Tool for Environmental Assessment and Risk Screening for Rural Water Supply

A working tool for field teams planning rural water supplies dependant on shallow groundwater (up to 20m deep).

J Haywood, F Greaves, Tearfund 2015
Adapted from *"Environmental assessment and risk screening for rural water supply"*, Eva Ludi and Roger Calow (ODI), July 2015

Water Resource Availability

Achieving long-term increases in rural water supply coverage depends on many factors, including sound financing, strong community engagement, and effective capacity building in system upkeep and repair. For a scheme to be sustainable, planning also needs to consider the resources that are available – whether there is enough water, of suitable quality, to meet demand across seasons and between good and bad years. Water supplies that depend on shallow groundwater are generally more vulnerable to changes in rainfall (and therefore groundwater recharge) and demand than those exploiting deeper groundwater storage. Risks to water systems posed by flooding, land degradation and other environmental hazards also need to be considered and mitigated where possible, especially as climate change accelerates. For existing schemes, understanding patterns of seasonal recharge and demand, as well as the likely impact of environmental hazards, can help implementers develop more sustainable management approaches.

Why Develop A Tool?

In many projects, funds and expertise are not always available to conduct detailed hydrogeological surveys for new systems that are dependent on shallow groundwater. In their absence, simple guidance is needed to help identify and mitigate environmental risks to long-term water availability and quality.

Who Is The Tool For?

The tool is designed to be used by teams with engineering expertise and experience of working with community-based water supply. We stress that a tool of this kind will be much less reliable than an assessment by a professional hydrogeologist, so it should only be used when that is not an option.

What Does The Tool Involve?

The tool helps to answer three key questions for new and existing shallow groundwater sources:

- **Is there enough water of suitable quality to meet demand across seasons for the long term?**
- **What are the main environmental risks to ensuring a sustainable supply of safe water?**
- **How can these risks be mitigated?**

The tool sets out four steps to do this:

1. Understand how much water is potentially available, through knowledge of local geology and source behaviour.
2. Calculate community demand for water.
3. Compare supply and demand and determine how big the catchment of a well must be to provide this water.

4. Protect sites and sources by identifying environmental risks, and design a management plan.

How Should The Tool Be Used?

The activities proposed in this tool are useful where water points are developed that access shallow groundwater (up to approximately 20m deep), such as hand dug wells, shallow boreholes equipped with hand pumps, and springs. The tool does NOT cover all aspects of providing WASH services and should therefore be used alongside existing guidance and tools, such as water safety plans, and more formal environmental impact assessments where they are mandated by national regulations, or where resources are available.

Different activities are outlined in some of the stages of the tool, depending on whether the water source being investigated is a well or a natural spring. Take care to follow the right guidance.

Where it is not possible to complete a certain stage, continue with inputting whatever relevant information you may have: an informative outcome is still possible even if the tool inputs are incomplete.

The tool is a simplified guidance based on the SWIFT tool for environmental assessment and risk screening for rural water supply. For further detail on any steps, and more information on why each step is needed, follow the links below. Please note that the steps in this tool do not exactly match those in the SWIFT guidelines.

1: Introduction to SWIFT tool: http://policy-practice.oxfam.org.uk/publications/introducing-the-swift-tool-for-environmental-assessment-and-risk-screening-for-582298

2: SWIFT tool, guidance document: http://policy-practice.oxfam.org.uk/publications/environmental-assessment-and-risk-screening-for-rural-water-supply-guidance-not-560965

Step 1 | Step 2 | Step 3 | Step 4

STEP 1: LOCAL GEOLOGY AND SOURCE BEHAVIOUR

In this step we will look at geology, and tap community knowledge in order to find out how much water is potentially available. By adding our newly gathered information to a map of the area we will be able to see where the best place for a new project water source should be.

In Step 1 we will achieve the following outputs:

- Map of the area
- Estimate of reliability of yield for existing water sources (aquifers)
- Table showing community knowledge of existing water sources
- Decision on which part of area will be best for siting water source in terms of yield reliability

Stage 1: What types of rock are dominant in this area? Which of these usually form good aquifers[1]?

