The Federal Democratic Republic of Ethiopia
Ministry of Water, Irrigation and Energy

Community Led Accelerated WASH in Ethiopia (COWASH)

Climate and Environmental Risk Screening for COWASH Project

Regional Level Training of Trainers (ToT) Manual

September 2015
Addis Ababa, Ethiopia

List of Acronyms

BGR	Benishangul Gumuz Region
BoA	Bureau of Agriculture
CMP	Community Managed Project
COWASH	community-Led Accelerated WASH
CR-WSP	Climate Resilient Water Safety Plan
DEM	Digital Elevation Method
EIA	Environmental Impact Assessment
FTAT	Federal Technical Assistant Team
NRM	Natural Resource Management
O&M	Operation and Maintenance
ODI	Oversea development Institute
SNNPR	Southern Nation's Nationalities People Region
ToT	Training of Trainers
WASH	Water Supply, Sanitation and Hygiene
WASHCO	WASH Committee
WUA	Water User Association

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Section 1: Introduction *(1hr)*

1.1. Overview of the ToT Manual

This manual is prepared based on the climate and environmental screening guideline prepared by Overseas Development Institute (ODI). The training manual addresses the resource sustainability mainly the water resource and environmental and climate risk elements to the water scheme posed by flooding, land degradation, and climate change. The aim is to show how participants from the WASH implementing organizations, working in partnership with communities, can integrate these concerns into rural water supply planning and implementation activities.

The focus of this manual is on groundwater-based, community-managed wells and springs in rural areas as these systems are *potentially* most vulnerable to climate change impacts. Systems that depend on shallow groundwater from wells and springs are generally more vulnerable to changes in rainfall (and therefore groundwater recharge) and demand than those exploiting bigger groundwater storage. The activities proposed in this ToT manual are most useful where water points are developed which access shallow groundwater, such as hand-dug wells, shallow boreholes equipped with hand pumps and springs. This manual does not address:

- Formal Environmental Impact Assessments (EIAs), which should be carried out routinely where deeper drilled boreholes are planned.
- Water quality assessment or sanitary surveys, which typically form part of a CR-Water Safety Plan (CR-WSP).

1.2. Who Use the ToT Manual

It is proposed to train about 34 experts from FTAT, experts from regional water bureaus (Hydro-geologists, and water engineers); one NRM expert from BoA; and staffs from regional support unit working on site selection (Hydro-geologist) and capacity building experts. These target groups are selected because they are responsible for cascading the training to Woreda level training. In Amhara region there are Zonal COWASH advisors that are proposed to be part of the training so that they can support regional experts during Woreda training and follow up activities during site selection. Hence, zonal advisors with hydrogeology/geology background from Amhar region may participate on the ToT. Thus, the manual is used for all these target groups and Woreda and zone WASH sector experts who are involved in rural water supply planning, implementation and monitoring activities. Details of the regional ToT participants are presented in table 1.1 below.

Table 1.1. Proposed Trainees who are to participate on the regional ToT

Region/Federal	Regional Participants		Zonal Advisors	Woreda Advisors	Total
	Regional Water, Mine and Energy Bureau, BoA	Regional Support Unit (RSU)			
FTAT					5
Oromia	3*	2	-	-	5
Amhara	3*	2	3	-	8
SNNPR	3*	2	-		5
Tigray	3*	3	-	-	6
BGR	3*	2	-	-	5
Total	**15**	**11**	**3**	**2**	**34**

*(one hydro-geologist and one water resource engineer, and one NRM expert from BoA)

1.3. Objective of the ToT Manual

The main objective of the manual on the climate and environmental risk screening is to provide the basic knowledge and skill on climate and environmental risk screening for regional COWASH sector experts and zone and Woreda COWASH advisors. It will also provide the required skills and tools for the trainees to cascade the training themselves to zone and Woreda COWASH sector experts who are doing the actual work of climate and environmental risk screening. The manual helps the regional WASH sector experts to effectively deliver the required knowledge and skill on environmental and climate risks screening for Zone and Woreda COWASH sector experts to enable them better plan, identify risks and take measures to prevent/mitigate or effectively respond to environmental and climate risks.

It is also important that these new skills and knowledge on the climate and environmental risk screening are internalized within the trainees for effective environmental assessment and climate risk screening of COWASH project and that trainees have the knowledge and skills to work closely with Zonal and Woreda WASH sector offices to adapt the ToT Manual.

1.4. Outcome of the ToT Manual

After the successful completion of this manual:

- ✓ Trainees will be acquainted with the basic knowledge of climate change impacts on the WASH facilities mainly on shallow groundwater abstraction technologies like spring development and HDWs, and the adaptation measures for the impacts;
- ✓ The capacity of trainees on the knowledge and skill on basic concepts of environmental assessment and climate risk screening will be enhanced;
- ✓ Trainees will understand how to identify and manage environmental and climate risks on the COWASH project;

- ✓ The trainees will be provided with the knowledge, skills, and tools/methodologies to cascade the training to Zone and Woreda experts in an understandable manner to people who don't have detailed background knowledge and skill of these issues.

1.5. Structure of the ToT Manual

This manual is organized in five sections.
Section 1: Introduction. This section give general overview of the ToT manual, the target groups, the objective, and outcomes of the ToT, and the structure of the manual.

Section 2: Climate Change Risks on WASH - This section brief the main climate change impacts on WASH and the corresponding adaptation strategies to reduce/minimize the risks.

Section 3: (*Understanding Water Availability – Tapping Existing Knowledge*) - this section focuses on the importance of collecting existing information such as geology of the area, performance of existing water sources, and yield of the different water sources; and how to do it. The section also describes the factors that are likely to influence the availability and sustainability (and quality) of water for a village or group of households. This is the first step (step 1) in environmental assessment and climate risk screening in rural water supply planning and implementation.

Section 4: (*Ensuring Sustainability - Estimating Supply and Demand*). The second step in environmental assessment and climate risk screening is discussed in this section. This section focuses on describing how to estimate the supply and demand of water so as to identify potential sites for a well or spring that can provide water, at the required yield, on a continuous basis for domestic needs.

Section 5: (*Protecting Sites and Sources – Hazard Assessment and Mitigation*). The main focus of *this section* is assessment and management of environmental and climate risks posed to water sources. This is the main section in this ToT manual in assessing the environmental and climate risks to the rural water supply projects, and identifying the feasible mitigation measures for those identified risks.

To make the ToT practical and attractive, a variety of training methods are used in each of the training sections. Trainers should take care to avoid lengthy lectures or large group discussions, always remembering that each individual learns in a different way. Trainers should try to use as many of the following training methods as the length of the training session allows:

- ➢ Lectures by the trainers (using PowerPoint presentations, overhead projectors),
- ➢ Group discussions,
- ➢ Group exercises, and activity questions,
- ➢ Practical exercises in the field,

- Presentations by participants after group exercises, and field exercise
- Check in and reflection session of the previous training day at the beginning of each day.

For the field visit activity, site will be selected and confirmed ahead of the training.

Trainees assessment and evaluation

At the beginning of the ToT, trainees will be assessed/evaluated on their knowledge and skills on the subject matter to be covered by the ToT manual. At the end of the ToT, participants will be assessed/evaluated on the knowledge and skill on the subject matters covered by the ToT. The assessment/evaluation method is by preparing questionnaire to be filled by the trainees.

Section 2: Climate Change Risk on WASH

Overview of the section: This section will introduce trainees on the impacts of climate change on WASH facilities, and the adaptation strategies to reduce/minimize the impacts by climate change on the WASH facilities especially on low technology rural water supply facilities mainly protected springs, HDWs and shallow wells.

Activity 2.1: Questioning participants *(10 minutes)*

Before fully getting into this section, the trainer uses this activity to build anticipation for the content and to gauge how much the trainees knows about the impacts of climate change on the WASH facilities, and the adaptation strategies to minimize/reduce the impacts. Start the discussion by asking participants a few simple questions about the impact of climate change on WASH facilities and adaptation strategies.

Activity questions:

- What is climate change?
- What is the impact of climate change on the WASH sector from your local experience?
- What adaptation strategies can be implemented to minimize/reduce them?

Activity 2.2: Power point presentation *(30 minutes)*

This activity will introduce participants to the impact of climate change on WASH facilities especially on those technologies used for the abstraction of shallow groundwater, and the adaptation strategies to be taken to reduce/minimize the risk. Ask participants if they have any questions and get their feedback and reactions to the presentation.

2.1.Climate Change Risk on WASH

Climate Change: According to IPCC definition Climate Change refers to any change in the climate over time, whether due to natural variability or as a result of human activity.

Water is predicted to be the primary medium through which early climate change impacts will be felt by *people*, *ecosystems* and *economies*. Both observational records and climate projections provide strong evidence that freshwater resources are vulnerable, and have the potential to be strongly impacted by climate change and variability.

Many water supply services rely on groundwater, particularly in rural settings, so developing a better understanding of climate-groundwater links is vital. The development of groundwater for rural water supply offers significant advantages (compared to surface water sources) in terms of climate resilience because of the storage groundwater aquifers offer, specifically, large storage volume per unit of inflow makes groundwater less sensitive to annual and inter-annual rainfall variation and longer-term climate change.

Recharge to groundwater is highly dependent on prevailing climate as well as land cover and underlying geology. Climate and land cover largely determine rainfall and evapotranspiration, whereas the underlying soil and geology dictate whether a water surplus (precipitation minus evapotranspiration) can be transmitted and stored in the subsurface. Groundwater recharge will also be affected by soil degradation and vegetation changes, both of which may be affected by climate change and variability, and human activity.

When there is increased intensity of rainfall there is increased risk of flooding, leading to both infrastructure damage and contamination of surface and groundwater supplies. In rural areas for example, floods can damage or inundate springs, wells, rainwater harvesting systems and boreholes, though boreholes are typically less vulnerable. This can hamper both access to water and cause contamination and health risks. The pit latrines widely used in rural areas are also vulnerable to flooding and can cause serious environmental contamination, although adapted designs are available and latrines can be upgraded.

Impact of environmental degradation on WASH sustainability

Degraded micro-watershed has significant impact on the sustainability of the water supply. In the one hand, degraded micro-watershed has low recharging capacity of the ground leading to decreased yield of the water point. In the other hand, degraded micro-watershed generate more flood that may damage the water supply infrastructures and cause contamination of the shallow groundwater resource. For the detail of this issue, refer section 5 of this ToT manual.

In general table 2.1 below shows the impact of climate change on WASH facilities and the corresponding adaptation measures.

Table 2.1. Climate change impacts on WASH facilities and adaptation measures

Intense rainfall events - risks and adaptations			
Protected Spring			
Hazard	**Impact**	**Adaptation: Planning, design**	**Adaptation ongoing**
Entry of contaminated water from surrounding area; erosion around spring box	*Public health risk:* Water quality deteriorates – maybe rapid but short term, or longer term if wider aquifer contaminated	Prepare hazard map with community; address direct threats identified above or investigate alternative sites/sources Construct bunds or cut-off drains to divert runoff away from collection area. Integrate watershed management activities with the rural water supply project.	Regularly check and repair infrastructure. Monitor & maintain bunds, drains & other catchment protection measures
Inundation of spring – entry of contaminated groundwater. Damage to infrastructure from	Water quality deteriorates – maybe rapid but short term, or longer term if wider aquifer contaminated	Implement land management activities in wider catchment to reduce severity of floods e.g. terracing, drainage, retention basis, re-vegetation. Ensure water collection & storage infrastructure is properly designed, and	Sanitary inspection. Implement communication protocol – advise on safety; provide support for household treatment if necessary.

land slips and gullies.		built from durable materials. Raise awareness of risks from water quality changes during & after flooding, and need for household water treatment/use of safer alternatives. Develop communication plan: (1) when to avoid contaminated sources for drinking during & after floods until water quality is verified; (2) what are the safe alternatives (e.g. household treatment, different sources).	
HDWs			
Increased contamination of groundwater and lateral flow in soil. Damage to infrastructure e.g. from landslips, gullies	Water quality deteriorates – maybe rapid but short term, or longer term if surrounding aquifer contaminated	Prepare hazard map with community; address direct threats or investigate alternative sites/sources. Site well away from latrines and other sources of groundwater pollution. Address direct flood risk by building bunds or cut-off drains to divert runoff. Implement land management activities in wider catchment to reduce severity of floods e.g. terracing, drainage, retention basis, re-vegetation. Improve and/or extend well lining to prevent ingress of contaminated water; raise well head. Raise awareness of risks from water quality changes during & after flooding, and need for household water treatment/use of safer alternatives. Develop communication plan: (1) when to avoid contaminated sources for drinking during & after floods until water quality is verified; (2) what are the safe alternatives (e.g. household treatment, different sources).	Seal any abandoned wells to protect groundwater quality Regularly check and repair infrastructure. Monitor & maintain protection areas and wider catchment protection measures. Sanitary inspection. Implement communication protocol – advise on safety; provide support for household treatment if necessary. Shock chlorinate well water after floods have subsided
Dry periods and droughts: Risks and adaptations			
Protected springs			
Hazard	**Impact**	**Adaptation: Planning, design**	**Adaptation ongoing**
Seasonal or drought-related reductions in spring yield, or spring dries up completely Seasonal or drought-related reduction in	Seasonal or drought-related shortages – insufficient water for demand. Public health risk from water rationing/cut-backs, or use of alternative (unsafe)	Collate secondary information on geological conditions to understand water availability & supplement with field observations. Discuss seasonal yields of alternative sites with community – select most reliable	Regularly check and repair infrastructure. Monitor & maintain protection areas and wider catchment protection measures.

water quality – less dilution of pollutants	sources Public health risk from deteriorating water quality at end of dry season or drought	source(s). Estimate spring yield and catchment size needed to meet current and projected demand. Increase capacity of collection and storage facilities. Raise community awareness about need to prioritise water use for drinking over other uses, and/or water rationing at times of peak demand & low flow. Investigate management practices that might increase infiltration and groundwater recharge – in vicinity of spring and in wider catchment. Develop supplementary sources if necessary to spread risk.	Excavate spring further if necessary Monitor water quality during high risk periods at end of dry season or drought
HDWs			
Seasonal or drought-related reductions in well yield, or well dries up completely Failure of hand pump as demand increases and water levels fall Seasonal or drought-related reduction in water quality – less dilution of pollutants	Seasonal or drought-related shortages – insufficient water for demand. Public health risk from water rationing/cut-backs, or use of alternative (unsafe) sources Public health risk from deteriorating water quality at end of dry season or drought	Collate secondary information on geological conditions to understand water availability & supplement with field observations. Discuss community experience of well performance past & present (water quality, availability) as guide to selecting optimal site. Estimate well yield and catchment size needed to meet current and projected demand. If marginal, investigate alternative sites and options. Test yield of well at peak of dry season to assess resilience. Raise community awareness about need to prioritise water use for drinking over other uses, and/or water rationing at times of peak demand & low flow. Investigate management practices that might increase infiltration and groundwater recharge – in vicinity of well and in wider catchment. Develop supplementary sources if necessary to spread risk.	Regularly check and repair infrastructure Focus 'back stopping' hand pump maintenance in dry when mechanical failure most likely. Consider deepening wells if feasible/appropriate

2.2. Risk screening approaches

Climate risk management describes the process of identifying climate-related risks and implementing measures to reduce such risks to acceptable levels. Risk assessment has been defined as '…*a methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend*'. Therefore, both the physical climate hazard, and the vulnerability of the system, is considered under 'risk'.

