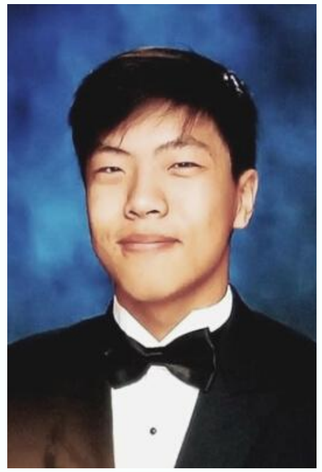
GHCC 2023: Group 1

MCHELE

Ashley Kim, Brian Kim, Chaewon Kim, John Lee, Jun Hee Shin, Micah Yu

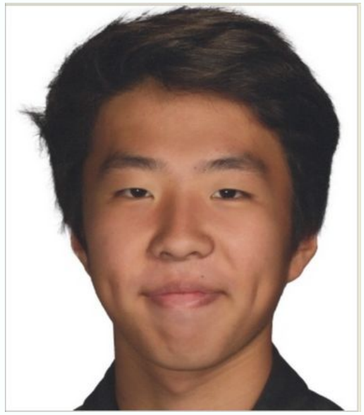
TEAM

ASHLEY KIM



BRIAN KIM

CHAEWON KIM



JOHN LEE

JUN HEE SHIN

MICAH YU

MCHELE (noun): husked rice

/mtʃɛlɛ/

Migori

Community Involvement

Health

Education

Long-Term

Evaluation & Expansion

MIGORI COUNTY, KENYA

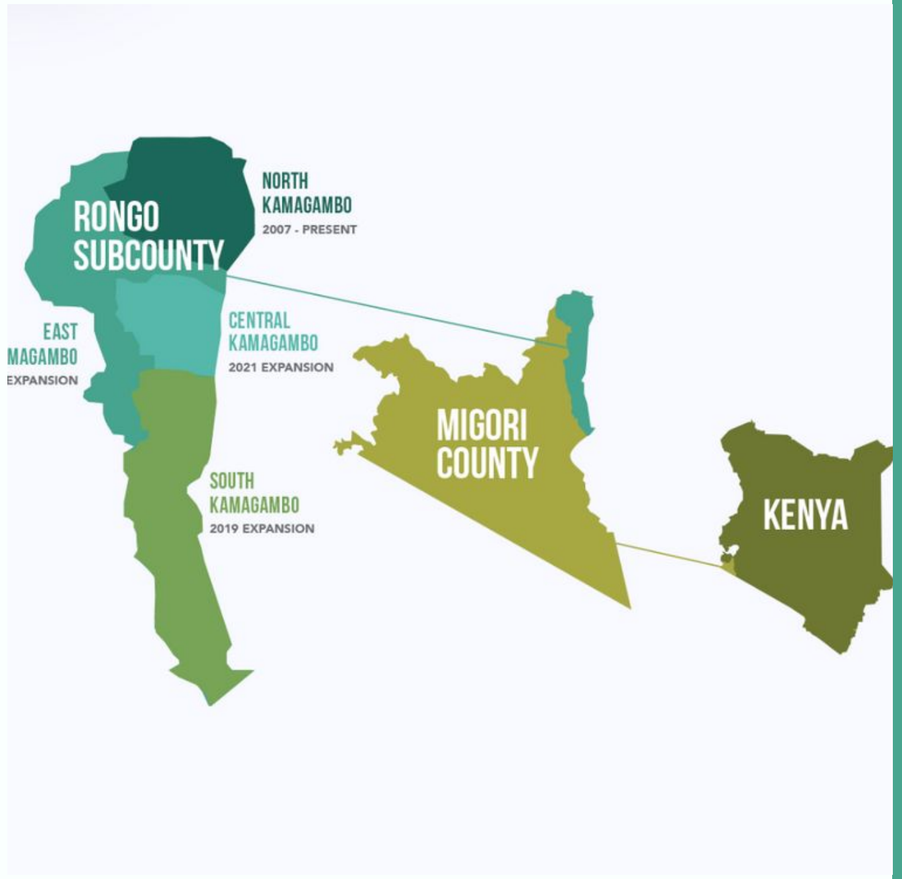
BACKGROUND

Rural Population: 949,236

Climate: Rainy and Dry seasons

Agriculture: rice, sweet potato

Government involvement: agriculture with rice and irrigation



PROBLEM STATEMENT

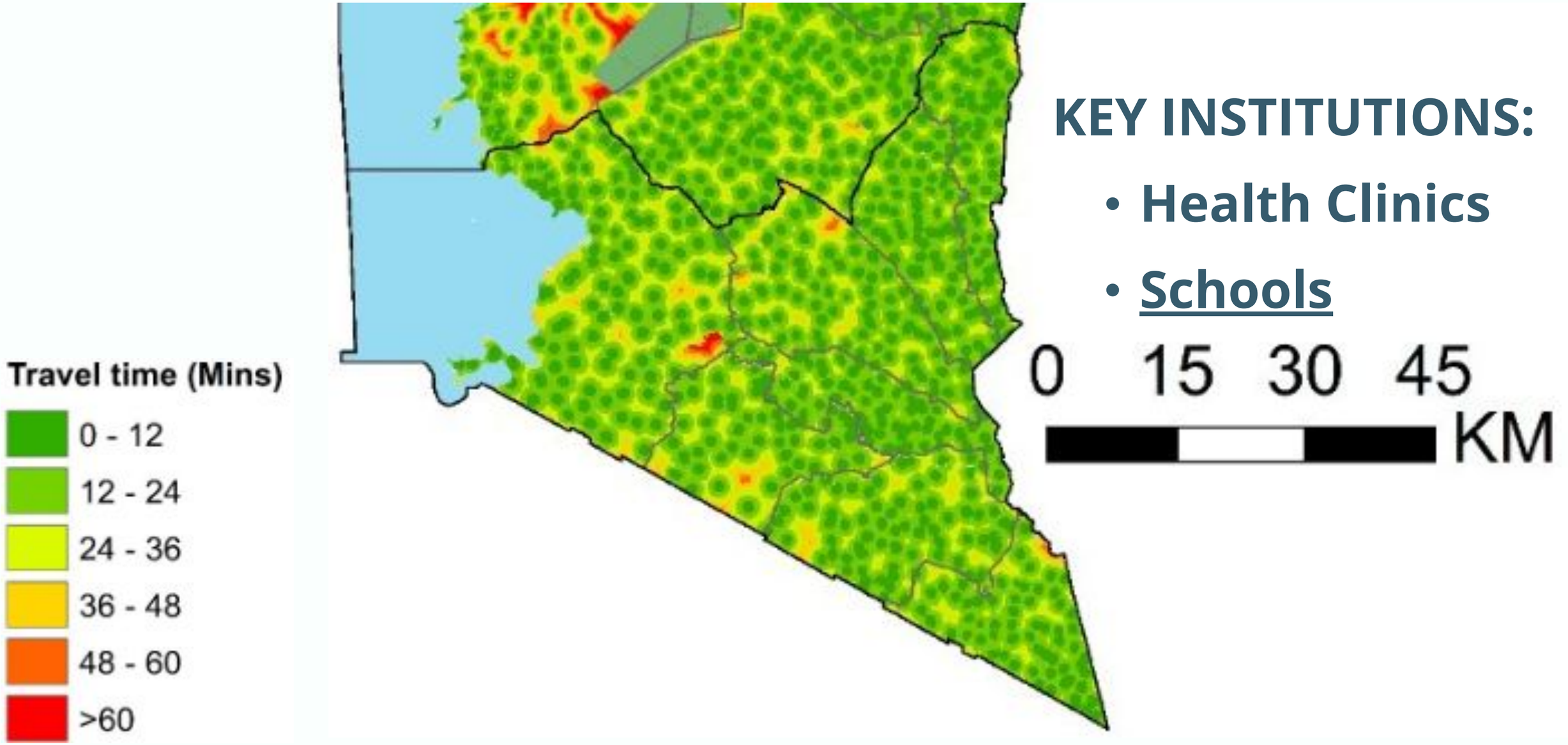
