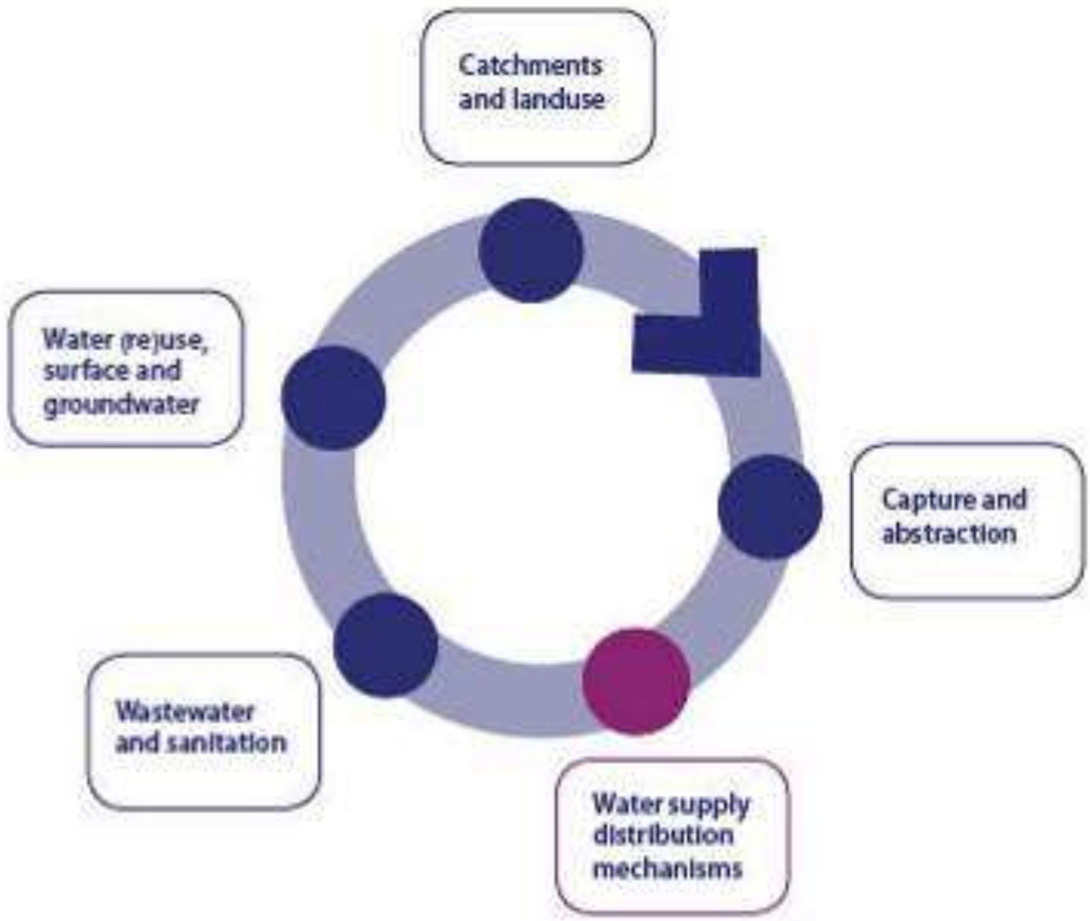
Guided Learning to Improve Water Catchment Management with Emphasis on Water Utilities in Ethiopia



Guided learning to improve water catchment management with emphasis on water utilities in Ethiopia

These Guided Learning modules have been developed to support the S2TAB project to reach out to water utilities in Ethiopia to benefit from the experience of the project partners. The concept of guided learning has been applied in different locations in Ethiopia.

The development of the modules has been a collaborative effort under guidance of Jan Teun Visscher with key inputs from Girma Senbeta and Simon Chevalking from MetaMeta. The course modules are based on training activities that were implemented in the S2TAB project with the water supply companies from Addis Ababa and Adama. Some of the illustrations in the manual are taken from the work done by course participants

January, 2020

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Preface

Significant progress has been made in the provision of safe water supply both in urban and rural areas in Ethiopia in the past 20 years. The comprehensive Water Sector Policy and the Water Sector Development Plans of the Government of Ethiopia have been very instrumental for making progress, but still very important challenges exist related to ensuring access to safe drinking water and the financial sustainability of water supply companies. The challenge is to provide higher levels of service at a fair price to a growing population in a sustainable manner.

The second Growth and Transformation Plan (GTP II) covering the period 2016 to 2020 stipulates increasing the safe water supply coverage, upgrading the service level, ensuring good governance in urban and rural water supply to enhance sustainability, effectiveness, efficiency, as well as including climate resilient WASH and emergencies and building the sub-sectors' overall capacity. GTP II includes the overall rural goal to raise water coverage to 85 per cent with a per capita water consumption rate of 25 l/c/d and within a one kilometre radius by 2020. The urban goal is to raise coverage from the current 54.7 per cent to 75 per cent with per capita consumption of between 40 and 100 l/c/d, according to the set classification of towns. These are ambitious goals that cannot be achieved without making important efforts to protect the water sources and water catchment areas.

Many water companies in Ethiopia face considerable problems due to man-made interventions in their catchment or recharge areas, changing conditions in the environment and climate change. Water patterns, including water quantity and water quality may change due to interventions in water catchment areas and competition over water sources may increase due to interventions of other actors from industry and agriculture. These interventions may represent a very serious risk for the sustainability of the water sources and may increase competition over water sources as water availability may reduce and water sources may become more polluted.

It is crucial for Ethiopian water enterprises (both urban and rural) but also for other water users that the sustainability of their water sources is guaranteed. This implies that the enterprises need to interact with multiple (level) actors to be able to achieve this. Whereas enterprises may have the knowledge and capital to protect their sources they do not have the authority and the right mechanisms do so.

The Source to Tap and Back Program (S2TAB) is particularly looking at the water catchment areas that are essential for AAWSA and ACWSA. It is working with the different actors involved to jointly identify the risks in the catchment area of the water supply of these water companies in order to be able to prioritise these risks and identify and propose catchment protection plans that include specific mitigation measures to counter the main risks. The development of these plans was taken up in a staged approach which included training and subsequent development and discussion of the plans. The experience obtained with this approach forms the basis for this training manual which aims at supporting the development of practical action plans for catchment area assessment and protection. The manual includes practical approaches to delineate, and assess the situation in, catchment areas as well as suggestions for mitigation and protection measures. This course is meant to facilitate water enterprises engagement in developing and rolling out of water catchment protection together with local stakeholders by having learned about the legal framework, bio-physical and social context of a catchment or recharge zone of a water source

Taking into account the limited impact of class room teaching as well as the relatively high turnover of staff an innovative approach to capacity building is chosen. In this approach, training activities are embedded in the daily routines of staff. Key to the approach is that participants in the course obtain a set of training modules as a document, complemented by the same course package and additional resource materials in electronic form. The self-learning modules comprise key information, specific field assignments with 'learning-by-doing' exercises and a question and answer section where participants can check their own progress. The training is arranged in short modules each of which addresses a main issue that needs to be understood by participants, some practical exercises that can be implemented at the place of work and questions to review the level of learning.

Together the modules build up towards making an assessment of the water catchment area(s) and a plan to improve and better protect these areas. The exercises are implemented by participants and together they will build up to the water catchment management plan. Preferably the effort is implemented with help of facilitators including for example staff of different organizations that have been working in theS2TAB project in the field of water catchment management. An interested water company can approach these actors and involve them in the role of facilitators. In that case participants that use the training modules can share the results of the exercises with these course facilitators through internet, normal mail and/or face to face contact.

Facilitators should come to the place of work of the small groups of trainees and go with them into the field to jointly review the main field assignments. The main premises underlying the approach is that practical, problem-based learning can make a difference in the performance of staff and can support them to develop a water catchment management plan that is revised by external advisors and can be directly implemented. The modules can also be used to quickly introduce new staff joining the water utility to water catchment management and in that way help to reduce the negative impact of high turnover of staff.

I. General introduction to the course

Considerable efforts have been made in Ethiopia to improve water and sanitation coverage. As a result the number of improved water supply systems is growing but management and maintenance of these facilities is not well developed putting their sustained functioning at risk. Another serious threat to the water supply systems are problems related to the sustainability and protection of their water sources.

According to FAO (2016) important environmental issues related to water management are erosion and siltation of water infrastructures. Erosion is caused by natural factors, such as topography, torrential rains and wind. It is also caused by human activities, in particular deforestation for agriculture, charcoal, construction, roads, mining, or by grazing, all due to unsustainable utilization and rapidly expanding human and livestock populations. Silt content of most rivers is high and as a result, water bodies are silting up. Sedimentation in dams, such as the Koka, Aba Samuel, Borkena and Gondar, reduced their storage capacity. Water levels of natural lakes have decreased, in particular Awasa, Abaya, Alemaya, Lange, Rudolf, Chew Bahir, Adele and Zway, and some show signs of drying up.

Water pollution is still limited to industrial, mining and urban areas, but is a growing problem as most cities and industries discharge their waste into nearby water bodies without any treatment. Also irrigation management is a growing problems resulting in nutrients reaching the water bodies. The effect is increasing pollution of water bodies with industrial chemicals, but also with nitrates and phosphates leading to water hyacinth infestation and algal blooms.

Water catchment management thus becomes crucial to ensure the sustained functioning of water supply systems. A complicating factor is that the water utilities do not have a clear say in water catchment management. FAO (2016) also indicates that the country possesses twelve major river basins. However only in three of these basins River Basin Authorities have been established to ensure integrated water resources management at basin level. Basin Master Plans are expected to rule and detail water allocation, but since most of them are outdated, they do not reflect the actual water needs. In addition, formal water rights are not yet in place, so customary water rights dominate, such as for example the rights associated to communal land tenure in pastoralist areas. However, but these traditional institutions are not always adapted to increasing water scarcity and mobility. This implies a complicated situation for water utilities which need to pay more attention to the situation in the areas where their water comes from.

In many municipalities in Ethiopia the situation is even more complex as the population has access to multiple water sources and their use may vary over the year depending on water availability. So during part of the year users may prefer these other water sources for which they may not have to pay, thus leaving the water utility with lower income during those periods.

Management of water utilities are key actors to initiate better water catchment protection even though it is not their legal role. They have a very big stake in good water catchment management as they completely depend on it for the long term sustainability of their water source(s). This training will help their staff to seek to work with other actors to explore the situation, identify the prevailing risks and to identify mitigation measures and to jointly develop a water catchment management plan. The training course includes the following course modules:

1. ***Integrated water resources management (IWRM)*** which helps participants to understand the overall concept, the water cycle as to obtain some insight in the legislation that is involved
2. ***Water catchments*** which includes learning about the concepts involved and approaches to identify and prioritise important water related problems in water catchments
3. ***Actor analysis*** which helps participants to obtain an overview of the actors involved and their possible interests
4. ***Practical improvement measures*** which includes an overview of different solutions that have been applied in water catchments
5. ***Towards implementation of a water catchment plan*** which includes completing the plan and a management and monitoring programme

At the end of the course participants will be able to: Indicate the main problems related to their water sources, will have developed a water catchment improvement plan and can explain this plan to the management of their utility and to other actors.

II. How to go about the course

This training course follows an innovative approach of guided self-learning, where participants can access training modules, resource materials and resource persons, in different ways. The access may be through a paper based approach, electronic devises or the Internet. Participants will learn in their work environment and have face to face contact with fellow participants, course facilitators and resource persons. A proposed structure and possible timing of the course are shown in Table 1. Timing is based on an on average availability of one day per week. A shorter period can be used if participants have more time available per week or are already having considerable experience.

Table 1. Possible course structure and timing

Module	Activities	Timing of completion
Preparation	Formation of teams of trainees Agreement with water utility Development of a description of the water system by trainees	Prior to introductory workshop
Introductory workshop	Identification of trainer per team Establish contact arrangement with trainer Review Module 1 and key concepts of module 2 and 3	Start: two day meeting; (alternative is to visit trainees in their utility)
Module 1	Revisit module 1,and revise the information on the water supply system with the team and complete assignment	End of week 2
Module 2	Review module 2, meet with team, explore the water catchment area, seek support as needed, submit assignment	End of week 3
Module 3	Review module 3, meet with team, make an overview of actors and their possible interests, submit assignment and meet with facilitator	End of week 5
Module 4	Review module 4, meet with team, explore improvement options for your catchment area(s), submit assignment and meet with facilitator	End of week 7
Module 5	Review module 5, complete assignments, complete the plan and the monitoring system; discuss with management and meet with facilitator	End of week 9
Final review	Half day meeting with management and other relevant actors to present and discuss results;	Week 10
1. All assignments can be done in your utility, but some may require visiting the catchment area and water intake		

The course includes field assignments in which participants will work in small teams. Assignments in principal can be done in the area of their water supply system and may include interviewing for example water users, testing water meters, checking for leakages, and talking to staff involved in repairs.

Module 1 Integrated Water Resource Management

This module provides an introduction to Integrated Water Resource Management and Water Catchment Management in Ethiopia. At the end of this module the participant will be able:

- *to explain the concept and components of IWRM and WCM*
- *to present and explain the water cycle and its relation with water supply and demand*
- *to present the main features of IWRM related legislation*

1.1 Introduction

Many water supply systems in Ethiopia face considerable problems with their water sources. For surface water based systems this may include having to cope with increasing loads of suspended solids, increase in nutrient content that may lead to algal blooms and increase in chemical and microbial water pollution. They also may face changes in runoff patterns in the catchment area leading to more extreme changes in the water discharge of rivers higher peak flows and stronger reduction in water discharge in the dry season. These problems may be the result of changes in the water catchment areas (deforestation, agriculture practices, road construction, growth of settlements, etc.), change in behaviour of other water users including higher water abstraction for irrigation.

Such problems may have a very negative impact on the quantity of water that is available for the water company with peak flows possibly damaging water intake structures. It may also affect water quality which in turn may increase water treatment requirements and cost.

For ground water based utilities the water sources also may be affected because of changes in the water recharge areas of the aquifers. On the positive side recharge may be increased due to changes in the catchment area, but it is far more common that water recharge is reduced and also that groundwater is increasingly used by other water users and particularly by farmers for irrigation. The result may be that water tables are falling thus implying that water has to be pumped from greater depth which involves higher cost and may require the construction of new boreholes. Falling water tables may also have an impact on water quality which in turn may require changes in water treatment.

It is therefore crucial for water utilities to review the performance of their water sources in terms of water quality and quantity and to be aware and try to influence possible developments in the water catchment areas that are related to their water sources. This situation is not unique in Ethiopia, but is a necessity for all water utilities around the world with some being in a better situation as in a growing number of countries government is more actively involved in water catchment protection.

Effective assessment of the situation in the water catchment areas and water recharge areas can help utilities to respond to both current and future challenges to sustain the performance of their utility and to meet the need of their customer. This includes putting attention to systematic data collection to be able to monitor the behaviour of the water source(s) in terms of quantity and quality.

Water catchment management is part of Integrated Water Resources Management (IWRM), the process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2018).