Climate risk screening typically avoids probabilistic calculations associated with traditional (more technical) conceptions of risk assessment. Rather, it involves systematically examining activities (or projects, programmes, policies, technologies) with the aim of:

- Identifying hazards which could potentially cause harm.
- Identifying inherent vulnerabilities in the system.
- Assessing whether these risks – the product of hazard and vulnerability - are being taken into account.
- Considering the extent to which risks can be reduced or mitigated.

Since the probability of the hazard occurring cannot be reduced, this implies exploring opportunities for reducing the vulnerability associated with physical hazards. The usefulness of a risk management approach lies in its emphasis on preventative rather than reactive measures. Whilst the complete elimination of risk is seldom possible, what is important is identifying the most significant risks and prioritizing their mitigation

Section 3: Understanding Water Availability – Tapping Existing Knowledge (Step 1)

Section Overview: This section introduces how to collect existing information on the factors that are likely to influence the availability and sustainability (and quality) of water for a village or group of households. This may include geology of the area, performance of existing water sources, yield of the different water sources. This is the first step in climate and environmental risk screening processes.

Why this section is important?

Having the knowledge and skill on how to collect *existing information* on the factors that are likely to influence the availability and sustainability of water can help the project team assess (a) what water supply options (e.g. springs, wells, boreholes,...) are likely to be feasible and cost-effective; and (b) the likely yield and sustainability of water sources. This can save time and money later on, and means that only those options that are likely to be feasible are discussed with communities.

Taking the time to tap *community knowledge* can provide valuable information on which sources and locations are the most reliable. This information can also be used by the project team, in partnership with the community, to make informed choices on technical choices and sitting. For example, older members of the village (particularly women) are likely to know which sources fail seasonally or in particularly dry years, and may be able to 'tell the story' of water development successes and failures in a village.

Outcome: upon completion of this section, trainees will be able to:

1. Describe the geology of the area to assess resource potential and inform technical choices (e.g. shallow wells, deeper boreholes, springs).
2. Describe the performance of existing sources over time (yield, reliability, quality) to help decide on technical choices and sites.
3. Measure the yield of existing sources to see whether they meet regulatory and/or local needs, and as an input to the catchment sizing process (see section 4).

Activity 3.1: Questioning Participants *(10 minutes)*

Before fully getting into the substance of the training of this section, the trainer uses this activity to build anticipation for the content and to gauge how much the trainees knows about the geology of their respective local area so that the trainer can tailor her/his delivery accordingly. The trainer start the discussion by asking participants/trainees a few simple questions about the importance of knowing the local geology, performance of existing sources, and measuring the yield of the existing sources in selecting technologies, site, and sizing catchment.

Activity 3.2: Power Point Presentation *(1hr & 10 minutes)*

The trainer will present a power point to the trainees on the topics presented under this section. This activity will introduce trainees to the importance of understanding local geology, understanding source behavior, and measuring the yield of the existing sources to select technologies, site, and size catchment. Use this session to clear up any misconceptions on these three issues. Ask participants if they have any questions and get their feedback and reactions to the presentation.

Section Contents

- *Understanding Local Geology*
- *Understanding Source Behavior*
- *Measuring the Yield of the Existing Sources*

3.1. Understanding Local Geology (Step 1.1)

Knowing 'where you are' in terms of underlying geology is a first step. This can be approached in two ways: (a) looking at secondary information (e.g. maps, well records) to assess groundwater potential and likely yields; and (b) follow-up observation in the project area – looking at rock outcrops and exposed soil/rock profiles – to understand *geology* and *groundwater* condition and *potential*.

The underlying geology of an area will determine whether water is *stored* in underground formations, how much is stored, and the ease with which water can flow to a water point. This determines the *yield* of an individual source. Geology can also influence water point choice, construction, cost and periodic rehabilitation requirements. Storage is the key factor affecting the resilience of water supplies. Aquifer storage transforms highly variable natural recharge from rainfall into more stable natural discharge regimes.

Storage is the key factor affecting the resilience of water supplies. Aquifer storage transforms highly variable natural recharge from rainfall into more stable natural discharge regimes. Storage is a function of rock porosity. The most porous geologies (e.g. alluvial sediments, highly weathered hard rocks) can store large volumes of water, so that when recharge from rainfall or discharge through pumping occurs, changes in water levels are relatively small. However, if the porosity of the rocks is small (e.g. with mudstones, shales, unweathered hard rocks), changes in recharge or discharge will have a bigger impact on water levels and a well or spring can dry up. Please refer Annex 2 for groundwater potential of major African hydro-geological environments.

Hint – when to seek expert advice

If there is no previous experience of well digging or spring development in the project area, the advice of an experienced geologist should be sought to help decide (a) if well/spring development is feasible; and (b) well sitting, if well development is feasible.

If previous wells have failed or do not provide water throughout the year, or if there is evidence of hard rock at shallow depths, alternative options (e.g. a borehole) should be considered.

If a large number of wells in a particular area are planned, it may be cost effective to employ a geologist and possibly geophysical techniques in the sitting of wells, since the increased success rate may offset the extra cost of hiring a specialist.

Key questions

When the geologist or team of experts are doing site investigation for the rural water supply project, the following key questions should be answered by the geologist or team experts.

- What is the geology of the area? What is their likely groundwater potential?
- How might geology vary within the village boundary?
- What information or evidence (if any) did previous project teams/drillers leave behind that might help?

How to get answers for these questions?

- Consult a *geological map* of the area. What sort of rocks are likely to be present?
- Visit places where rocks are exposed. River, valleys, cliffs and hills are often good locations
- Look at boulders in the village used for seats, grinding stones etc. Where did they come from? What kind of rocks?
- Visit wells that have been dug previously and examine soil-rock profiles
- Encourage people to investigate potential sites themselves e.g. by digging trial pits or using a shallow auger.

Note that *the trainer is expected to assist trainees to exercise being in group on the key questions indicated above and use the approaches indicated to answer the questions.*

Hint - local observation

Field guidance sheets *can be used to help the non-expert identify rocks in the field and place their water scheme in a geological context.*

A field guidance sheet can help the user identify rocks at hand specimen scale, at outcrop scale and regional land setting scale. Photographs and block diagrams can be included as an aid. The photographs of hand specimens can be used to identify color, texture and mineral composition of rocks for comparison with field specimens.

At outcrop scale a set of features of rocks (e.g. color, layering, thickness) can be captured in index photographs. Such photographs can later be used by practitioners in the field as reference. The same applies to observation of regional geomorphologic setting. Geomorphology is an index to geology. It is much easier to describe geomorphology (such as dome forming, cliff forming, undulating, flat laying, plateau, valley forming, dissected, etc) than to name rocks.

Annex 1 provides an example of a field guidance sheet prepared for project staff in the highlands of Ethiopia. Similar sheets may already be available in country, or could be developed with the help of a geologist.

What next?

The information collected above (sub section 3.1 of this section) – from secondary sources and/or field observation – could be used to draw a rough map of the project area showing *geology, existing water points* and *springs (functional and non-functional)* and *likely groundwater potential*. Notes on the performance of existing water points (see table 3.1 below) could also be added. This will help focus discussion on which areas and source types are likely to provide the most reliable sources of water. *The trainer is expected also to assist trainees prepare their own map based on the information collected above on their locality. For illustrative example, see fig 3.1 and 3.2 below. The two figures shows how maps are used as a guide for water point siting.*

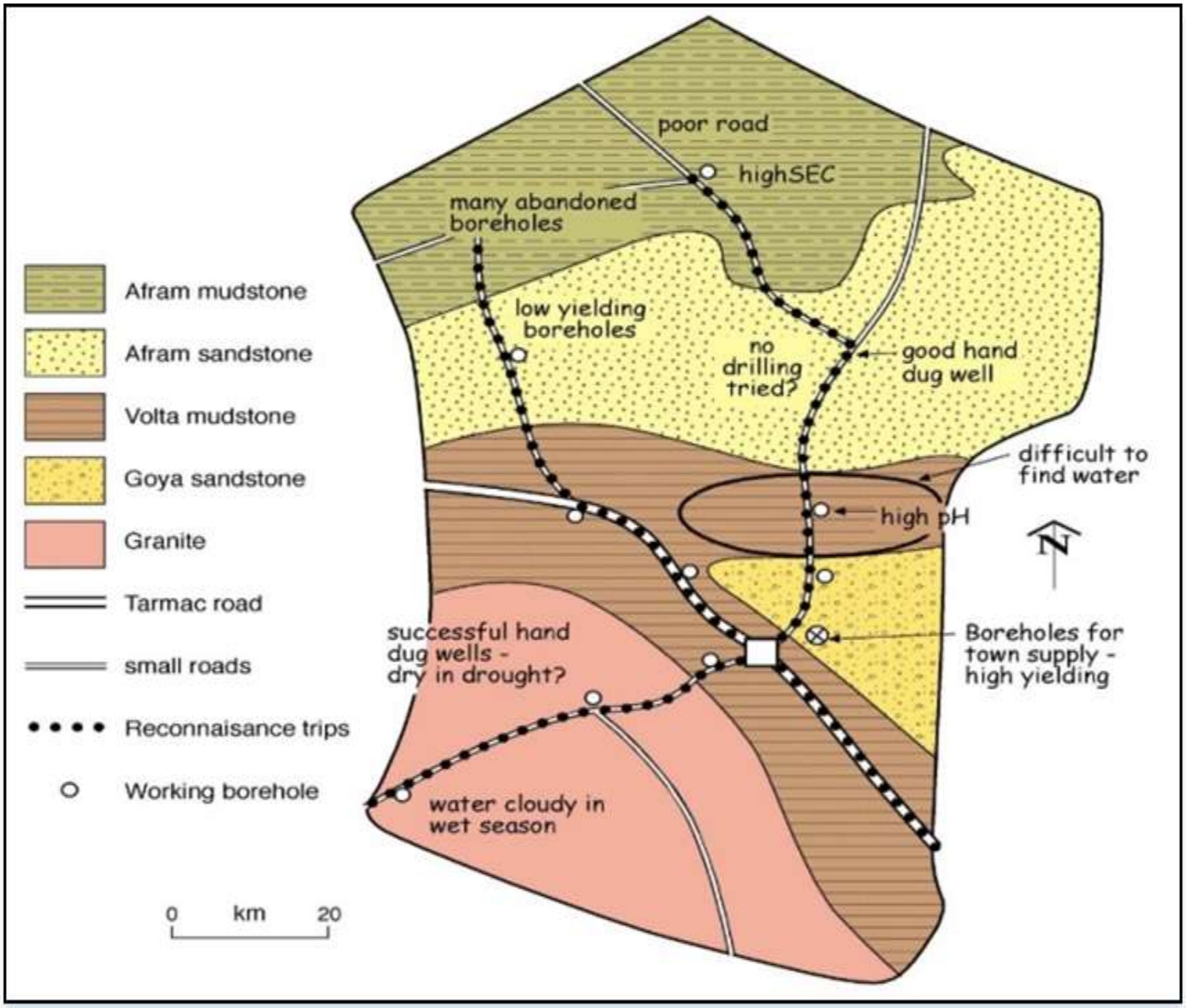


Fig. 3.1. Figure showing how hydro-geological field notes can be plotted on a geological base map