Contamination in groundwater sources

Lack of centralized water source

Community Involvement

The first step...

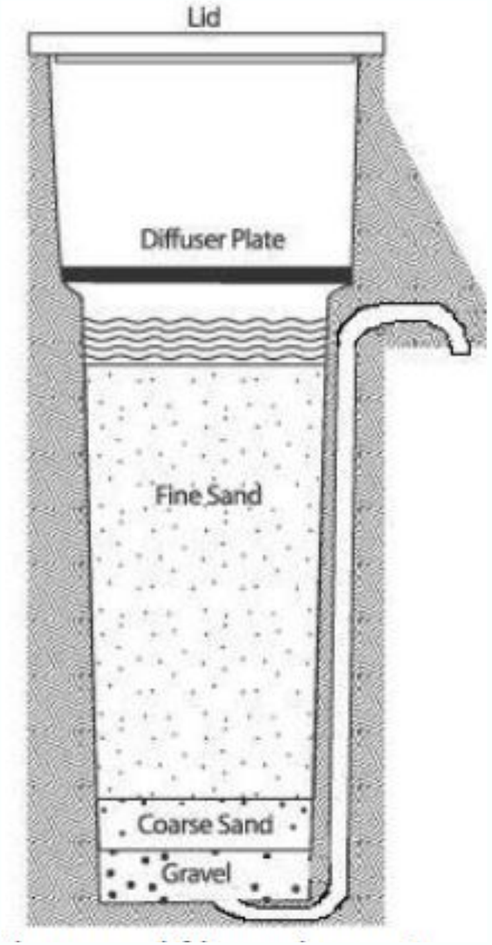
- Local Leaders
- Community Health Workers
- Local farmers

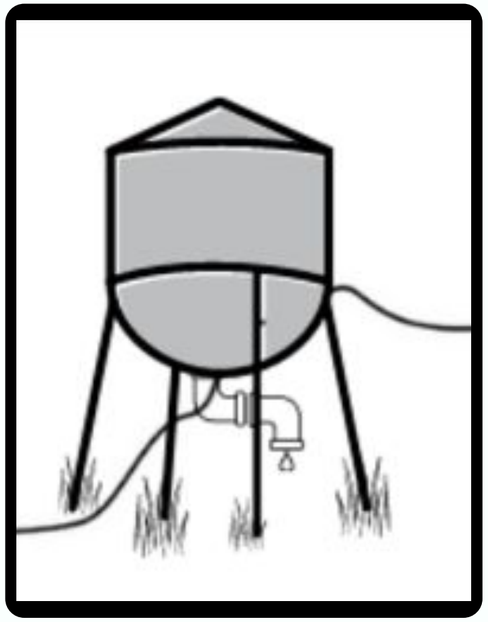


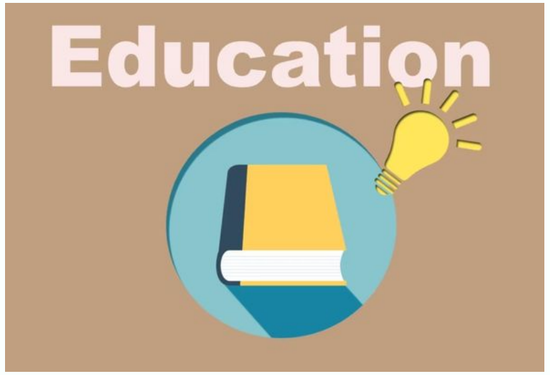
KEY INSTITUTIONS:

- **Health Clinics**
- **Schools**

RESOURCE CENTRALIZATION







HEALTH - NITRATE CONTAMINATION

Nitrate on Health

over **10** mg/L can be harmful

Can cause Methemoglobinemia

Can promote the onset of birth defects

Can result in pregnancy complications

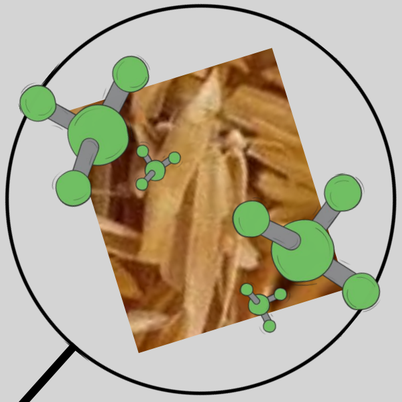
Can increase the risk of thyroid disease