The importance of IWRM is growing as all human activities and natural processes are related to water. However, it is no longer a guaranteed resource for all uses. The limitations associated with water resources include the growth of the population, which generates a greater demand for food and drinking water, the increase in economic activities, the growing pressure on ecosystems, important coordination problems between actors, and climate variations and climate change. Hence the management of water resources must address the social challenges of managing the various natural 'commons' in the face of changing social and natural circumstances.

Different instruments may be available to support IWRM (Table 1.1) with their application depending on the local context.

Classification	**Type of instrument**
Voluntary mechanisms	Water reuse (little used) ISO to improve business management (more private sector) Cleaner Production Mechanisms
Command and control	Licences Concessions Water basin management plans
Economic instruments	Water use fees Charges for waste water discharge Subsidies Water markets
Government expenses	Institutional strengthening Financing infrastructure

The approach in this module is less comprehensive than IWRM by focusing on just water catchment management, particularly looking at imminent risks that are present in the catchment area that may affect water quality or the quantity of water that the water supply system requires. It is to be noted that this risk assessment and possible risk mitigation is a first step that in quite some cases may require a more comprehensive follow-up to move towards the development of a comprehensive integrated water resources management plan for the catchment area and the water basin in which it is located. The initial fact finding is crucial however as it will show the problems and risks the water supply system is facing which then can be used to discuss the situation with relevant other actors instead of just waiting until serious water quality and quantity problems occur which at that time may be impossible to solve.

One special feature of the conditions in many small and medium towns in Ethiopia that should be kept in mind is that particularly in smaller communities people have access to multiple water sources. This may imply that the utility may be competing with other water sources including for example polluted rivers, rainwater fed ponds and shallow wells. Although some of these supplies may be unacceptable to outsiders, they may be well appreciated by local user. People create their own 'world view' and have their own perception of their situation which is shaped by history. This makes that the work of the water utility is not a straightforward engineering problem. In essence it is about people and much less about technology. Men, women and children may have different views about their water supply and its quality, and they, knowingly or unknowingly, interfere with their water supply systems.

In many places we see that people continue to use traditional water sources even after a piped supply is installed for example because they do not like the taste of piped water, they may have to walk further, wait longer or have to pay. This behaviour may be particularly happening in and after the rainy season when more water sources may be readily available. Hence it is important to also take these other water sources into account when looking at water catchment management.

The approach proposed in this module is to carefully look at possible problems and risks that may exist in the water catchment area and the water source and identify possibilities to mitigate these problems. The overall aim of the approach is to help a small team of the water utility to work with some other actors to jointly identify and prioritise problems and propose mitigation measures that can be quickly implemented, including activities that may lead to the development of a more comprehensive integrated water resources management approach to safeguard the long term sustainability of the water sources for the water supply system. It is not a one of approach as the dynamics of catchment areas and water supply systems may change over time. In the next section we will briefly discuss the water cycle.

> ***"Exploring options to improve water catchment management is essential to ensure the long term sustainability of water supply systems"***

1.2 Description of the water cycle

To be able to analyse problems in the water catchment area it is necessary to understand the water cycle (Figure 1.1). But in fact it is better to talk about water cycles as the water follows different paths.

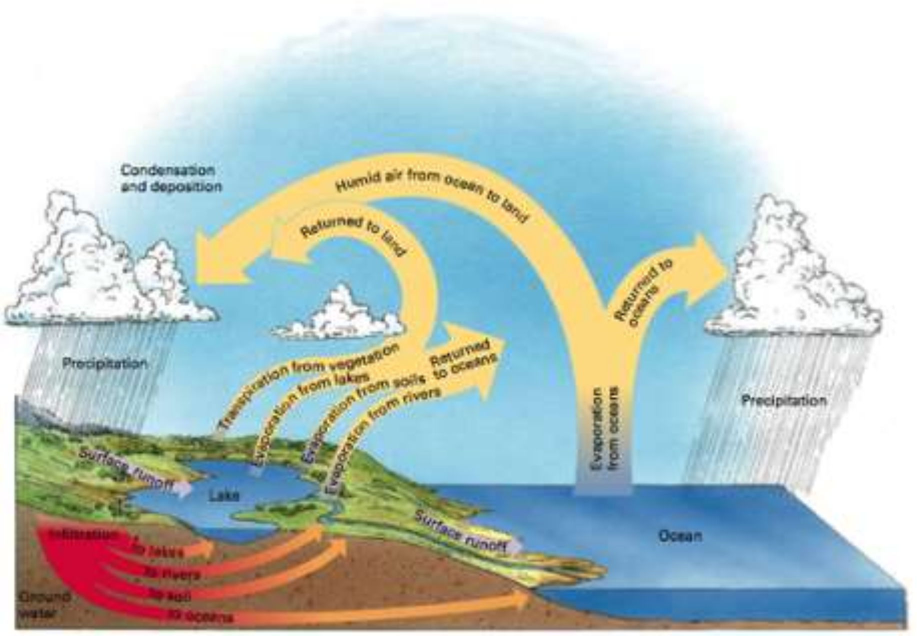


Figure 1.1 The water cycle(s) (Strahler & Merali, 2008)

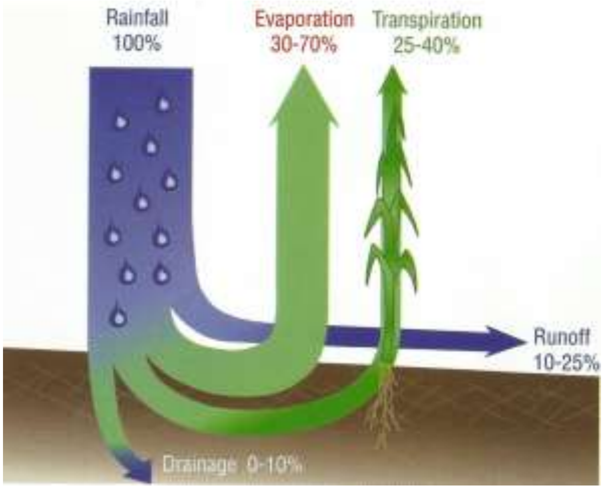
When rain reaches the ground it:

- Can be **retained on leaves** and other objects and evaporate again
- May be stored in soil surface **depressions** or may flow over its surface (surface runoff)

- **Infiltrates** into the soil adding to the moisture content of the soil and if sufficient in quantity may turn into groundwater through **deep percolation**

Groundwater slowly moves underground and it emerges again to feed **springs, rivers, wetlands and lakes**. Groundwater together with surface runoff feeds river systems

Evaporation and transpiration are two key elements of the water cycle and greatly affect human activities.



They are two natural processes that return water from the land system to the atmosphere. Some of the water used by plants is lost to the atmosphere in a process called **Transpiration**.

Some water is also lost to the atmosphere directly from the soil or water bodies. This process is called **Evaporation**. The effect of these processes may be considerable (Figure 1.2)

Figure 1.2 Processes related to the water cycle

Much water is lost as non-productive evaporation and runoff water, whereas it could be safely stored in the soil and reservoirs and infiltrated to recharge the aquifer. If water is stored in the soil, agricultural and in general biomass production would become more sustainable and resilient to dry spells. At the same time, runoff that too often evaporates directly to the atmosphere can be productively used.

Today there is a lot of attention for predicting larger climate trends: regional long-term patterns of rainfall, temperature peaks and averages. Yet for water catchment management the understanding of micro-climates is even more important. According to van Steenbergen and Mehari Haile (2015), Microclimates are the local interplays between factors such as soil temperature, air temperature, wind directions, soil moisture and air humidity – affected by day-night effects and seasonal effects. They are determined by the particular landscape, soil conditions, vegetation and land use and water retention. Basically they are where meteorology lands on earth and where a dynamic interaction of forces – local heat exchanges, capillary rise over seasons, moisture retention - determine, the moisture available to the different ecosystems, the presence of dew and frost, the actual temperatures for plant growth, the vigour of soil biotic life and capacity to fixate nitrogen and the occurrence of pests and diseases.

The effect of microclimate may buffer against climate change or may amplify its effects, be it temperature peaks, droughts, more irregular or later rainfall.

1.3 Water supply and demand

The availability of water in a catchment area depends on many factors including rainfall, evaporation, transpiration and infiltration. The essence of IWRM is to effectively ensure the balance between water supply and water demand.

Water demand, or water use, can be classified into consumptive and non-consumptive use.

- ***Consumptive use*** which includes water for domestic use, water for livestock, water for industry, water for food security (irrigation) and water for ecosystems. This kind of use intervenes in the water cycle and can generate changes in water quality and quantity. Two important problems associated with this type of use are the low efficiency in water use particularly in irrigation but also in domestic water supply and water pollution

- ***Non-consumptive use*** which includes issues such as navigation, electricity production, and recreation. This kind of use affects the water cycle to a lesser extent compared to consumptive use. However, large-scale negative effects may occur in terms of pollution and other environmental impacts, for example due to the construction of hydroelectric plants. These effects may include: alterations in ecosystems, displacement of native species of animals, displacement of native communities, flooding and drought of areas, increased contribution of greenhouse gases.

A range of interventions may be required to be able to meet this balance both on the supply side (making more water available) and on the demand side (using water more efficiently).

1.4 Water legislation in Ethiopia

The constitution of Ethiopia issued in 1931 already addressed some natural resources management issues which were strengthened in the revised constitution of 1955. The constitution of the PDRE issued in 1987 was designed in accordance with socialist principles indicating among others that the state shall ensure that the ecological balance and all Ethiopians were given the duty to protect and conserve nature and natural resources, especially to develop forests and to protect and care for soil and water resources.

The Federal Constitution of 1995 which reflects the federal system of government stipulates public ownership of both rural and urban land as well as all natural resources. Thus, both ground and surface water are part of the public domain and its management is therefore vested in the State. The Constitution has several provisions which have direct policy, legal and institutional significance for the management of the water resources of the country. The Federal Government determines the management and use of water resources in the country while Regional States have the mandate to administer the water resources within their respective States in accordance with federal laws. As part of its prominent role the Federal Government is responsible for drawing up general policies pertaining to common interests and benefits while the nine Regional Governments as well as Zonal and Woreda Governments are usually implementers of these policies. The constitution indicates that the Federal Government can delegate its powers and responsibilities to Regional States or other bodies for the proper management of the water resources of the country (Tamrat, 2008).

The social objective of the Constitution in fact calls for an integrated approach as it indicates that *'To the extent the country's resources permit, policies shall aim to provide all Ethiopians access to public health and education, clean water, housing, food and social security'*

The Constitution does not explicitly call for the possibility of delegation to other bodies such as River Basin Organisations (RBOs) but it does not negate this possibility either as long as Regional States are on board. The Ethiopian Water Resources Management Policy (EWRM policy), 1999, adopts the river basin as a planning unit for the development and management of the water resources of the country. Moreover, most of the major river basins of Ethiopia cut across more than one Regional State or are trans-boundary in nature (Tamrat, 2008). The EWRM policy aims to enhance and promote the efficient and fair use of water resources for socio-economic development in a sustainable manner. It has specific provisions related to water supply and sanitation, irrigation, and hydropower, and also specifies policy on cross-cutting issues such as allocation of resources, watershed management, technology and gender.

Most of the major powers and responsibilities of the Federal Ministry of Water Resources, which is the executive arm of the Federal Government with respect to water resources, have now been delegated to River Basin Organisations (RBOs) that are to be established phase-by-phase. It is expected that Regional States will play a prominent role in decision-making in the RBOs to be established although this is yet to be seen.

The EWRM Policy embraces several fundamental principles including:

- Water is a natural endowment commonly owned by all the peoples of Ethiopia;
- Water resources development shall be underpinned by rural-centred, decentralised management, and a participatory approach as well as an integrated framework; and
- Focus must be on the promotion of the participation of all stakeholders, user communities (particularly women’s participation) in the relevant aspects of water resources management.

Other relevant policies and strategies with a relation to IWRM that were issued include:

- Ethiopian Water Sector Strategy (2001)
- Rural Development Policy and Strategy (2003)
- Ethiopia’s Agricultural Sector Policy and Investment Framework (PIF) 2010-2020

These policies are relevant for IWRM but the problem is with their implementation, and particularly policies related with water and environment. Customary law in Ethiopia is widely practiced and respected by the people, with the connotation that it is not valid in cases where it is not in line with the constitution.

The overall legal situation is complex as a considerable number of proclamations have been issued to manage water, protect the environment, and biological diversity:

- Environmental Protection Organs Establishment (No. 295-2002),
- Environmental Impact Assessment (No. 299-2002),
- Environmental Pollution Control (No. 300-2002),
- Solid Waste Management (No. 513-2007),
- Environmental Impact assessment (No.299-2002),
- Environmental Pollution Control (no.300-2002) and
- Biological Diversity Convention Ratification (No. 98/1994).

These proclamations have the necessary guidelines and standards for their implementation whereas this is not the case with a series of other proclamations related to water resources management that have been issued including:

- Proclamation of the Ethiopian Water Resources Management (No. 197/2000),

- River Basin High Councils and Authorities (No. 534/2007),
- Ethiopian Water Resources Management Regulation (No.115/2005),
- Abay Basin High Council and Authority Establishment (No. 151/2008),
- Awash Basin High Council and Authority (No. 156/2008),
- Rift Valley Lakes Basin High Council and Authority Regulation (No. 253/2011)
- Forest Development Conservation and Utilization Proclamations (No. 542-2004)
- Proclamations to establish:
  - Ethiopian Standards Agency (Reg. No.193-2010),
  - National Metrology Institute (Reg. No.194-2010) and
  - Ethiopian Horticulture Development Agency (Reg. No.152-2008)

An important problem is that several of the policies and proclamations have overlaps and imply overlapping mandates and activities between different organizations as shown for example in Figure 1.3.

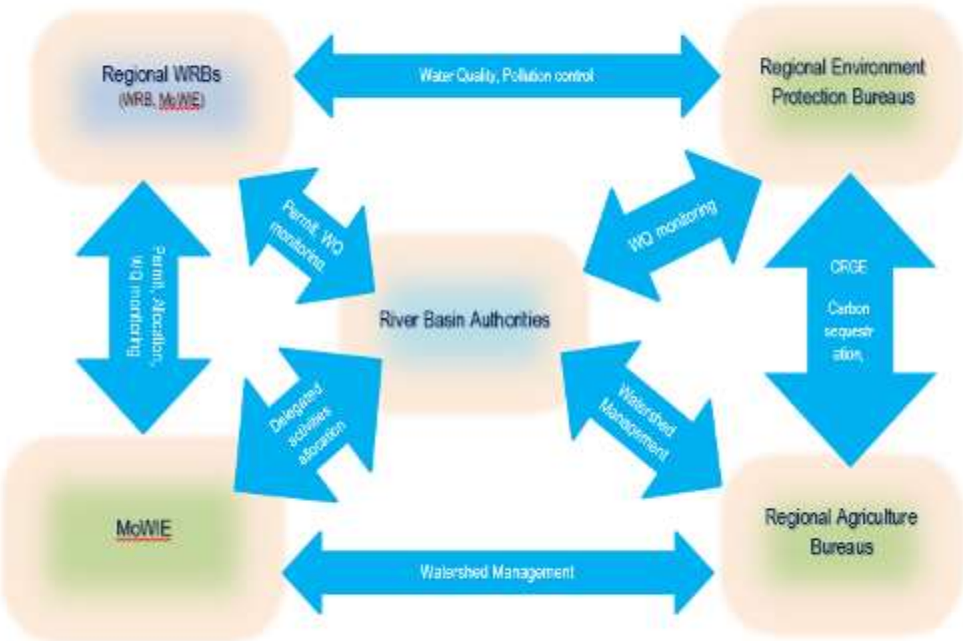


Figure 1.3 An example of overlapping mandates and activities between institutions

1.5 Self Evaluation

This is an individual evaluation of your understanding of the information presented in this module. Answer the (multiple choice) evaluation questions and check your own answers (section 1.8) and review the module again if you had many mistakes.