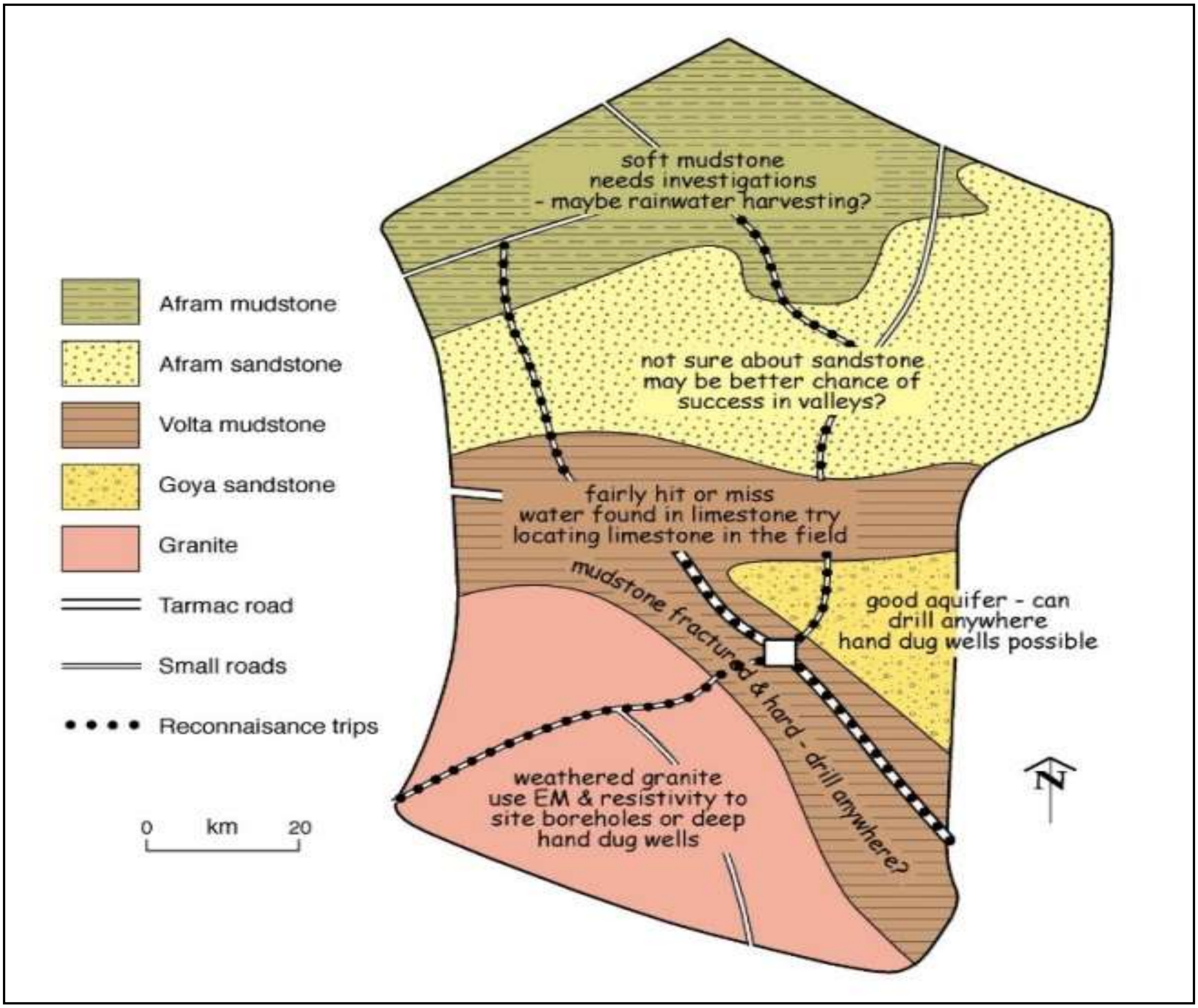


Fig. 3.2. Preliminary groundwater development plan developed from information collected in the field

3.2. Understanding Source Behavior (Step 1.2)

Asking communities about the performance of existing sources can provide useful information on which areas and sources provide the 'best' groundwater – the most reliable, as well as the highest quality and most accessible. This information can be used to inform the selection of new sites and sources, and/or the rehabilitation of existing ones. Note, however, the danger of projects simply developing new sources around existing 'successes': the result may be good on paper (another successful well!), but bad for the community (areas where groundwater conditions are more difficult, but where many people live, are avoided).

The trainer can ask trainees the following questions and get feedback while presenting this sub section.

- What are the main sources of water available for use by the community, or by groups within it? What sources no longer provide water, and why?
- How does water availability vary between sources? Which are the most reliable, and why?
- How does availability from these sources change over time, e.g. across seasons and between good and bad years?
- What other factors affect the use and performance of sources, e.g. mechanical failures, environmental hazards (flooding, drought, contamination,...) etc?

The following tables can be used to capture information on the type, number and functionality of existing schemes, and on the reasons for any water supply problems.

Hint – how to get information on source use and behaviour

A good place to begin is with a map, drawn with community members, showing where different water sources are, what they are used for, and by whom. Notes can be added on the characteristics of these sources. If a rough geological map was prepared in Step 1.1 above, this can be used as the base.

Notes can be supplemented with more detailed water point histories, best conducted at the water sources themselves with women, exploring in detail changes in water levels, yields, recovery times, queuing etc. The aim is to build up a picture of which sources, in which areas, provide (or are likely to provide) the most reliable groundwater.

Table 3.1. Source type, functionality and access

Source type	No.	No. fully functional schemes	No. schemes functional part year (indicate months when functional)	No. non-functional schemes	Access (Open to all? Restricted to some? Only available to owner?)
Hand-dug well					
Drilled well/borehole					
Protected Spring					
Unprotected Spring					
Roof catchment					
Open source (e.g. stream)					
Other (specify)					

Table 3.2. Source problems and their causes

Scheme name and type	Not enough water found on drilling/digging	Collapse of wall or sedimentation	Hand pump failure	Environmental hazard e.g. flood, erosion, gullying	Water table decline; decline in spring yield	Other (specify)

3.3. Measuring the Yield of Existing Sources (step 1.3)

The equipment used and procedure employed to measure the yield of a water sources are mentioned below.

Equipment needed to measure yield: bucket & stop-watch
Measuring yield: How long does it take to fill a bucket of a known volume?

Example:
If a 10 liter bucket took 8, 10 and 6 seconds to fill at different time, then the average yield of the water point = (10/8 + 10/10 + 10/6)/3 = (1.25+1+1.67)/3 = 1.3l/sec
Ideally, yield should be measured during the dry season to assess whether the well or spring is viable (i.e. can meet demand) . The yield has to be measured three times and the average be taken as the yield of the source. For a well equipped with a pump, information from the community on

how much water can be extracted in a 24 hour period may be more valuable than an instantaneous measure of pump yield.

Table 3.3. Yield of existing water source

Source	Yield (l/sec) dry season	Yield (l/sec) wet season

If the yield (in l/sec) for different seasons is not available, ask the following questions: How do people using this source describe its yield over the year (e.g. fluctuation between dry and wet season, months when source is dry, etc.)? Use table 3.3 below to measure the yield during the dry and wet seasons. Is the source producing enough water throughout the year for all users? If not, where do people get water from during the time when the spring is dry?

What next?

The information collected above will provide an indication of:

- Groundwater availability, groundwater quality, groundwater development potential and the likely cost of developing it (e.g. whether spring sources can be developed, or whether shallow groundwater can be accessed via wells)
- The likely resilience of groundwater resources and sources (based on an understanding or groundwater storage, and the behaviour of existing sources)
- The kinds of sources that may be feasible to develop, or rehabilitate (e.g. do existing technology types and designs provide reliable water supplies? If not, can they be developed/rehabilitated to meet target requirements, or do new sources need to be developed?

Activity 3.4: Group Exercise (1hr & 20 minutes)

Exercises 1.1

1. Describe rock types indicated below (including their hydro-geologic environment) that are most commonly found in Ethiopia. Describe their implication in water resource potential (average yield) and technology/scheme selection. For the group exercise, you will have five groups one per region.

a. Basement Rocks
b. Sedimentary Rocks
c. Riverside alluvium
d. Volcanic Rocks

Rock type	*Description of hydro-geologic environment*	*Average yield or likely Groundwater potential*	*What type of schemes are appropriate for this type of rocks with that hydro-geologic environment*
Basement Rocks			
Sedimentary Rocks			
Riverside alluvium			
Volcanic Rocks			
Other (specify)			

2. Based on the information under question number 1 above, and from the performance of one or two existing water points which you know well in your field experience and having one of the geological formation mentioned above:

i. *Describe the geology of the existing water point in terms of its ground water potential, quality and reliability.*
ii. *Describe the water point/points in terms of the type of water scheme/technology constructed; and quality, quality and reliability of providing water throughout the year.*
iii. *If nearby community (where the geology is similar to the existing water points) request for the construction of water point:*
   a. *Which technology type you propose to provide quality, sufficient and reliable water throughout the year?*
   b. *Describe the likely resilience of groundwater resources (based on an understanding or groundwater storage, and the behaviour of existing sources) to climate change and environmental hazards.*

Activity 3.3: Group presentations *(40 minutes)*
Trainees after group work on the above exercise present their work.

Activity 3.4: General Discussion *(20 minutes)*
The trainer facilitate the general discussion by asking key questions related to the topic covered, and encouraging trainees to ask question and participate actively.

Section 4: Ensuring Sustainability - Estimating Supply and Demand (Step 2)

Section Overview: This is the second step (step 2) of environmental assessment and climate risk screening). The section focuses on estimating how much groundwater is needed to meet current and projected needs of the community beneficiaries, and how big does the catchment (recharge) area of a well or spring need to be provide this water. This section describes how to identify potential sites for a well or spring that can provide water, at the required yield, on a continuous basis for domestic needs

Why this section is important?

Working through this section will help WASH staffs identify potential sites for a well or spring that can provide water, at the required yield, on a continuous basis for domestic needs. Note that the guidance provided in this section can also be applied to completed projects. In other words, an understanding of which sites are likely to provide reliable water can also help project staff identify which existing sites might fail to provide enough water during the dry season, or during drought. Marginal sites could be targeted for extra monitoring, or could be re-visited to develop additional 'back-up' sources.

Comment – catchment areas for wells and springs

If a well is sited without an adequate catchment area, this increases the risk that it will be dry, or that dry season yields will be insufficient to meet community needs.

For a spring source, local knowledge is normally used to assess whether dry season flows are adequate, and so springs will not normally be developed if the catchment area cannot provide enough water.

In both cases (springs and wells), if catchment areas are marginal in relation to required yield and demand, then any reduction in recharge, whether from climate variability or catchment degradation, will put the source under strain.

Outcome of the section: upon completion of this section, trainees will be able to:

- ✓ employ the basic rules of thumb for selecting site of a water point,
- ✓ estimate water demand based on the number of households a scheme needs to serve and their per capita water needs, and
- ✓ estimate the catchment size needed to meet the water demand.

Activity 4.1: Questioning Participants *(10 minutes)*

The trainer, before fully getting into the substance of the training, uses this activity to build anticipation for the content and to gauge how much the trainees know about the rules of thumbs for selecting water points, estimating water demands of the community, and estimating the catchment size so that the trainer can tailor his/her delivery accordingly. The trainer shall start the discussion by asking participants a few simple questions on the rules of thumbs for selecting water points, estimating water demands of the community, and estimating the catchment size. *The trainers can write the answers on flip chart.*

Activity 4.2: Power Point Presentation *(3hrs & 20 minutes)*

This activity will introduce trainees on rules of thumbs for water point site selection, estimating water demands of the community, and estimating the catchment size. The trainers shall use this session to clear up any misconceptions on these three interrelated issues. The trainers shall ask trainees if they have any question and get their feedback and reactions to the presentation.

To achieve the section objective, the following interrelated three steps (step 2.1 through step 2.3 of this section) should be implemented and followed.

Section content

- *Selecting sites - rules of thumbs*
- *Estimating water demand*
- *Estimating catchment size*

4.1. Selecting sites – rules of thumb (Step 2.1)

Before looking in detail at the catchment size needed to meet demand from a source, it is useful to look firstly at the ***topography of the project area – the relief or terrain of the land*** (*the first rule of thumb).*

The importance of drainage

Steep slopes pose a challenge for siting water points. Water within an aquifer will naturally drain to the lower parts of a catchment. In the worst case, an aquifer may have adequate annual recharge, but be unable to sustain dry season yields as recharged water drains down slope (See fig 4.1, and table 4.1 below).

For this reason both catchment area and topography (drainage) need to assess the vulnerability of a water point to change – from climate variation, environmental degradation or changes in population and demand.