The rock type, and its area of coverage, determines how much water can be held in aquifers below the ground, so this knowledge will allow us to see which parts of our intervention area could have a useful quantity of groundwater.

If it is possible, ask a geological expert, and/or consult a geological map. Otherwise, use local knowledge of rock type. Then, use the table below to assess the potential water quantities from each type.

Rock type	**Hydrogeology**	**Groundwater potential**	**Average yield (L/sec)**
Crystalline basement rock	Highly weathered and/or fractured basement	Moderate	0.1– 1 L/sec
	Poorly weathered or sparsely fractured basement	Low	0.1– 1 L/sec
Consolidated sedimentary rock	Sandstone	Moderate – High	1 -20 L/sec
	Mudstone and Shale	Low	0– 0.5 L/sec
	Limestone	Low	1–100 L/sec
	Recent coastal and calcareous island formations	High	10–100 L/sec
Unconsolidated Sediments	Sand and Gravel layers	High	1 – 40 L/sec
	Small dispersed deposits (thicker and well sorted sand/gravel)	Moderate	1 – 20 L/sec
	Loess	Low – Moderate	0.1 – 1 L/sec

[1] Pores and fissures within some rock types hold water – this water-bearing rock layer is called an aquifer. This water is accessible via wells, boreholes or springs, and is replenished when it rains through a process called (aquifer) recharge.

	Valley deposits in mountain areas (stable areas of sand and gravel/river worked volcanic rocks/blocky lava flows)	Moderate – High	1 – 10 L/sec
Volcanic Rocks	Extensive volcanic terrains	Low – High	Lavas: 0.1 – 100 L/sec Ashes: 0.5 – 5 L/sec

Source : Adapted from MacDonald, A., Davies, J., Calow, R., and Chilton, J. (2005) *Developing groundwater: a guide for rural water supply.* Bourton-on-Dunsmore, UK: ITDG Publishing.

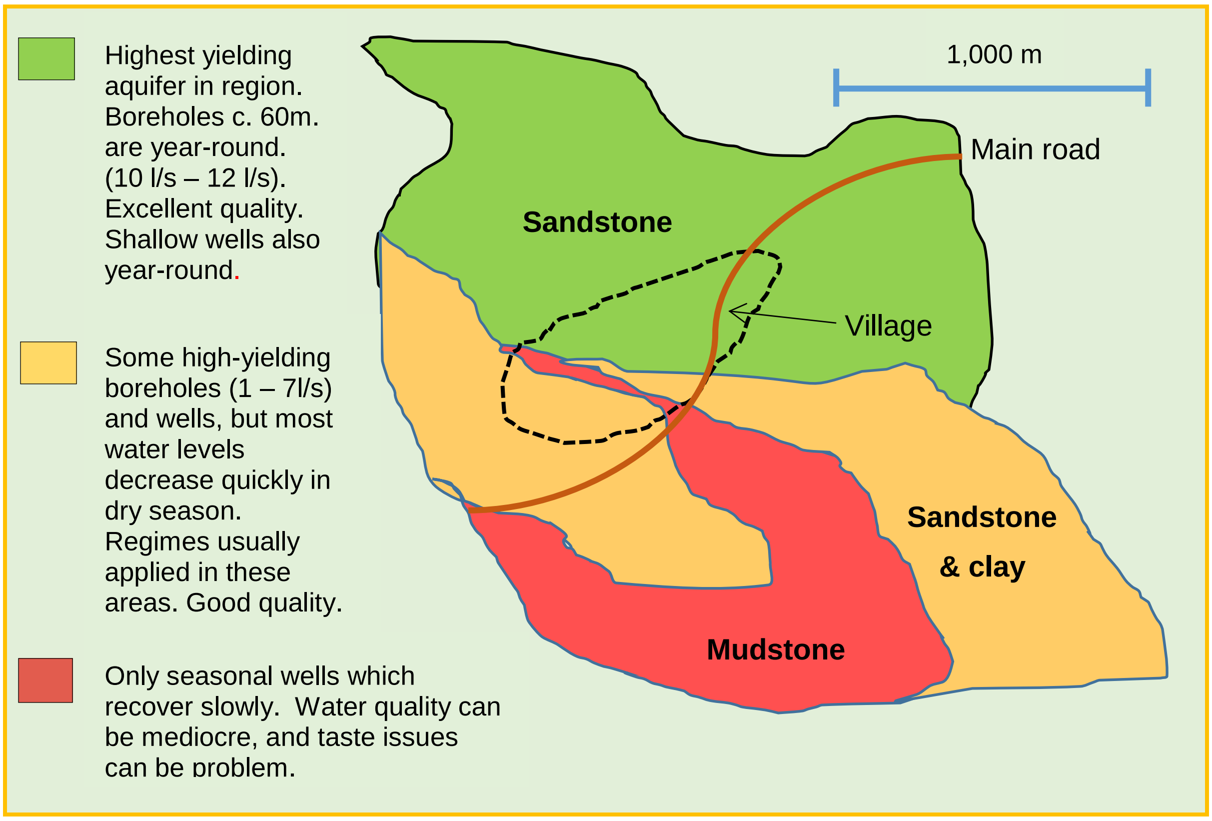
Stage 2: Score the geology, and illustrate it on a sketch map