Q1. Which of the following answers are correct? (Multiple answers possible)

A: IWRM stands for integrated water resource management

B: Water reuse is an instrument for IWRM

C: Water licences are economic instruments for IWRM

D: Water use fees and waste water discharge fees are economic instruments for IWRM

Q2. What is the difference between Evaporation and transpiration?

A: No difference. Transpiration and Evaporation are the same thing;

B: They both imply the passage of water from liquid to vapour state that is then transferred to the atmosphere. Evaporation takes place from the soil or from surface water. Transpiration instead is the water that is transferred from plants to atmosphere;

C: With transpiration plants adsorb water from the soil. With evaporation plants loose part of the water to the atmosphere;

Q3. Which of the following answers are correct? (Multiple answers possible)
A: The water cycle includes evaporation, rain, and surface water and is not affected by human actions
B: Climate change generates changes in the water cycle
C: Groundwater is part of the water cycle
D: Water that infiltrates in the ground will become groundwater

Q4. Which of the following answers are correct? (Multiple answers possible)
A: Integrated water resource management puts emphasis on balancing water supply and demand
B: Consumptive use includes water used to generate electricity
C: Non-consumption use includes water for navigation

Q5. The IWRM policy is well developed in Ethiopia, the instruments and institutions are in place and the policy is being implemented.
A: Correct: The IWRM policy is well developed and properly being implemented by strong institutions using clear instruments
B: Partially correct: The IWRM policy is well developed but it is not being implemented adequately and instruments are institutions are weak
C: Not correct: The IWRM policy is very weak

1.6 Assignment

In this section you will find the assignments related to this module. Preferably you do this assignment with your training group by dividing the tasks and make one collective answer.

1. Make an overview of the water sources your company uses
2. Make a brief description of the water sources the population uses
3. Make a brief report on water quality and water quantity problems of your water supply system
4. Make a list of main problems in the water catchment areas of the water sources of your water utility you and your colleagues know (without visiting the area)

Action: *Copy the collective answers of your group to assignments 1, 2, 3 and 4 and submit this or show this to your trainer through the means of communication you have agreed upon.*

1.7 References and further reading

This section includes the references for the section as well as some publications that may be interesting to gain more insight in the issues that are being discussed

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1.8 Answers to self-evaluation questions

Q1. Answers A, B and D are correct
A: IWRM is indeed Integrated Water Resource Management
B: Water reuse is an instrument for IWRM as it enhances the water use efficiency and reduces the stress on available resources
C: Water licences are not economic instruments for IWRM but are command and control instruments for IWRM and are essential to fairly distribute water among different actors
D: Water use fees and waste water discharge fees are economic instruments for IWRM as they can be used to motivate users to reduce consumption and pollution

Q2: Answer B is correct
A: Evaporation and transpiration are different
B: Evaporation is the process that involves the evaporation of water from the soil and surface water sources, whereas transpiration is the water vapour that is transferred from plants to the atmosphere
C: Is not correct (see answer B)

Q3. Answers B and C are correct
A. Is not correct because the water cycle is affected by human actions
B: Is correct because climate change generates changes in the water cycle
C: Is correct because groundwater is part of the water cycle
D: Water that infiltrates in the ground will add to the soil moisture content and only will become groundwater if the soil is saturated

Q4. Answer A and C are correct
A: Integrated water resource management puts emphasis on balancing water supply and water demand
B: Consumptive use does not include water used to generate electricity
C: Water for navigation is indeed non-consumptive use

Q5. Answer B is correct.
A: Is not correct: An IWRM policy exists but it is not properly being implemented
B: Is correct: The IWRM policy is well developed but it is not being implemented adequately and instruments and institutions are weak
C: Not correct: The IWRM policy is fairly well developed

If you failed to provide several of the correct answers, then review this module again.

Module 2 Water catchment management

This module provides an introduction to analysing water catchment management. At the end of this module participant will:

- *Be able to explain the concept of and physical, legal and institutional considerations related to the water catchment*
- *Have identified different methods to delineate watershed and recharge zones*
- *Have prepared a global map of their water catchment area(s) with the main water related problems that have been identified*

2.1 Introduction

A water catchment, also known as watershed or drainage basin, is an area of land where all water drains to a central point like a river, or stream. When rain falls on the land part of this water will turn into runoff, water that flows over the surface by gravity force to a lower location. On this journey water infiltration may continue and water may be retained in pools, ditches, ponds and larger reservoirs but in the end part of this water will eventually make its way to that central point. It may even be the case that water that infiltrates may resurface from springs in the watershed, or may flow (more slowly) underground to the river. However groundwater may have a flow pattern that is different from the surface flow as it may recharge deeper aquifers which not contribute to the river but may pass even hundreds of meters below it depending on the geological formation. The time it will take for the water to drain to the central point depends on various factors such as steepness of the slopes, type of soil, amount of plant life and existence of ponds, lakes and other water retention structures.

Water catchments are widely recognized as the most effective management unit for the protection of water resources, both water quality and supply. A water catchment area is home to a complete water-cycle system. Water catchment management thus implies catchment, conservation and making wise use of all water in the system. This may include a wide range of issues such as shaping the landscape to retain and guide the water on its journey, planning and management of water use, management of vegetation, organization of agriculture, and development of water management infrastructure. The development of a water catchment management plan preferably starts with a catchment baseline to understand the situation at hand.

The aim of a water catchment management baseline is to visualize the current situation of water resource management in the water catchment and, with the different actors, find the problems and prioritize them.

With the information from the baseline a management plan can be developed together with the main actors involved in the water catchment. The first step in the baseline is the establishment of the boundaries of the catchment area as will be discussed in the next section

2.2 Water catchment and recharge zones delineation

The boundary of a water catchment is drawn by the natural landscape with mountain ridges being natural divides between watersheds. It is important to define the boundaries of the water catchment area to be able to to determine run-off patterns and to plan water related interventions. Water catchment may be small (micro-catchments) which may be relevant for local water sources or may be larger which often will be the case for utility water supply systems. To identify the boundaries a step wise approach is suitable which includes the following:

- Outline the main stem of the stream that you want to examine
- Trace all perennial or influential tributaries
- Locate the lowest point/outlet of the main stem and work uphill identify the ridges and hill tops that divide the water from flowing into separate water catchments

Different techniques exist to delineate a water catchment area some of which will be presented here. An important point is that a combination of techniques will generate best results.

2.2.1 Topographic sheets and aerial photographs

To delineate a water catchment area using a topographic map requires visualizing the landscape as represented by the map. This is not difficult but requires understanding the basic concepts as explained by NRCS (1991 p.1). “Each contour line on a topographic map represents a series of points with the same ground elevation or vertical distance above a reference point such as sea level. The difference in elevation between two adjacent contours is called the contour interval. This is typically given in the map legend. It represents the vertical distance you would need to climb or descend from one contour elevation to the next. The horizontal distance between contours, on the other hand, is determined by the steepness of the landscape and can vary greatly on a given map”. On relatively flat ground, two 5 meters height contours can be far apart horizontally, whereas on a steep hill these may be very close. This technique takes time and its accuracy may not be that good.

Figure 2.1 Delineating a water catchment

How do contours relate to water flow (idem p2)? “A general rule of thumb is that water always flows downhill perpendicular to the contours (topographic lines). As one proceeds upstream, successively higher and higher contour lines first parallel then cross the stream. This is because the floor of a river valley rises as you go upstream. Likewise the valley slopes upward on each side of the stream. Topographic lines always point upstream and with that in mind one can make out drainage patterns and the direction of flow on the landscape” and you can identify the high points in the landscape. If you join all of these high points around the stream you have established the water catchment boundary.

Aerial photographs allows for better delineation (scale larger than 1:15 000) using stereoscopes.

2.2.2 Field mapping using GPS

According to Poff et all (2005) a handheld GPS receiver can be used to record position and elevation to establish the boundary of a water catchment. GPS data need to be recorded every few seconds but sometimes this may take longer depending on reception of the signal. The boundaries of small and medium sized water catchment s can be recorded in one or two days whereas large catchments may take much longer. Data need to be downloaded as soon as possible (preferably each day) and obvious outliers need to be deleted. e data files on either the same or the next day to eliminate outlier points. Such outliers would include points that were several meters away from where we walked in a straight line with the GPS. After cleaning up the individual line files data can be processed using a GIS software application (ArcMap) to establish a polygon-shapefile for the watershed. Poff et all (2005) compared the GPS approach with the use of topographic sheets and found the method to be more accurate.

2.2.3 Google Earth

With Google earth a lot of information can be obtained about water catchment areas. And it also is a great feature for monitoring change (Figure 2.2).

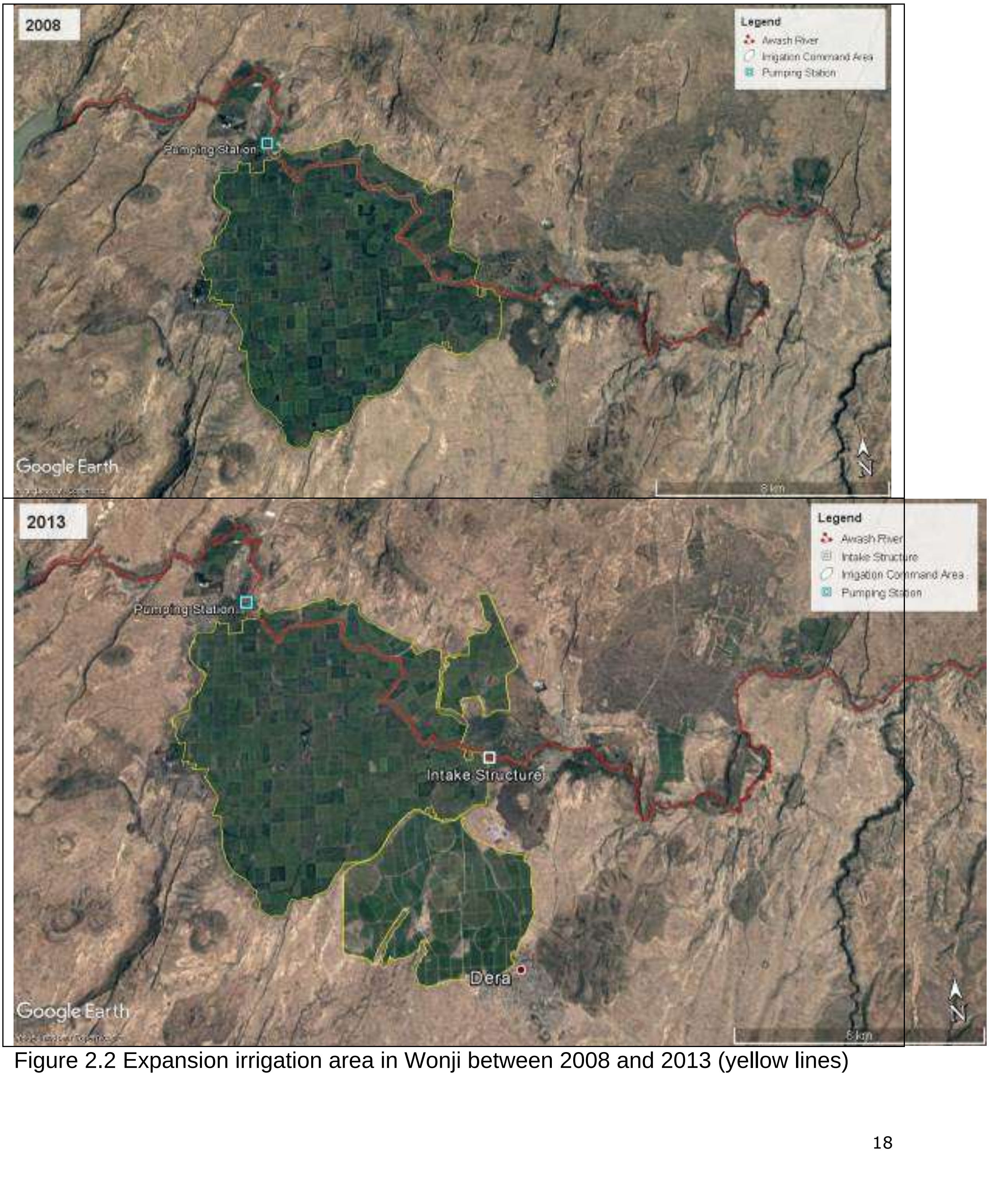


Figure 2.2 Expansion irrigation area in Wonji between 2008 and 2013 (yellow lines)

Figure 2.2 shows a marked difference in irrigation area between 2008 and 2013 and with that it may be expected that the water demand for irrigation increased considerably. Also erosion and contamination (from nutrients and pesticides may have increased)

To be able to use Google Earth you will need to have experience which in many cases may not be readily available in the teams working on the water catchment plans. If that is the case you will need to seek external support to help you with this issue

Google earth may also help to identify the areas that contribute most to the source(s) of your water supply as this may in fact only be a limited part of the total water catchment area.

2.2.4 General data about the water catchment

Once you have identified the water catchment area you need to establish the general data that you need which may include primarily the data in Table 2.1.

Table 2.1 General data of the water catchment area

Item	**Information**
Name of watershed	
Woreda and Zone	
Population (+Households)	
Area (hectares)	
Important area for water supply (%)	
Altitude	
Range in slopes	
Main Livelihoods	
Local sources of water	
Main problems	
Average runoff	

In case you have an outlet station that records water level and water discharge in m3 per second of the stream over time you use the data to develop a discharge graph per month. This graph will give you a clear indication of the changes in the monthly discharge over the year. Your water catchment will have a size in km2 (1 million m2). Divide the monthly m2 by the area in square meters, and you will get meters of water yield averaged over the catchment. This you can then compare with rainfall data.

2.3 How to analyse the situation in a water catchment

Developing a water catchment management plan requires the use of different methods to collect information including:

- Review of literature (reports, papers, etc.)
- Using different types of maps to specify the water catchment area
- Field visits (transect walks)
- Talking to people (Semi-structured interviews, Focus group discussions)

Start by identifying what you need to know. A good approach is to develop and annotated content page of your water catchment report. This is a brief document that indicates section by section what you plan to include. Keep checking in the course of the process whether the information you are collecting is useful as often we collect way too much information

The internet provides a rich source of information including for example information from Google Earth, GIS software (e.g. Arcview, ArcGIS). Information may also be available in the different organizations involved in the catchment. This may include plans, reports, evaluations, topographic maps, Aerial photographs etc. This should allow you to get a fair idea of the organizations involved in the catchment, population patterns but also issues such as soil condition, land use management, and vegetation cover (especially trees).

