APPENDIX

Examples of Problem Solving that Graduates Will Be Able to Do

Lack of Hydrogeological Information Sharing

Issue: In many African countries there is very little information available on the hydrogeology of the area, or even on boreholes that have been drilled previously. Almost exclusively, NGOs, individuals, communities or industry hire a driller to drill a borehole. Sometimes a hydrogeological study is conducted beforehand (as in Kenya) but often it is left up to the driller to decide when to stop drilling. In many cases contracts are set up based on the number of metres to be drilled, established arbitrarily and since the driller is paid by the metre, the main aquifer may be overdrilled resulting in reduced flow to the well.

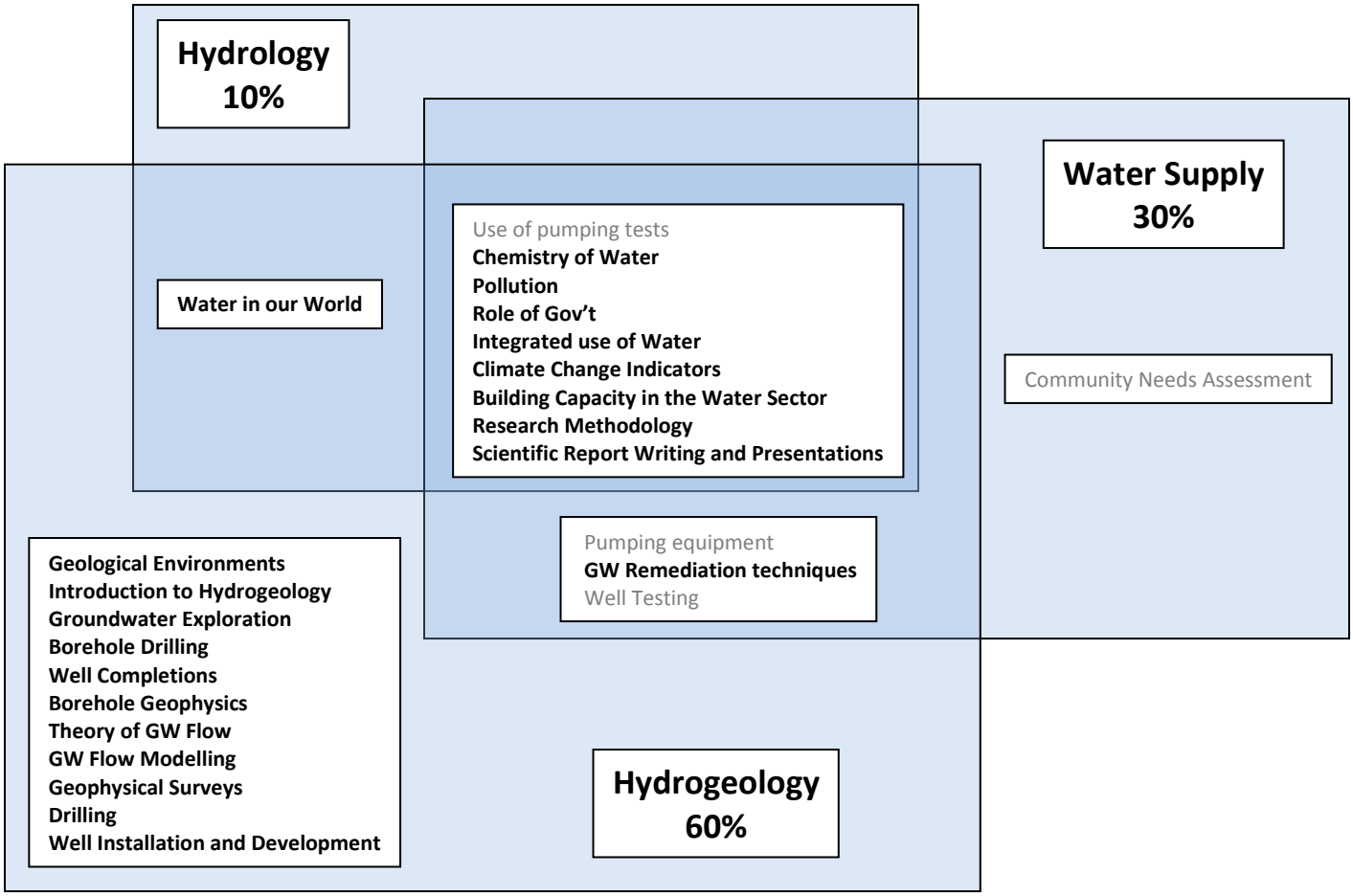
In cases where there is a well that has a good production rate, for example adjacent to a river in the gravel. In order to increase the amount of water, more wells are drilled in close proximity to the first well. This new well often attracts more people to the area, the wells are pumped more to fulfill the increased demand, which causes the water table to decline, reducing the total amount of water that is available. In extreme cases the water level in the river may be impacted, reducing flows and harming aquatic life in the river as well as reducing flows downstream.