Table 4.1. Importance of topography to avoid rapid drainage

Slope	Level of vulnerability
> 20 m drop off within 150 m	Highly vulnerable
10 - 20 m drop off within 150 m	Vulnerable
5 - 10 m drop off within 150 m	Possibly vulnerable
< 5 m drop off within 150 m	Adequate

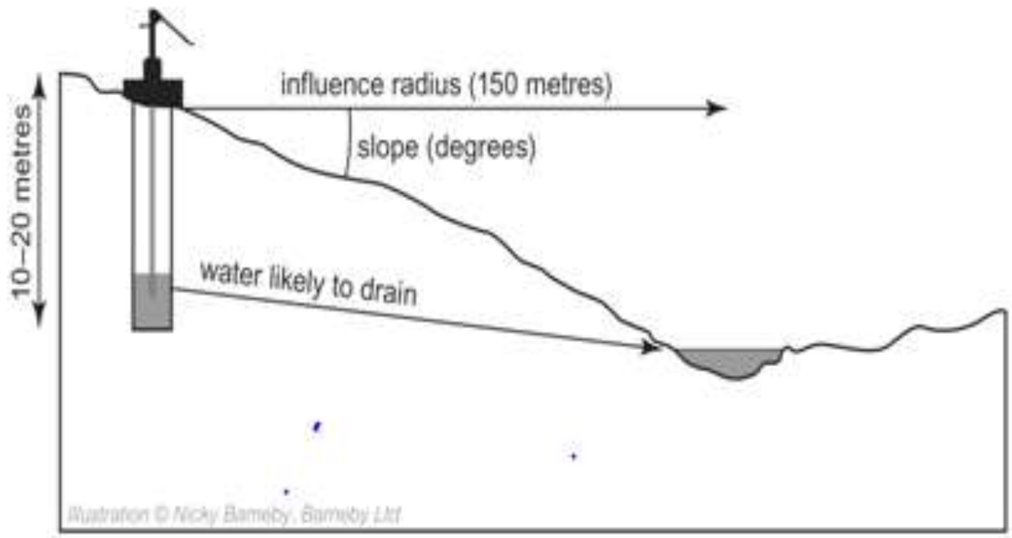


Fig 4.1. Estimating the slope to avoid rapid drainage

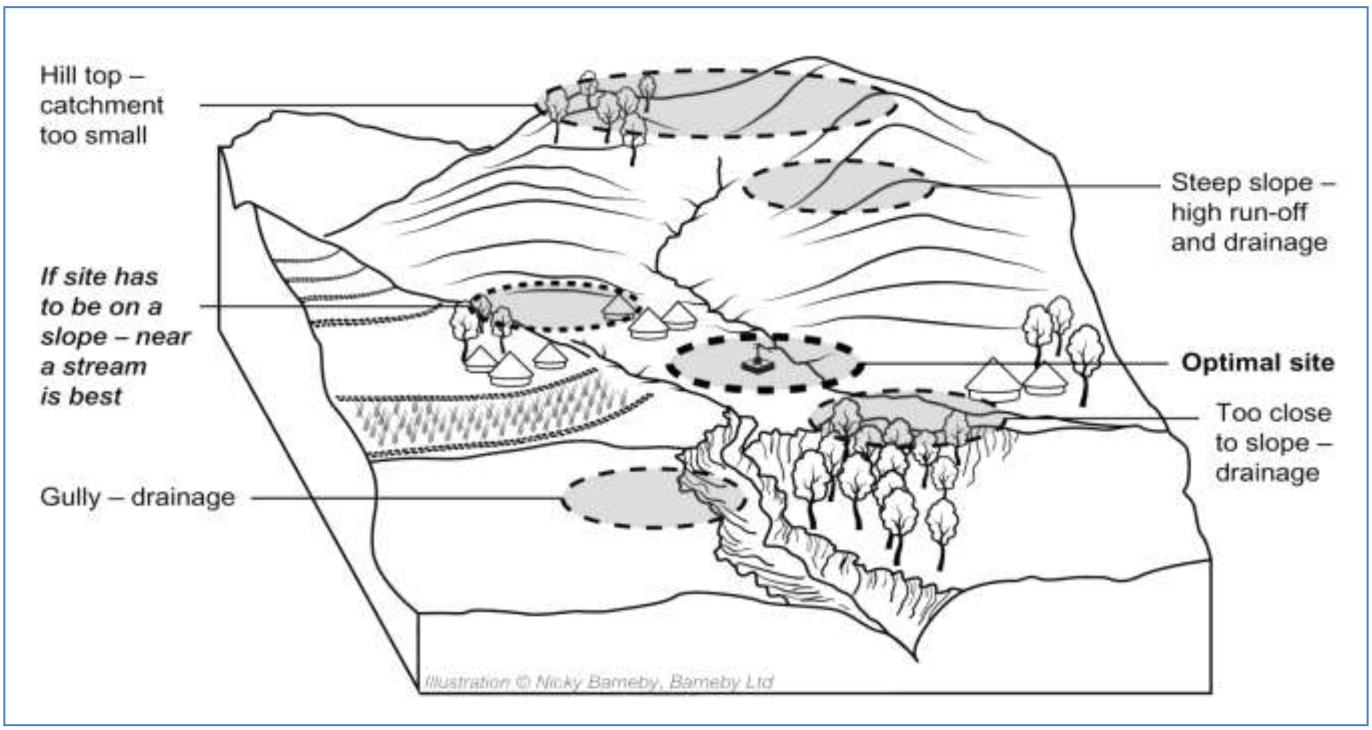


Fig. 4.2. Scoping the best sites for a water point – the influence of drainage

The ***second important rule of thumbs*** employed when selecting a water supply site is to consider ***contamination risk***. Table 4.2 below provides some similar 'rules of thumb' for minimizing the risk of water contamination.

Table 4.2. Minimum Distances from Sources of Pollution

Feature	**Minimum distance from water source**
Community-level solid waste dump	100m
Storage and dumps of petroleum or pesticides	100m
Slaughterhouses / areas where animals are slaughtered	50m
Toilets / latrines (open pit)	30m
Household waste dump	30m
Stables / kraals	30m
Main road	20m
River / lakes	20m
Laundry place	20m
Dwellings	10m

Source:

Comment – minimizing the risk of contamination
The recommended distances above will not always be possible to achieve. In densely populated areas, for example, latrines might be closer to water sources than the recommended 30 m. In such cases, it might be necessary to upgrade latrines from open pit latrines to either sealed pit latrines or latrines with septic tanks.

4.2. Estimating demand (Step 2.2)

To assess the catchment area needed to provide sustainable supply, water demand can be estimated based on the number of households a scheme needs to serve and their per capita water needs.

For domestic uses, i.e. drinking, food preparation, personal and domestic hygiene, a figure of 25 litres per capita per day (lcd) is planned for rural Ethiopia during the GTP-II period. This figure may need to be increased if sources are used for 'productive' water uses such as small-scale irrigation, brewing, brick-making or livestock watering.

Table 4.3. Estimating water needs

Water use (assuming 5 persons per household, demand = 25lcd for rural Ethiopia during the GTP-II period)			
Households	**People**	**Daily needs (m^3)**	**Annual needs(m^3)**
20	100	2.50	912.50
50	250	6.25	2,281.25
100	500	12.50	4,562.50
500	2500	62.50	22,812.50
1000	5000	125.00	45,625.00
2500	12500	312.50	114,062.50
5000	25000	625.00	228,125.00

Estimating current water demand

For 50 HHs, the total beneficiary will be 50*5 = 250;

The daily demand is 250 person*25lcd*1m^3/1000Litre = 6.25m^3

The annual demand/need = 6.25m^3*365days/year = 2,281.25m^3

Hint – estimating future demand

If to build resilience to carry out the assessment for the current number of households that will use the well/spring and how the situation might look like in 10 years' time/in 20 years' time. Also consider that a new well/water point might draw in additional people from the vicinity currently unserved.

<u>Example</u>

Current population: 250 people

Growth rate: 2.5%/year

Population in 10 years' time: 321

Formula used: $N_t = N_0 \times e^{(rt)}$ where:

Nt = Future population after t years

N_0 = Current population

e = Euler's number = 2.718

r = growth rate (e.g. 0.025)

t = Number of years

$Nt = 250 * e^{(0.025*10)} = \underline{321}$

So, estimate the daily and annual demand of the estimated population using the same water point after 10 years assuming the same 25 lcd.

Daily neeeds = 321 person*25 liter pcd*1m^3/1000Litre = 8.03m^3

The annual demand/need = 8.03m^3*365days/year = 2,929.13m^3

4.3. Estimating the Required Catchment Size (wells) or yield (springs) - (Step 2.3)

The catchment area can be used to assess the *vulnerability of a water supply system* to change (be it climate variation, environmental degradation, or changes in population and demand). *If the catchment area is sufficiently large the water point should, other factors being equal, be resilient to climate variability, and have some capacity to satisfy increases in demand. At the other extreme, catchment areas that are marginal with respect to the required yield are likely to be more vulnerable to change.*

Comment – a simplified water balance

For a system to be sustainable in the long term there must be balance between recharge to the aquifer, and discharge from the aquifer, whether natural or from pumped abstractions. An assessment of the catchment water balance for an aquifer, quantifying the sources of recharge, natural discharges and artificial abstractions (water use and projected demand) is an important part of water resource management.

A detailed assessment of the water balance of an aquifer in a catchment is complicated, requiring long term monitoring of rainfall, groundwater recharge, natural discharges (e.g. to base flows in rivers) and human withdrawals. However, simple methods can give reasonable estimates of the recharge area (i.e. catchment) needed to meet demand from a source based on *rainfall data*, assumptions about *how much rainfall recharges groundwater resources*, and the *required yield of a source.*

As a rule of thumb, and based on evidence from numerous empirical studies across Africa, recharge can be assumed as 10% of rainfall in areas with over 750mm of rainfall per year. In areas with less rainfall, the linear relationship between rainfall and recharge breaks down and recharge is related more to extreme rainfall events than averages.

Not all recharged water can be withdrawn from a well, borehole or spring. This is because some of the '10% recharge' may infiltrate deeper aquifers, discharge laterally to rivers, or evaporate back into the atmosphere. ***Recoverable*/*Extractable recharge*** may therefore be only 10 - 30% of the '10%' recharge that infiltrate into the ground water aquifer.

The required catchment area can be calculated as demand (in m^3) divided by recharge (in m), or 'recoverable recharge'.

Hint – calculating a catchment area for a source in flat terrain

Demand = 50 HH x 5 members x 25 l/day x 365 = 2,281,250 litres per year; 2,281,250 l/year/1000 = **2,281 m^3/year**

Marginal area: Recharge = 10% of rainfall of 1300 mm = 130 mm; 130mm/1000 = **0.13 m/year**
Required catchment area: 2,281m^3/year/0.13 = **17,000 m^2**

Small area: Recharge = 3% of the rainfall of 1300mm= 390mm; 390mm/1000 = **0.039m/year**
Required catchment area: 2,281m^3/year/0.039 = 56,000 **m^2**

Adequate area: Recharge = 1% of rainfall of 1300 mm = 13 mm; 13 mm ÷ 1000 = **0.013 m/year**

Required catchment area: 2,281m^3/year/0.013 = **168,500 m^2**

N.B: If the catchment area is less than the marginal area, it is ***'Inadequate area'***.

The table below shows the required catchment area for a source under different demand and rainfall – recharge assumptions, plus the required spring yields needed to meet different demands.

*Here we assume that the catchment size is likely to be **marginal** if we base calculations on an optimistic rainfall-recharge-recoverable groundwater scenario: that recharge is 10% of rainfall, and all of this (10%) can be captured by a source. Small and adequate catchment area calculations are based on more cautious assumptions: that recoverable/extractable recharge is 3% and 1% of rainfall, respectively.*

Table 4.4. Estimating the catchment size and spring yield needed to meet demand

Demand				Approx catchment area for well			Spring yield
(assuming 5 persons per household, demand = 20 litres/capita per day)				(assuming 1300mm average rainfall)			L / sec
Households	Persons	Daily needs	Annual needs	**Marginal**: Extractable recharge - 10% of rainfall	**Small:** Extractable recharge - 3% of rainfall	**Adequate**: Extractable recharge - 1% of rainfall	
		m^3	m^3	m^2	m^2	m^2	
20	100	2.50	912.50	6,700	22,500	67,500	0.03
50	250	6.25	2,281.25	17,000	56,000	168,500	0.07
100	500	12.50	4,562.50	34,000	112,000	337,000	0.14
500	2500	62.50	22,812.50	168,500	561,500	1,685,000	0.69
1000	5000	125.00	45,625.00	337,000	1,123,000	3,369,000	1.39
2500	12500	312.50	114,062.50	842,500	2,808,000	8,423,000	3.47

Hint – interpreting the catchment size table

In Table 4.4 above, the 10% figure gives the required catchment area assuming that 10% of rainfall infiltrates, and that *all of this* (100% of the recharge) is available to a water point (an optimistic assumption – see comment above). Any *existing* water point that does not satisfy this criterion is highly vulnerable, and additional sources should be provided. A proposed site that fails to meet the criterion should only be developed if there are no better options, and as one of a number of water sources.

The 10% figure indicated in the table 4.3 above assume that 100% of the recharge (10% the rainfall - 1*0.1*100% = 10%) is available to the well, 3% figure assumes that 30% of the recharge (0.3*0.1*100% = 3%) is available to a well, and the 1% figure assumes that only 10% of recharge (0.1*0.1*100% = 1%) is available. These are the extractable recharges. The latter assumption is much more cautious, and should produce water points that are relatively secure.

Once the rough catchment area in m^2 is known, the area itself needs to 'walked out' on the ground. In flat terrain, the catchment can be viewed as a circle around the water source, and the radius of the circle used to 'walk out' distances from the source.

Hint – calculating a catchment area for a source

Demand (in m^3)/recharge (in m^3)

<u>Example – flat terrain</u>

<u>Demand</u> = 50 HH x 5 members x 25 l/day x 365 = 2,281,250 litres/1000 = 2,281.25 m^3/year

Extractable Recharge = 10% of rainfall of 1300 mm/year = 130 mm/1000 = 0.13 m/year

Required catchment area: 2,281.25 m^3/yr/0.13m/yr = 17,548.08 m^2

- ⇨ Approximate square catchment = 132.47 m * 132.47 m
- ⇨ Circular catchment = 74.74 m radius from source

Example – hilly terrain:

From the selected well site, estimate the length in meters of the catchment either estimated visually or paced out upstream to the ridge line. The width of the catchment is estimated by taking the distance between ridge lines, or alternatively half the distance between the valleys or stream lines on either side of the well under investigation. The catchment area is the two measurements multiplied – fig 4.3, and example below.