Give the rock types relevant to your area a traffic light score according to 'usability' (how much water there is to use):

	Red	Amber	Green
Groundwater potential	No/Very little groundwater	Variable groundwater (e.g. water table varies between wet & dry season).	Plentiful groundwater year-round

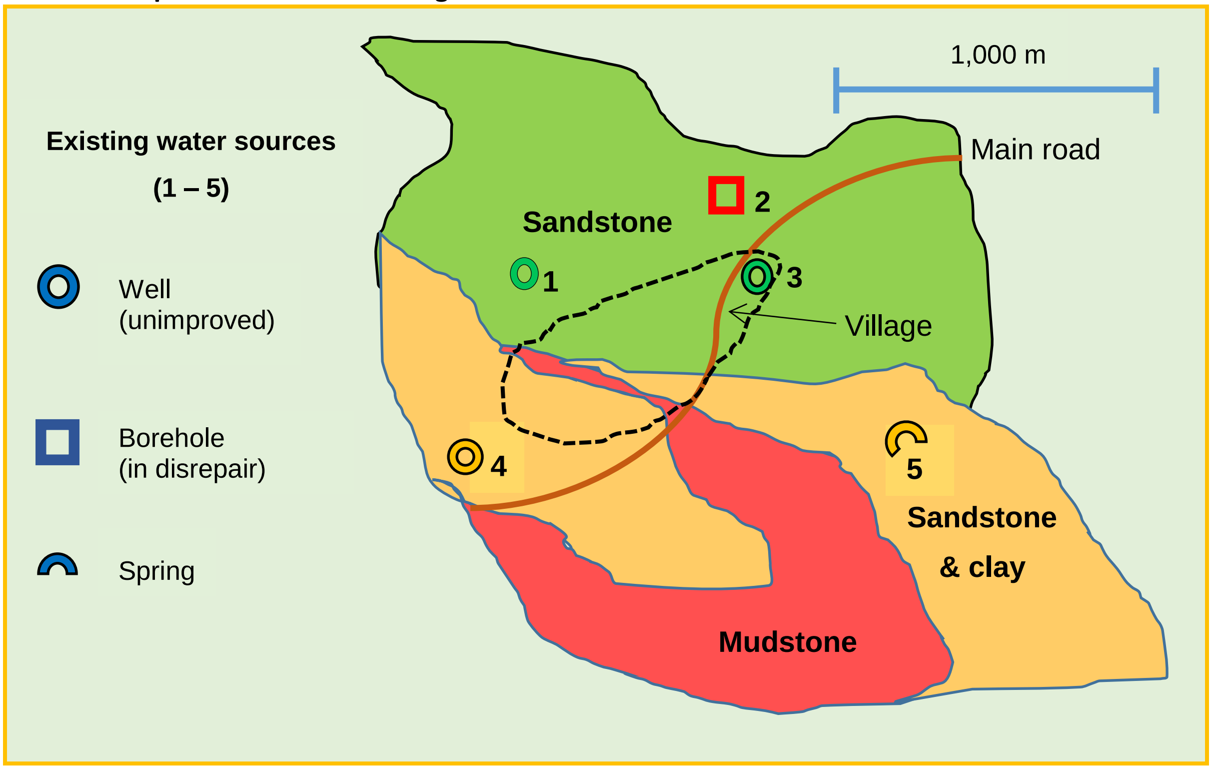
Make a sketch of the local area and shade in the different rock types and their locations. Use the colours from the traffic light system, and add comment boxes to give additional information such as rock type, quality and yield. The extent of the area of your map will be influenced by the potential type of project water source, and existing water source locations. (Where wells and spring point-sources are dominant, 2 or 3 km beyond the village boundary will be sufficient. Where gravity-fed systems exist, the sketch should be extended so that their spring sources are included).