Potentially carcinogenic to humans

Rice Chaff

Efficiently removes nitrate from aqueous solutions

Agricultural waste product from rice harvesting

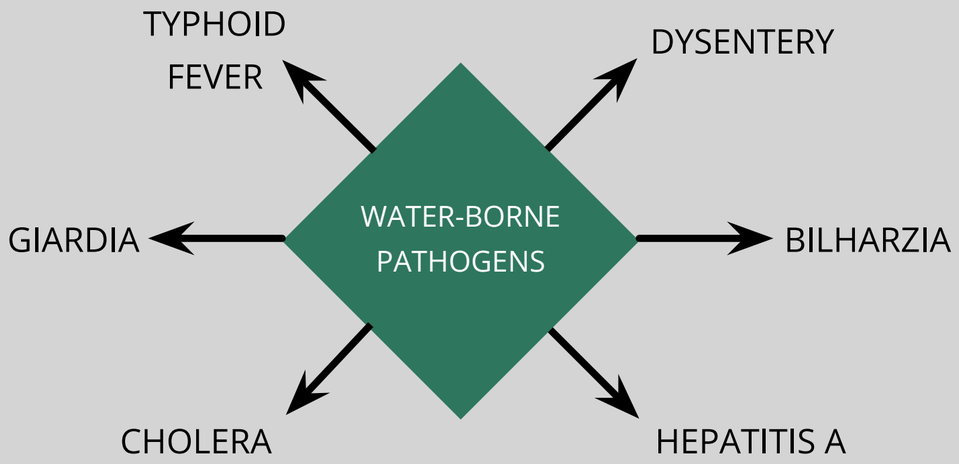


Easy preparation, easy storage

Sustainable, reusable, biodegradable

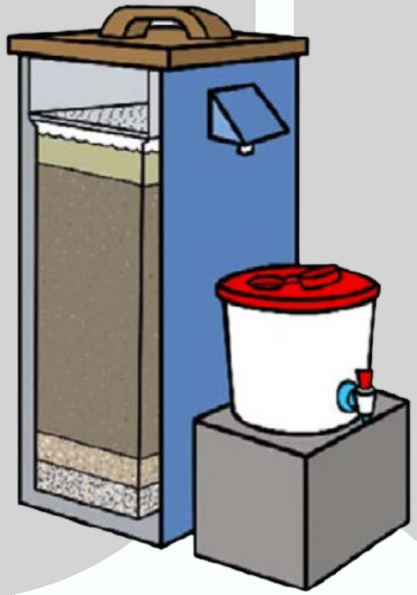
Low-cost and highly accessible

HEALTH - PATHOGEN CONTAMINATION

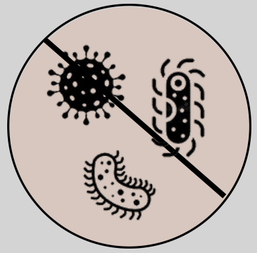


Diarrheal diseases are the 3rd leading cause of death

Reducing incidence also reduces spread

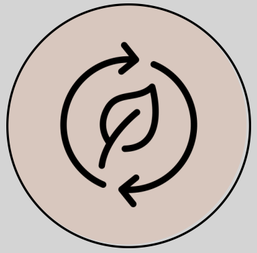


Slow Sand Filtration



Proven reduction of bacteria, protozoa, and viruses

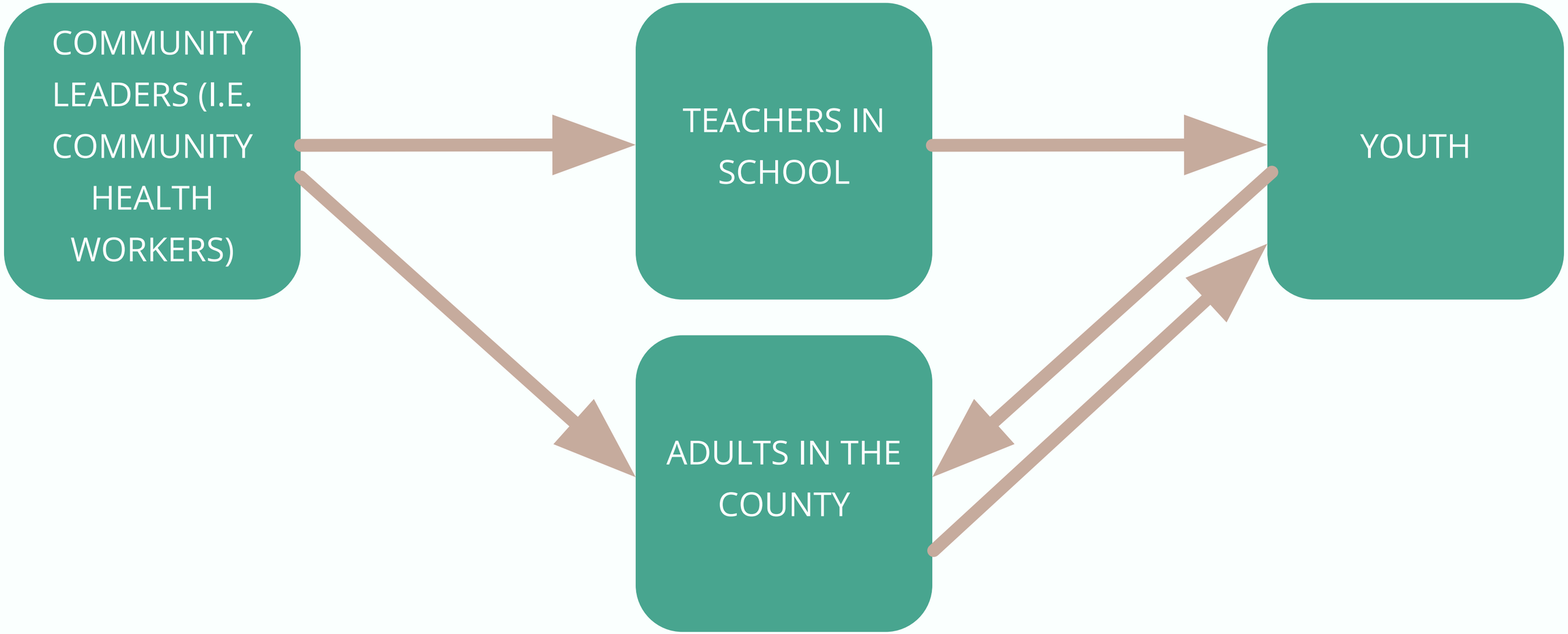
fast-acting, affordable, low-maintenance



