Integrated Micro-Irrigation and Surface Water Catchment System for Water Management in India

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Executive Summary

The EWB India Project team is working in conjunction with the rural community of Bhutiya in Rajasthan, India to combat climate change-driven water scarcity, overexploitation of groundwater resources, and poor water management. During a recent assessment trip to the village in January 2019, community members expressed a need for an increased water supply to support agricultural practices and tend to livestock, their primary sources of income. Community surveys, as well as qualitative and quantitative data collected on existing water sources, indicate that further technical research regarding spatial and environmental data must be conducted in order to ensure a successful and sustainable design solution. The next phase of this project involves the investigation into and design of an integrated micro-irrigation and water management system for household implementation.

Project Scope

This project aims to collaboratively design and implement a water access project in Bhutiya that is to be owned and maintained by the community. The project will focus on developing a hybrid between micro-irrigation and a surface water catchment system to relieve dependence on groundwater pumping. The surface water catchment system is aimed to be used in two ways: to provide a water source for the irrigation system and to catch runoff from the fields to recycle water. The irrigation system will use the water from the catchment system to irrigate crops, and then direct runoff back into the catchment system. The coupled system is aimed to function in a cyclical manner, promoting more effective and efficient water usage, while decreasing waste. There will be an emphasis on education and training workshops in regards to system upkeep by Bhutiya community members. EWB students will continue to monitor and evaluate after research design and implementation phases are complete.

Background Information

Before traveling, the team established a connection to the partner NGO, Jagran Jan Vikas Samiti, and the local council, Bemla Gram Panchayat. The first assessment trip, conducted in January 2019, served to collect technical data and conduct community surveys. Community members reported limited access to water and inability to grow enough crops as the first priority need. Trip findings also illustrated that wells generally run dry during the summer months, where only hand pumps can be utilized during this time. Agricultural practices of community members generally rely on monsoon rainfall due to open wells and natural rivers running dry during the summer months. Community industry has transitioned in recent years from cash crops to dairy production due to decreased rainfall averages. EWB at GWU entered a community commitment, verbal and written, in conjunction with local government representatives to devise a solution to combat overexploitation of water resources.

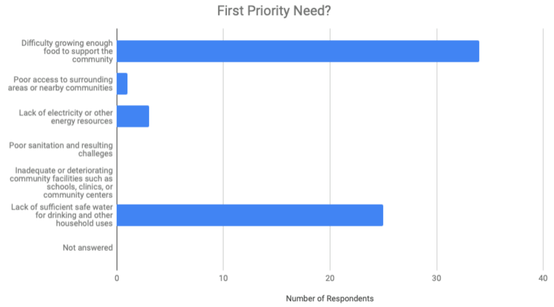
Importance of Project

The livelihood of rural communities throughout the world is being threatened, with water preservation for agricultural uses being absolutely critical. Current climate conditions, resulting in unpredictable yearly rainfall, is causing the depletion of the groundwater table and open wells to run dry earlier than expected. Building resilience against climate variability for vulnerable communities, such as Bhutiya, is essential for the survival of local peoples. This research supports the design and implementation of a novel solution to increase the efficiency of water collection, storage, and irrigation for private land plots. Integrated systems are both affordable and preserve the farming tradition of communities that are impacted by climate change.

Water Sample Collection from Hand Pump and Tube Well, respectively

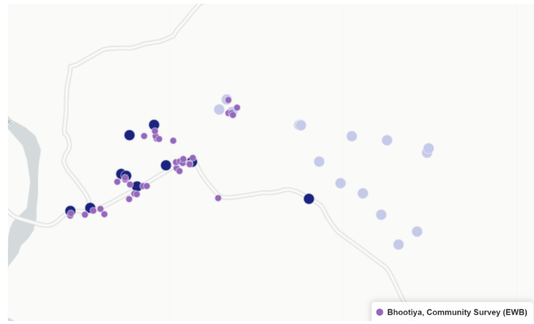
Identification of Problem

The first assessment trip determined that water priority heavily falls on agriculture sector, thereby placing financial burden on local peoples. The Indian Ministry of Agriculture has determined that drought is a regular issue in the Udaipur district, as well as across the state. Seasonal drought and the depletion of groundwater tables leads to water shortages, which provides hardship for community members.



Responses to Community Survey

Most community members reported "difficulty growing enough food to support the community" and "lack of sufficient safe water for drinking and other household uses" as their first priority need.

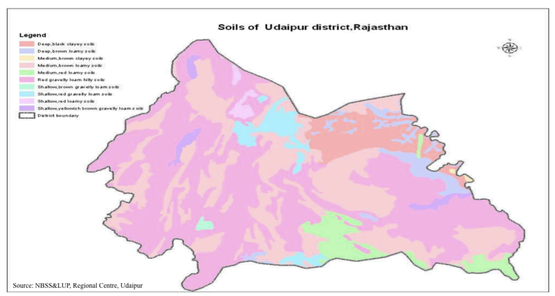


Relative Geospatial Location of Water Points and Location of Surveyed Households

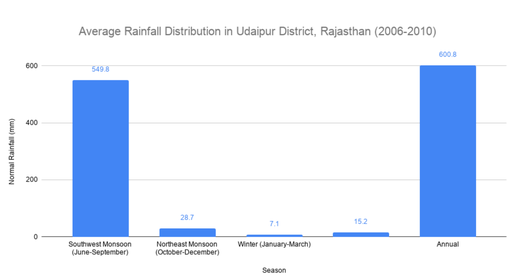
Water points are subdivided into dark blue, which represent the Bhutiya village, and light blue, which represent a neighboring village. Purple dots signify the locations of survey points.