In Kenya, there is no central database of information. The information that is collected consists only of location and depth, and that data is incomplete at best due to torn paper copies of maps and no cross-referencing of data (ie date drilled, location and reference number). When a map is damaged or lost, the information contained is also lost. When a change in government structure is conducted, many permanent records have been misplaced or lost.

In the unusual case where a full hydrogeological study is commissioned by an agricultural or mining corporation, a foreign-trained hydrogeologist is contracted to conduct it. The resulting report and information typically stays with the company and is not shared openly.

Solution: Graduates from the MSc program learn how to supervise drilling programs, including the collection of hydrogeological data during the drilling by taking soil samples, measuring flow rates, conducting borehole geophysics, surveying the locations of the well, and recording critical well construction details that will aid in maintenance and repair of the well.

Graduates also learn the benefits of working with government departments to establish a central depository for this valuable information. This database needs to be built such that the information is stored and accessible to others doing subsequent drilling programs. It could easily be built using a GIS system and coupled with computer modelling tools. As part of the MSc programme students learn how government has a vital role to play in regulating the use of water resources in order to sustain the supply into the future.

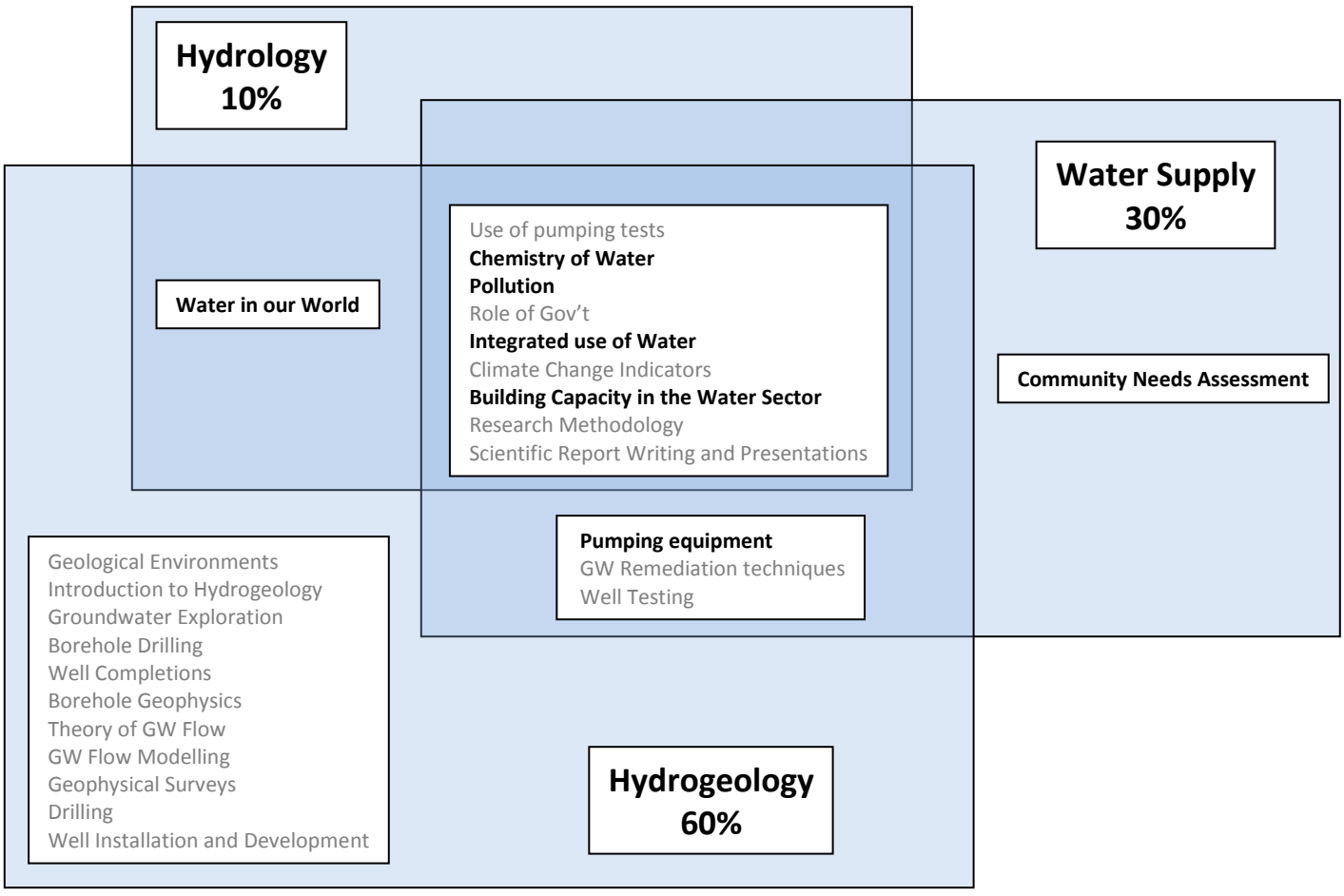

Hydrology
10%
Water Supply
30%
Use of pumping tests
Chemistry of Water
Pollution
Role of Gov't
Integrated use of Water
Climate Change Indicators
Building Capacity in the Water Sector