Long-lasting, sustainable, environmentally friendly

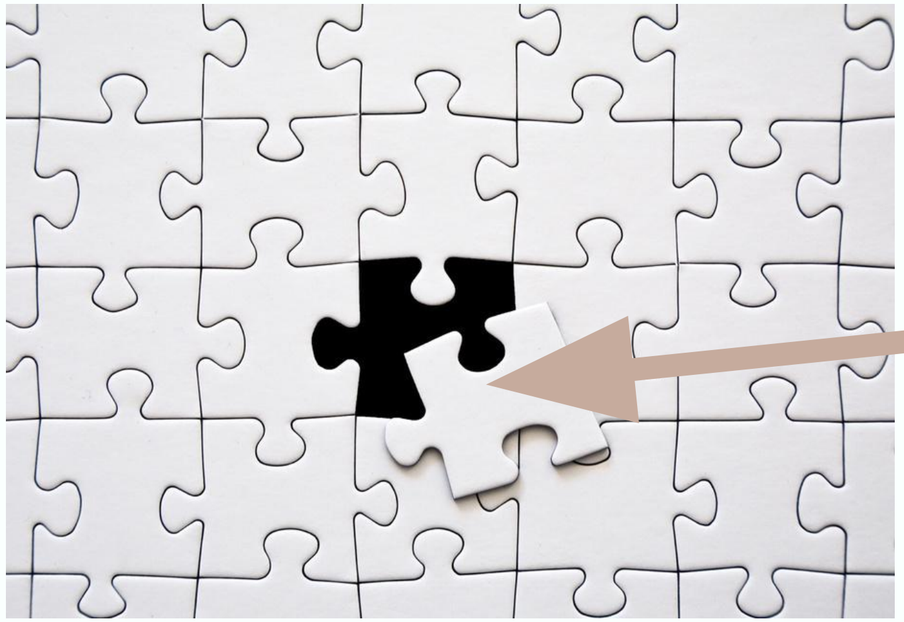
Size-variable, scalable, home adaptable

EDUCATION CHAIN



EDUCATION TOPICS

Adding onto topics that are already being taught



Implementation of Personal Hygiene
(Hand Washing, Open Defecation,
Menstrual Hygiene)
+
Water Treatment
+
Assessing Clean Water

DELIVERY

Comic

- Easily approachable to wide range of people + literacy is not required
- Template: Koko and Magic Glasses
  - Previously used to teach wash and open defecation in subsaharan Africa
  - Microscopic glass that lets kid observe pathogens
- Distributed Digitally and Physically

Practice makes perfect!

Long-term

Increased education and adaptable curriculum

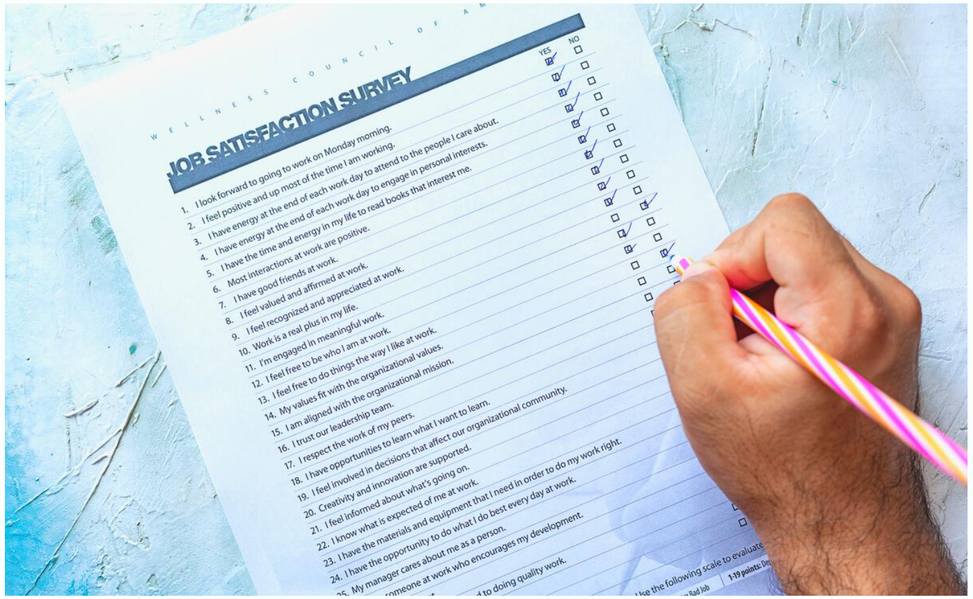
Community committees responsible for maintenance

Environmentally sustainable

Economically and socially favorable

Adaptable to increasing water demand

EVALUATION & EXPANSION



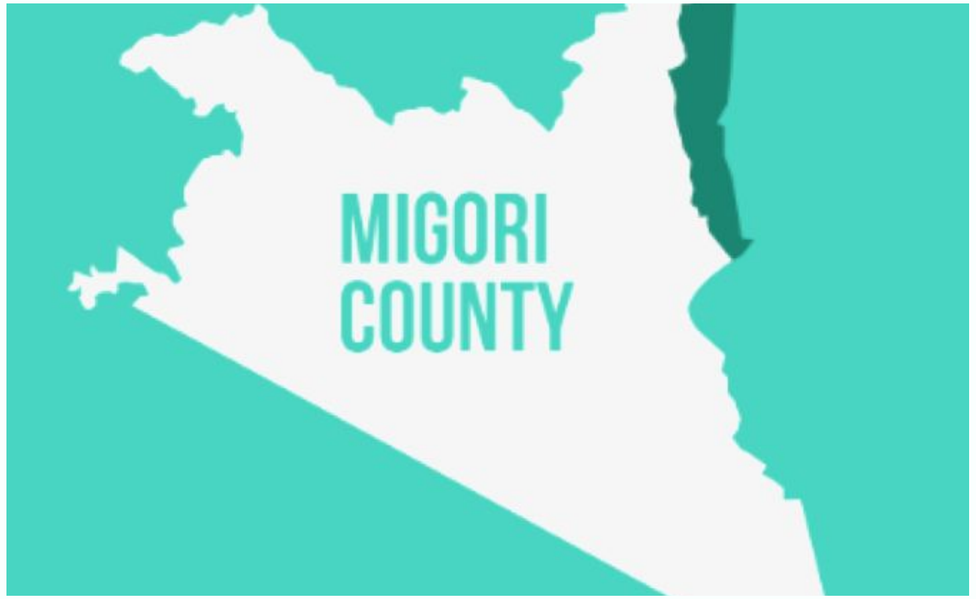
DATA COLLECTION

Survey (baseline, mid, endline)