Sketch-map 1: general assessment of aquifer potential according to geology



Now, on your geology sketch map, mark the locations of all current water sources used by your community:

Sketch-map 2: Potential of existing water sources



Stage 3: Community knowledge

Ask the community questions about the quality, flow rate, and any technical/chemical/practical problems of ***existing*** water sources. Measure the yield of water from the well/spring:

Measuring yield of wells: Water is abstracted from a well ideally by using a de-watering pump mounted on the ground. Failing this, a bucket (s) can be used. Standing water level (pre-abstraction) is marked on the inner-well lining. Abstraction over a set period (e.g. 20 mins) is measured, and the time for the water level in the well to recover to the pre-pumping level is recorded. This pumping rate can be increased in steps as long as the recovery period consistently and comfortably occurs within a time period which is less than the period agreed for the well to be locked (typically during the night).

Measuring yield of springs: Take a bucket of known volume and time how long it takes to fill it from the spring.

Example

If it takes 8 seconds to fill a 10 litre bucket, then flow = 10litres/8s = **1.25 l/s**, or **75 l/min**

IMPORTANT

Well and spring yields should be measured in the advanced period of the dry season when water tables and spring discharges are at their lowest.

Produce a table similar to that shown below:

Existing water sources	Source type	Months functioning per year	Yield (Litres/min.)	Quality (chemical/biological) (cfu: coliform units)	Access
1	Dug well	11 – 12		Calcium higher than WHO guidelines. No faecal presence	Restricted due to private grazing land.
2	Borehole	12, but currently in disrepair		Water slightly saline No faecal presence	No restrictions
3	Dug well	12		Occasionally slightly turbid 5 cfu/100 ml in rainy season	Crossing main road is issue for some
4	Dug well	8 (Rainy season)		Can be turbid Only occasionally 0-5 cfu/100 ml	No restrictions
5	Spring	9 - 10	90 l/min	Can be turbid in high rainy season. Occasional low faecal count (rainy season)	Difficult access from village

Stage 4: Traffic Light Assessment

With the knowledge from Stages 1, 2 and 3, assign a traffic light colour to show the overall 'usability' of **each existing water source** (how much water, how good it is and how practical it is to get to). Use the table below as a guide.

	Red	Amber	Green
Usability	Doesn't work / poor quality / no human access	Works part of the year/ variable yield / some human access	Works year round / high quality / fully accessible

Colour-code the actual sources on the sketch from Stage 1 accordingly.

Looking at Sketch-map 2 in Stage 1, we should now be able to see which areas, and which actual sources, have the best potential for a new, sustainable water supplies.