Research Methodology
Scientific Report Writing and Presentations
Water in our World
Community Needs Assessment
Pumping equipment
GW Remediation techniques
Well Testing
Geological Environments
Introduction to Hydrogeology
Groundwater Exploration
Borehole Drilling
Well Completions
Borehole Geophysics
Theory of GW Flow
GW Flow Modelling
Geophysical Surveys
Drilling
Well Installation and Development
Hydrogeology
60%

Disused Infrastructure

Issue: Infrastructure installed in Kenya in the 1950s by the British were once good facilities but now lie disused and abandoned due to lack of knowledge regarding maintenance and repair. In the village of Tot, two cisterns had been designed and installed to collect groundwater from a spring but no one knew how it was constructed below ground. The cisterns were full yet no water was flowing into/out of them. Water from the spring was bypassing the cisterns, creating a wetland with vegetation growing – an ideal environment for mosquito breeding, leading to malaria health concerns.

Upon excavating the accumulated silt from around the spring area and the cisterns it was possible to understand the collection and storage design. The cisterns were drained, cleaned out and sanitized. The outflow of the lower cistern was connected to a series of pipes that gravity-fed the water to a tap about 500 m away so that people in a village could access it.

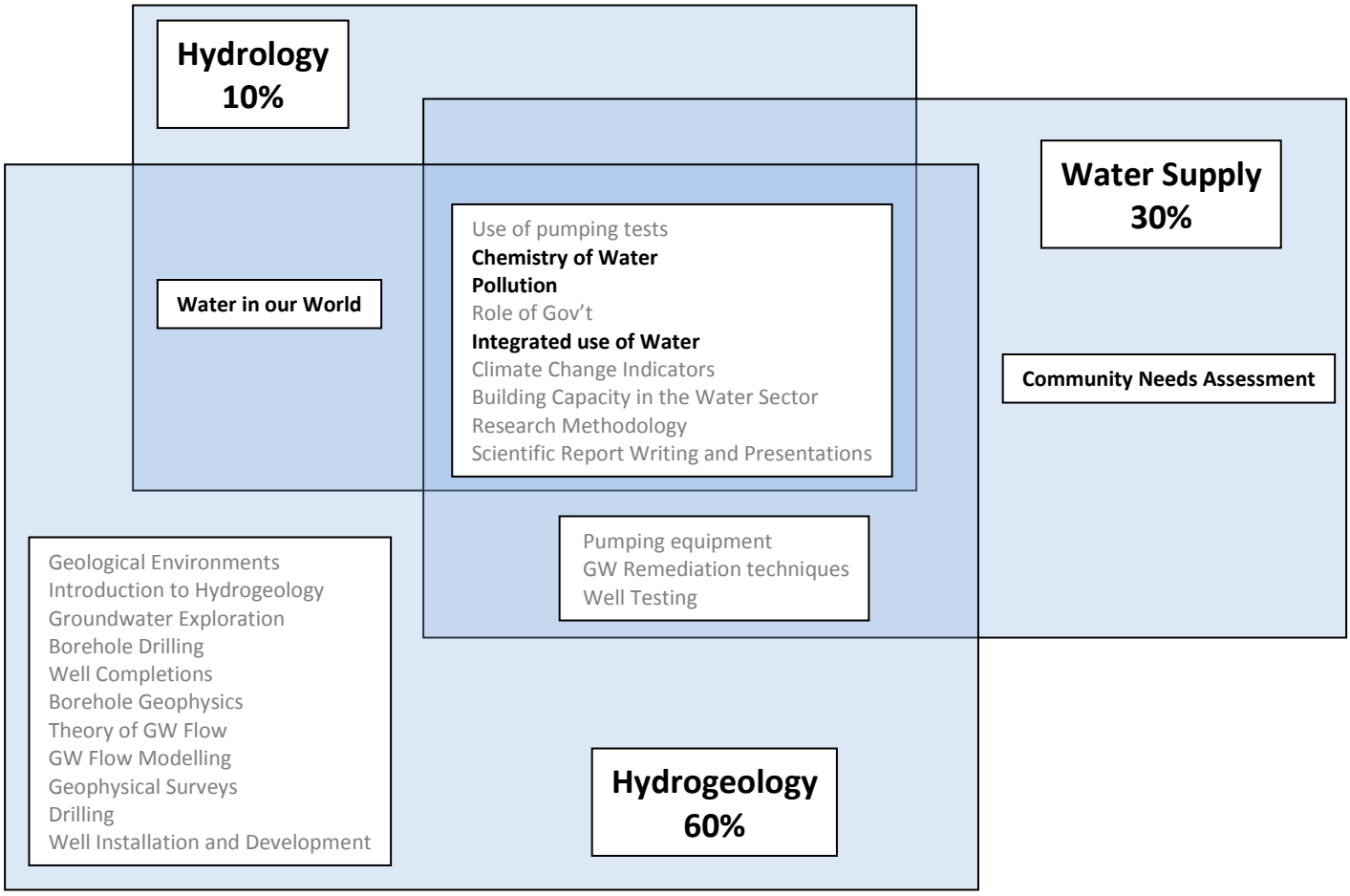
Solutions: Graduates from the MSc program learn about typical designs for groundwater spring protection and construction; they learn the health concerns related to standing water and contamination of surface water by people/animal defecation, and the need to keep groundwater isolated from the ground surface to retain its purity from bacterial pathogens; they learn how to design gravity-fed distribution systems.