One problem is that information in literature may not be reliable. For example a report may state: We visited the Hope river for three days and took several water samples. Average turbidity was 5 NTU with a variation between 3 and 7 NTU. This information does not give the full story but may be copied by others as the average turbidity of the Hope river is 5 NTU. Hence it is important to carefully analyze and triangulate information (checking it by using different sources) as it reflects the views of the author(s).

2.3.1 Obtaining information in the field

It is important to try and obtain information about the area and the community before you visit. This may include checking written information from the internet but information also may exist in your office. Furthermore it is good to talk to people who may know the area and you need to find out who can be your local contact, taking into account that everybody may have its own interests and therewith may orient the way they provide information. Having information about the local situation will help you to better plan your visit.

To obtain information from different actors you can use different techniques, but first you need to check if others have not collected this information as people may get bored to have to give the same information again without seeing any action on the ground. Against this background it is also very important to present yourself and have your team members present themselves and to explain why you are there, which in essence is to try to understand the situation to see if you can assist in improving the situation.

Techniques to collect information include:

- Semi-structured interviews; using a number of pre-determined questions with the opportunity to further explore particular responses
- Focus group discussions; bringing together a group of people from similar background, experience or gender to discuss specific issues
- Questionnaire surveys (households, providers, leaders etc.)
- Transect walks

When you work with a team it is very important to make sure that tasks are clear and materials and equipment are available. Furthermore you need to stress that taking notes during visits is very important particularly of the unexpected.

People in the catchment area know about the situation; they are a prime source of knowledge but may need to be guided to give the right information. It is essential to take into account that people may not tell you the real situation because:

- They may not trust you
- They may have their own interests
- They may not understand (see) their problems

So use what you hear, see and not see to get the picture and even more important to look behind the picture to truly understand the situation.

2.3.2 Transect walk and time line

A transect walk, is used to establish a systematic cross-section of the catchment to collect data and exchange knowledge. This is a good approach to make a systematic analysis of the catchment area and to identify where the water is coming and to help identify possible hazards in a catchment area. The approach involves walking along straight lines to explore the situation. A transect walk in the catchment area by an experienced person or team may be very important to assess possible risks that may affect the long term water availability or water quality. If the water catchment is not well protected and signs of deforestation, overgrazing and erosion are visible the water source may be at risk. Furthermore farming using fertilizers and pesticides may also negatively affect the water quality of the water sources and may lead among others to increase in nitrate levels which may generate a risk for small babies.

Figure 2.3 A part of a catchment area

From the top: eucalyptus plantation, farming land, Foot paths and cattle trafficking lines, gully

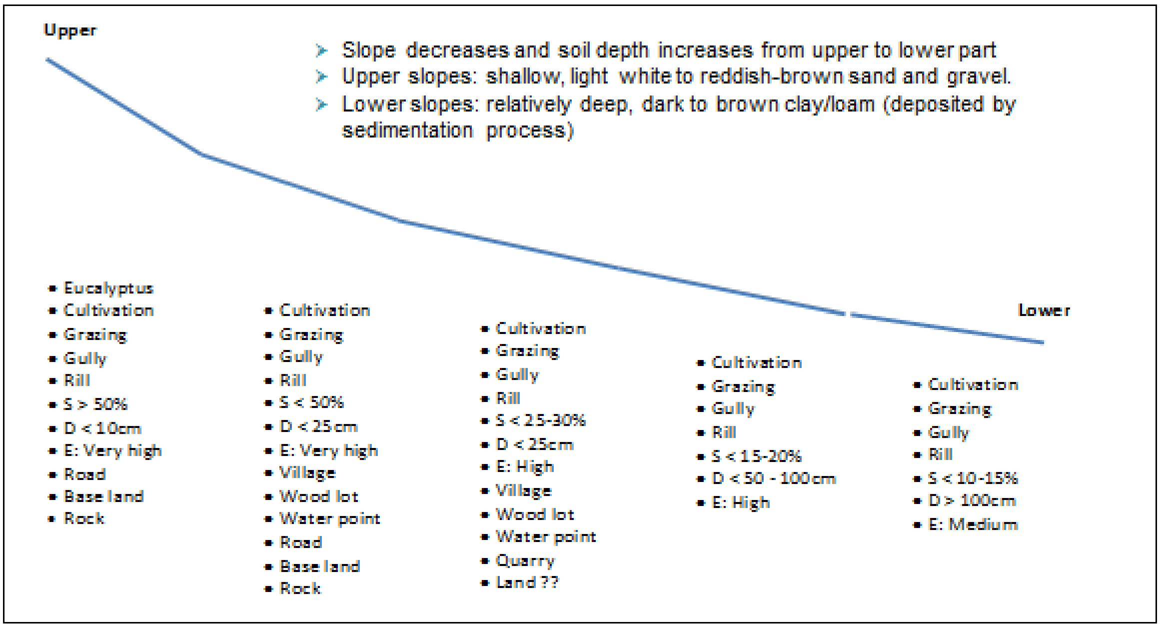


Figure 2.4 Transect profile

The transect walk(s) may generate different types of information including, for example, a map of current land use practices (Figure 2.5).

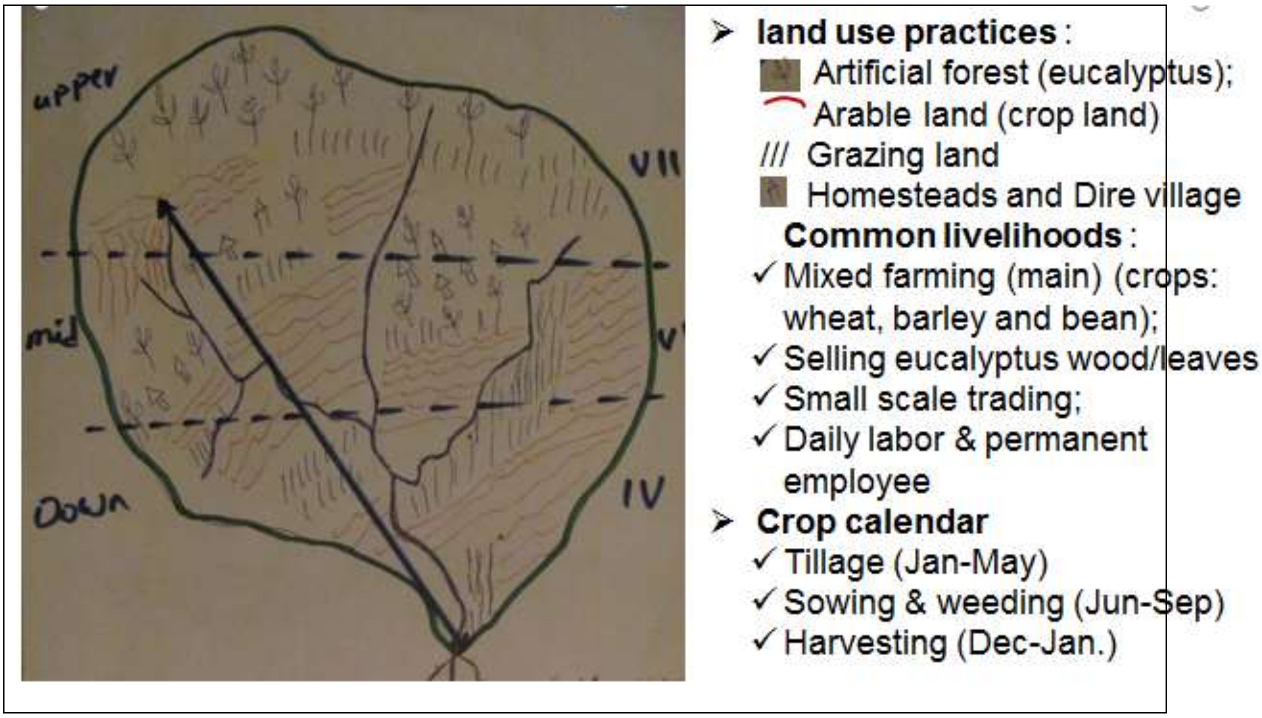
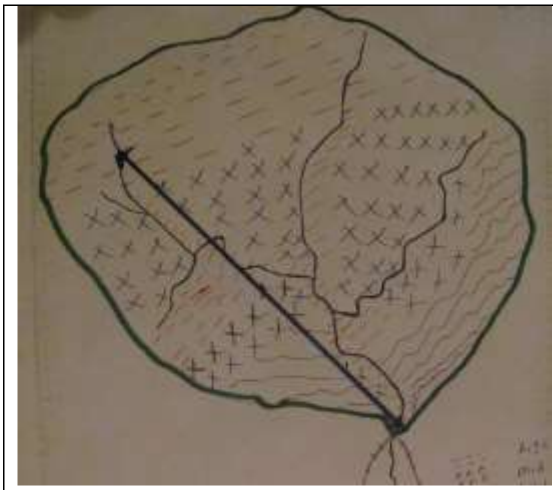


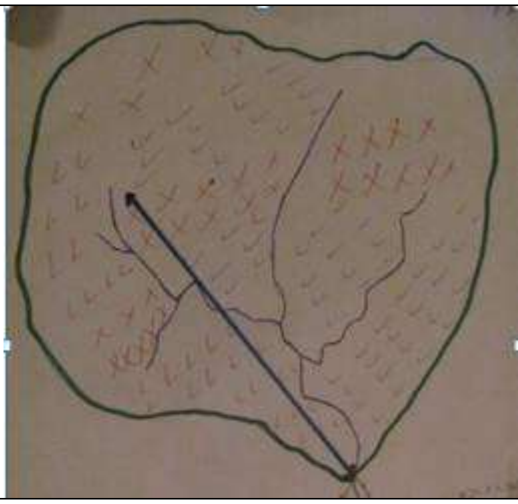
Figure 2.5 Land use map

Other maps may include an erosion risk map (Figure 2.6a) which has a lot to do with the steepness of slopes, but also (absence of) vegetation, drainage patterns, (over)grazing and agricultural practices. Also a pollution risk map may be useful and may have a lot to do with loss of topsoil due to erosion with nutrient loss being higher in pasture and range lands, use of fertilizer and herbicides, open field defecation, waste water discharge and cattle.



----- High erosion risk
XXX Medium erosion risk
Low erosion risk

Figure 2.6a Erosion risk map



XXX High risk of pollution
VVV Medium risk of pollution
LLL Low risk of pollution

Figure 2.6b Pollution risk map

A time line may also be very useful to make an analysis of historic trends in the changes in the catchment area. This generates insights into system dynamics, potential for change over time or in response to disturbance/intervention.

You can build a timeline by asking people living in the catchment and this may help them to put things in perspective. Some gradual changes for example may have gone unnoticed and in that case a timeline helps to really show the (often negative) trends

2.4 Risk assessment and priority setting

Identifying hazards and assessing risks are important aspects of preparing a water catchment management plan. A **hazard** is something that is known to cause harm. Bartram et al. (2009) define a hazard for water supply systems as 'a physical, biological, chemical or radiological agent that can cause harm to public health'. In the case of a water catchment this definition applies if the focus is on the water supply and in that case it may well be that only a part of the catchment area may need to be analyses, the part that provides water to the water source(s) of the water supply system. But it is also feasible to look in a broader way and assess the problems in the catchment area as a whole thinking of all actors that may be affected.

Risk is the likelihood or probability of the hazardous event occurring and the magnitude of the resulting effects (Risk = Likelihood x Severity) (see Box 2.1).

An example; if you are driving a car one **hazard** is that you run out of fuel. What is the **risk** involved. The occurrence of the hazardous event may be small provided you observe the fuel meter. Hence one part of the **risk assessment** is the evaluation of the frequency that the hazardous event may occur. The other part is the evaluation of the potential harm if the hazardous event will happen. In this case this depends on the circumstances. If you normally drive your car in a town it may be easy to find fuel so the harm is small and as the frequency is small as well the risk is small. Yet if you drive in a remote area or in the desert the potential harm of running out of fuel is much higher, it may even get you killed. Hence in that case even though the frequency may be small the risk is high.

Box 2.1 Hazards and risks in water supply systems
Hazards are harmful microorganisms (bacteria, parasite, protozoa, and/or virus), or chemicals (fluoride, arsenic, lead, etc.) or physical (turbidity etc.) and/or reduction in the available water that might affect health of the consumer or affect the water supply system.
Hazardous events are unfavourable conditions that may allow hazards to enter or affect the water system and therewith interfere with the delivery of sufficient safe water.
Risk is the probability of the hazardous event occurring and the magnitude of the resulting effects (risk = likelihood of the hazard x severity of its possible impact)

It is important to never assume that people see potential risks the way you see them. People living all their life in a polluted environment may be so accustomed to it that they do not appreciate possible health hazards. Children seeing that mothers handle faces of babies as if they are harmless are likely to adopt this behaviour as well.

Managing hazards implies confronting situations that pose a level of threat to life, health, technologies or environment. Most hazards are dormant or potential, but once a hazard becomes 'active', it can cause harm. The risk involved in a hazardous event (and the management attention it merits) depends on the likelihood that it can become active and the seriousness of the damage it can cause. To establish the risk involved in a catchment area we need to explore:

- The hazardous event
- The likelihood of its occurrence, and
- Its potential impact on water quality or quantity

Hazardous events may be related to potential sources of turbidity (suspended solids), faecal material or chemicals that may drain directly into the water supply source (e.g. the location of areas of erosion or intensive agriculture in relation to the water source). But they may also be related to indirect factors; factors that represent a lack of a control measure to prevent contamination or avoid erosion to occur. Allowing some cows to graze in a catchment area may not lead to erosion, but allowing many animals to enter the area will lead to overgrazing and erosion.

Assessing hazards and risks in a catchment area for a water supply system implies the needs to assess the area that drains into the water source in terms of possible problems.

The sanitary inspection, the transect walk, google earth and discussion with actors are the main tools to assess the risks. It is however not a one off assessment as conditions and possible hazardous events may vary during the year and change over time. For instance in rural areas microbial contamination may peak at the start of the rainy season but then rapidly diminish as the reserve of faecal material diminishes. Man-made interventions in catchment areas may cause erosion and change of runoff patterns which may negatively affect springs in terms of quality and quantity.

The sanitary survey also needs to take into account problems caused by the technology and inadequate maintenance. This may for example result in lower production levels of pumps which may lead to longer waiting times at collection points. Users than may go to alternative (polluted) sources or buy water from vendors (forcing them to spend more on water).

2.4.1 Exploring hazards related to water catchment and water sources

Looking at managing hazards related to water sources implies posing a number of questions. The first question to pose is: Where is the water coming from?

