Prospectus

Design of the Maphoveleni Footbridge in the Manzini Region of Eswatini
(Technical Topic)

Analysis of the Success of the Ria Abajo Footbridge in Nicaragua
(STS Topic)

By

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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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Introduction

As climate change progresses, natural disasters will increase in frequency and severity (Biniarz, 2021). These natural disasters, such as flooding, earthquakes, and hurricanes, inequitably affect low-income communities. Oftentimes, these events further hinder the economic development of the impoverished areas that are affected. For this reason, infrastructure systems that can sustain natural disasters are crucial to lift vulnerable communities out of poverty and build robust economies for years to come.

From 2000 to 2015, the total population at risk from flooding grew 20 to 24 percent (Tellman et al., 2021). When rivers flood in agriculturally-centered communities, members of that community can be cut off from education, healthcare, and a source of income. Currently, individuals in rural areas either resort to provisional stream crossings such as log structures and rafts or dangerously attempt crossing in high water with no accomodations in place to reach important resources.

Attempts to cross the river without adequate infrastructure can lead to catastrophic results including injuries and fatalities. If communities are continually threatened due to isolation during flooding, their economies will be heavily limited by and dependent on high-water events. Injuries will continually put people out of work and agricultural production and education will be limited to only times when the river is low. In order to combat these effects of geographic isolation due to flooding and promote local economies, engineered systems, such as footbridges, must be constructed to allow for a safe passage over high waters.

In Zombodze and Boyane, communities on either side of the Mtilane river in Eswatini, the majority of individuals are farmers or industrial workers that require passage of the river to reach buyers and markets in the closest city of Manzini. The local municipality has enlisted the help of the Engineers in Action Bridge Program to design and build Maphoveleni, a suspended footbridge, to allow for safe passage over the river. To address the dangers of increased flooding and river crossing, my team will propose a design for a structurally-sound pedestrian footbridge as a part of the Engineers in Action bridge program.

In developing the footbridge, both social and technical design factors will need consideration. The bridge must fit the needs of various stakeholders within the community including farmers and schoolchildren as well as meet structural design standards. The project has the potential to improve the quality of life for local residents by increasing access to agricultural revenue and therefore, fostering the local economy. Below I outline the technical process for designing the Maphoveleni footbridge to suit the needs of the Zombodze and Boyane communities. I will then apply actor-network theory (ANT) to the Rio Abajo footbridge in Nicaragua to analyze the design process, community efforts, and economic impact of the project. The build in Nicaragua strengthened the local economy by providing year-round access over the Pueblo Nuevo river. The ANT analysis will be applied to the Maphoveleni footbridge in Eswatini to ensure that the proposed design similarly serves the community and economically benefits the local residents.

Technical Problem

The Kingdom of Eswatini is a small, landlocked country home to around 1.5 million citizens (Eswatini Country Review, 2021). Located just outside of the city of Manzini, the communities of Boyane and Zombodze are split by the Mtilane River. Heavier rainfall in Eswatini occurs in the summer months with the climate classified as Cwa, monsoon-influenced humid subtropical climate, by the Köppen-Geiger classification system (Climate: Swaziland, n.d.).

In an area with heavy rainfall and no suitable infrastructure in place, river flooding can create a geographic barrier that isolates members of the local community from key resources such as schools, hospitals, and agricultural areas. In Eswatini, flooding of the Mtilane River occurs year-round, producing devastating effects on the community. Individuals are either cut off from integral parts of their life or risk injury or worse in attempting to cross the river. Currently, the only way to traverse the river is an unstable, temporary log structure. In the past three years, six injuries have occured due to river crossing, two of which were agricultural workers attempting to transport crops and machinery (Mhlapho & Mdluli, 2021).

The goal of the technical project is to create a design for a suspended cable footbridge that will provide year-round access to education, healthcare, agricultural fields, and markets for the citizens of Boyane and Zombodze. The team will work in collaboration with a non-profit organization, Engineers in Action, previously known as Bridges to Prosperity, that organizes volunteers and engineers to design and build suspended footbridges. We will utilize AutoCAD modeling software as well as basic principles from statics and mechanics coursework to develop the design of the bridge. There are several deliverables and components within the design process to complete including a detailed plan set, calculations of load capacity, geotechnical foundation analysis, and hydrological erosion analysis as well as review calls with the Engineers in Action bridge program advisors. We will complete required training modules to ensure technical competency for designing the bridge including courses on advanced suspended bridge design, project management, construction management, and more. We will have three review calls with Engineers in Action over the course of the year where we will present initial ideas for the bridge design, a finalized design, and safety and construction plans, sequentially.

The successful design and construction of the Maphoveleni footbridge will directly impact 2000 individuals including 1200 children and 650 women of child-bearing age (Mhlapho & Mdluli, 2021). Through providing access to markets and trading in Manzini, the bridge will indirectly impact approximately 5000 individuals. Children attending primary and secondary school will have improved access to education while community members will experience greater connectivity to churches, bus stations, and medical care.