Ending Open Defecation

Issue: In many poor countries open defecation is still practised due to insufficient latrines and knowledge of the hazards that this presents to human health. In Kenya, human feces were observed in contact with water that was used for drinking water downstream. In many cases in rural settings, people bath and wash clothes and dishes in the rivers creating quality degradation due to phosphates in the surface water.

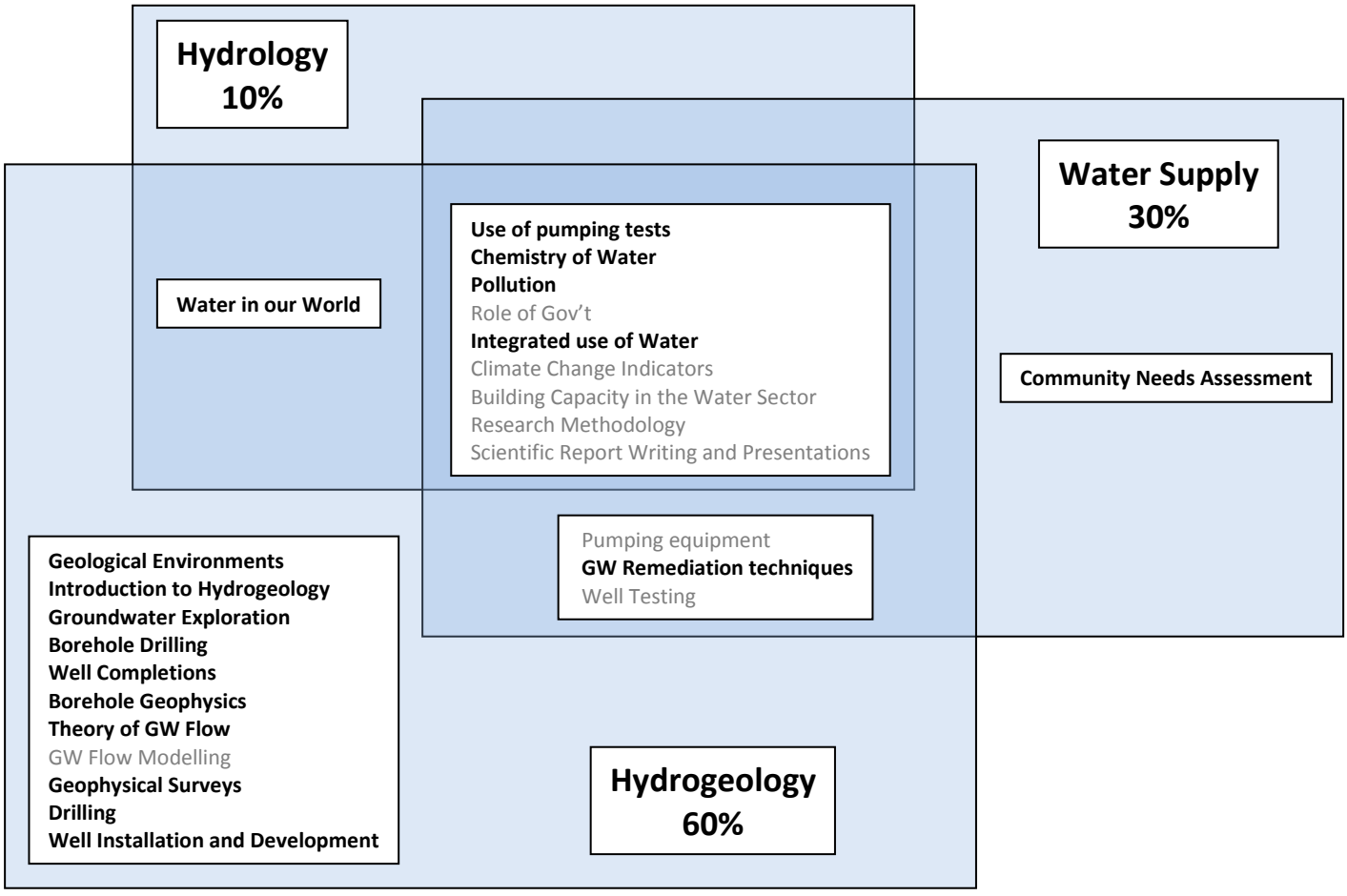
Solutions: Graduates of the MSc program learn the health aspects related to containment of human waste and behaviour modification that can improve the health of ecosystems on which they rely on for their own personal health.