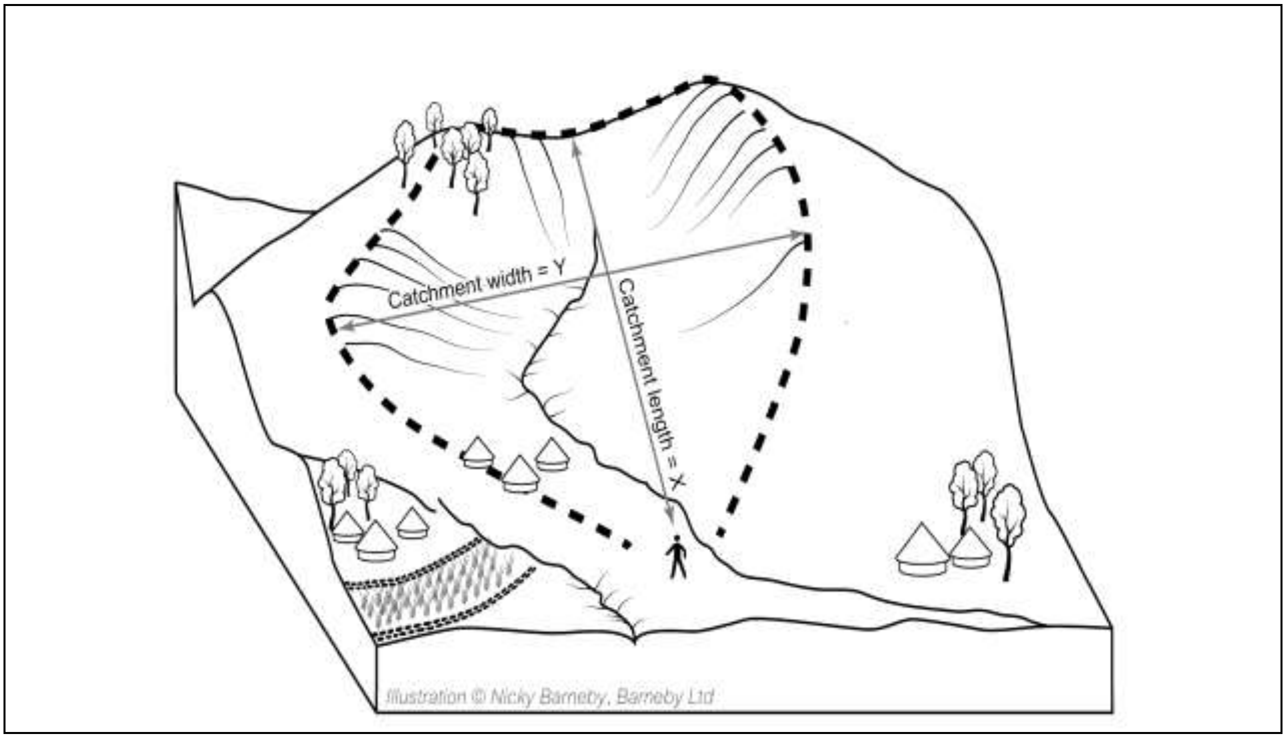


Fig 4.3. Width and Length of a catchment to calculate the size of a catchment

To decide whether it is worth developing a spring, a simple assessment is made comparing yield with demand, based on the population served, or likely to be served in future. As a precaution, the yield of the spring during the *driest period of the year* is used for the calculation.

Hint - comparing spring yield to demand
To assess whether the yield of a spring is sufficient to meet demand, calculate the total water demand of the population to be served annually and compare this to yield. The calculation of total yield should be done based on the lowest yield as measured during the dry season.

<u>Demand</u>: Number of Households*number of household members*25 l water per day per capita*365
<u>Yield</u>: spring yield (l/sec)*60sec/min*60min/hr*24hrs/day*365days/year

Example:
<u>Demand</u>: 50 households*5 members*25 l per day*365 days = 2,281,250 l/year (2,281 m^3/year)
<u>Yield</u>: Yield during driest period: 1.25 l/sec*60 sec*60 min* 24 hours*365 days = 39,420,000 l/year (39,420 m^3 / year). The yield of the spring is safe in terms of providing what is demanded.

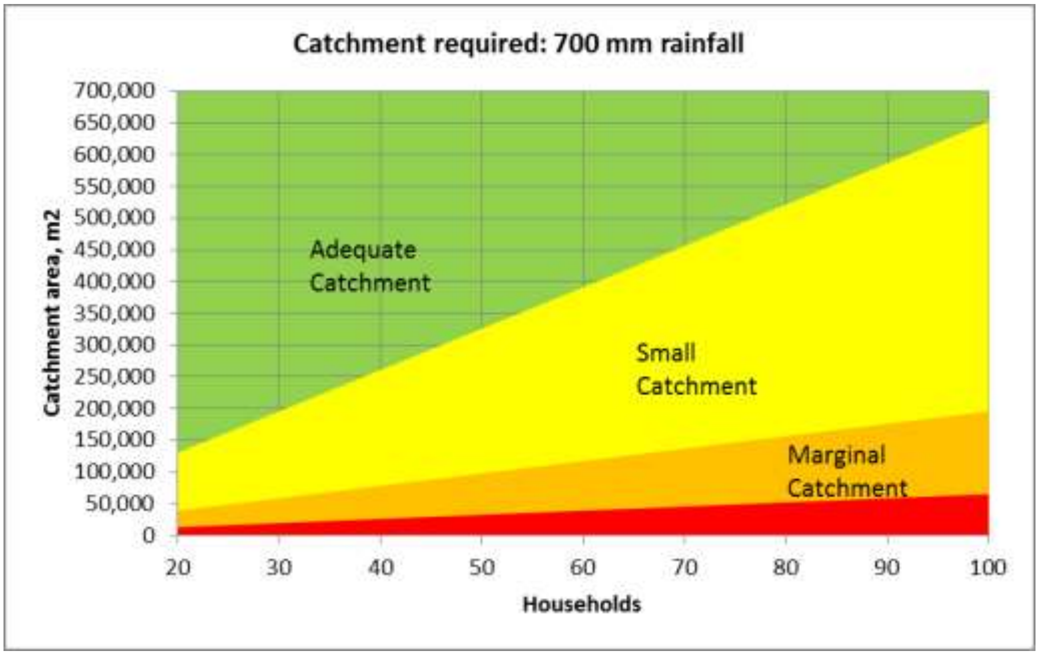
The calculations above may appear daunting for some users. For this reason, they have been embedded in the 'look up' graphs below (Figure 4.4). These allow users to find the catchment areas needed to meet demand for different numbers of households under different rainfall-recharge scenarios. Alternatively, they can be used to see if an existing well is likely to have a marginal, small or adequate catchment area.

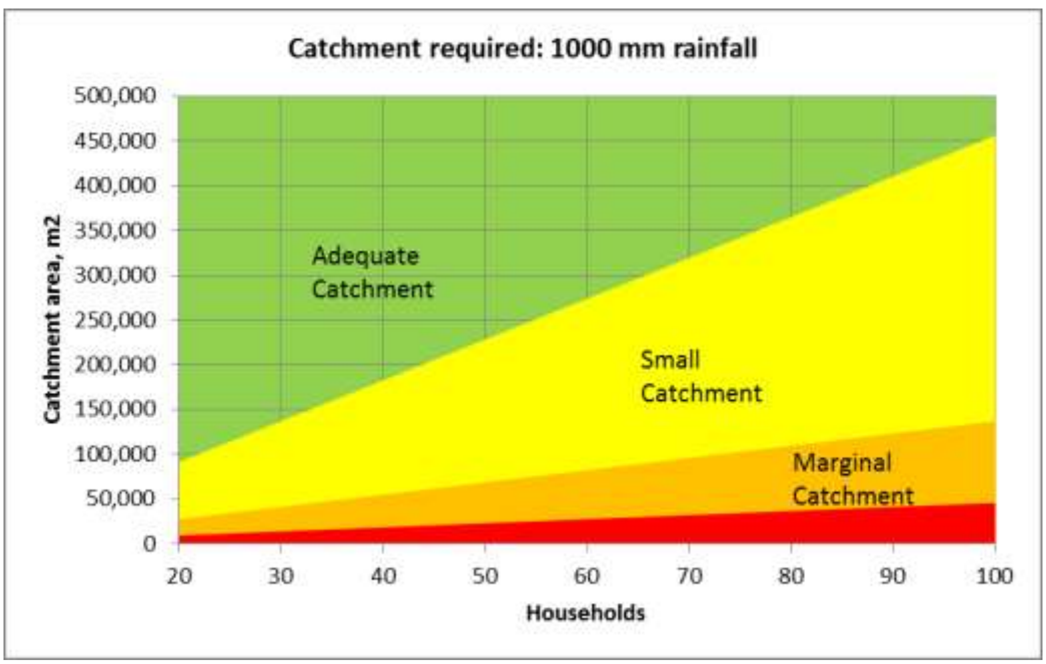
For an existing well, select the graph closest to the mean annual rainfall for the community. *Using measured or estimated catchment areas, plot the area on the vertical axis against the number of households served by the well*. If the site plots in the red zone at the bottom of the graph, the well has an inadequate catchment for current demands. In the orange, marginal catchment zone, wells are likely to be very vulnerable to seasonal variation in rainfall. In the yellow area catchments are still small and vulnerable to environmental change. If a well is in the green zone this suggests it has an adequate catchment area, although its performance will depend on local aquifer properties and topography.

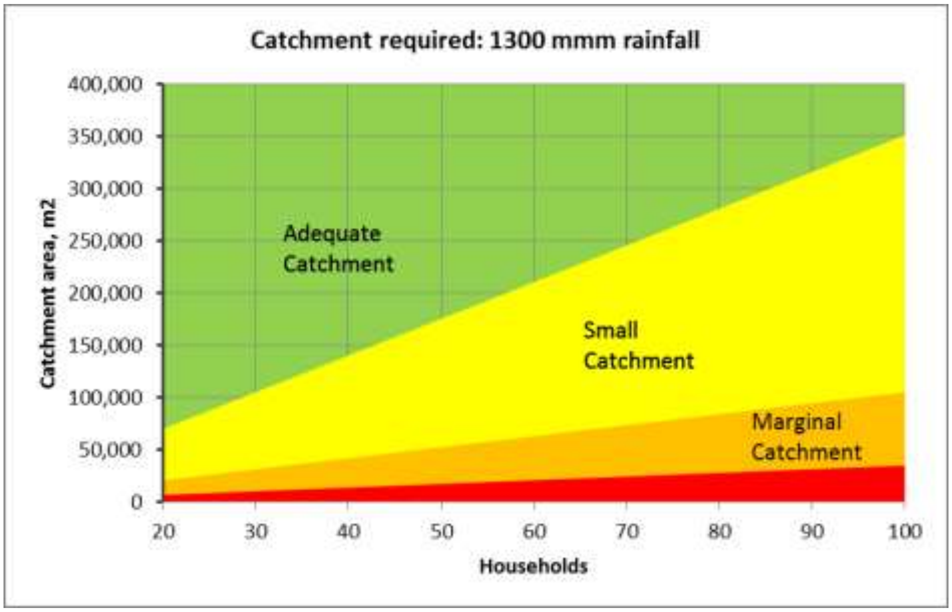
For a proposed well, the graph should be read upwards from the number of households to find areas associated with adequate, small and marginal catchments. Other factors being equal a site with an adequate catchment will be preferred. If the communities' preferred sites have a marginal catchment, the risk of seasonal well failure should be explained before commencement of excavation.

Although primarily designed to assess shallow dug well catchments, the same graphs can be used to assess the security of spring sources. If dry season flow measurements suggest a spring is marginally able to support the desired number of households, a catchment area calculation can suggest whether the spring is likely to be vulnerable to low flow in particularly dry years.

Fig 4.4. Catchment sizing for different rainfall, recharge and demand scenarios







Hint – sustainability risks for existing water points

The approach outlined above can also be used to assess whether existing water points are vulnerable in terms of their topography-drainage and catchment characteristics.

Project staff may already have an informed opinion about which sources *might* be vulnerable. They can apply the tools above to check/confirm and, if necessary, consider developing additional water sources that would help spread risk.

Activity 4.4: Group Exercise *(3hrs)*

Exercise *4.1. (30 minutes)*

1. Discuss how topography and catchment area/size influence the vulnerability of water points to climate variations, and environmental degradation or change in population and demand. How were you managing this when you were planning and implementing rural water supply?

2. Discuss the experience that you have when sitting water points to protect the water points from contamination (please do against the rule of thumbs mentioned in this module if you know them before; or what precaution measures you were taking). Did you consider the environmental health aspects of the rural water supply to ensure the water is safe?

Exercise 4.2 (2hr & 30 minutes

1. Do you estimate the population of a particular rural community when planning to construct a water point so that the water point will be resilient to the increased water demand due to population growth? For what years you predict most commonly? Which prediction formula you use? Using the following information/data and population prediction formula:

i. *Calculate the daily and annual needs (m^3) of the community; and estimate the catchment size for the 10%, 3% and 1% extractable recharge, and comments catchment size for each case. Use 1000mm rainfall data of the area.*
ii. *Predict the population after 10 years*

$N_t = N_0 \times e^{(rt)}$ *where:*

Nt = Future population after t years

N_0 *= Current population*

e = Euler's number = 2.718

Current household who requested water point construction are 70, and assuming 5 persons per household, demand = 25lcd. the population growth rate is 2.5% (e.g. 0.025)

iii. *For the estimated population under question #ii above;*

a. Estimate the daily and annual needs (m^3) of water after 10 years

b. size the catchment (for spring and well separately) for the predicted population assuming that the extractable/recoverable recharge is 10%, 3% and 1%. The average annual rainfall of the area under consideration be 1000mm. What will happen when the catchment area is 75,000m2 for the recoverable recharge of 3%? Can the water point provide sufficient and reliable water throughout the year?

c. Calculate the yield of the spring if spring is the selected technology?

d. Do you plan the water point with the current population or for the predicted one?