Interviews

Observation

Water Quality Collection



NEXT STEPS

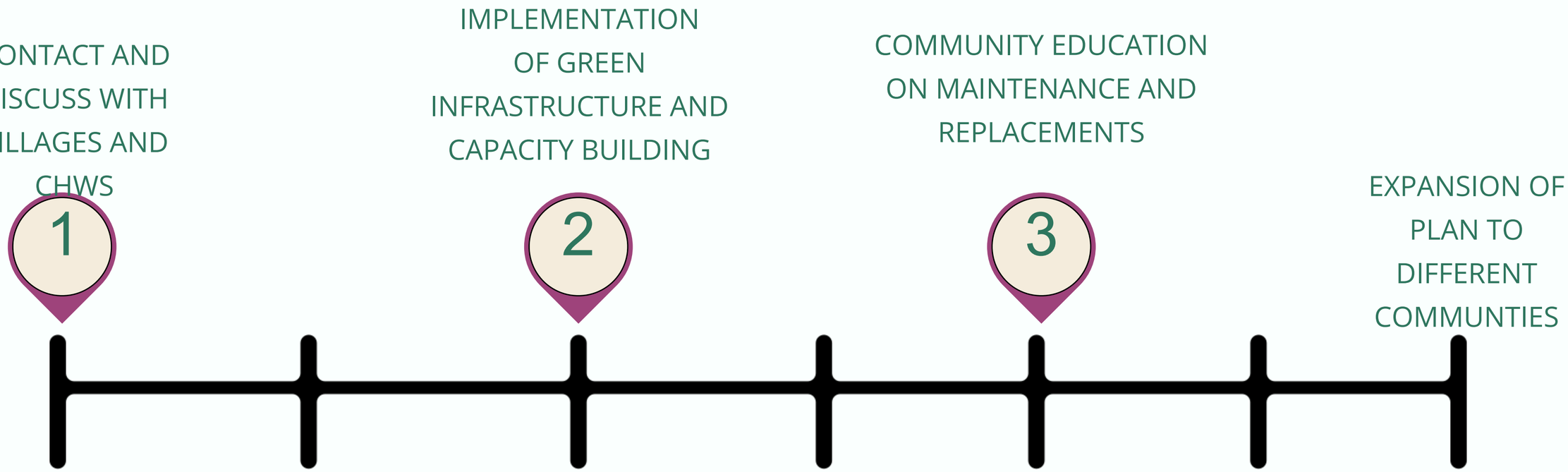
Discussion with community on improvements and feedback

Identify new villages and areas

TIMELINE: 3 YEAR IMPLEMENTATION

8 Pilot Locations

CENTRALIZATION → **INFRASTRUCTURE** → **EDUCATION**



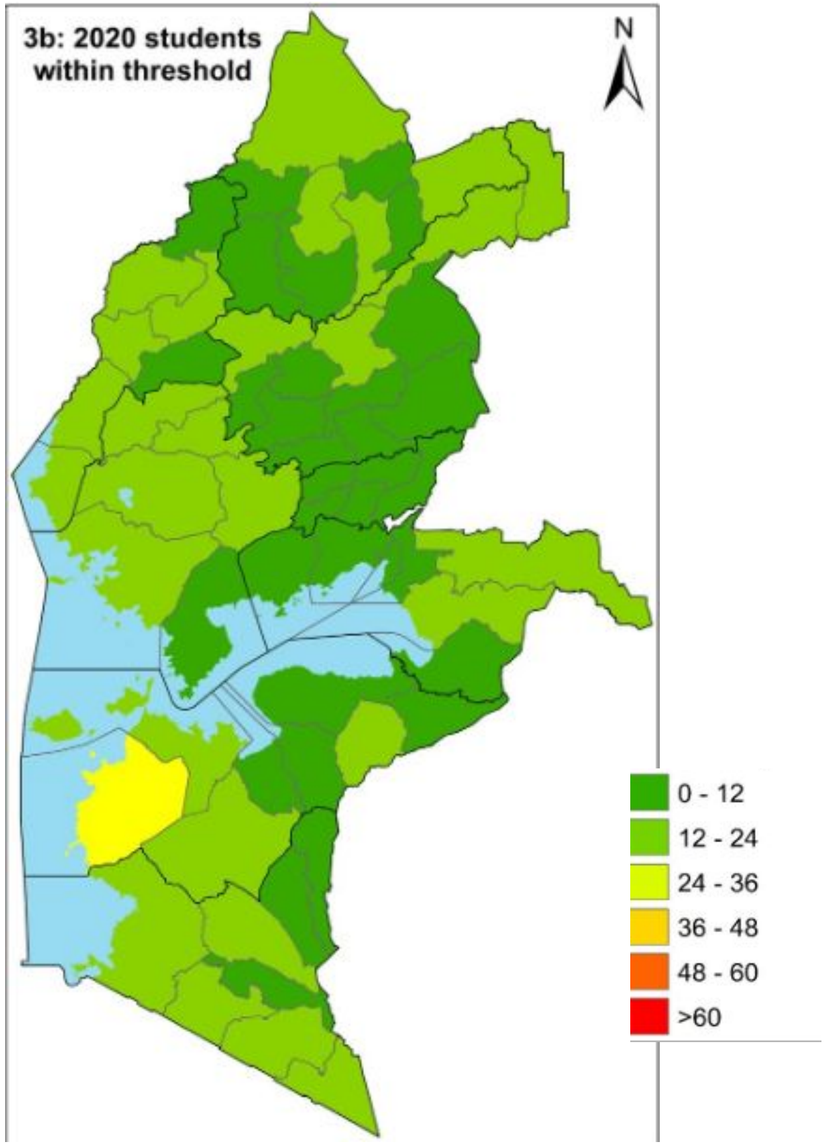
APPENDIX

Appendices:

Appendix A: School Walking Distance

A 2020 study by Macharia et al. set out to map geographic access to public primary schools in Kenya. They accomplished this task by first creating a database of all known public primary schools by geographic location. Taking in to account factors such as roads, vegetation barriers, elevation, and major barriers such as game reserves and rivers, they were able to utilize an algorithm to estimate travel times to the nearest schools by walking distance along paths of least resistance. The data did not take into account private or special education school as well as boarding schools.

Results show that by 2020 a large majority of primary school going children live within the recommended threshold of 24mins (2km) away from a public school.