Use of Filthy Sources of Water

Issue: In the dry season, people sometimes drink water from muddy puddles of water on the ground that is shared by goats and cows. Evidence of animal feces is present. Often the water is consumed without boiling it first, as this requires an added effort to collect wood to burn.

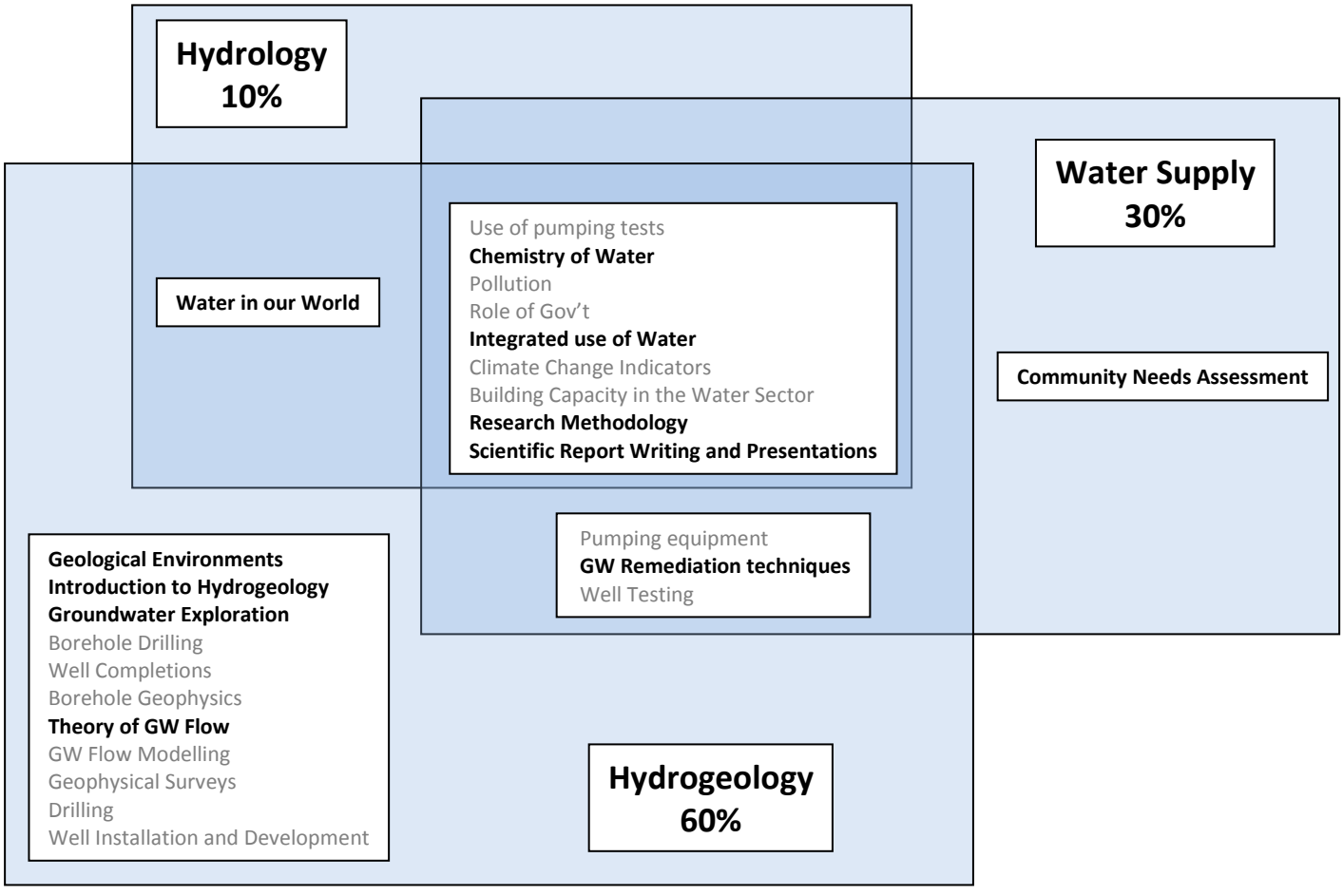
Solutions: Graduates learn how to obtain clean drinking water from groundwater resources and how to protect those sources against contamination; they learn how to take contaminated water and make it safe to drink by using different purification techniques such as filtration, reverse osmosis, solar radiation, chlorination, and others; they learn how to build biosand filter systems sufficient to support a household or community water supply; they learn what the health risks are due to consumption of bacterial-contaminated water; they learn how to keep water supplies separated, for different uses as appropriate.