For both ground and surface water we need to understand the hazardous events that may be present in the water catchment area. For a surface water source this may be more easy to identify and possibly to control. That is, if it concerns a catchment area that is nearby. For larger rivers and lakes a more comprehensive approach with many more actors will be needed. For groundwater a similar situation exists as in some case the recharge area where rainfall percolates into the ground may be nearby, whereas in other cases the ground water may come from much further away. For areas that are closer it may be feasible to introduce protective measures such as restrictions on, say, fertiliser or pesticide use. Hence in relation to the water source we need to identify:

- The main microbial, chemical and physical contamination hazards
- The main pathways that exist for contamination to enter the source
- The main actors involved and in what way do they contribute to the risk
- Possibilities to reduce or block hazards and/or pathways

If the water catchment is not well protected and signs of deforestation, overgrazing and erosion are visible the water source may be at risk. Other hazardous events may include farmers using fertilizers and pesticides which may negatively affect the water quality of the water sources and may lead among others to increase in nitrate levels which may generate a risk for small babies. Mining activities may be present in the area and deforestation (causing erosion) may be severe in strategic parts of the catchment. The catchment may also be prone to landslides or flooding. House building may also be an issue and may be legal or illegal.

Some water systems have multiple water sources and in that case risks need to be identified for each of the sources and abstraction points. The information on the water source(s) will also need to include the behaviour over the year (dry and wet season) looking also at climate variability which may result in extreme weather events that may affect the source water quality and quantity. It may be feasible to use information from the climatic zone assessment report. It is also necessary to explore changes (comparing historic and current data) that may have taken place for example in flow discharge of the source and water abstraction for the water supply system.

Another crucial area for analysis is the nature of the land use including anticipated development in the future looking particularly at issues such increase of urban areas, changes in agricultural areas, introduction of irrigation, industrial growth but also possible soil and water conservation interventions that may be in place or may be planned.

The information you need to collect will need to be sufficient to help you define the risks for each of the water sources of the water supply system. The risks will be water scheme specific, but may be quite generic in similar water systems in the same area. Once the risks are identified it may be possible to take specific action to prevent or strongly reduce them.

2.4.2 Risk prioritization

Risk is the likelihood that a hazard affects the water supply system and the severity of the effect. Risks can be prioritised if the likelihood of a hazardous event and the severity of the associated impact are known. A method of undertaking a risk assessment quantitatively is to use a risk matrix as shown in Table 2.2 (Bartram et al, 2009). The severity of the effect (impact) of a hazard (ranking as shown in Table 2.3) and its likelihood can be multiplied together to arrive at a number that indicates its risk score.

Table 2.2. A risk matrix for risk assessment.

Effect	No/minor impact 1	Serious impact 3	Very serious impact 5
Likelihood[1]			
Rare (1) < 1% of the time, cases, land area	1	3	5
Moderate (2) 1 – 20% of the time, cases, land area	2	6	10
Likely (3) > 20% of the time, cases, land area	3	9	15
Risk levels: low risk < 3; medium risk 3 – 6; high risk 7 – 10; intolerable risk > 10			
Adapted from Bartram et al, (2009) Based om British Standard 8800 (1996)			

Table 2.3 Ranking of possible effect

Impact	**Definition**
Minor	Minor water quality impact (not health related) or disruption in operation affecting few customers; insignificant rise to complaints
Serious	Minor water quality impact (aesthetic impact, not health related) affecting many customers, clear rise in complaints, community annoyance, minor breach of regulatory requirement
Very serious	Major water quality impact (health-related), illness associated with the water supply, large number of complaints, significant breach of regulatory requirement

[1] The likelihood depends on the situation that is being assessed and may be established in terms of time, number of events per year, number of connections etc. The idea is to establish a reasonable level of likelihood to be able to prioritise risks.

The risk rating can then be assessed in terms of risk level and different risks can be compared. Table 2.4 gives an indication suggesting that if an intolerable risk exists this needs to be taken care of immediately. But also risks with the indication of significant and moderate need to be taken into account as these risk levels will need to be reduced.

Table 2.4 Tolerance levels with guidance on necessary action

Tolerance level	**Guidance on necessary action and timescale**
Very low risk	These risks are considered acceptable. No further action is necessary other than to ensure that the controls are maintained.
Low risk	No additional controls are required unless they can be implemented at very low cost (in terms of time, money and effort). Controls should be maintained, but actions to further reduce these risks are assigned low priority.
Medium risk	Consideration should be given as to whether the risks can be lowered, where applicable, to a tolerable level, and preferably to an acceptable level, but the costs of additional risk reduction measures should be taken into account. The risk reduction measures should be implemented within a defined time period. Arrangements should be made to ensure that the controls are maintained, particularly if the risk levels are associated with harmful consequences.
High risk	Substantial efforts should be made to reduce the risk. Risk reduction measures should be implemented urgently within a defined time period and it might be necessary to consider suspending or restricting the activity, or to apply interim risk control measures, until this has been completed. Considerable resources might have to be allocated to additional control measures. Arrangements should be made to ensure that the controls are maintained, particularly if the risk levels are associated with extremely harmful consequences and very harmful consequences.
Intolerable risk	These risks are unacceptable. Substantial improvements in risk controls are necessary, so that the risk is reduced to a tolerable or acceptable level. The activity should be halted until risk controls are implemented that reduces the risk so that it is no longer very high. If it is not possible to reduce risk the activity should remain prohibited.
Based on BS 8800 1996	

To illustrate the application of a risk matrix we show the following example.

Hazardous event: Heavy rain in a catchment area (frequency 2 times a year = moderate level 2); Hazard is that suspended solids load increases as slopes in the catchment area are not protected. The high load of suspended solids interferes with the treatment process and the water supply needs to be stopped for several hours, which implies a serious impact leading to a score of 2*3 = 6 and if it needs to be stopped for several days the impact will be very serious, leading to a score of 2*5 = 10.

2.5 Common problems in water catchment areas

Some common problems related to surface water based systems in catchment areas are indicated in Table 2.5 and some examples are shown in Figures 2.7a,b and c.

The same hazardous events may also have an effect on groundwater as they may influence the possibility to retain and infiltrate water in the catchment area. But in that case the distance to the water source may be much larger. Some common problems in catchment areas related to ground water based systems are indicated in Table 2.6.

Table 2.5 Some hazardous events and hazards in surface water catchments

Hazardous event	Hazard
Deforestation in combination with rainfall	Pollution of water source with suspended solids
Inappropriate agricultural practices causing erosion	Pollution of water source with suspended solids
Construction of new houses or industries resulting in waste water discharge	Pollution of water source with bacterial and chemical pollution
Changes in run-off patterns because of interventions in the catchment area (road construction, irrigation systems)	Increased pollution due to gully formation or (partial) interruption of drainage to the water source leading to water shortage
Siltation of lakes	Possible reduction in water availability

		
Figure 2.7a Gully erosion due to roadside runoff (Tigray)	Figure 2.7b Severe scouring and a damaged gabion (Adama)	Figure 2.7c High turbidity due to erosion (Huluka river)

Table 2.6 Some hazardous events and hazards in ground water catchments

Hazardous event	Hazard
Reduction in infiltration capacity due to changes in the landscape (deforestation, road and other infrastructure, house construction, agricultural practice, siltation of lakes)	Reduction in water availability (falling ground water tables)
Over pumping of the aquifer (often due to irrigation)	Reduction in water availability (falling ground water tables); changes in chemical quality; in some areas possibility of salt intrusion
Direct infiltration of polluted water (inadequate protection of the well)	Pollution of water source with bacterial and sometimes also chemical pollution

An important difference exists between shallow and deep ground water. Shallow ground water may be present at less than a few meters. Recharge in general will be more quickly (days, weeks, or months) and this implies that it is more prone to possible contamination (organic pollution, leach water from latrines and waste pits, waste water discharge). Deep groundwater is mostly characterized by slow recharge (years, decades, or centuries) and it may be even fossil groundwater which means that it is not being recharged. Sometimes natural contamination may be present such as salts or fluoride.

2.6 Self evaluation

This is an individual evaluation of your understanding of the information presented in this module. Answer the (multiple choice) evaluation questions and check your own answers (see section 2.9). In case your answers had many mistakes it is suggested that you review the module again before doing the assignment.

Q1: What is a water catchment?

A: Water catchment is defined as any landscape area of which runoff water resulting from rainfall is collected and drained to a common point;

B: Water catchment is the line that connects all the highest point in a landscape and encloses a catchment;

C: Water catchment is a planning area that is defined by administrators. It follows administrative boundaries;

Q2: A water catchment management baseline:

A: Is an overview of the desires of the community in the water catchment area

B: Visualizes the current situation of a water catchment and presents a prioritization of the problems at hand that have been identified with the different actors involved in the area

C: The baseline is not the volume of water that can be collected in a water catchment area

D: The baseline may include information on forest coverage in a catchment area but this is only part of the information as the focus is on problems that have been identified

Q3. Indicate which of the following statement is correct. (Several statements may be correct)

A: Before doing a detailed assessment of a water catchment in the field it is very important to collect information about the area

B: The community is an essential source of information and need to be involved as most catchment interventions will need their support

C: It is important to critically review the information you receive from different actors as they may have vested interests or may not trust you

Q4. Indicate which of the following statement is correct. (Several statements may be correct)

A: A time line related to a water catchment is the time you estimate to do the intervention to improve the situation

B: A transect walk provides you with all the information you need to delineate the water catchment area

C: If a water catchment is not well protected and signs of deforestation, overgrazing and erosion are visible the water source may be at risk.

2.7 Assignment

In this section you will find the assignments related to this module. Preferably you do this assignment with your group but you may distribute the tasks. After completion discuss with your training group, finalize the assignments and share with the facilitator.

1. Identify the water catchment area(s) of your water company and collect basic information available in your utility
2. Delineate the water catchment(s) on a map. For this assignment you may need to involve a person with experience in water catchment delineation

3. Make a description of the water catchment area(s) and add maps for example from Google Earth.
4. Make an overview of the main problems you are aware of in the catchment area(s) for which you can use the information you prepared for the first assignment
5. Confirm the problems in a visit to the catchment area

Action: *Provide results of the assignments to your facilitator.*

2.8 References and further reading

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2.9 Answers to self-evaluation questions

Q1. Answer A is correct.

A: A water catchment - also called a watershed - is the ideal hydrological planning unit. It consists of all the areas of which runoff is collected and drained to a same, common point. It is defined by the water catchment divide that is an imaginary line that connects the highest points in a landscape, which defines in which direction the rainfall will flow. On one side it will flow to a water catchment, on the other side it will flow to another, adjacent water catchment.

B: Is not correct as this is the definition of the water divide

C: Is not correct; in fact it is very rare that a water catchment coincides with administrative boundaries and this may complicate the management of the catchment

Q2. Answers B is the correct answer

A: Is not correct as the baseline is not a wish list

B: Visualizes indeed the current situation of a water catchment and presents an overview and a prioritization of the problems at hand that have been identified with the different actors involved in the area

C: Is the volume of water that can be collected in a water catchment area

D: Provides a detailed overview of the forest coverage in a catchment area

Q3. All answers are correct

A: It is indeed necessary to collect information about the area before doing a detailed assessment of a water catchment in the field to be able to make a good plan for the assessment and interviews and to avoid repeating work that already has been done

B: The community is an essential source of information. They live in the catchment area and with them you can explore current problems, but also changes over time. Furthermore many catchment interventions will need their support

C: People will provide you with information that they have processed. This information however may not be correct as they may give answers they think you want to hear, they may be ashamed, they may not trust you, but they also may give answers they think will generate most benefits for them

Q4. Answer C is correct

A: A time line related to a water catchment is an overview of the changes that have taken place in the catchment area over a period of time. This is a powerful tool to help people see changes over time and to better understand how the catchment has responded to possible interventions

B: A transect walk provides you with a lot of information by walking through a cross section of the catchment area, but it is not the tool for delineating the water catchment area

C: If a water catchment is not well protected and signs of deforestation, overgrazing and erosion are visible the water source indeed may be at risk, but the risk level will also depend on the area were the problems occur as not all part of the catchment contribute in the same way to providing water to the water source.

If you failed to provide several of the correct answers, then review this module again.

Module 3 Actor analysis

This module helps participants to obtain an overview of the actors involved and their possible interests. At the end of this module the participant:

- *Will be able to explain why it is important to connect to the actors involved in water resources management and their needs*
- *Can explain the different roles of the actors including water users and water polluters*
- *Can distinguish between positions, perceptions and interests*
- *Will have applied some techniques to involve different actors*

3.1 Introduction

Water catchment management is a complex field that involves shaping the landscape balancing the wide range of interests that may be involved. In many cases water catchment areas may be dominated by the demands of the agricultural sector. Farmers and farmers associations in search of more land to cultivate have moved agricultural boundaries uphill and have planted vast areas with mono-cultures and irrigated. Free roaming livestock is another factor of importance in the deterioration of catchment areas. Other actors also may play an important role including for example mining industry which may have an important effect on water resources. Gradually also actors with a recreational or ecological interest are increasing their influence.

Water catchment areas should function as the prime area to store water for water supplies, provide space for valuable nature areas and unique landscapes, may have to function as living and working space for people, and may need to provide opportunities for economic production, transportation and recreation. At the same time they should be preserved for future generations. It is therefore of great importance that the right balance is struck between the various uses of the catchment areas.

Against this background it is important that actors including states, water users groups and individuals realize that they all are dependent on each other, not only now but also in future (van der Zaag 2007). Hence it is necessary to involve all actors in water catchment management. The use of stakeholder analysis in water management increased considerably as of 2004 but still today equity among stakeholders in decision making seems hard to find. According to Coleman's Social Theory (Coleman, 1990), decision making is to be perceived of as a negotiation process in which agreements are reached on the exchange of control over issues between actors in the policy domain. For the implementation of exchanges, it is important that actors have a good insight into the distribution of interest and control. This concerns both actors living or working in the catchment area and those from outside.

3.2 Looking at the actors

Preferably actors and their interactions are described from different perspectives which include looking at their networks, perceptions and their resources. In this context it is worthwhile to mention Actor Network Theory (ANT) (Latour, 2005). Although being controversial, ANT is an approach that looks at all 'actors' going beyond human and institutional actors. This theory also includes for example rainfall which may have a strong impact in a catchment (erosion, landslides etc.) or tree cutting (less retention --- less groundwater). This is an interesting perspective as non-human actors including climate change may indeed have severe effects on water catchments and therefore need to be taken into account when looking at water catchment management. Another important issue is that the situation in most catchments is not stable; actors may move out but more often move in to the area.

In this module we will focus on stakeholders, the human actors that have a stake in the water catchment. This may range from people living in the area to government institutions in charge of water catchments. Figure 3.1 shows an example of actors that may be involved in a water supply system. Many of these actors may equally be involved in water catchment management.