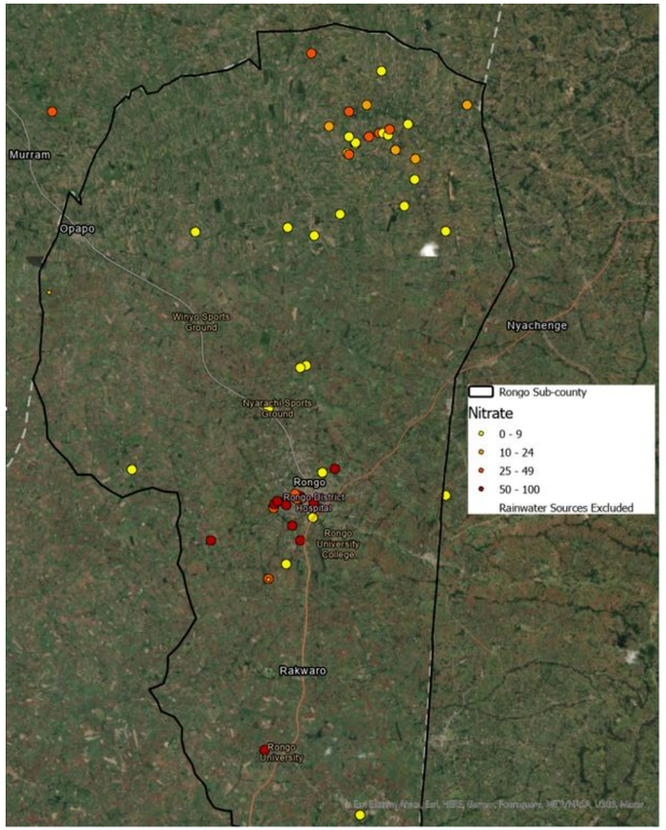
Appendix B: Nitrate Contamination

Nitrate is a groundwater and surface-water pollutant. Sources of contamination include irrigation systems that carry water from farms, livestock manure, and septic systems. [12]

In Migori county, there are a numerous amount of agricultural sites with extensive inorganic fertilizer use and animal manure, leading to runoff that contains nitrate. Furthermore, open defecation can add on to nitrate contamination, and it is therefore important to continue combatting this problem.

Nitrate contamination in water occurs at greater levels in urban areas, which is observable in the water resource map of the Rongo subcounty.

Nitrate levels greater than that of 10 ppm, or 10 mg/L, are considered to be dangerous and can result in health complications. [12]



Dalforno, R., Akinyi, E., Odira, R. (2022). Drinking Water Source Quality Pilot Assessment in Rongo Sub-County, Kenya. Lwala Community Alliance, Rongo, Kenya

Appendix C: Nitrate Removal

There are currently various methods that remove nitrate from water, but are considerably much more expensive and not sustainable. These methods include:

- Reverse Osmosis
- Distillation
- Ion Exchange

[11]

These methods have many drawbacks due to their large size, expensive setup, and slow rate of nitrate removal.

The implementation of these nitrate removal systems would be inefficient as many rural areas lack the proper resources and infrastructure.

Other treatments include adsorbents, which are substances that collects solute molecules from a liquid or gas. There are various classes of adsorbents, which include:

- metal oxides/hydroxides
- organic polymers
- carbon-based materials
- agricultural wastes

[5]

Agricultural waste products such as rice chaff are a low-cost, sustainable, and environmentally friendly alternative.

In addition, they can be collected in great amounts due to their natural abundance. In addition to rice chaff, elephant grass may be another low-cost alternative for nitrate removal, as elephant grass is a perennial weed found in Africa. [1]

Appendix D: Nitrate Removal cont.

Rice chaff is able to adsorb nitrate molecules, as well as other chemicals due to its innate chemical and physical properties.

Rice chaff has low combustion value and low potential to harm the environment, making it the ideal candidate for large-scale use.

In order to maximize denitrification, it is important to activate the rice chaff, or other biomass. Activation, via thermal decomposition, creates a porous carbon. [5]

Furthermore, if technology and infrastructure allows, biochar can be produced out of rice husk or other natural substances such as elephant grass. Preliminary data has shown that biochar is able to remove significant amounts of nitrate from drinking water. [1]

Factors influencing the adsorption of nitrate:

pH of solution

- preliminary data indicates that adsorption rate decreases at acidic and basic pH, which is ideal as the pH for drinking water should be 6.5 - 8.5.

Adsorbent dosage

- simply put, the greater the amount of adsorbent used in solution, the greater amount of nitrate will be adsorbed

Contact time and nitrate concentration

- Adsorption of nitrate is rapid in the initial stages and slows down as equilibrium is reached
- Increase in initial concentration of nitrate also presents an increase in adsorption

[5]

Appendix E: Rice Agriculture in Migori County

In recent years, Migori rice farmers have been urged to use a new rice strain named CSR36, which has properties that are favorable by Kenyans: This strain is long, slender, non-sticky and separates upon cooking. [6]

The Migori County Chief Officer for Agriculture, Linus Origa, stated that this new rice variety that was developed by the International Rice Research Institute (IRRL) and Kenya Agricultural and Livestock Research Organization (KARLO) will improve the yield of rice. [6]

The popularity of farming rice in Migori has increased dramatically, as it lucrative economically, and many fisherfolk have begun farming instead. [20]

Rice is becoming a staple crop in Kenya, and is sponsored and funded by the government in the hopes of obtaining food security by 2030. [6]

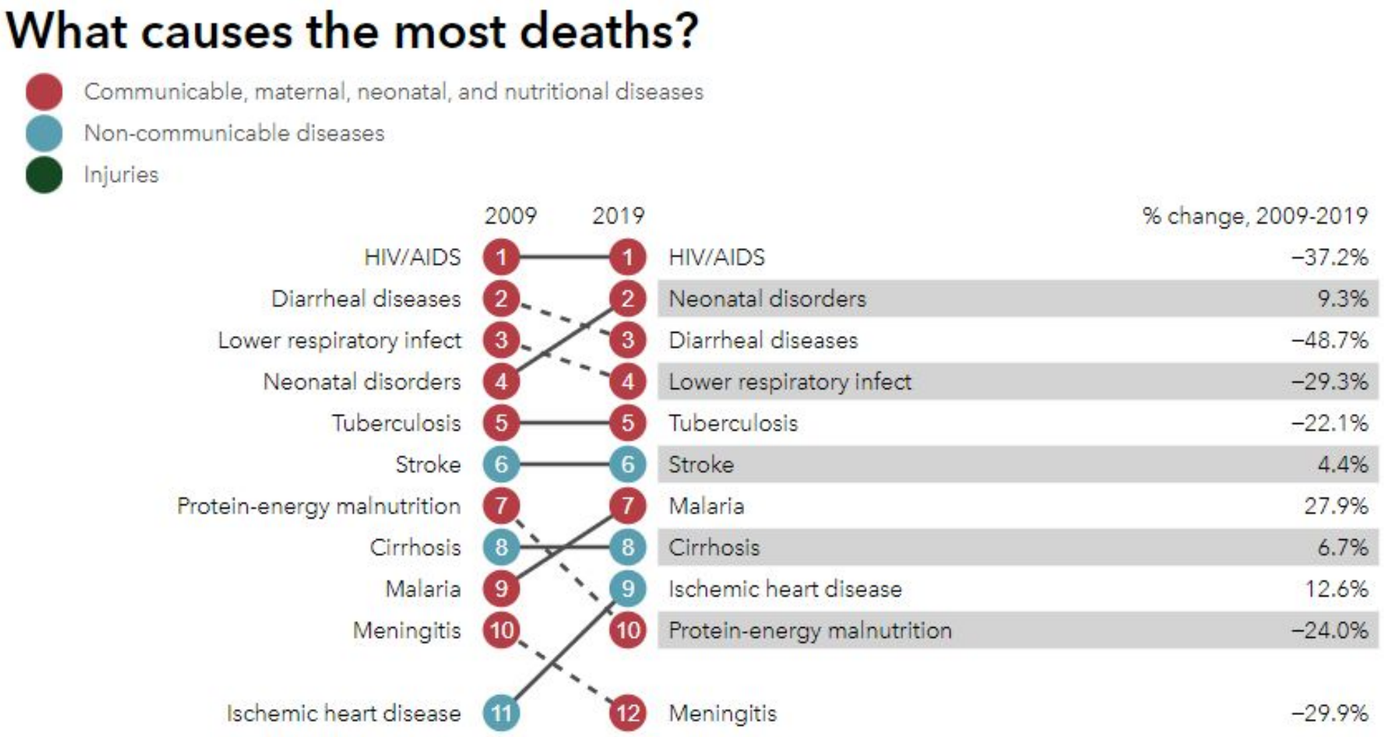
In other studies where rice husk was used as an adsorbent, they describe the quantity of rice harvesting in Kazakhstan.