Fluoride Concentrations in Drinking Water

Issue: Health impacts of dental and skeletal fluorosis are present in many areas of sub-Saharan Africa due to consumption of groundwater that is naturally high in fluoride. Natural concentrations of fluoride are often many times the safe drinking limit of 1.5 mg/L established by the World Health Organization (WHO), yet in some countries, the national drinking water guideline is much higher than the WHO because of economic barriers needed to reduce the fluoride concentration to an acceptable level. For example, in Tanzania the guideline is set at 8 mg/L, because it is better to lower all potable water to this concentration rather than lower a limited amount of water to the lower, WHO guideline.

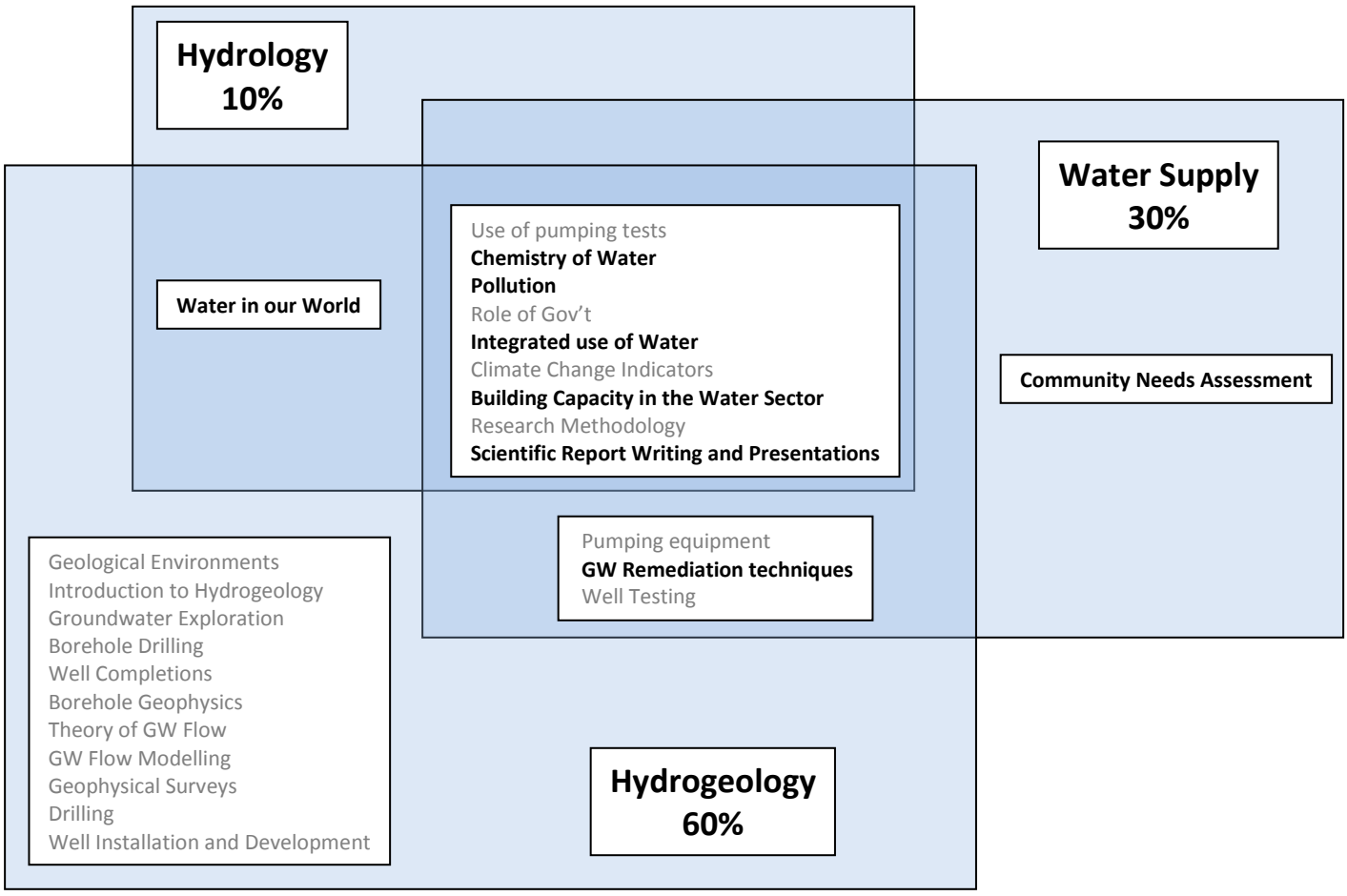
Solutions: Graduates from the MSc program learn how to delineate areas of high fluoride waters as well as low concentration aquifers. By learning the intricate behaviour of water in the subsurface, detailed studies can optimize utilization of some aquifers while others can be used for non-potable purposes. Coupled with sources of fresh, low fluoride waters, such as rainwater or treated water, satisfactory supplies may be produced as a result of mixing waters of different sources. There are new techniques currently being developed for treating high fluoride concentrations on a large scale. Using the technical abilities of professionals in this field has the potential of dramatically improving the lives of many people on the African continent.



Consumption of Unsafe Water Supplies

Issue: Even when children have dissentry/diarrhea, cholera, typhoid fever there is a lack of connection between the illness and drinking unsafe water. Doctors stress the need for boiling the water, but locals feel drinking boiled water makes them less resilient to poor quality water, so when the sick person recovers, they resort to drinking unsafe water again. This leads to reoccurrence of sickness.

Solutions: Graduates of the MSc program learn the health aspects related to containment of human waste, and other sources of pollution. They learn ways to communicate this information to an uneducated audience, transforming difficult, technical information into an understanding message of how behaviours can improve the lives of those who are vulnerable to disease. These actions will increase the health of the population overall.

