Title:

Groundwater Health Index (GHI): A Data Driven Approach to Climate-Resilient Water Management

Motivation:

I am [redacted] a Master's student focusing on Machine Learning for development at UC Berkeley who is finishing [redacted] I have a strong academic and professional background in machine learning, software engineering and data science and I am passionate about using machine learning to address pressing climate change related environmental challenges. Groundwater quality is one of the areas that is heavily affected by climate change and this problem has to be urgently addressed considering how much groundwater is important to the ecosystem. I am motivated by the potential of data-driven approaches to help solve this problem and pursuing a PhD will allow me to deepen my expertise and contribute meaningfully to this field.

Research Problem:

Quality groundwater is a vital natural resource in [redacted] which supports different ecosystems. However, climate change and anthropogenic activities threaten groundwater quality leading to risks such as contamination, droughts, and general ecosystem degradation. This problem makes monitoring groundwater quality essential. Unfortunately, many current monitoring systems are reactive and lack the predictive capabilities needed for proactive ground water quality management. To address these challenges, there's a need for innovative and data-driven solutions that can model and predict groundwater quality to inform stakeholders on proactive actions that could be taken to manage groundwater quality.

Research Objectives:

My research aims to build on the work being done by ESR in developing a Groundwater Health Index (GHI), a novel framework that leverages machine learning (ML), metagenomics, and real-time sensor technologies to:

1. Monitor groundwater quality in near-real-time.
2. Predict contamination events and ecosystem responses to stressors.
3. Provide actionable insights for policymakers, industries, and communities.

Key research questions include:

1. How can machine learning models improve the prediction of groundwater quality trends?
2. What are the key microbial and chemical indicators of groundwater health?
3. How can real-time sensor technologies be optimized for widespread deployment?

Methodology:
This research will employ a **three-phase methodology** to achieve its objectives:

1. **Data Collection and Preprocessing**:
    - Collect groundwater samples from diverse sites across [redacted] analyzing chemical, microbial, and environmental data.
    - Use **metagenomics** to characterize microbial communities and identify biomarkers of contamination and ecosystem health.
    - Integrate historical climate, land-use, and hydrological data to build a comprehensive dataset.
2. **Machine Learning and Predictive Modelling**:
    - Develop **machine learning models** (e.g., Random Forest, LSTM networks or more advanced ones like Deep Neural Networks and State Space Models) to predict groundwater quality trends and identify tipping points.
    - Use **cheminformatics** to model chemical degradation pathways and metabolic reactions in groundwater ecosystems.
    - Employ **Generative Adversarial Networks (GANs)** and **Active Learning** to optimize model performance and reduce uncertainties.

The innovative aspect of this research lies in its integration of advanced technologies with practical, stakeholder-driven applications, offering a scalable solution for groundwater management.

Alignment with the University of Auckland:

I am particularly drawn to the University of Auckland, because of its strong reputation as a top research university in [redacted] I am drawn to the work of Dr [redacted] who runs the machine learning lab in the computer science department dealing with diverse machine learning problems which align perfectly with my research goals. I am excited about the opportunity to collaborate with ESR which closely works with [redacted] lab.

Expected Contributions:

This research will deliver:

- A real-time groundwater monitoring platform with predictive capabilities.
- Early warning systems for contamination and ecosystem stress.
- Policy recommendations for sustainable groundwater management.
- Community empowerment through accessible data and decision-making tools.

By addressing critical gaps in groundwater monitoring, this research will contribute to the fields of environmental science, data science, and water resource management and provide practical solutions for [redacted] and beyond.

Conclusion:

I am looking forward to pursuing this research at the University of Auckland, where I can leverage the institution’s expertise,resources and ecosystem to achieve my academic and professional goals. I am committed to making a sustantial contribution to the field of groundwater health and excited about the

opportunity to work alongside leading researchers and stakeholders in [redacted] I believe this PhD program will provide an ideal environment for me to develop innovative solutions to one of the most pressing challenges of our time.