Step 1 | Step 2 | Step 3 | Step 4

STEP 2: CALCULATING DEMAND

We must know how much water is needed by the community, so that we can ensure the new water source will supply enough throughout the year and in the future.

The outputs of this step are:

- An estimate of future population size
- A calculation of annual water demand

Stage 1: Estimate Future Population Size

Assume a constant growth rate for the community - situations change and water sources can attract new people

Use the formula below to estimate future population:

Future population = $Current\ population\ x\ Euler's\ number^{(growth\ rate\ x\ number\ of\ years)}$

Example: Future population = $150\ x\ e^{(0.025x10)}$ = $150\ x\ e^{0.25}$ = 150 x 1.28 = **192**

e= 2.718

Use this result in Step 2, Stage 2

Stage 2: Estimate Demand

For domestic water use, assume 20 litres per person per day (20 LCD). Let us assume 6 people per household.

Demand = Number of people x water use x 365 (days per year)

Example: 192 x 20 x 365 = **1,401,600 L/year (1,401 m^3/year)**

Use this in Step 3, Stage 3

Add estimated water demand for any institutions (Schools, hospitals, clinics). And add estimated demand for small-scale, household-level productive activities for which often water from domestic sources is used (e.g. raising chicken and small livestock, vegetable gardening, etc.)

Now we have calculated the community demand for water, we must use these figures in Step 3 where we will compare them to the supply of water available.

Step 1 | Step 2 | Step 3 | Step 4

STEP 3: DEMAND vs SUPPLY

We have now estimated how much water the community needs, and the most promising locations to develop new water points to meet these needs. The next step is to determine whether the potential supply can meet the demands we have calculated.

The outputs of this step will depend on whether we are looking at a spring or a well.	
WELLS 1. Well **Recovery** potential (previously measured from unimproved well at desired location, and recharge rates from nearby wells) vs **Demand** 2. Calculations of the **required catchment size** to meet this demand flow	**SPRINGS** **Yield** (calculated from the unimproved (potential project) spring vs **Demand** Protecting a spring (if done carefully) usually results in realising a greater captured flow than is measurable from the pre-protected source. Commonly, we can estimate this potential increase as follows: **Potential dry season flow** **= Measured flow (pre-project) x 1.5**

Stage 1: Yield v Demand

In order to determine whether or not a water source will provide enough water from a community its yield must be compared with the demand calculated in Step 2.

To see whether a **<u>well</u>** has a sufficient recovery potential to meet the needs of the community without being depleted we need to compare *annual* demand with *annual* well yield. Assume we measured a well recovery rate of 1.5 L/minute. Annual well yield = Well recovery (L/min) x 60(mins) x 24(hours) x 365(days) ***Example***: 1.5L/min x 60 x 24 x 365 = 788,400L/year = **788.4 m³/year**	To see whether the **<u>spring</u>** yield will meet demand, compare *annual* demand *with annual* total yield (As a conservative measure for years of low rainfall, this will be based on lowest yield measured during the dry season). Let's assume the flow measured from the currently unimproved spring at the desired location suggests a reliable dry season flow (of the completed project spring) of 1.25 l/s Annual yield = dry season spring yield (L/sec) x 60(s) x 60(mins) x 24 (hours) x 365 (days) ***Example:*** 1.25L/s x 60 x 60 x24 x 365 = 39,240,000L/year = **39,240m³/year**

Is this higher than the annual demand calculated in Step 2?
<u>If the annual well recharge or the annual spring yield is lower than the annual demand, this water source is unsuitable.</u>
<u>If the annual supply is higher than, or equal to the annual demand, this water source has the potential to be useful.</u>

<u>In the next Stage we will consider the potential of the aquifer itself to be able to sustain the well yield throughout the year.</u>

Stage 2: Aquifer Recharge

This is a simple measure for estimating the rate at which water is replenished in a shallow aquifer. It is related to how much rainfall is stored in the aquifer and is available for recovery of the well. Aquifer recharge is assumed as being 10% of rainfall in areas with more than 750mm of rain annually. However because some recharge will move to deeper aquifers, evaporate, or be discharged into rivers it may only be 1-3%.