This project will be completed by a team of eight students over the course of two semesters in CE 4990 and CE 4991. Aspects of the design process will be split equally among all members and various team roles will be assigned based on the strengths of team members and previous coursework. Roles among team members include Project Managers, Design Manager, Quality Control Manager, Fundraising Manager, Cultural Relations Manager, Safety Manager, Construction Manager, and Media Manager. Meetings among team members, with the capstone project advisor Professor Gomez, and with mentors from an Engineering firm, Thornton Tomasetti, will occur frequently to ensure the necessary tasks are completed satisfactorily for the project. As a multitude of stakeholders are involved in the design of the Maphoveleni footbridge, communication will be maintained with the EIA bridge program in order to best meet the structural and communal needs with our design.

STS Problem

Vulnerability to flood risk increases as Gross Domestic Product decreases for countries globally (Jongman et al., 2015). A possible reason for this correlation is the necessity for low-income communities to settle in floodplains (Tellman et al., 2021). Investments into adaptive measures for flooding, including footbridges, are essential in resolving the disparity between high and low-income areas and flood risks. An example of such an investment is the Rio Abajo footbridge in Nicaragua (see Figure 1).

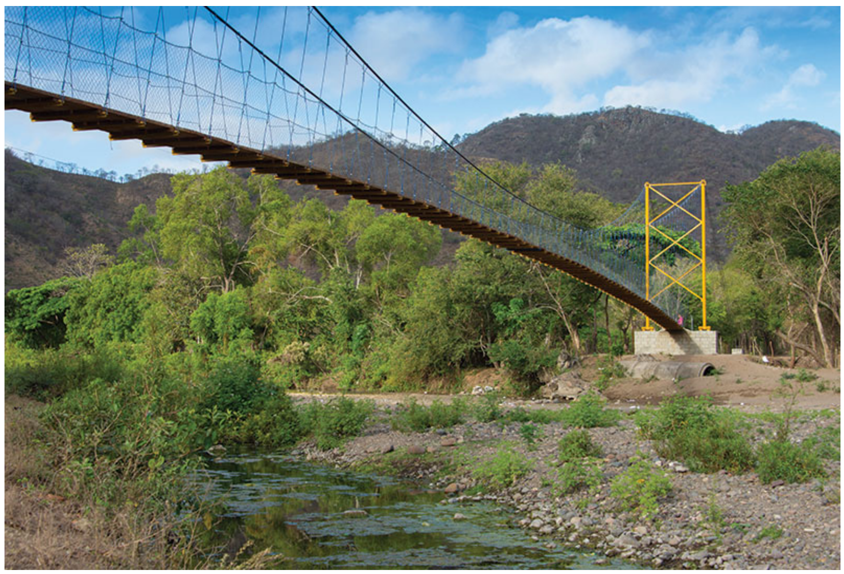

Figure 1: Rio Abajo Footbridge in Nicaragua

In this case, the implementation of a footbridge greatly benefited the local economy through connecting the community with access to markets, trading, and agricultural areas. Prior to the bridge being built, residents in the area either had to walk nine kilometers to the nearest town of Condega or swim across the Pueblo Nuevo river to reach the town of Pueblo Nuevo (Westerink and Kreisa, 2016). Officials in Nicaragua claimed flooding and geographic isolation greatly hindered the development of the country (World Bank, 2008). Following the implementation of the Rio Abajo footbridge, farmers increased spending on fertilizers and pesticides by 60% and experienced greater farm profits of 75% (Brooks and Donovan, 2020).

The footbridge enabled farmers to increase production through greater access to farming inputs, which in turn spurred greater revenue. Bridges to Prosperity director of engagement Alissa Smith says, “On a household level, the effect of a bridge is enormous.” Her organization led a study that found that the average return of a footbridge in rural Nicaragua is around $10,000 USD a year (Matthews, 2017).

According to some accounts, the improvement of a local economy in Nicaragua following the construction of a suspended footbridge is not related to the bridge and will not be sustained for individuals within that community. However, these accounts fail to consider the suspended footbridge as a network composed of varying human and non-human actors that will continually exert power over the local economy. They lack insight on the direct impacts of the network on agricultural productivity and the attitude of other actors involved. In the case of the Rio Abajo footbridge, I argue that the implementation of sustainable infrastructure in rural Nicaragua greatly advanced agricultural productivity and enhanced the local economy. In order to make this analysis, I will utilize Actor-network theory, which states that heterogeneous engineering can be applied toward a problem to achieve a solution. Applying the theory of translation, in which an actor network is formed, I will analyze how actors such as local farmers and their families, volunteers, and a non-profit organization created the Rio Abajo Footbridge network that then influenced the local economy in Nicaragua. In my analysis, I will utilize specific studies on the local economy preceding and following the implementation of the footbridge, an interview from someone who has been involved with the Rio Abajo footbridge project, as well as Michel Callon’s theory of translation.

Conclusion

The final deliverable for the technical problem discussed in the paper is a drawing set with the full suspended Maphoveleni bridge design including the necessary calculations to ensure structural soundness. The deliverable will also incorporate suggestions from the citizens of Zombodze and Boyane to ensure a successful design in terms of communal acceptance. The STS research paper will examine a case study in Nicaragua in which the Rio Abajo footbridge lifted the local community out of poverty and provided access to healthcare, education, and agricultural land. An analysis will be done through applying Actor-Network theory to explain the synthesis of the footbridge network through the collaboration of numerous actors. In addition, the analysis will explore how the Rio Abajo footbridge network exerted power on the Nicaraguan economy. The combined results will show how the Maphoveleni bridge will economically benefit the agricultural communities of Zombodze and Boyane in the Manzini region of Eswatini.

Word Count: 1723

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