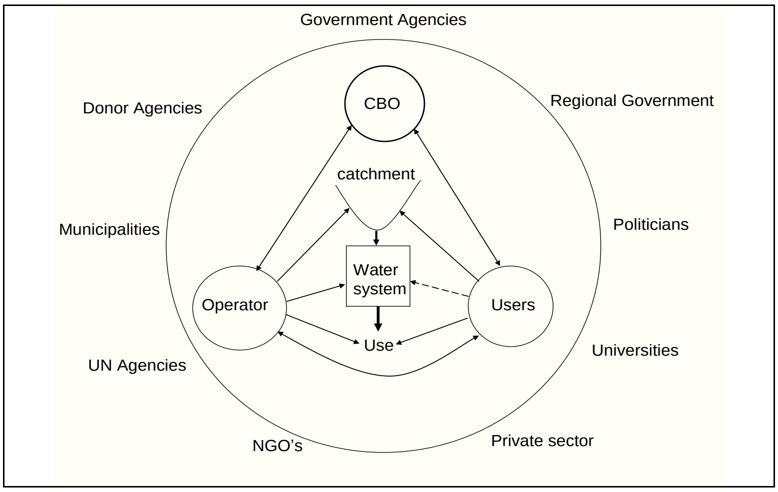

Figure 3.1 Example of actors that may be involved in a water supply system

It is important to realize that often limited time and resources are available so a very practical approach will be required to establish a stakeholder analysis. Steps involved in this analysis include:

- Identification of stakeholders
- Analysis of role of stakeholders
- Analysis of stakeholder interests and positions
- Development of a plan of action with stakeholders

Identification of stakeholders
Different options are available including sitting together with your team and make a first overview. You will then have to approach these stakeholders to confirm the information and to explore how they can become involved in the catchment management development exercise.

Timmermans (2005) mentions another approach. He identified actors to be invited to a workshop with a snowballing questionnaire, posing two questions which were adapted to water catchment management:
1. In the attached table, organizations that were approached with this questionnaire to date are listed. Please tick the parties who in your opinion have a considerable interest in and influence on the water catchment?
2. Which organizations not listed to date do in your opinion have a considerable interest in and influence on developments in the water catchment?
The questionnaire was send with a request to reply within a few days. Then the table was updated and the questionnaire was sent out to actors that were added by the first respondents.

Stakeholders may include:

- People living (and possibly working) in the catchment area (legal or illegal)
- Persons and organizations having properties in the catchment area but living elsewhere
- Organizations with legal responsibilities towards the catchment area
- People visiting the catchment area (tourists, workers)
- Organizations and people benefitting from the resources (such as water) developed/produced in the catchment area

Analysis of roles of stakeholders
Stakeholders will have very different roles in relation to catchment management and this may also reflect in their power of decision making. So it is essential to explore and register these roles. This can be done by your team with help of some resource persons or you can adopt a more participatory approach in which you arrange for a stakeholder meeting to explore their roles, positions and interests. An example of a stakeholder inventory is presented in Table 3.1.

Table 3.1 Stakeholder inventory Dire Catchment, Addis Ababa

No	Stakeholders	Role	Interest
1.	AAWSA	Overall coordination, financing, Capacity building (trainings, awareness), Water supply	Quality and sufficient water Safe water catchment
2.	Oromia Water, Mines and Energy Bureau (OWMEB)	Financing, planning, providing materials and technical support	Well managed water catchment; sustainable water supply and sanitation
3	Oromia Agriculture and Natural Resources Bureau (OANRB)	Increase the productivity of the area, introduce new methods and techniques of farming, soil and water conservation	Need to have enough water and fertile soil suitable for agriculture
4.	Forest, Environment and Climate Change Authority (FECCA)	Afforestation, Re-forestation, controlling deforestation, research studies	Clean environment free from pollution, reduced impact of climate change, carbon sequestration
5	Oromia Forest and Wildlife Enterprise (OFWLE)	Provide seedlings, technical advice, awareness raising trainings	Safe environment for wildlife; afforestation and re-forestation, reducing deforestation
6.	Awash Basin Authority (AwBA)	Financing, catchment planning, providing materials and seedlings	Well planned & managed catchment to get enough water for sectors
7	Woreda Administration	Political intervention, community mobilization (in SWC, guard, planting and coordination…etc)	Benefit for local community from well-maintained environment
8	Dire town Administration	Political intervention, community mobilization (in environmental sanitation, hygiene, construction, etc.)	water for local community, well planned and clean urban development
9	Local Farmers	Good farming practice, planting indigenous trees, environmental sanitation, participate in SWC	Benefit from water source, increase productivity, retain soil and economic benefit
10	Private Sectors	Financial contribution, technical and material support	Water access, expand investment, safe environment
11	Community Based Organizations (CBOs)	Communicate and mobilize the community	Benefit from the water resource, increase productivity, economic benefit, healthy social environment

Analysis of stakeholder interests and positions
This is an important step in the process as it will provide the basis for negotiation of intervention measures. We need to get to know these actors as they act on the basis of their perceived interests. Yet people may not realize that their perceived interests may not be their real interests and another crucial point is that some interests are not in the open (corruption, illegal activities).

Developing a plan of action
Eventually you will need to bring actor groups together to be able to discuss interests and find common grounds as we may only expect active participation if actors feel that their interests are served (such a meeting may be first time actors really meet).

In this type of meetings you may have to take into account that you may have supporters but also opponents of interventions in the water catchment area. Also it is important to see who really benefits and who loses out. In this context a gender sensitive analysis is crucial as often women may benefit less than men and may have less say in decision making.

After a first stakeholder meeting you may want to develop a matrix of opponents and supporters (Figure 3.2a,b) as this will allow you to identify what action to take to make progress. You may distinguish between main / primary stakeholders - who have the power to make the change that the utility is seeking i.e. they are or can influence the decision makers. Secondary stakeholder (Ally) - They will support the change being advocated for by the utilities because they will benefit either directly or indirectly from the change. The third group are Secondary stakeholder (opponent) - They oppose what the utility is doing. It is important to find out who would actively oppose the utility in achieving its objectives and what motivates them.

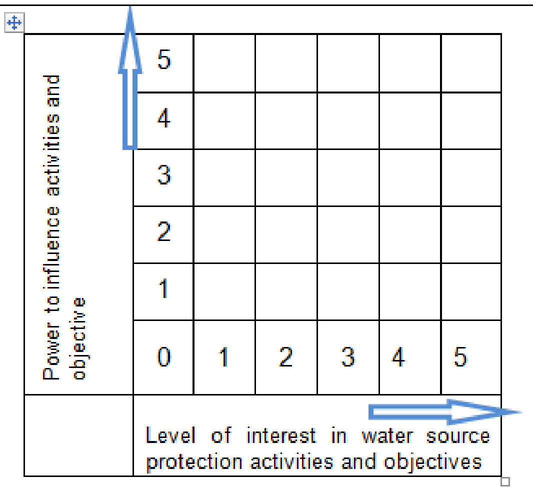

Figure 3.2.a Supporters matrix

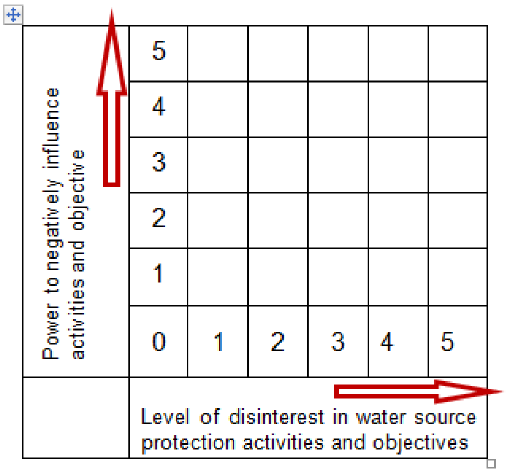

Figure 3.2.b Opponent matrix

Preparing a VENN diagram
A good way to obtain an overview of the relationships between actors is the development of a VENN diagram. This diagram consists of a graphic representation (circles and lines) of the relationships and interactions between different actors in a territory and in relation to a topic (in this case IWRM). The importance of actors can be shown by larger and smaller circles and the proximity between circles or the width of the connecting lines may represent the quality of the relationships.

3.3 Organizing stakeholder participation

Long term experience exists with stakeholder participation, but in fact it is a term which is not clearly defined. Its meaning may range from mobilization of people to eliminate hierarchies of knowledge, power and economic distribution to the involvement of relevant groups of actors in the design and implementation of development projects (based on Tufte & Mefalopulos, 2009). For sustained water catchment management it is necessary to involve all important stakeholders in planning, implementation and monitoring of interventions. The essence is to ensure that they feel responsible for protecting their water catchment.

The Ethiopian Government is adopting **Community Based Participatory Watershed Management and Development** (CBPWMD). This approach considers participatory watershed management as the rational and socially acceptable management and utilization of natural resources to fulfill local needs without depleting the local natural resources (Desta et all. 2005).

Under this concept planning and implementation of sustainable measures is advocated and implemented throughout the country. Each woreda is required to work with the local communities to assemble participatory plans for the management of small **community watersheds**, which constitute the smallest planning unit. In every watershed the community is organized in **Community Watershed Teams** (CWT) to become the backbone of the planning process. The CWT - together with local extension agents - carry out a range of participatory activities to compile development plans. At the end of the day the community together with the government will have selected a range of technologies to improve upon their situation. Implementation and monitoring will be also in the hands of the local community.

Despite challenges (i.e. difficulty for replication, engaging all land users in the watershed, implementation costs, etc.) positive results have been achieved in mini-watershed (area 400–2000 ha) and micro-watershed (less than 400 ha). However without continued dedicated support and capacity building long term impact may not be achieved (Tongul and Hobson, 2013). Evidence of success includes improvement in water discharge levels, improved water table levels, and reduced sedimentation problems. A recent survey showed however that the picture is more diverse. Kebeles have strong organizational structures that have authority and responsibility to motivate participation in intensive watershed management work. These teams significantly contribute to the development of tree/shrub plantations, rehabilitated lands, fodder grass established on bunds, and the planting of soil fertility improving species. On the other hand in many areas common use lands were universally severely degraded and showed gully formation, survival rate of seedlings proved limited and in some watersheds structure design requires review. An interesting finding was that interventions follow the administrative boundaries of Woredas and in some cases this meant that the upper part of the catchment area was not protected for being in a different Woreda (Wola Wolancho 2013).

The role of the extension agent is very important in the process of catchment improvement yet they may have to learn that facilitating change is not about telling people what to do but to help and inspire them to review their situation and identify and adopt new practices to improve their situation. It is essential that they don't think they are the only experts but truly recognize that local knowledge is of very great importance. This implies a shift from telling people what to do to encouraging dialogue and facilitating the discussion among local community members. This in many cases implies sitting back and listening carefully. In fact to empower people to unleash their knowledge is important to start a dialogue. In a dialogue there is not a winner and a loser, but a free exchange of views and ideas.

3.4 Conflict management

In a catchment area a considerable number of conflicts may exist. A conflict can be defined as “a social situation where one party tries to profit from a given situation or tries to solve its own problems in such a way that it negatively affects other parties”.

It is essential to deal with prevailing conflicts as conflicts are normal and in fact may be having a great potential for growth if the negative energy can be transferred into joint action (Visscher, 2008). So the challenge is not to avoid conflict but to manage it. Conflict avoidance and neglect can worsen the situation. Many conflicts can be dealt with in a positive way through negotiation and joint problem solving. A few key aspects include:

- All parties need to understand the conflict and gain insight in the (subjective) views of the other parties
- Dialogue as the basis for problem solving in which actors listen to each other
- Separating the people (emotions) from the problem, but dealing with both. This aspect may require the involvement of a mediator to facilitate the process. Actors need to learn how to jointly face the problem instead of each other
- Focus on interests instead of positions. The crux in conflicts is that they often involve positions of actors based on their own perceptions (that may differ among stakeholders. So it is necessary to explore the perceptions that are underlying the position of stakeholders and then to go one level up and look at the real interests that are at stake.
- Can problems be turned into opportunities by the actors allowing benefits to be enlarged and better shared?
- Develop multiple solutions to choose from and insisting on using objective criteria, independent of the will of either side, to choose the solution.

If conflicts are identified then actions need to be planned to deal with these conflicts and that may include seeking external support.

The main elements in conflict analysis include:

- Identify the problems (these may be complex and may require complex solutions)
- Who are the actors and what are their ‘positions’; how do they lose out or benefit?
- What interests are at stake?
- How can solutions be found involving the actors (part of problem and of solution)?
- Can the problem be turned into an opportunity to enlarge and better share benefits?

3.5 Self evaluation

This is an individual evaluation of your understanding of the information presented in this module. Answer the (multiple choice) evaluation questions and check your own answers (section 3.8). In case your answers had many mistakes it is suggested that you review the module again before doing the assignment.

Q1: Indicate which of the following statement is correct. (Several statements may be correct)

A: Top down decision making is the best option for sustained water catchment management
B: All actors need to be involved in water catchment management as states, water users groups and individuals are dependent on each other, not only now but also in future
C: The Actor Network Theory refers to human and non-human actors. This implies for example that rainfall is an actor
A: A stakeholder analysis only has to be done ones for a catchment area

Q2. The stakeholder analysis includes: identification of stakeholders, exploring their roles, positions and interests
A. Yes
B. No

Q3. Indicate which of the following statement is correct. (Several statements may be correct)
A: Ethiopia has developed an approach under which community watershed teams are responsible for the management of smaller watersheds
B: The extension agent is the authority who has to tell the people in the watershed what to do
C: It is important in conflict management to separate the problems from the emotions to be able to come to agreements.
D: One crucial element in conflict management is to identify the positions of the different actors and to explore the underlying interests

3.6 Assignment

In this section you will find the assignments related to this module. This assignment you will need to start with your group.

1. Develop an overview of the actors in relation to the water catchment area(s), give an indication of their role and their possible interests;
2. Draft a VENN diagram that includes the different actors and their relationships

At this point in time the idea is to develop this with your team possibly seeking some external inputs. In the future you can confirm the results in a stakeholder meeting.

Action: *Provide results of the assignments to your facilitator*

3.7 References and further reading

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3.8 Answers to self-evaluation questions

Q1: Answers B and C are correct.

A: Top down decision making is not the best option for sustained water catchment management as stakeholder involvement in decision making is essential

B: It is correct that all actors need to be involved in water catchment management as states, water users groups and individuals are dependent on each other, not only now but also in future

C: The Actor Network Theory indeed refers to human and non-human actors. This implies for example that rainfall is an actor

D: A stakeholder analysis will have to be repeated as the situation in the water catchment may change over time with new actors coming in and existing actors going out

Q2. Answer A is correct

A: Yes The stakeholder analysis includes: identification of stakeholders, exploring their roles, positions and interests

Q3. Answers A, C and D are correct

A: Ethiopia has indeed developed an approach under which community watershed teams are responsible for the management of smaller watersheds

B: The role of the extension agent is very different in a more participatory approach where the agent is the facilitator of the process helping local actors to come to grips with the situation

C: It is indeed important to separate the emotions from the problems as strong emotions makes adequate listening impossible. So the crux is to separate the two for example by having mediators acting as spoke persons

D: Positions in conflict management are important, but even more important are the underlying interests of actors as these will provide indications how problems can be solved

If you failed to provide one of the correct answers, then review this module again.

Module 4 *Practical improvement measures*

This module introduces improvement options that may help to overcome priority problems that have been identified in the catchment area. This includes legal, technical and organizational mitigation measures which will serve as an input for developing a protection and mitigation plan for the risks that were identified.