We will assume recharge = 1% of rainfall

Example: 0.01 x 1300mm per year = **13mm per year (0.013 m per year)**

This information will help in Stage 3, when we map catchment areas.

Stage 3: Catchment size

The vulnerability of a water supply to climate variation is related to catchment size. Catchment sizes are related to the rate at which groundwater is being removed from an aquifer, and how quickly it is being replenished by rainfall (recharge of aquifer).

For protected **springs**, where existing yield can be directly measured and there is less choice about siting, we can just focus the sufficiency of the measured yield to meet current and projected needs, as we have done in Stage 1.

For **wells** we must further consider the catchment size.

Calculate the minimum catchment size to ensure sufficient yield of the well throughout the year.

Catchment size (m^2) = Demand (m^3) / Recharge (m)

Example: 1,401 m^3 per year / 0.013 m per year = **67,380 m^2**

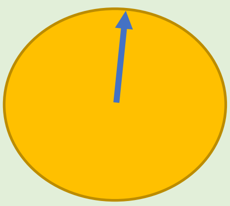
We now need to apply this catchment size calculation to the potential water sites identified in Step 1. The area the water source will collect from depends on whether the terrain is flat or hilly. Therefore this stage has two methods for determining an estimate of the required catchments size:

- **For flat terrain**, the catchment area will be circular and so we work out a radius length, and then use this to map the catchment around the water source;
- **For hilly terrain**, the catchment is not circular as hills and ridges influence how much water can reach the water source. For this method the distance between the ridgelines must be calculated.

For flat terrain:

Use this equation to calculate the radius: Radius $=\sqrt{Area/\pi}$. Then use this to draw a circular catchment around the water source. For the Area, use catchment size calculated above.

Example: Radius = $\sqrt{Area/\pi}$ = $\sqrt{6740m^2/\pi}$ = *64m*



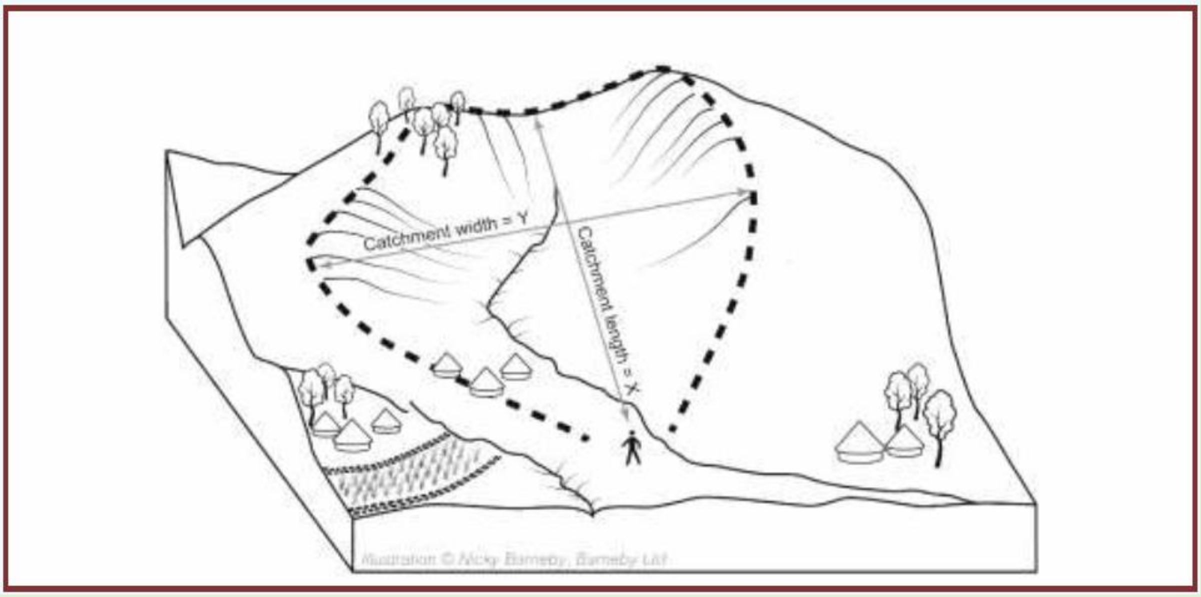
$\pi = 3.14159$

Where the arrow represents the radius (64m) from centre of circle.