These exercise will also help trainees for the Woreda training which they are going to give for the Woreda people.

Activity 4.5: Group presentations *(1hr & 10 minutes)*

Trainees after group work on the above exercise present their work.

Activity 4.6: General Discussion (20 minutes)

The trainer facilitate the general discussion by asking key questions, and encouraging trainees to ask question and participate actively.

Section 5: Protecting Sites and Sources – Hazard Assessment and Mitigation (Step 3)
Section overview: This section focuses on how to assess the direct environmental hazards to the water point, and the indirect environmental degradation processes in the catchment. The importance of doing this is also discussed in the section. The section also describes how to identify measures to address direct and indirect hazards via a catchment protection plan

Why the section is important?
Besides the impacts of well construction and spring protection on the environment (e.g. cutting trees, temporary water pollution, improper disposal of dug out sub-soil), a well-protected and managed environment is crucial for the sustainability and functioning of water points. This is because:

- Direct environmental hazards, such as expanding gullies, floods and landslides can damage water points directly.
- There are indirect environmental aspects to consider as well, relating to degradation processes within the broader catchment that can affect the sustainability of a water system.

Ultimately, the sustainability and resilience of a water system is influenced by how well a catchment of a water source can absorb rainfall through infiltration - water that will eventually feed into the (shallow) groundwater on which the water system depends.

Outcome of the section: upon completion of this section, trainees will be able to:

- Assess direct environmental and climate change hazards to the water point,
- Assess indirect environmental degradation processes in the catchment, and
- Identify measures to address direct and indirect hazards via a catchment protection plan.

Activity 5.1: Questioning Participants *(10 minutes)*
The trainer, before fully getting into the substance of the training, uses this activity to build anticipation for the content and to gauge how much the trainees know about the direct and indirect environmental and climate change hazards that may result near the water points and general catchment, and developing catchment protection plan including monitoring plan to mitigate the hazards identified so that the trainer can tailor his/her delivery accordingly.

The trainer shall start the discussion by asking participants a few simple questions on their knowledge and experience on the direct and indirect environmental and climate change hazards that may result near the water points and general catchment, and on how to develop catchment protection plan including monitoring plan to mitigate the hazards identified. The trainers shall write the answers on flip chart.

Activity 5.2: Power Point Presentation (1hr & 50 minutes)

This activity will introduce trainees on the direct and indirect environmental and climate change related hazards that may result near the water points and general catchment, and developing catchment protection plan including monitoring plan to mitigate the hazards identified. The trainers shall use this session to clear up any misconceptions on these issues. The trainers shall ask trainees if they have any questions and get their feedback and reactions to the presentation.

Contents of the Section

- ✓ *Assessing Direct Hazards Near a Water Point*
- ✓ *Assessing Indirect Environmental Hazards in the Wider Catchment*
- ✓ *Developing a Catchment Protection Plan*

Once a site has been identified (section 3 and 4 of this training manual), direct and indirect environmental and climate change hazards should be assessed. If there are direct hazards in the vicinity of the proposed water point (section 5.1), these need to be addressed. If that is not possible – because of the size of the hazard or the lack of financial or technical capacity – alternative sites may need to be considered.

Figure 5.1 below summarizes the decision-making process in relation to site selection. Once a final site has been identified, indirect environmental and climate change hazards in the wider catchment of the water source should be identified (section 5.2) and addressed (section 5.3).

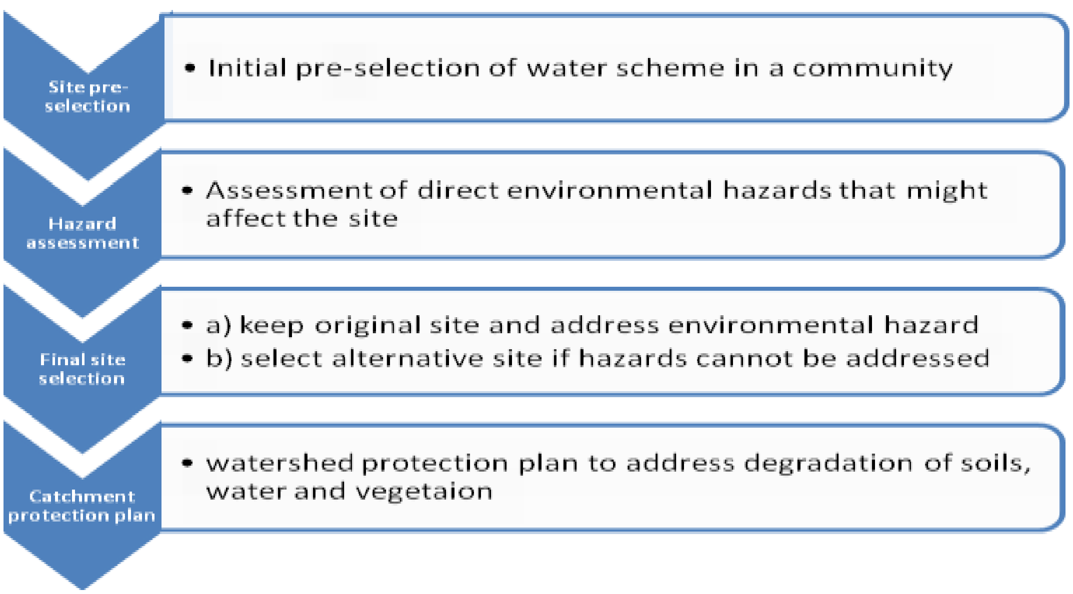


Fig. 5.1. Integrating environmental risk assessment in water point sitting

5.1 Assessing direct hazards near a water point (Step 3.1)

The first step in assessing the environmental hazards and identification of mitigation measure is assessing direct hazards near a water point. A good place to start is with a map of the vicinity of the water point (approx. 150 m radius), whether planned or an existing source – showing the main hazards and degradation features. These may include *gullies*, *areas affected by flooding*, *landslips* or *areas prone to landslides*. *Pollution risks* can also be included, such as *latrines* and *waste dumps* (see Table 5.2).

Degradation features that might not pose an immediate threat to the water point but left untreated might be a hazard in future (e.g. rills, cattle tracks developing into a gully, etc.) can also be included.

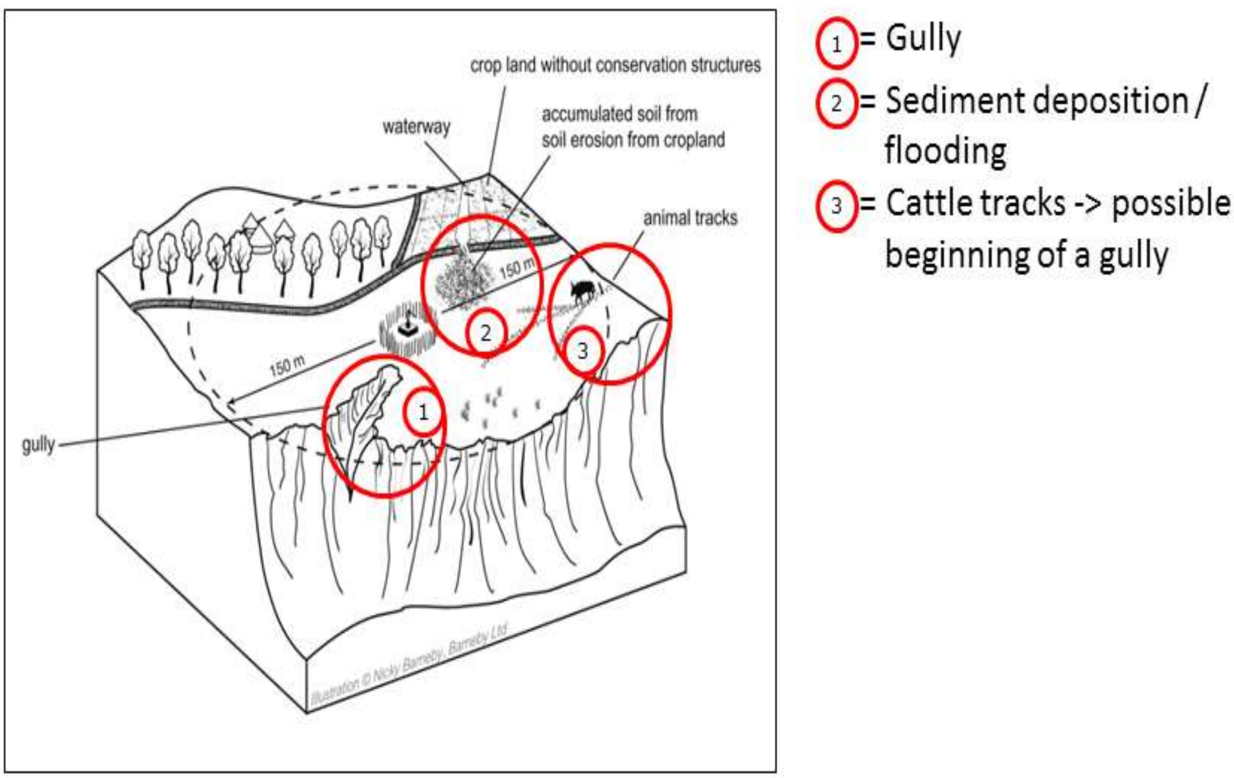


Fig 5.2. Environmental hazards that might affect a water source

In order to decide whether to go ahead or not with the final site selection, direct environmental threats should be assessed for their severity. If they are so severe that they cannot be resolved within reasonable limits, it might be better to identify alternative sites.

i. Gullies

The existence of gullies in an area do have a multitude of impacts in the rural water supply system including, but not limited to:

- Local lowering of the water table (gullies suck water from springs, dug-wells and hand pumps, because by lying below they have an effect of negative pressure)
- Damage to infrastructures such water supply schemes

Figure 5.3 shows active and deep gully that may pose serious damage to the water point both infrastructure damage and lowering of water table.

Fig. 5.3. Picture showing active and deep gully

Table 5.1 below provide a simple ‘traffic light’ system to identify whether gullies might pose a major threat to water points.

Table 5.1. Assessing the risk posed by gullies to water points

		Dimension (length x width x depth = m^3)		
		0-10m^3	11-25m^3	>25m^3
Number of gullies in vicinity of water point	1		(C)	(B)
	2-3	(C)	(B)	(A)
	4 or more	(B)	(A)	

Low

High

Example: length (25m) x width (2m) x depth (0.5m) = 25 m^3

Hint – what to do about gullies

If there is a gully or gullies in the vicinity of a water point, they need to be treated – i.e. if in a yellow-shaded cell.

Consider identifying alternative locations for a water point if you identify several and or significant gullies – i.e. in a red-shaded cell.

In both cases, consult natural resource management experts or relevant guidelines for how to do this.

If a gully of a given dimension and/or frequency is located down slope of the water point it is often *posing a more serious* threat to the water point than if the gully is located elsewhere. In that case, consider relocating the water point and initiate gully rehabilitation measures.

- If a gully of the dimension/frequency labelled 'A' in Table 5.1 above is in the down slope area of the water point, classify as highest ('severe') threat level.
- If a gully of the dimension/frequency labelled 'B' in Table 5.1 is in the down slope area of the water point, classify as second highest ('high') threat level.
- If a gully of the dimension/frequency labelled 'C' in Table 5.1 is in the down slope area of the water point, classify as third highest ('moderate') threat level.

ii. Area affected by flooding

Regular flooding

If the area where a water point is to be constructed and its immediate environment (e.g. within a radius around the site of the water point of 150 m) is regularly flooded (e.g. during the rainy season) then consider the following actions:

- Relocate the site of the water point away from flood prone areas
- Raise the well head and seal the well to prevent any polluted flood water from entering the well
- Manage water flows through cut-off drains, artificial water ways and levees
- Ensure areas from where floodwater originates is open-defecation free and free from other pollutants
- If water point is not accessible during periods of flooding, ensure alternative protected water sources are available

Periodic flooding

- Raise the well head and seal the well to prevent polluted water from entering the well.

Hint – thinking about extremes
Also consider flooding that might happen less frequently (e.g. every 5 years, every 10 years) during very heavy rainfall events that might affect a large area and/or create a lot of damage. Consider measures that might reduce the impacts of such extreme events.

iii. Landslides/slips
Landslips may occur because of a variety of natural (geological and morphological structures, such as weak or weathered material, differences in permeability of material) and human causes (deforestation, cultivation of steep slopes, road construction). Often they are found on steep hillsides where vegetation is disturbed, for example along a foot path or where rills have developed as a result of uncontrolled runoff. Landslips can also develop around springs because springs often appear at the intersection of different rock formations

Landslips need to be treated otherwise there is a danger that they expand and result in more severe damage to a water point.

Fig 5.4. Landslips/landslides

5.2. Assessing Indirect Environmental Hazards in the Wider Catchment (step 3.2)

Once a potential site for a water point has been identified and deemed safe, i.e. *not threatened by environmental and climate change hazards*, potential indirect environmental hazards should be identified in the wider catchment of the water point. This is important as natural resource degradation in the wider catchment can affect the risk of flooding, and gullying that might draw down local water tables.