At the end of this module the participant will be able to:

- *Present different options to solve problems in water catchment areas*
- *Indicate which of these measures are more relevant for their water catchment*

4.1 Introduction

The introduction of improvement measures will depend on the type of problems that have been identified and whether we talk about a groundwater or surface water based system. In the case of groundwater it is also important to distinguish between shallow and deep groundwater. In general we may be faced with two types of problems being water quality problems and water quantity problems.

In Table 4.1 a number of problems related to groundwater based systems are indicated and possible remedial action is mentioned and several of these actions are described in some more detail in section 4.2.

Table 4.1. Action to prevent or reduce risks in existing groundwater sources

Problem	Remedial action
Pollution of aquifer “upstream” of the water source by infiltration. This may be more relevant for shallow ground water unless we talk about contamination with chemicals	Avoid or remove latrines, waste dumps, cattle ponds and pools and seal old wells close to the water collection point. Also agriculture activity using herbicides and pesticides should be avoided. The ‘safe distance’ above the water point needs to be assessed locally as it depends on the travel time of harmful bacteria or chemicals and the direction of flow of the ground water.
Reduction of infiltration because changes in the environment which increases run-off; irrigation activities	Identify zones that need to be protected in the catchment area, ensure adequate protection avoiding overgrazing, and deforestation; built water retention structures (bunds, trenches) to enhance infiltration
Direct infiltration of pollution in the source which particularly applies to springs but in some cases also this may apply to deep wells in they are flooded or poorly protected	Ensure fencing of springs to avoid erosion of the protective cover (back fill). Review system components (spring box, well cover etc.) for possible cracks and repair them Disinfect the source after pollution has occurred (which may be shown by an outbreak of diarrhoea)
Wells running dry and/or salt water intrusion	Avoid possible over-pumping of groundwater in the area as this may cause a fall in the water table. In some areas it may also result in salt water intrusion. Another option to look into is to enhance recharge of the groundwater for example by improvements in the catchment area or by building of subsurface dams

In Table 4.2 a number of problems related to surface water based systems are indicated and possible remedial action is mentioned and several of these actions are described in some more detail in section 4.2. Water quality changes are more of a problem in surface water systems as changes in water quality may be considerable and may be heavily influenced for example by increase in erosion, use of fertilizer and other man made activities. Water availability may also be affected and may differ considerably between the wet and dry season.

Table 4.2 Actions to prevent or reduce problems in existing surface water sources

Problems	Remedial action
Pollution of water source "upstream" of the point of collection	Avoid, remove or reduce, waste water discharge, cattle grazing, human intervention, agricultural activities and mining that may affect the water quality and water availability. Close intake if water quality deteriorates (dead fish, bad smell, strange colour etc.). Adequate water catchment protection is a good start to ensure good water quality, but almost always some form of treatment of the surface water will be needed
Loss of storage capacity due to different problems including unsustainable land use, wrong agricultural practices, lack of maintenance of water retaining structures, and siltation of reservoirs and lakes	Improve agricultural practices, avoid overgrazing, ensure adequate vegetation cover, control cereal dominated farming system which gives little ground cover during the onset of the erosive rainfall, reduce water runoff and ensure proper maintenance of water retaining structures, turn roads into water catchment opportunities instead of generators of erosion problems
Increased run-off due to interventions in the catchment area (deforestation, road construction). Usually this implies reduced runoff in the dry season	Identify zones that need to be protected in the catchment area and ensure adequate protection; avoiding overgrazing, deforestation and inadequate land management. Construct bunds and implement other protection and corrective measures if erosion is increasing.

The 3R approach

A powerful concept in water catchment management that has been developed is called the 3R approach which stands for ***Recharge, Retention and Reuse***. This concept in essence tries to keep as much water as long as possible in the landscape in the water catchment area. It involves water management as well as land management using both traditional and innovative practices. The approach embraces the concept of ***water buffering***, storing water when it is plentiful and making it available for the dry periods. The water buffer is the capacity of the landscape to hold water (sum of groundwater, soil moisture and reservoirs). The idea is to store water where feasible in a decentralised manner. This buffer can be enlarged by strategic ***recharge*** and ***retention***, which includes building structures that retain the water and stimulate infiltration. The approach uses all components available in the landscape including roads which in fact may be a good source for water collection by channelling it to retention structures. The concept of ***reuse*** is much wider than treating and reusing wastewater. It implies trying to collect the water that is used in different parts of the catchment area and to reuse this directly or arrange for capturing it in retention and recharge structures to avoid that it just turns into surface runoff. This approach may be beneficial to reduce or avoid water quantity problems, but may also improve water quality by controlling surface runoff.

An added advantage of 3R is that it includes buffering water in the subsoil which improves soil moisture and increases the availability of shallow groundwater. This way of buffering makes an important contribution to 'green water management'. Green water management is the management of soil moisture based on improved tillage, mulching, physiochemical and biological processes. By infiltrating water into the soil, 3R contributes to green water management in a way that leaves a positive footprint on both ecosystems and agricultural production.

4.2 Water catchment interventions

4.2.1 Administrative interventions

The issue of administrative interventions often are not much mentioned. In the case of Ethiopia the government has issued regulations that force actors to participate in watershed management campaign work.

Another option to explore is ***payment for environmental services*** (PES). This approach follows the "beneficiary pays principle" which states that communities and individuals who use their land or other environmental goods in a way that contributes to the provision of environmental services should be paid. A case study in Colombia (Pagiola and Rios, 2013) reviewed the application of a PES mechanism in a Silvopastoral Project in Quindío. Results show that payments had a positive and highly significant impact on land use change. On average PES recipients converted over 40 percent of their farms to environmentally-friendly land uses over 4 years, increasing environmental service provision by almost 50 percent. In contrast, control group members converted less than 20 percent of their farms, increasing environmental service provision by 7 percent.

Water licences provide an actor with a right to use or pollute surface water or groundwater. Use may be consumptive (where water is not returned to the source e.g. irrigation) or non-consumptive (hydropower, cooling). A licence normally identifies the water source, the location of abstraction, the amount of water to be impounded, diverted or abstracted, the priority of the "water right" established by the licence, and conditions under which the diversion and use must take place including limits on use, time limits and other restrictions such as drought conditions (Warner et all, 2009). A water licence grants the right to abstract, and use a certain amount of water during a certain time period, subject to certain conditions, and often against a certain fee. It may grant the use of a fixed amount (m3 per day) or a proportional (time) share of a water flow. A licence implies rights and responsibilities for users and the issuing authority. It presupposes effective water control down to the level of the licence holder.

Wastewater discharge fees are another mechanism to help protect a water source from receiving high levels of pollution. The discharging of waste may adversely affect the quality of the receiving waters, and, as a result, may interfere with ongoing activities, plans, rights of users of such waters - from commercial users to conservationists - and with the diffuse interest of the general public in a healthy and clean living environment. Waste water discharge fees are usually based on volume and water quality using for example the Biological Oxygen Demand (BOD) as an indicator. Introducing this type of charges encourages industry for example to reduce their wastewater flows and improve their waste water quality to reduce payments.

4.2.2 Improving existing (agricultural) practice

Agriculture in sloping terrains may have a very negative impact particularly on water quality but also on water retention. Erosion of agricultural lands may often be strongly reduced by introducing simple measures several of which are indicated in this section.

Covering barren lands is another practical method. This may be done by the use of **mulch**. This implies spreading a thin layer of organic materials over the soil surface after the harvest like a thin blanket. This will reduce evaporation, limit weed growth, and protect from erosive runoff and rain splash. Organic mulch also provides a source of nutrients and favours the biotic life of the upper soil layer. Common mulch materials are agricultural residues, hay, branches and all sorts of plant residues. An alternative is the use of plastic polyethylene sheet, which is more expensive and may hinder infiltration.

Contour ploughing, instead of downhill ploughing which leaves great pathways for erosion. This implies that you follow the contour lines when ploughing so the trenches are perpendicular to the flow direction of runoff water and help to reduce the flow and increase water infiltration (Figure 4.1).

Contour ploughing is better than uphill ploughing as it generates less opportunities for the formation of runoff channels; other measures such as strip cropping will be also required particularly on larger areas and steeper slopes

Figure 4.1 Contour ploughing to avoid creating runoff channels

Increasing the organic matter content of the soil helps to enhance the moisture content of the soil in sandy soils making more water available for plants whereas in clay soils it increases the possibility for water to infiltrate.

Managing irrigation is another valuable intervention as often “over irrigation” takes place in many irrigation schemes. This is the phenomenon that more water is provided than needed and this increases runoff, leaching out of fertilizers and removal of valuable topsoil.

Strip cropping is another option to maintain vegetative barriers to reduce soil loss and increase infiltration. An alternative is to maintain ***grass strips*** that follow contour lines and alternate with other crops or with sections planted with productive three growing. Depending on the grass used, the strips may provide fodder for livestock as well.

Controlling free roaming livestock in the water catchment is an approach that ensures that the number of livestock is kept at a low level to avoid overgrazing. In some more vulnerable areas it may be considered to avoid livestock entering the area and for example adopt an approach where cattle is kept a specific areas at the farm and provide them with additional fodder harvested for example from grass strips.

Enhancing vegetation cover as this will help to reduce evaporation by lowering the temperature, and reducing the effect of wind speed.

Area closure is an approach that helps to improve the quality of highly degraded lands or to protect areas that are liable to degradation such as unprotected hill sides. It is particularly important in the management of communal lands that are affected for example by overgrazing.

4.2.3 Introducing technical measures for water retention

Different measures may be used to improve the water catchment. A group of measures aim to reduce runoff, which occurs on hillsides when the rainfall exceeds the infiltration rate of the soil and the topography (small depressions in the soil) cannot retain the excess water. The water will then most likely flow overland, at first as sheet (or dispersed) runoff but further downhill it turns into concentrated runoff which can create a lot of problems.

A number of technical measures can be taken including some of the improved farming practices mentioned in 4.2.2 can help to reduce runoff, but often technical interventions will also be needed. Technical measures may include keeping water on the spot by reducing runoff and increasing infiltration (Figure 4.2). This may help to increase to increase the availability of groundwater, but also has a direct benefit for farmers as reducing water runoff will reduce erosion of valuable topsoil and limit leaching out of nutrients making for example the use of fertilizers more effective.

		
Construction of water retaining bunds possibly including planting of trees	Building of water retaining terraces	Constructing terraces separated by grass strips
		
Growing vetiver grass strips	Construction of trenches to retain and infiltrate water	

Figure 4.2 Measures to reduce runoff and increase infiltration

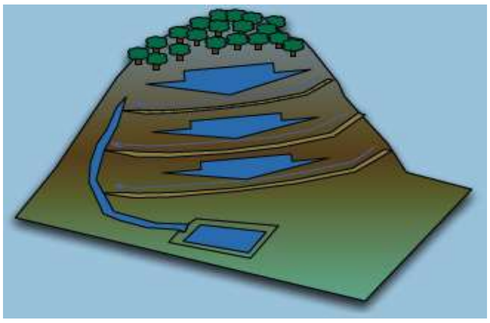
Another important measure may be to concentrate runoff and guide it in a controlled way to a storage reservoir (Figure 4.3). This may include systems that collect water from roofs, rocky areas, and roads but also systems that retain the subsurface flow in rivers. Important differences exist between systems in terms of water quality with rooftop systems providing better quality with a lower sanitary risk, whereas runoff caught from the surface is likely to contain more contamination. In the case of sand dams the water quality depends on the area were water is infiltrating and the distance the water travels through the soil to the place where it is abstracted. Evaporation depends on the type of system with open reservoirs being more affected than subsurface storage and closed tanks.

An emerging option that has important potential is the use of the runoff from roads. This has multiple advantages as in many situations existing roads or new roads may have serious impacts in the landscape which may be avoided by organizing a proper drainage system (Figure 4.4). If this water subsequently is taken to a storage reservoir than local farmers may benefit by using the water for their crops.

Rooftop water harvesting

Harvesting water from surface (Gibraltar)

A water harvesting pond for small scale irrigation



Graded bunds can be used to direct water to natural or artificial waterways and finally to a water reservoir/infiltration pond

Wetlands can also help to retain and infiltrate water

Sand dam to harvest water from surface and subsurface water flow in a river bed

Figure 4.3 Measures to concentrate runoff and guide it to a water storage system

Roadside runoff causing gully erosion

Collection gutter channelling water from the road to a pond

Figure 4.4 Controlling roadside runoff is needed and may generate additional benefits

4.2.4 Protecting gullies

Gullies may be present in many places and may cause severe erosion. Two aspects need considerable attention, the reduction of water flowing to the gully and lowering of the flow velocity in the gully. Allowing less water to flow to the gully implies taking water retention measures as indicated in Sections 4.2.2 and 4.2.3. Reducing the flow in the gully requires the installation of water retention structures some of which are shown in Figure 4.5

	
Gully rehabilitation with gabion check dam	Vegetation growth before the check dam in a gully
	
Farming in gullies is attractive because of the fertile soil and longer availability of water	Wooden check dam

Figure 4.5 Different options to control the flow in gullies

4.3 Introducing improvement measures

The introduction of improvements measures depends to a considerable extent on landscape and particularly the slope Figure 4.6. The interventions related to the type of slopes are presented in section 4.3.1. For steeper slopes the question always arises whether it is prudent to use this for agriculture or cattle farming.

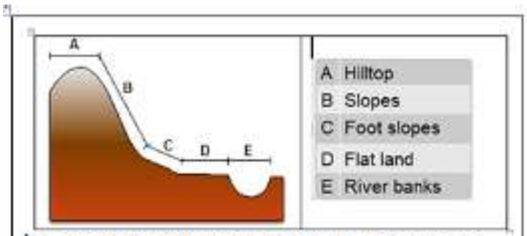


Figure 4.6 Differences in the landscape

Another key element in relation to introducing improvements is about planning and monitoring which will be discussed to some extend in section 4.3.2.

4.3.1 Selecting improvement measures

In Table 4.3 an overview is presented of the more common interventions in the areas mentioned in Figure 4.6.

#	Section	Interventions
1	Hilltop	• Flatter areas on top of gentle hills and older mountain reliefs preferably are used for managed pastures (if required cut and carry); sheet erosion (erosion of topsoil) needs to be controlled with barriers and vegetation cover • Steep hilltops should preferably be protected from cereal farming and grazing livestock
2	Slopes	• Preferably slopes are left with a permanent vegetation cover; steeper slopes preferably are closed and this also applies for slopes used as micro-catchments for water supply • Farming and tree growing on slopes up to 50% requires terraces, trenches and other barriers such as bunds, and vegetation strips • High value trees may be an option in several areas provided tree cutting is done on a rotation basis
3	Foot slopes	• Cutoff drains to protect the land from incoming runoff; properly protect gullies including the construction of check dams • Bunds, grass strips, agroforestry and terraces to stabilize the slope, increase infiltration and control soil losses • Recharge structures such as pits and trenches • Ponds to collect water from upper slopes
4	Flat lands	• Protection from incoming runoff; • Construction and maintenance of bunds and furrows, keep the soil covered
5	River Bank	• Permanent vegetation cover to protect the river as much as possible; in some cases construction of sand and silt traps to reduce inflow of suspended solids although this may apply more to water storage reservoirs

4.3.2 Monitoring and reporting

One common problem is that different interventions may be planned and implemented but reporting on the process may be weak. The implementation process can be managed by following each of the interventions and by reporting on progress against the planned interventions. Indicators of progress may include the length of canals or bunds constructed, the area planted with protected land cover, and the number of weirs constructed in gullies. This however does not relate to the effect that is anticipated which particularly relates to erosion and runoff control. This should be measured in terms of reduction in suspended solid loads in lakes and reservoirs and in streams leaving the area and in the reduction of runoff that is being achieved and or the additional volume of water that is being stored.