This step may need to be repeated for several potential water source sites

For hilly terrain:

Measure the distance between ridgelines. Multiply the width by the length in order to calculate the area.



Source: Ludi et al., 2015

Example:
*Catchment length **x** = 50m*
*Catchment width **y** = 70m*
*Catchment area = **xy** = **3,500m2***

This step may need to be repeated for multiple water source sites.

Is this catchment area bigger than the catchment size needed (calculated in Stage 3)? If not the site will not provide sufficient water to meet demand. If it is move on to Step 4.

See table 2.3 in the SWIFT guidelines for approximate catchment area and spring yield requirements for differing community sizes.

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STEP 4: ENVIRONMENTAL RISK

In this step we will be considering the need to protect the sites and water sources by identifying environmental hazards of site degradation and water supply contamination, and by creating a management plan to deal with these risks.

The outputs for this step are:

- List of direct hazards
- Map of water source catchment
- Showing indirect hazards
- Catchment Protection Plan

Now that we know which of the potential sites have adequate catchment areas to meet water demand and provide it sustainably, we need to know whether there are any hazards and threats affecting the water source.

Stage 1: Direct Hazards

By direct hazards we mean the main hazards and direct features near a water point which may have an immediate effect upon the water source. They may include gullies, flood prone areas, landslip prone areas and pollution risks.

Within a 150m catchment around the water source, do you observe any direct hazards? Can they be dealt with? Use the table below for guidance.

Hazard	**Present within 150m radius?**	**Manageable? Act as soon as possible if yes.**
Gully	*Example: Yes, downslope of water point* *Example: Yes, upstream of water point*	*No, relocate* *Yes, re-vegetation / fencing / check-dam/ diversion ditches/ drainage, etc.* *See: Link to TILZ*
Flooding	*Example: Area prone to floods*	*No, relocate* *Yes, raise the well head and seal the well / manage water flows / ensure floodwater is defecation free and free from other pollutants/diversion ditches*
Landslide	*Example: Yes, prone to landslides*	*No, relocate* *Yes, Improve drainage / Construct walls / Buttress the toe / afforestation, etc.* *See: Link to landslide prevention*
Animal Access	*Example: Yes*	*No, relocate* *Yes, Build fences and animal deterrents*
Waste Dump	*Example: Yes*	*If nearer than 100m, relocate* *If further away water source is OK*
Latrine	*If nearer than 100m from water source, relocate.*	*If nearer than 30m, relocate* *If further away water source is OK*

Stagnant Water	*Example: Yes*	*If nearer than 30m, relocate* *If further away water source is OK*

For more management plans mitigating direct hazards see the annex of additional materials attached to the SWIFT guidelines document.