Changes in land use and land degradation can also have longer term impacts on groundwater conditions by affecting local water balances. Making predictions is difficult, however, because recharge to groundwater is strongly influenced by prevailing climate, as well as land cover and underlying geology (see below).

Comment – catchment protection and groundwater recharge

Recharge to groundwater is highly dependent on prevailing climate, as well as land cover and underlying geology. Climate and land cover largely determine rainfall and evapotranspiration, whereas the underlying soil and geology dictate whether a water surplus (precipitation minus evapotranspiration) can be transmitted and stored in the sub-surface.

Land use change can have a very significant impact on groundwater recharge, and outcomes can be counterintuitive. For example, it is often assumed that planting trees and 're-vegetating' catchments will increase groundwater recharge and availability. In practice the reverse can be true, because trees and perennial native vegetation can draw up and evaporate a lot more water than grass or crop land. So a decrease in runoff and greater soil moisture retention can still translate into less groundwater recharge if plants end up using more water.

As a first step, a base map of the catchment of the water point should be drawn, main land cover units mapped and major degradation features identified. An example is provided in fig. 5.5 below, and in three-dimensional form in Figure 5.6.

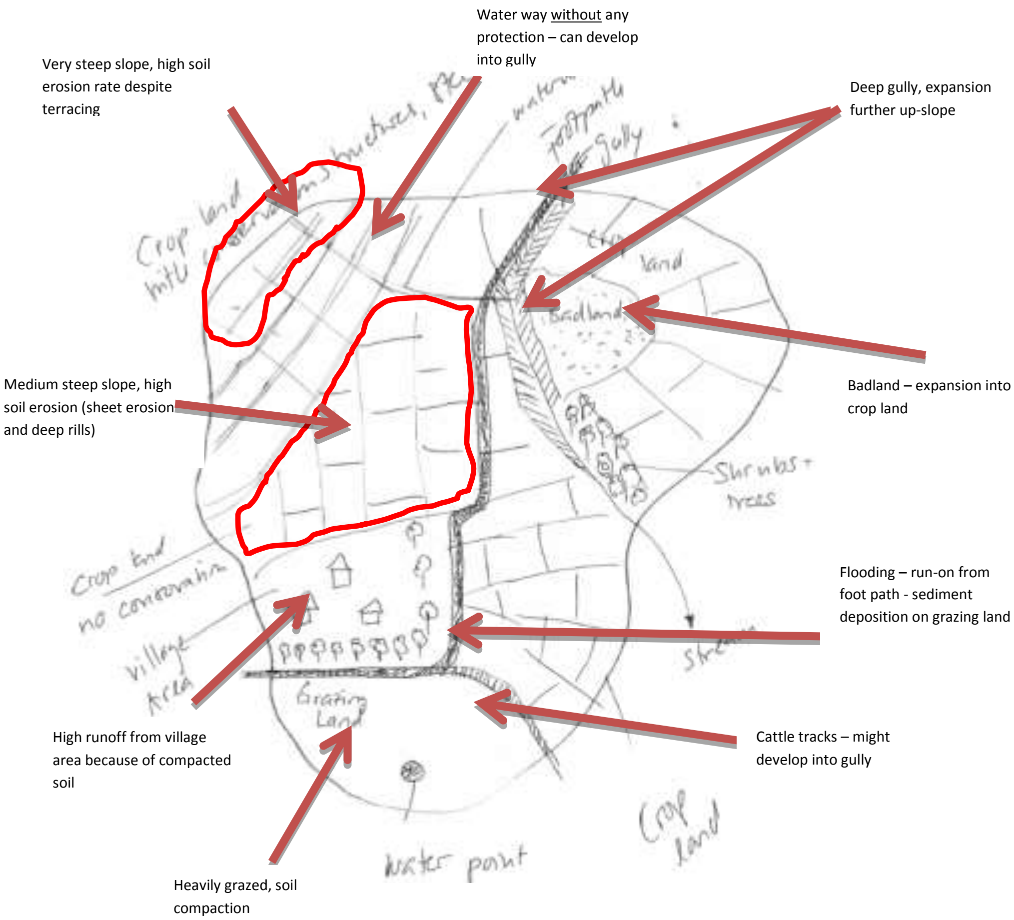


Fig 5.5. Topographic base map showing areas of environmnetal degradation and initial identification of causes

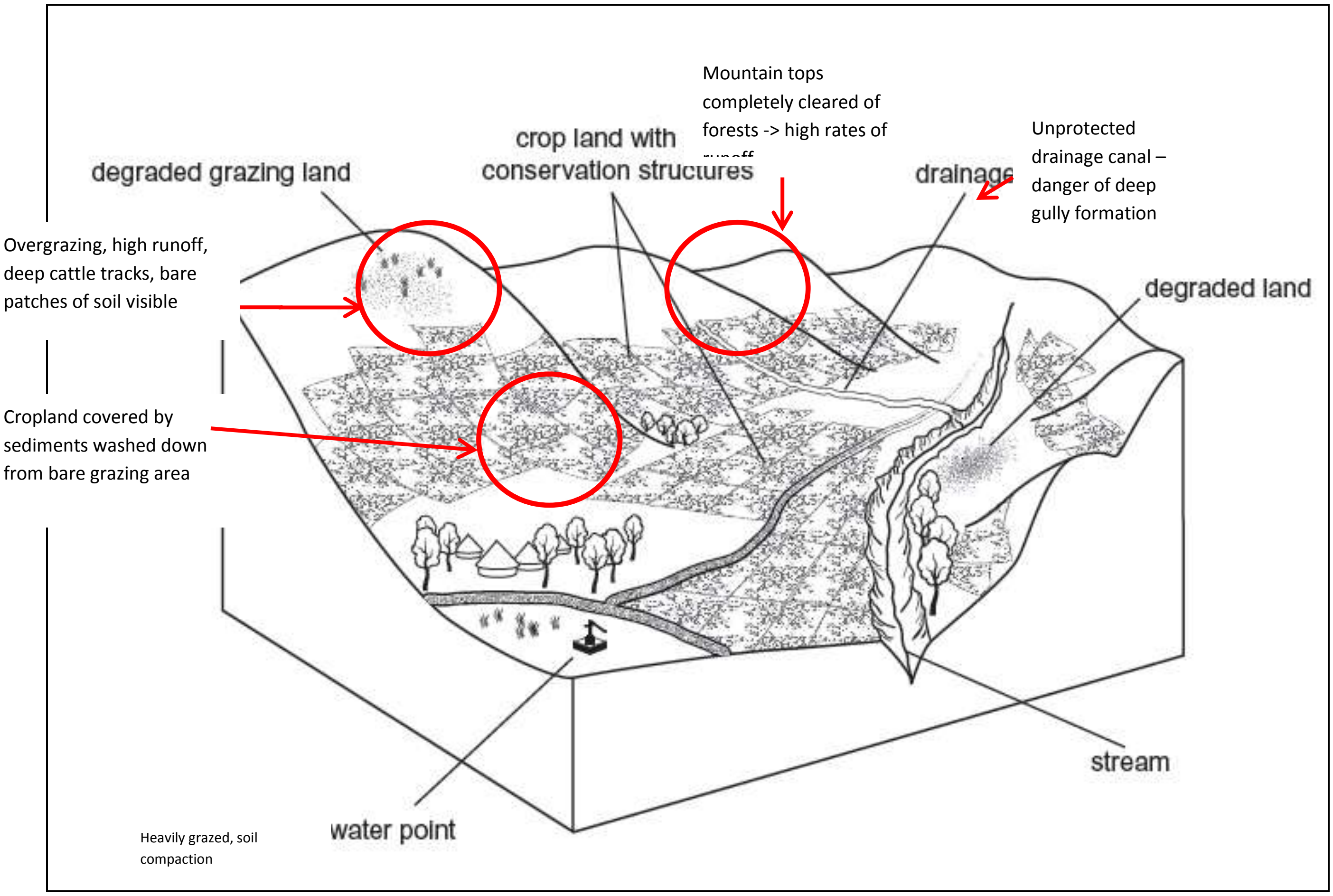


Fig 5.6. Similar base map including major areas of environmental degradation and initial identifications of causes

Hint – accounting for gender

Involve both men and women in drawing the catchment map – this might identify special features particularly important for either men or women – for example, accessing water points on a steep slope might be more of an issue for women if they are mainly responsible for collecting water. Or certain areas may be used for defacation by different groups.

Table 5.2. Examples of degradation features and possible reasons

Degradation feature	Location	Possible Reason
Gully	on grazing land	Overgrazing, Cattle tracks
	on crop land	Traditional furrows to drain excess water Ploughing up & down the slope Absence of constructing cut off drain above the crop land
	on bush/forest land	Bush/forest clearing
	as a result of foot path/sealed area/cattle track	Alignment, lacking maintenance
Sheet & rill erosion	on crop land	land management practices
Flooding	on grazing land/on crop land	Inappropriate drainage Insufficient water infiltration
Land slips	On steep crop & grazing land	Land management practices
Land slides	Along rivers, Around springs, On steep slopes	Deforestation

An assessment of the severity of indirect hazards can also be carried out. This can help establish priorities for action – see Table 5.3 below.

Table 5.3. Assessing the severity of degradation features

Description of degradation features	Severity/extent of degradation				Comments
	none	Low	medium	high	
Sheet/splash erosion on crop land					
Rills[1] on crop land					
Gullies[2] on crop land					
Gullies on grazing land					
Gullies on degraded land					
Gullies in forest land					
Sediment deposition					
Cattle step					
Land slip/land slide					
Riverbank erosion					
Deforestation					

[1] Rills = can be smoothed out completely by normal land management / cultivation practices.
[2] Gully = larger than rills and can no longer be smoothed by normal cultivation practices, persistent.

NB: Gullies or landslips identified in this step are gullies/landslips in the catchment/watershed area and are **not** a direct threat to the water point. Nevertheless, such environmental degradation features in the catchment/watershed need to be addressed as well.

5.3 Developing a Catchment Protection Plan (Step 3.3)

Using the base map drawn in step 3.2 showing the main indirect hazards and areas where degradation processes are ongoing (see Table 5.2 and 5.3), identify appropriate mitigation measures.

For all degradation processes classified as medium or high seek collaboration with relevant authorities (office of agriculture) or partners with expertise in natural resource management to identify the most appropriate conservation technology. Table 5.4 below provides some examples of corrective measures depending on the degradation feature and its location. It also provides some ideas what the underlying causes of the degradation feature might be which should be addressed as well.

Table 5.4. Possible corrective measures for main degradation features

Degradation feature	Location	Cause	Correction
Gullies	Grazing land	Overgrazing Cattle tracks Absence of cut-off drain above the grazing land	✓ Check-dam ✓ Fencing ✓ Re-vegetation of gully & surrounding areas ✓ Construction of cut-off drain
	Crop land	Traditional furrows to drain excess water Absence of cut-off drain above the crop land Ploughing up & down the slope	✓ Ploughing along the contours ✓ Cut-off drain & area closures above crop land to reduce run-on & increase infiltration ✓ Terracing ✓ Check-dam
	Bush/Forest land	Bush/forest clearing	○ Area closure ○ Cut &carry
	As a result of foot path/sealed area/cattle track	Alignment Inefficient maintenance	➢ Re-alignment ➢ Cut-off drains ➢ Stone paving and check structures
Sheet & rill erosion	Crop land	Land management practices	➢ Land management practices (e.g. contour ploughing, increasing organic matter content of the soil) ➢ Soil & stone bunds ➢ Artificial water ways ➢ Cut-off drains above crop land
Flooding	Grazing land/Crop land	Inappropriate drainage Insufficient water infiltration	○ Artificial water ways ○ Cut-off drains ○ Soil and/or Stone bunds on crop land to enhance water retention and infiltration ○ Area closures/afforestation on hill tops / steep slopes

Degradation feature	Location	Cause	Correction
Land slips	Steep crop & grazing land	Land management practices	
Landslides	Along rivers Around springs	Deforestation	○ Area closure ○ Afforestation ○ Retention walls ○ Fencing to avoid damage from livestock

Once the main degradation features and corrective measures have been identified and drawn on the base map (Figure 5.7), a catchment protection plan should be elaborated and agreed by all relevant stakeholders. Such a plan should include where which corrective measure is best suited, how much resources (labour, finance, in kind and other) are needed, who should provide the resources, who provide technical support including monitoring, and what additional material might be required.

In addition to the catchment protection plan, monitoring plan should be prepared that include the objective of monitoring, the parameters/indicators to be monitored, who and when to monitor, frequency of monitoring and the resources required to monitor.