In 2017, Kazakhstan produced 291,000 metric tons of rice, where 20% of that mass was rice husk. [9]

Some concerns with the distribution of rice husk is cost, but the price of rice husk doesn't go over $71 per metric ton, and the researchers found that most farmers gave away their rice husk for free as it decreased the price of their waste disposal. [9]

Rice farmer in Migori County [9]

Appendix F: Pathogen Contamination



Top 10 causes of total number of deaths in 2019 and percent change 2009-2019, all ages combined

See related publication: https://doi.org/10.1016/S0140-6736(20)30925-9

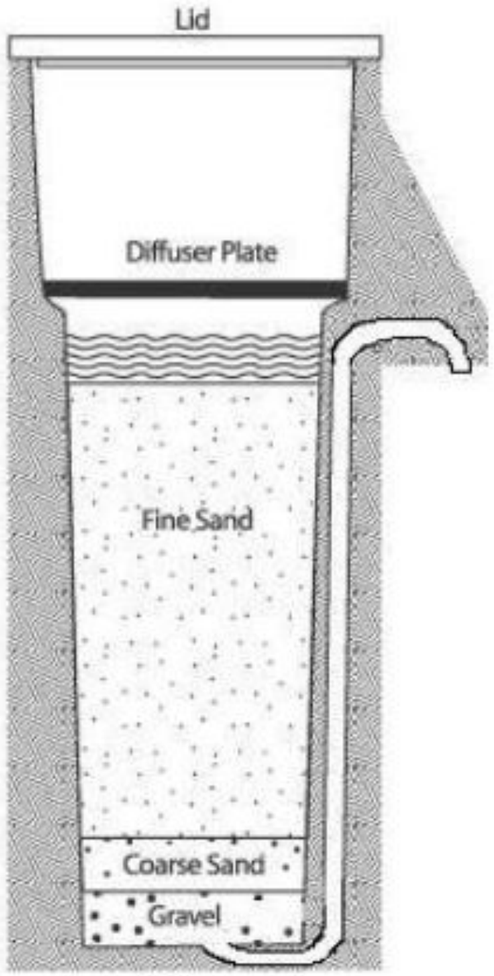
Among leading causes of death in Migori county the following are or can be caused by water-borne pathogens

- Diarrheal diseases
- Cirrhosis

Though trends are pointing downward for these causes, it is still important to limit its spread within the community by targeting its source [23]

Since much of water contamination is caused by poor water care (such as open defecation), the benefits of targeting diarrheal diseases will be compounding

Appendix G: Slow Sand Filtration



Slow sand filter schematic
CAWST

Here is a general schematic of a slow sand filtration unit. [19]

While the core filtration layers are usually standardized, the top layer can be variable to fit the local resources that can be found.

- Diffuser plate
- Organic bio-layer (moss, plants, etc.)
- Cloth from old clothes

Given the landscape of Migori county, filter materials like sand and gravel should be available.

- Rice chaff can also be used as a filter medium

The filter also removes physical impurities from water along pathogens, including microorganisms, toxic metals, debris. This improves the turbidity of water.

The general functionality of the filter is as follows:

- Fill the filter by pouring the water through the top
- Close the lid to prevent contamination of the filter
- Prepare a collecting container where the water comes out
- Once the water is done filtering, the user can take the water back

The filter can be constructed to preference and functionality. For example, a feeding tube can be connected to the entrance of the filter from a water tank to have continuous filtering from a source, but then a continuous collecting strategy must be implemented

Appendix H: Examples of Implementation

Slow sand filter system in Haiti
Pure Water for the World

Picture of a slow sand filtration system being used in a local school in Haiti. We propose something similar to be implemented at our planned centralized locations. [19]

Appendix I: Comic Design

In order to educate people who are not literate, comic will be delivered with the in-person narrator (community leaders and teachers). Script, which will be created through collaboration with the community leaders, will still be on the comic for people who are able to read. There will be both digital and physical copies of the comic.

How and what to narrate on each scene of comic will be carefully determined through the collaboration with the community leaders, and those information will be passed down to the teachers in school by the community leaders.

Koko and Magic Glasses have effective graphics and easy storyline to inform the health risks of open defecation, lack of hand wash, and failure to drink clean water. The differences in our comic would be that we will focus less on the soil transmitted disease, but more on the bacterial pathogens and nitrate. Furthermore, not only describing the importance, we are planning to show how to implement proper hygiene. [15]

Appendix J: Education Topics

Topics that are comprehensively covered in Kenyan schools are source, storage, quality, conservation, and treatment of drinking water; waterborne diseases, such as Cholera; and environmental hygiene. Importance of WASH is also taught but implementation of WASH is not covered in specificity.

Due to the social stigmas associated with menstruation, teachers in school feel uncomfortable about this topic and end up not providing proper education on it. Using unsanitary absorbents could lead to toxic shock syndrome, RTI, and different vaginal diseases. Furthermore, disposing absorbent outside could be a source of HIV, and disposing in toilet could make it harder for households to maintain their latrine use. Therefore, education on risks associated with improper menstrual hygiene should be provided, and sustainable methods, like using reusable cloth as an absorbent, should be taught. [22]

Appendix K: Rainwater Tank Maintenance

We propose that the community be responsible for rainwater tank maintenance with specific emphasis on rainwater collection maintenance which can then be spread and applied to individual homes.