Stage 2: Indirect Hazards/ Degradation Risks

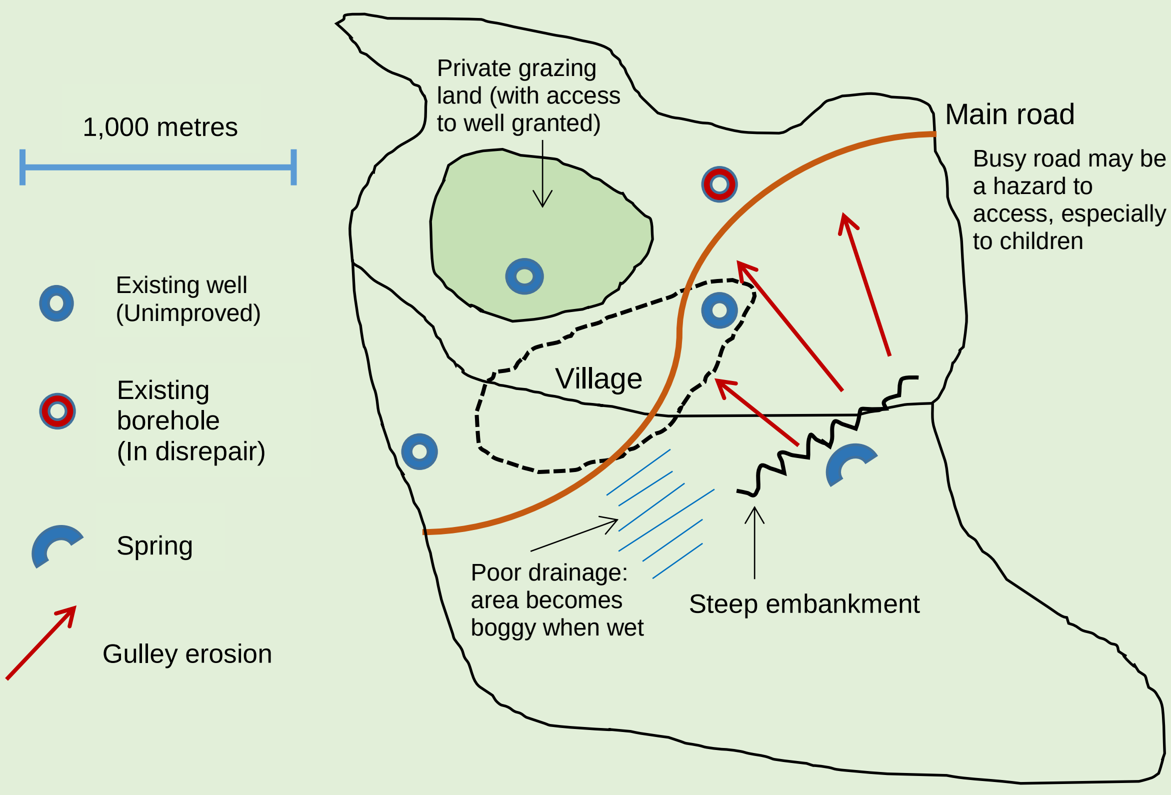
Sketch the catchment area and identify any major causes of degradation and their causes. Show the level of severity using a traffic light system.

SPHERE standards suggest that nobody should travel more than 500m to collect water. Within this area, consider if there are there any hazards which will increase the time taken to collect water, or make water collection dangerous or impossible. **If there is a risk that water points cannot be adequately protected by erosion control or drainage measures, alternative sites must be sought.**

Such hazards may include standing water bodies, areas of private land, or land insecure to cross, steep, rocky land that would be difficult for some community members to cross, etc.

Sketch-map 3: Environmental hazards affecting water sources

Mark key environmental hazards on your sketch map of the area



Stage 3: Create a Catchment Protection Plan

Discuss with the community to determine best ways to deal with indirect hazards in order to reduce impacts. Use table below for guidance.

For further information see the SWIFT guidelines document and the associated annexed documents.

Hazard	**Cause**	**Protection Measure**	**Who is responsible?**	**When is this due?**	**What resources are needed?**
Landslips	Land management	Soil and Stone bunds on crop land	*W*	2 months	Digging tools Measuring tools Lines for marking
Gully	Overgrazing	Gully plugs	X	3 weeks	Digging tools Measuring tools Gabions Stones
Flooding	Inappropriate drainage	Waterways	Y	3 months	Digging tools Stones
Sheet erosion	Land management	Cut-off drains	Z	1 month	Digging tools Stones

Summary:

We have now worked through all 4 Steps of this Environmental Assessment work tool.

We have examined all potential sites for a new water source, assessed their potential to provide sufficient water of suitable quality and consequently chosen the best position.

We have worked with the community and created a catchment plan which will help to ensure the water source remains sustainable.