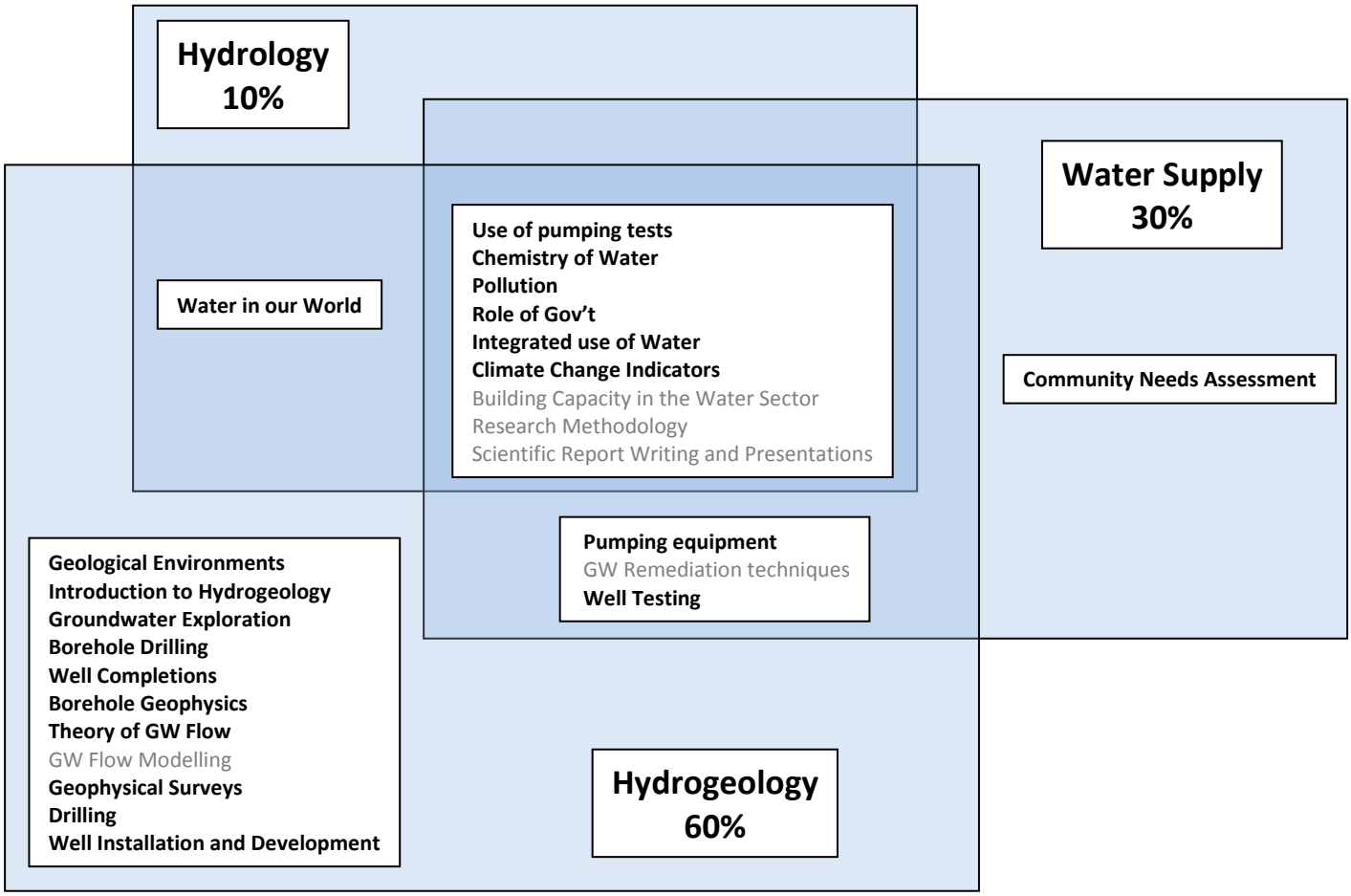


Distances to Obtain Water

Issue: People, mostly women and children, in rural areas having to walk great distances to collect water, often 3 to 5 km each way. Many times there are boreholes that have been installed nearby by NGOs or the Ministry of Water, but either the borehole isn't functioning or the local people don't have permission to use it.

Solutions: Graduates from the MSc program learn to drill boreholes properly, optimizing the aquifer resources by properly designing and construction of the well; they learn which pumps are readily available in the area, and for which ones parts are easily obtained; they learn about well maintenance and repair; they learn how to direct drillers so that the desired outcome is achieved – this leads to wells functioning for longer than 1 year, and are more likely to last for 20+ years.

Graduates are taught how to communicate technical aspects of the local water supply to laypeople who sit on the local Water Committee thereby encouraging people to take an interest in protecting and maintaining their well. The local hydrogeologist will be able to act as a mediator between the Ministry of Water, or other 'owner' of the well to ensure the local people have access to a borehole close by their homes.



Responses to Drought and Climate Change

Issue: As climate change continues to make dry areas dryer and wet areas wetter, how water is managed will be critical to the health of many people. Currently there is a need for rainwater harvesting to optimize the supply of fresh water when it is needed by way of storing water. There are situations that do not make the best use of storage tanks, such as in Tot, Kenya where a borehole was drilled and groundwater was initially pumped into a storage tank for use by a nearby hospital. However, due to the borehole not being drilled deep enough, there was an insufficient supply of groundwater to meet the needs at the hospital. To alleviate this situation, it was decided that surface water (contaminated with fecal bacteria) should also be pumped into the storage tank. In doing so, the entire water supply was contaminated and all the water needed to be sterilized prior to use in the hospital.

Solutions: A graduate from the MSc program would know that mixing these two water supplies would create a larger problem for the hospital, either because all water would need to be boiled, or alternatively, the untreated, contaminated water would be used in the hospital at great risk to the patients. By learning alternative solutions to this situation, such as providing a separate storage tank for each source of water, would allow the contaminated surface water to be used for non-sterile uses such as washing floors and flushing toilets, and saving the higher quality groundwater for sterile purposes. In doing so the effort needed to boil all the water is reduced, as is the time, and energy needed to collect and burn firewood to boil the water.