Current Research

- Initial assumptions of insufficient amounts of drinking water in the Bhutiya were proved to be incorrect through community survey review. Hand pumps and tube wells are still functional and supply sufficient water for daily household use and livestock feed.
- One of the most notable concerns facing the community of Bhutiya is insufficient water for agriculture, which is both a supply and distribution issue. Current irrigation practices are not optimal for drought efficiency and involve field flooding. Flood irrigation is resource intensive and has high water loss due to evaporation.
- Data collection methods include interviewing professionals and professors native to Udaipur, gathering knowledge and previous reports from the NGO, surveying community members, taking inventory of local water infrastructure and testing water from handpumps, tube wells, open wells, and in-house. According to the Indian Ministry of Water Resources, groundwater resources are being utilized at a rate of 107% on average in the Udaipur district region[1],effectively being categorized as "over-exploited" by the Indian Ministry of Agriculture. Existing water infrastructure in the community of Bhutiya include government-installed hand pumps, privately and publicly owned tube wells, open wells, an anicut structure, and a check dam. Ideally, project design will involve a combination of a micro-irrigation method as well as water harvesting system. The second assessment trip will be focused on implementation of a prototype solution on a plot of land owned by Jagran that will then be reproduced for the community for household use.



This map shows the various soils found in the Udaipur district of Rajasthan, India.



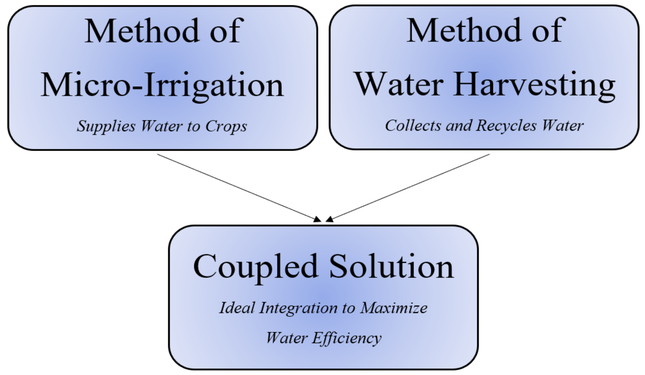
This graph shows the distribution of average rainfall in the Udaipur district of Rajasthan, India.

Potential Solutions

1. Drip irrigation is used to maximize water preservation and minimize evaporation through the uniform drip of water directly to plant roots.[2] This type of irrigation method is appropriate for implementation in the community of Bhutiya, as it allows farmers to alleviate their dependence on flood irrigation methods for land plots, while still satisfying the need for enough water for plants.
2. Furrow irrigation is a type of surface irrigation where furrows, small parallel channels, are dug in between ridges, or rows, of crops.[3] The types of crops most suitable for this system are row crops, including maize, wheat, and barley. Water usage can be maximized when coupled with certain mechanisms, like the capture and reuse of runoff in percolation ponds.[4] This type is irrigation is well suited to the project, as furrow irrigation is a recommended way to irrigate certain types of crops, like maize and wheat, which are commonly grown in Bhutiya. Additionally, the community members are already familiar with this type of irrigation system, as they currently use flood irrigation to water their crops.
3. Percolation ponds can be used as a mean to capture rainwater and to trap, filter, and store tail water and surface runoff from irrigation systems. Percolation ponds are constructed at the end of the field, and the runoff is channeled into the pond by sloping the land downwards towards the pond. The water is then pumped to the top of the field.[5] This system is attractive due to its economical and environmental advantages. Pumping water from the ponds to the field is significantly cheaper and less energy intensive compared to pumping groundwater. This an affordable solution that also decreases dependence on groundwater, while promoting recharge. Additionally water is being conserved and recycled that would otherwise be lost due to evaporation.

Key Findings

- The initial assessment trip changed the general understanding of why additional water structures are needed in the community of Bhutiya. Prior to the trip, the general understanding was that the community members lacked enough water to perform their daily household tasks. Additionally, other projects, like sanitation and energy, were being considered at the time. After community surveying, the project scope was revised to specifically address water scarcity in agricultural practices.
- The prevalence of droughts has increased due to climate change, especially in areas with seasonal rainfall. The agricultural sector has taken a big hit in this aspect, with water resources to properly irrigate crops becoming more difficult to obtain. Agriculture is used to sustain families and also provides a source of income. Community surveys reported that many families have had to switch industries in order to sustain themselves.
- Based off of problem identification and thorough research, micro-irrigation coupled with a surface water harvesting system is seemingly the best solution. This design addresses the issue of water scarcity for agricultural use while also promoting a more efficient use of water, greatly reducing waste. It decreases groundwater dependence, an issue very prevalent in the area. The independent implementation of a micro-irrigation system or a water harvesting structure decreases the efficiency of water usage. Crops will not effectively be irrigated, a significant water will be lost due to evaporation, and groundwater pumping will be still required. The success of this project is dependent on the coupling of these two systems.
- Solidified with the Community Partnership Agreement, the inhabitants of Bhutiya have expressed a great interest with working with EWB on an integrated solution.



Future Work

The EWB-USA designated 6-year plan includes a second assessment trip, upcoming in January 2020. Results from this trip will solidify a design, which will be implemented through system construction by students in 2021. System performance will be monitored and minor repairs will be conducted as needed in 2022 and future years.

References

1. "Ground Water Scenario Udaipur District Rajasthan." *Central Ground Water Board*, Government of India, Ministry of Water Resources, 2013.
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4. "Irrigation Methods: Furrow or Flood Irrigation." *U.S. Geological Survey*, U.S. Geological Survey,
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Common Method of Flood Irrigation Demonstrated in Sample Plot of Land during the Dry Season