Common practices for cleaning rainwater tanks include cleaning and clearing gutters and filters regularly and cleaning the inside of the tank every 1-3 years. The inside of the tank can be disinfected with surface cleaning products such as soap, rinsed with hot water and then drained, ensuring that no residue of cleaning products is left over.

When rain first begins, it is common practice to divert the first flush of water outside of the tank as it often carried dirt, debris, and leaves from roofs and gutter pipes. This can be done manually with temporary physical barriers.

Appendix L: Sustainable Practices

Agroforestry

- Regreening Africa utilizes method of agroforestry, which is a technique of incorporating organized tree planting into agricultural practices
- This method helps reduce runoff as the presence of trees will help the soil absorb more water.
- Trees provide a source of shelter in face of rough weather for crops closer to the ground and thus leads to greater crop yield
- Presence of certain trees can help fix nitrogen in the soil and thus serve as

Using Earthworms for organic fertilizer

- A technique called vermicomposting that is scalable and already being used in some areas in Kenya.
- Using earthworms to consume organic waste and produce organic fertilizer
- Before giving it to the earthworms, farmers combine soil and the organic material.
- The process is fast and prevents the loss of nutrients in the soil.
- Will help provide higher crop yields.

Rice chaff as organic fertilizer

- One the rice chaff is used to purify the water and absorb the nitrate from the groundwater, members of Migori county can reuse the rice chaff as a means of fertilizer
- Provides a method of utilizing natural resources efficiently
- Increases crop yield and soil's absorptivity
- Improves overall soil quality

Appendix M: Community-Driven Water Assessment

Our goal is to work with the universities in Migori County, which include Rongo University and MOI Institute of Technology, as well as other community members interested in the care of their water sources. This method of citizen science presents a large scale, low-cost method of collecting data that would previously be much more time consuming.

It is important to train citizen scientists and students through learning programs to ensure that the data collected is correct. The involvement of the general public contributes to raising awareness around important WaSH topics and promotes the need for clean drinking water in their communities.

The Secchi disk is a standardized method of measuring turbidity in bodies of water, mainly estuaries and lakes. It is a low-cost and simple alternative to gathering optical data on bodies of water that will provide information indicative of biological activity, sediment load, and pollution. [16]

Researchers have developed a miniature version of this Secchi disk with an Forel-Ule (FU) color scale via 3D printing. The FU color scale is important in quantifying the color of water. When in use with the smartphone application "TurbAqua", citizen scientists are able to collect data continuously from August 2019 to March 2020. [16]

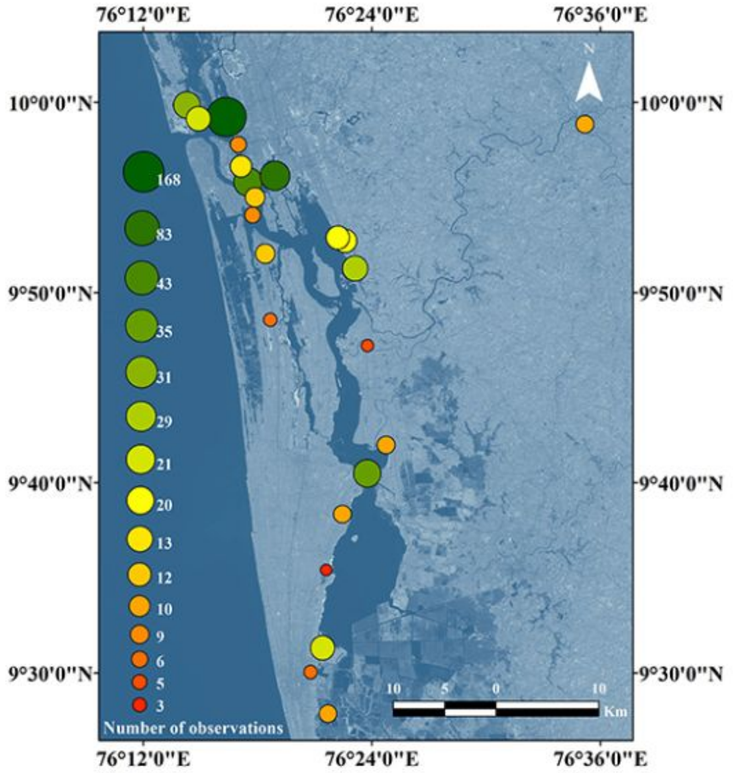
Because the Secchi disk is primarily made via 3D printing and basic workshop tools, virtually anyone is able to build them and use them.

Appendix N: Water Assessment cont.

Training programs were designed for students at universities who were focused in biology, environmental sciences, and fisheries, as they were thought to have the most interest in water quality assessment.

This case study was taken place in India, where they tested water quality in Vembanad Lake, was a success in how data was continuously collected for a period of 17 months. Furthermore, 643 data points out of the 735 readings collected had all the of the requisites required for data collection.

It is important to establish citizen-scientist networks in order to foster a collaborative community that promotes the wellbeing of their environment and stress the importance of water quality. [16]



Number of observations made by citizen scientists from each point of the lake [16]

Appendix O: SWOT Analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Community-centered • Contamination remediation is low-cost and long-term • Implements preventative measures	• Quantitative monitoring is needed for several years (to ensure success) • reliance on community support	• Increases knowledge exchange across communities • More comprehensive understanding of rice chaffs	• Rice chaff monopolization • Lack of motivation to filter water • Lack of community interest in education topics

Appendix P: SMART

SPECIFIC

Remediate and prevent nitrate and bacterial contamination in groundwater sources

MEASURABLE

Quantitative and qualitative data collection from beginning to end of implementation

ATTAINABLE

Data-based solutions that rely on locally-sourced materials with minimal training required

RELEVANT

Solutions that are community-focused, community-led, and community-driven

TIME BOUND

3-year timeline for implementation of the project with evaluation and monitoring

Appendix Q: Budget

	Total Cost per Unit (USD)	Cost Per Village (USD)	Total cost for 8 Pilot Villages (USD)
Rainwater Tank (Kentanks)	305.36	305.36	2442.88
Slow Sand Filter	15	150	1200
Rice Chaff	0	0	0
Educational Costs:			
Creating our original comic	1000	1000	1000
Physical copies for delivery	300	300	2400
Total Cost			7042.88

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