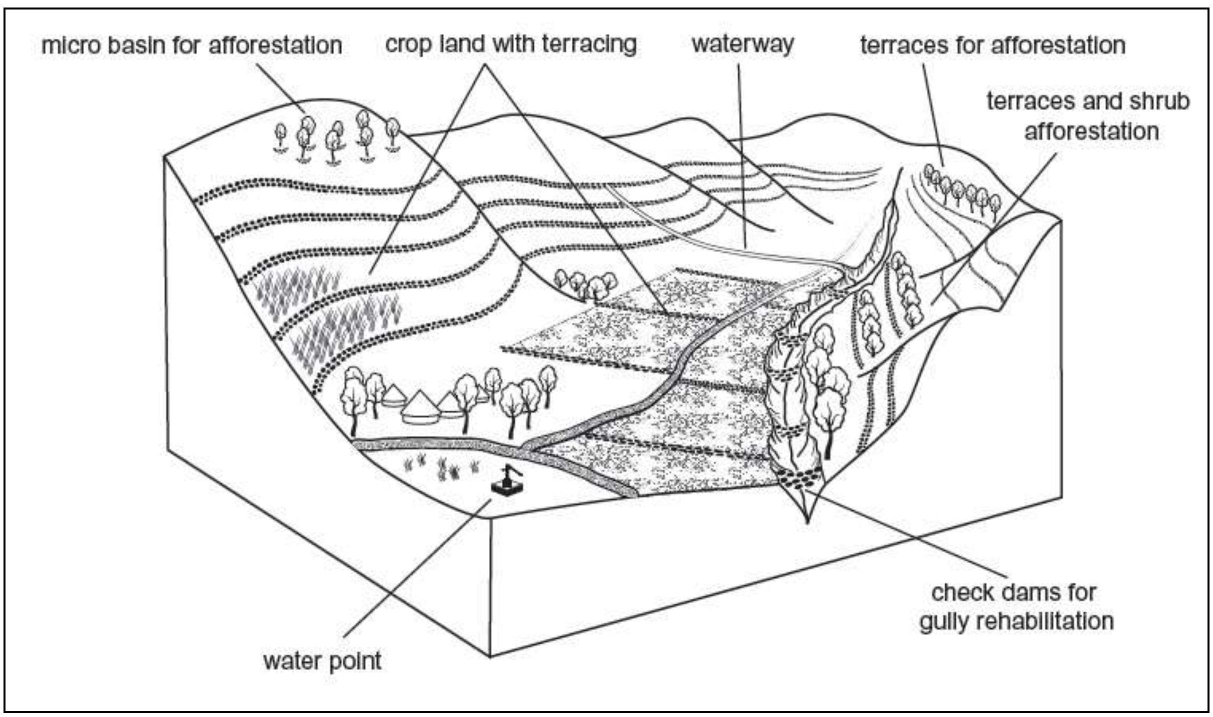


Fig. 5.7. Base map showing measures to address catchment degradation

Activity 5.3: Group Exercise *(1hr& 30 minutes)*

Group exercise 5.1

1. *Why is important to consider the direct and indirect environmental hazards when planning and implementing rural water supply? What are the implication not considering them? Answer separately for direct and indirect environmental hazards.*
2. *Discuss how you were managing the environmental hazards (both direct and indirect) when planning and implementing rural water supply schemes. Which environmental hazards were major problem in your localities? With which organizations you are working to manage these hazards?*
3. *Have you been considering the impact of climate change when planning and implementing rural water supply? Discuss how.*
4. *Take one micro-watershed in your locality that may have a number of water points within the micro-watershed. Prepare a base map and Identify major direct and indirect hazards, and develop mitigation measure to avoid or minimize the impacts/hazards. Develop catchment development plan, and monitoring plan for it.*

This will help trainees for the Woreda training which they are going to give for the Woreda people.

Activity 5.4: Group presentations *(40 minutes)*

Trainees after group work on the above exercise present their work.

Activity 5.5: General Discussion *(20 minutes)*

The trainer facilitate the general discussion by asking key questions on the topics covered in this section, and encouraging trainees to ask question and participate actively.

Section 6: Record Keeping

Section Overview: This section focuses on what, why and where to record, store and make available all relevant records of water points.

Outcome of the section: upon completion of this module, trainees will be able to understand what, why and where data should be kept.

Activity 6.1: Questioning Participants *(10 minutes)*

The trainers, before fully getting into the substance of the training, uses this activity to build anticipation for the content and to gauge how much the trainees knows about the on recording, storing and making available all relevant records of water points so that the trainer can tailor his/her delivery accordingly. The trainer shall start the discussion by asking participants a few simple questions on their knowledge and experience on recording, storing and making available all relevant records of water points. The trainers shall write the answers on flip chart.

Activity 6.2: Power Point Presentation *(40 minutes)*

This activity will introduce trainees on recording, storing and making available all relevant records of water points. The trainers shall use this session to clear up any misconceptions on these issues. The trainers shall ask trainees if they have any questions and get their feedback and reactions to the presentation. Handout should be distributed to the trainees before the presentation.

Content of the Section

- *What data should be kept?*
- *Why should data be kept?*
- *Where should the data be kept?*

What data should be kept?

- Geological field notes from reconnaissance trips
- Data from geophysical surveys (if any were carried out)
- The digging or drilling report (log), including all data relating to the drilling, construction and geological/geophysical logging, including all dry holes
- Data and results from pumping tests
- Water level (using a dipper, if required) across different season
- Number of people using the scheme and estimate of amount collected per person/household across different seasons
- Any incident when water supply system was not functional, reasons and actions undertaken
- Any incident when water supply system was damaged as a result of direct environmental hazards and actions undertake to fix the damage
- Any chemical, biological and physical parameters from water testing.

Why should data be kept?

This kind of information is helpful in building a picture of the hydrogeology of an area and can help better inform future water scheme developments. For example, it may help governments to develop planning tools, it may help the district hydro-geologist to increase his/her understanding of the groundwater occurrence in the area and it can help implementing partners in their decisions to develop further water schemes.

Where should the data be kept?

Collected data should be kept at local level and a copy should be made available to local and district authorities (e.g. at the office of the district water authority) and to implementing partners.

Hint – drilling logs

A drilling log is a written record of the soil layers and/or geological formations found at different depths. Soil/rock samples should be taken at regular depths (e.g. every meter) and described during the drilling or digging process. The soil/rock description is then recorded in the form of a drilling log. The drilling log will help to determine:

- ✓ The right aquifer for installation of the well-screen
- ✓ Depth and length of the well-screen
- ✓ Depth and thickness of the gravel pack
- ✓ Location of the sanitary seal

Activity 6.3: General Discussion *(20 minutes)*

The trainer facilitate the general discussion by asking key questions, and encouraging trainees to ask question and participate actively. The discussion may focuses on the experiences of training on managing records (what, why, and where aspects of keeping records).

Field Exercise (1day)

On the fourth day of the ToT in the afternoon, a half day field trip will be organized for the trainees exercise on all aspects of the issues covered by ToT manual with the objective of making the training practical. On the fifth day of the training, in the morning, trainees being in their respective groups will prepare power point presentation. On the same day in the afternoon, they will present their group exercise, and will have discussion based on the presentations.

1. Place of the field exercise

Since the ToT will be organized in Bahir Dar, the site will be most probably in Farta Woreda Woreda. The site will be selected in consultation with Amhara region RSU. It will be selected latest mid October 2015. The site to be selected need to have at least one water point (two preferable). WASHCO members are important to be there as the trainees may ask them questions regarding the performance of the water points, history of the water point, challenges, and other related issues. Woreda CMP supervisor also important to be there to give some information.

2. Objective of the field visit

The objective the field visit and exercise is to enable the trainees practice what they have acquired in theory so that it will help them to prepare them to cascade the ToT to Zone and Woreda trainees later on.

3. Group work on the field exercise (3hrs & 30 minutes)

Issues/focus area to be covered by the field visit

The trainees, after having the field visit, will work on the following:

i. Describe the geology of the site and its implication on ground water potential, and appropriate technology.

ii. Comment on the type of existing water scheme in relation to the hydro-geologic environment of the site. Is the existing water scheme appropriate? If not why? If yes, why?

iii. Describe the vulnerability of the water resource of that particular site to climate change and environmental hazard.

iv. Ask the yield of the water point during the driest period. And then, based on the annual rainfall data of the site/area and the total beneficiary of the water point (for both current and design), size the catchment. Is the catchment of the existing water point sufficient assuming that the recoverable recharge to the aquifer is 10%, 3% and 1% of the annual rainfall.

v. Draw a base map of the catchment of the water point consisting of main land use type, major environmental hazards (both direct and indirect), and possible reasons for the hazards.

vi. Rate the severity of the environmental hazards observed using the table below

Description of environmental hazards	**Severity/extent of hazards**				**Comments**
	none	Low	medium	high	

vii. Prepare catchment development plan (with separate development map).

Environmental hazards	**Location**	**Cause**	**Correction/mitigation measures**

viii. Develop a monitoring plan for the catchment development plan.

4. Group presentations *(2hrs)*

Presentation content

Two groups will present the observation of their field exercise. The group presentation will have the following content.

A. General description of the site (Woreda, Kebele, site, type of water scheme, beneficiary number - Male & Female).

B. General condition of the water point (functionality, protection of the water point - fencing, catchment protection, ...)

C. The answers of the field exercise questions indicated under #3 above of this field exercise.

Reference

1. Easter Nile Subsidiary Action Program (ENSAP), 2012. A field guide on gully prevention and control, Addis Ababa, Ethiopia.

2. Roger Calow, Eva Ludi, Andrew McKenzie, Seifu Kebede (2015). Climate Risk Screening for rural water supply in Ethiopia, a guidance note for program staffs, Addis Ababa, Ethiopia.

Annex 1: **A field guidance sheet that can help the user identify rocks and their water resource potential**

Basalt– Identification in shield volcanoes

Morphology: Cliff forming, flat topped, sharp edges

Outcrop: Variegated when weathered & dark when fresh

Hand-specimen: Minerals rarely visible, dark colored

Water schemes implication

- Zoned groundwater occurrence
- Groundwater occurs in joints, between flow contacts and in weathered top;
- Fractured zone is Low storage, high permeability ;
- Scorea zone is high storage high permeability; Weathered zone is high storage low permeability;
- Springs generally contact and focused type;
- Water quality is generally good ;
- Seasonal water level fluctuation is generally small
- Wells fill rapidly once pumped;
- Lining required near top (0-6 meters) and can be open in lower part
- Target weathered tops for successful water point
- Weathered zone is diagable, fresh zone is not

Trachyte– Identification in shield volcanoes

Morphology: dome forming

Outcrop: rounded cliff; low weathering degree

Hand-specimen: visible crystals/minerals; grey color, heavy

Water schemes implication

- Low storage, low yield, low permeability;
- Groundwater occurs in joints, between flow contacts and in weathered top (weathering is low in trachytes);
- Fractured zone is Low storage but high permeability ;
- Springs generally contact and focused type;
- Water quality is generally good ;
- Seasonal water level fluctuation is generally large;
- Wells fill rapidly up on drainage
- Low diggability

Volcanic ash– Identification in shield volcanoes

Morphology: gentle slope undulating; slope break when hard

Outcrop: Light colored, friable, sugary texture

Hand-specimen: light weight, porous

Water schemes implication

- Low yield but sustainable;
- Diffuse springs;
- Low water level fluctuation between wet and dry periods;
- High storage but low permeability (release to well);
- Springs generally diffuse discharge type;
- When deeply weathered is poor water bearing formation;
- Water quality is generally good may contain high F;
- Water level least vulnerable to rainfall variation
- Dispersion of ashes lead to sedimentation in well bottom– periodic dredging of sediment needed,
- Optional lining required in the top part

Alluvial sediments (Regolith)– Identification in shield volcanoes

Morphology: flat plain bounded by higher grounds

Outcrop: Occurs in foot hills of mountains, adjacent to rivers

Hand-specimen: Mix of clay, silt, sand, gravel, pebble, cobble

Water schemes implication

- High storage, high yield;
- Low to medium water level fluctuation between wet and dry periods;
- High storage and medium to high permeability;
- Springs generally diffuse discharge type;
- Water level least vulnerable to rainfall variation (decrease in recharge);
- Groundwater occurs in courser part of the formation;
- Groundwater occurs also at the contact between the soft rocks and underlying bed rock;
- Underlying weathered and decomposed bed rock is good water bearing zone;
- High digability, but vulnerable to collapse, need lining all the time

Annex 2: Groundwater potential of major African hydro-geological environments

	Hydrogeological sub-environment	GW potential & average yields	Groundwater targets
Crystalline basement rocks	Highly weathered and/or fractured basement	Moderate 0.1- 1 l/s	Fractures at the base of the deep weathered zone. Sub -vertical fracture zones.
	Poorly weathered or sparsely fractured basement	Low 0.1 l/s – 1 /s	Widely spaced fractures and localised pockets of deep weathering.
Consolidated sedimentary rocks	Sandstone	Moderate – High 1 – 20 l/s	Coarse porous or fractured sandstone.
	Mudstone and shale	Low 0 – 0.5 l/s	Hard fractured mudstones Igneous intrusions or thin limestone / sandstone layers.
	Limestones	Moderate – high 1-100 l/s	Fractures and solution enhanced fractures (dry valleys)
	Recent Coastal and Calcareous Island formations	High 10 – 100 l/s	Proximity of saline water limits depth of boreholes or galleries. High permeability results in water table being only slightly above sea level
Unconsolidated sediments	Major alluvial and coastal basins	High 1 – 40 l/s	Sand and gravel layers
	Small dispersed deposits, such as river valley alluvium and coastal dunes deposits	Moderate 1 – 20 l/s	Thicker, well-sorted sandy/gravel deposits. Coastal aquifers need to be managed to control saline intrusion.
	Loess	Low – Moderate 0.1 – 1 l/s	Areas where the loess is thick and saturated, or drains down to a more permeable receiving bed
	Valley deposits in mountain areas	Moderate – High 1 – 10 l/s	Stable areas of sand and gravel; river-reworked volcanic rocks; blocky lava flows
Volcanic Rocks	Extensive volcanic terrains	Low - High Lavas 0.1 – 100 l/s Ashes and pyroclastic rocks 0.5-5 l/s	Generally little porosity or permeability within the lava flows, but the edges and flow tops/bottom can be rubbly and fractured; flow tubes can also be fractured. Ashes are generally poorly permeable but have high storage and can drain water into underlying layers.