* and hypothetically release copper ions into the water. These positive ions perform "copper-silver ionization" with the silver ions released by the *MadiDrop*. They are attracted to the negatively charged bacteria, viruses, and fungi in the water. At this point the copper and silver ions adhere to the cell walls of the contaminates and killing them by sterilizing the DNA, suffocating the cell wall by inhibiting membrane transport, altering the cell metabolism causing it to starve, and immobilizing cellular proteins (Gomski, 2019). Together, these products do not filter the water, but the released ions disinfect or deactivate a multitude of waterborne pathogens, most notably Legionella, the bacteria responsible for Legionnaires' Disease (Letson, 2019). Further research on this topic is currently being conducted under Professor James A. Smith at the University of Virginia Water Quality Lab.

However, the design process faces several key challenges. The extent to which the copper mesh may interfere with the silver release rate of the *MadiDrop* is unknown and further testing is required to determine this. If the copper mesh reduces the silver release rate to a great extent the design will fail to properly purify water. These variables will be determined by testing different setups and proximities of the two components for copper and silver ions released over a specified

period. The design can then be optimized by determining ideal quantities of released ions for higher purification that does not lead to unsafe levels of copper or silver in the treated water.

Furthermore, the two components must be incorporated together into a single design. This design must serve as a container for the *MadiDrop* and mesh while also not physically impeding the ion release rates. This final deliverable should also be cheap enough to be produced and implemented on a large scale across many communities in need. Silivhere Technologies Incorporated is seeking a container design that can be further developed then mass produced for use across the globe. The design will likely directly impact hundreds of users as the company continues to expand in a goal to provide safe water for all. Additionally, there are plans to conduct regional tests over the Summer of 2023 in South Africa, bringing any new technologies directly to beneficiaries.

STS Topic

Since its inception, the United States has used foreign developmental aid as a tool for projecting international power and influence (Morgenstern & Brown, 2022). As stated by U.S. Senator Patrick Leahy, “Relations between the United States and other countries… are advanced by our willingness to help other countries in need. Foreign aid is essential to protecting U.S. interests around the world...” (Carle, 2011). Foreign developmental aid can be recognized as tangible and intangible forms of assistance to other countries. These often are in support of U.S. national security and commercial interests (Morgenstern & Brown, 2022).

Most of the foreign developmental aid from the U.S. comes through the United States Agency for International Development, or USAID, for the last 60 years. The organization was allocated $48.22 billion for FY2022, $8.5 billion of which goes directly to Sub-Saharan Africa. Interestingly, China budgeted $28.4 billion for the first half of FY2022 alone through the BRI

(USA Spending Report, 2022). Indicative of a massive discrepancy in regional focus projected by the U.S; based on the optics of the amount of money invested, the U.S. appears to care about Sub-Saharan Africa a lot less than China (Mukogo, 2019).

The investment discrepancy is only amplified when one looks at the ways in which U.S. foreign development aid projects have failed in the past compared to China's efforts in the BRI. For example, U.S. sponsored Peace Corps projects to provide latrines to communities in Ghana that failed because they were unable to connect it to existing infrastructure. Or another project in Kenya where computers were provided to schools, but they were locked away and never used, the teachers opting to educate on computer use through chalk on a blackboard. And finally, also in Kenya, an instance where a library was built and stocked full of English language books in an area where nobody speaks English. As put by Peter DiCampo, founder a failed aid reporting organization, the people of Africa "live with some forgotten aid project or another tucked in the corner of a room in their home" (DiCampo, 2019). A continuity amongst all these failed projects is clear – a overreliance on providing a technology without the support or need and a misunderstanding of how to apply it to beneficiary communities.

Tackling these challenges in U.S. foreign development is integral to promoting improved foreign development practices that can compete with Chinese methods. And to ensure the U.S. is succeeding in meeting its goals in support of national security and commercial interests. The STS theory used to assess this challenge will be Actor Network Theory (ANT) to determine each component of the technologic culture behind developmental aid. ANT is a method for breaking down a network and describing how contributors and stakeholders interact in a technological system. The contributors and stakeholders, known as actors, are any entity within the network and have connections to other network entities. ANT seeks to define the dynamic relationships

between actors and hypothesize the reasons behind how these relationships develop (Rydin & Tate, 2016).

Critics of ANT claim that identifying components of an actor-network is not enough to incite change. However, these critiques will be avoided by seeking to understand how each actor is immediately impacted by technology. Enabling hypothesis' to be drawn over how the applications of these technologies can shift to have a desired effect on the network. The main actors of this actor-network investigation will begin with the U.S. and federal development aid providers, or contributors, such as USAID. It will also draw specific examples from smaller Sub-Saharan communities to identify stakeholders, failed technologies, and foreign nations to understand the competitive nature of the network. The analysis is important because The U.S. cannot effectively force a cultural change in a beneficiary community, we must instead seek to change out mindset on U.S. foreign development projects are planned and executed and an understanding of the network behind these projects is critical to this change.

The main question being studied in the research will be: how does technology impact U.S. developmental aid in Sub-Saharan Africa?

This problem will be approached through network analysis, seeking to understand the fundamental perception and role of technology-based aid. Network analysis is the means to describe organizations structures through hierarchies, budgetary arrangements, membership, and actions between agents to understand a socio-technical network. Research will depend on primary and secondary sources describing failed and proposed foreign aid projects. Detailing how technology can detract from successful development of a struggling community. The analysis will also seek to include primary and secondary sources of successful aid projects in contrast with failed projects and identify key actors behind why projects have failed. Key

research descriptors of these sources will be foreign developmental aid, USAID, China, failure, success, technology, and Sub-Saharan Africa. These terms clearly outline combinations of potential sources that would provide insight into past aid projects as they pertain to technology use in Sub-Saharan Africa. They will also likely lead to identifying other key opportunities for change in U.S. aid policy.

Conclusion

With exciting innovation on point-of-use water treatment through the *MadiDrop* in the technical portion and an in-depth analysis of how the United States conducts foreign developmental aid in the STS potion, this thesis strives to provide a strong foundation for understanding American aid and the challenges it faces. The thesis should deliver policy recommendations considering the roles in which technologies impact beneficiaries.

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