It needs to be clear to whom reports need to be submitted and staff should also be aware of the possibility that their activity may be evaluated which may include repeating the procedure under supervision to ensure that they follow all the steps.

Effective monitoring needs to be simple and need to lead to effective and timely action. Crucial issues to be shown in the monitoring procedure include:

- What will be monitored and how this will be done (including frequency and location)
- Who will monitor
- Who will analyse the result and propose that action is taken
- The person that will take action

An even more important issue to monitor is the follow-up that is needed to sustain and maintain the intervention measures. Monitoring of maintenance and follow-up activities needs to be properly planned, monitored and as needed reported upon. Monitoring in this case in first instance needs to be ensured in such a way that the actor that is to take the action understands the importance and has simple indicators that verify the action that is needed. Indicators may include, for example: monitoring of the survival rate of seedlings that are planted for reforestation, the state of the bunds that have been developed, and the state of the gullies that have been improved. For each indicator an acceptable range needs to be established as well as activities that need to be implemented if results are not within the established range. In addition management needs to check at times if prescribed limits were passed and whether appropriate action was taken.

4.4 Self evaluation

This is an individual evaluation of your understanding of the information presented in this module. Answer the (multiple choice) evaluation questions and check your own answers. In case your answers had many mistakes it is suggested that you review the module again before doing the assignment.

Q1. Indicate which of the following statement is correct. (Several statements may be correct)

A: Water catchment management is not important for groundwater based systems
B: Water catchments of groundwater based systems may be far away
C: Water companies need to take water catchment management into account
D: Water catchment management is important in relation to water treatment

Q2: What is included in the idea behind the water buffering approach?

A: Store water when is abundant and make it available during the dry season
B: Create water storage all over the landscape where feasible and practical
C: Promote subsurface water storage
D: Build big reservoirs to keep water in a central location for the use of all local stakeholders

Q3: Indicate which of the following statement is correct. (Several statements may be correct)

A: Paying farmers for not using (part of) their land may enhance the sustainability of the water source of a water company
B: Contour ploughing increases erosion
C: Controlling free roaming livestock in the water catchment is very important as it reduces the negative impact on the environment and reduces the risk of erosion
D: Increasing the organic matter content of the soil is important both for sandy and clay soils

Q4. Indicate which of the following statement is correct. (Several statements may be correct)

A: Controlling runoff is one of the most important measures in water catchment management

B: The time after the harvest is critical for erosion control; keeping a cover on the land and having grass strips along the contour lines helps to reduce erosion

C: Road water harvesting protects the road and may be of benefit to farmers

D: Effective monitoring of the management of structures that have been constructed such as bunds, trenches and check dams in gullies are of crucial importance

4.5 Assignment

In this section you will find the assignments related to this module. Preferably you do this assignment with your group but you may distribute the tasks. After completion discuss with your training group, organize the field visit, finalize the assignments and share with the facilitator.

1. Use the overview of the main problems that you have identified in the catchment area as part of the assignment of modules 2 and identify possible solutions for these problems
2. Make a visit to the catchment area and confirm solutions with local actors (transect walk)

Action: *Provide results of the assignments to your facilitator*

4.6 References and further reading

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- Nissen-Petersen, E., DANIDA. (2006). Water from dry riverbeds
- NWP, Agua for all and other organizations (2007). Smart Water Harvesting Solutions Examples of innovative low-cost technologies for rain, fog, runoff water and groundwater
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4.7 Answers to self-evaluation questions

Q1. Answers B, C and D are correct.

A: Is not correct because water catchment management is important for groundwater based systems as this management will need to ensure water availability in the aquifer that is being used by the water utility

B: Water catchments of groundwater based systems indeed may be far away and water reaching the system may travel for a very long time in the aquifer from the recharge area to the well
C: Water companies need to take water catchment management into account because of its potential effect on water quantity and quality
D: Water catchment management is important in relation to water treatment as proper catchment protection reduces the risks related to water quality and availability

Q2. Answers A, B and C are correct.
A: Storing water when is abundant and making it available during the dry season is the main idea behind the water buffering approach
B: Creating water storage all over the landscape where feasible and practical is an essential component of the approach
C: Promoting subsurface water storage is an important element as evaporation of subsurface water is lower
D: Build big reservoirs are not part of water buffering concept of the 3R approach as they make massive changes to the landscape, require complex management bodies and are not practical for solving the problems of rural communities who are dispersed over the landscape

Q3. Answers A, C and D are correct.
A: Is correct because paying farmers for not using (part of) their land for agriculture but letting it return to its natural state may regulate runoff, improve water recharge and reduce erosion which all contribute to the sustainability of the water source
B: Is not correct because contour ploughing reduces the risk and severity of erosion
C: Is correct because it is important to control free roaming livestock as this may create a lot of damage in the water catchment area and may lead to severe erosion
D: Is correct because increasing the organic matter content of the soil helps to enhance the moisture content of the soil in sandy soils making more water available for plants whereas in clay soils it increases the possibility for water to infiltrate

Q4 Answers All answers are correct
A: Controlling runoff is indeed one of the most important measures in water catchment management. With high runoff more material will be carried down the slope, so it is very important to slow down or completely stop runoff
B: It is correct that the time after the harvest is critical for erosion control; if the land is barren soil will be more easily carried away. So keeping a cover of for example mulch on the land and having grass strips along the contour lines helps to reduce erosion
C: It is indeed correct that road water harvesting protects the road as it will ensure that rainwater flows in a controlled way to a water storage pond where it can be used by farmers
D: It is correct that effective monitoring of management of water catchment protection structures such as bunds, trenches and check dams in gullies is essential as damage to these structures may make them useless

If you failed to provide several of the correct answers, then review this module again.

Module 5 *Towards a water catchment plan*

This module completes the steps involved in developing and implementing a Water Catchment Plan includes completing of the plan, monitoring measures and a management programme.

At the end of this module participants will have:

- *Developed a water catchment management plan to overcome the priority problems, hazards and risks that were identified through practical mitigation activities*
- *Established a monitoring program to enhance the sustainability of proposed interventions*

5.1 Introduction

Planning and management are perhaps the most neglected aspects of water supply systems including water catchments in many parts of the world. It is very common that breakdown or reactive management is applied. This implies acting (repairing) when things have gone wrong. As a result many water supply systems show substandard performance and obtain water from surface sources with water catchments that are deteriorating. The same applies for ground water based systems that also obtain their water from (often more remote) water catchment areas with the additional difficulty that other users may use the same aquifer and together too much water may be pumped out resulting in falling water tables that in the long run may make the system unsustainable.

This underscores the importance to develop a water catchment management plan together with other actors. The analysis of the problems in the catchment area may already be a very important step for the water utility to explore the potential challenges they may be facing at this very moment but also in the near future taking climate variation and climate change into account. A water catchment management plan needs to be tailored to the specific local conditions clearly setting practical priorities that can be achieved. This implies a diagnostic approach, followed by the practical implementation of practical and achievable solutions. The two pillars are 1) getting a clear overview of the problems at hand and 2) working together with other actors and the local community in the catchment area(s) to find and implement practical solutions. Finding solutions will need to include reviewing local interventions that may be in place and may generate a foundation for scaling up instead of introducing external solutions that have not been applied before. In this context it is necessary to make a good assessment of interventions that have already been applied in the area and with what level of success and why. When solutions can trigger a WIN-WIN situation for the utility and for local actors they stand a better chance of success. In Box 5.1 an annotated outline for a Water Catchment Management Plan is provided.

An essential activity is to discuss the situation with knowledgeable persons in your utility and in the catchment community. You can learn a lot from these discussions and you may find for example that monitoring is not part of the daily routine and that breakdown maintenance is common, with the big disadvantage that this cannot be planned and so interventions may take more time and may come at an inconvenient moment.

It is important to take an action oriented approach from the beginning. The review of the catchment area will show a number of problems which sometimes may be very serious for the utility but also for the local community. It does not seem fair to just leave the community and write a report instead of already exploring possible ‘emergency’ improvements that can be implemented quickly. The key issue to problem solving is to get a good understanding of the situation and predict and prevent problems before they occur. At the same time it is essential to be practical and realistic and to keep in mind that it is necessary to find the balance between investing in water catchment improvements and the cost reduction in water treatment and the increased reliability of the water supply system.

Box 5.1 Annotated outline of a Water Catchment management Plan

1. **Introduction**: Brief presentation of water company, the link with the water catchment (including volume of water used) and reason for assessment - problem statement; (e.g.: water quality deterioration, uncertainty about security of the water source), indication target audience of report (e.g.: management); presentation WCM team; content report
2. **Objectives**: presentation of objectives; these may relate to possible identifying problems and solutions in the catchment area that may affect the water quality and quantity but also potential landslides affecting structures
3. **Methodology**: indication of the methods that were used in the study (secondary data, transect walk etc.
4. **The situation in the catchment area:** Description of catchment area and the water supply situation (including facts and figures and trend analysis and climate risk)
5. **The main problems**: Overview of the problems, hazards, hazardous events and risks (in relation to your main objective) to enable priority setting
6. **Stakeholder inventory** Description of the stakeholders, their connection (VENN diagram) and their role and interest in relation to the water catchment and the problems that have been identified
7. **Earlier interventions related to priority problems**: indication of earlier interventions in the catchment area (what has been done before, how, to what effect)
8. **The main solutions that will be introduced:** For each priority problem solutions will be presented as well as the actors involved
9. **The detailed plan:** including a list of activities and time frame to implement the solutions, the actors involved and the required budget
10. **Monitoring implementation and follow-up:** Providing an overview of the main actions to be monitored including post construction monitoring

The water catchment management plan needs to be prepared and include clear activities, responsible actors, a time frame and (financial) resources. This may include simple actions in relation to improving and organizing procedures to investments in the water catchment areas but many activities may be the responsibility of other actors which may make their implementation more complex. The plan may include short-, medium- as well as long-term activities which need to be planned with management and may require external support which in turn may have an impact on timing. When resources are scarce priorities need to be established carefully taking into account the cost involved and benefits that can be achieved for the different actors that are involved. Implementation of the plan needs to be monitored and reported upon. Some improvements may be rather easy to implement and at low cost. Even if these are not a priority it may be considered to implement these pretty quickly in order to show quick results.

5.2 Development of the water catchment management plan

The development of a Water Catchment Management Plan involves a number of steps:

- ***Establishing of a small WCM team*** that directly reports to management. The team needs a clear TOR that includes assessing and describing the situation, proposing objectives and concrete actions for WCM with clear cost estimates, and proposing an approach to enhance the interest of other actors. As catchment management is not the direct responsibility of a water utility the team needs to work closely with other actors. It may be decided to establish a team led by other organizations, but it is important that the water company has its own team that gains full understanding of the situation and may be able to influence other organizations. So in that sense it may be attractive to initiate the activities with an internal team and then build the case for a wider effort.

- ***Clarifying the objectives and methodology*** which is an important step because you need to be able to explain very well what problems you need to address. As the emphasis in this course is on the relation between a water supply system and the water catchment area you need to make sure that your objective reflects that. As a water utility your concern may be a deterioration of the water quality and reduction of the water quantity which would affect your sustainability.

  So the overall objective may indicate something like:

  - To identify and mitigate water catchment related problems (hazards and risks) that may affect the water supply system of Adama

  Specific objectives may indicate something like:

  - To analyse the situation in the catchment area to identify possible problems that may affect the water quality and or water quantity of the system
  - To explore possible problems in the water catchment that may affect the physical structures of the water supply system

  Once you have established your objectives you need to proceed with developing your methodology. This may include a number of main activities and techniques such as:

  - Review of information (published and unpublished) as you do not want to burden people by asking information they may have given before
  - Mapping the catchment area
  - Developing questionnaire(s) but be critical only asking what you really want and need to know (often we ask far too much)
  - Transect walk(s) (systematic approach to explore the water catchment area
  - Informal interviews and focal group discussions
  - Actor analysis using a VENN diagram

- ***Making a description of the catchment area(s)*** which needs to include the basic data presented in module 2. To be able to do this you need to delineate your water catchment area (Figure 5.1). It is further important to explore which parts of the water catchment are most important for your water source. This may relate to water quantity as not all areas contribute in the same way in the generation of runoff or water infiltration. This may also apply for water quality as not all parts of the water catchment have the same level of erosion and contamination.

  To be able to make the description of the water catchment you will need to collect data from existing reports and combine these with data that you can obtain in a field visit. The general data to be reported were already indicated in Table 2.1 in module 2 but it is also useful to add a time line as shown in Table 5.1.

Figure 5.1 Delineation of Dire Dam Water Catchment

Table 5.1 Catchment development pattern (Time line)

Land Use and Land Cover (LULC) Classes	1985	1997	2013
	Area (%)	Area (%)	Area (%)
Water body	2.1	1.9	2.0
Cultivated land	37.3	39.9	55.6
Settlement	1.5	1.6	15.8
Grazing land	31.0	19.1	5.3
Eucalyptus Plantation	4.6	20.3	16.2
Bare Land	23.5	17.2	5.1

- ***Making an overview of the main problems*** which needs to include a listing of the problems, hazards, hazardous events and risks (in relation to your main objective) and a priority setting to be able to focus on the main problems to be solved.

Table 5.2 Example overview of main problems

	Hazardous event*	**Hazard**	**Risk**	**Priority**
1	Deforestation	High sediment load due to soil erosion Reduced infiltration	High on steep slopes	High
			Moderate on gentle slopes	Medium
2	Intensive farming	High sediment load due to soil erosion Water pollution	High on slopes	High
			Moderate on flat land	Medium
3	Over grazing (on common lands)	High sediment load due to soil erosion	High on steep/gentle slopes	High
			Low on flat land	Low
4	Poor gully management	High sediment load due to soil erosion	High as flow from steep slopes concentrates in gully	High
5	Growth of settlement	Pollution	High as wastewater not treated	High
*	Most hazardous events are rainfall related			

- ***Preparation of a stakeholder inventory*** implies starting to make a list you're your colleagues and indicated the actors, the roles and their perceived interests (Table 5.3). Thereafter you can check this in a stakeholder meeting or separate interviews.

Table 5.3 Example overview of stakeholders related to the catchment

No	Stakeholders	Role	Interest
1.	Water utility	Financing, Capacity building (awareness), Water supply provision	Sufficient good quality water Protected water catchment
2.	Oromia Water, Mines and Energy Bureau (OWMEB)	Financing, planning, providing materials and technical support	Well managed catchment; sustainable water supply and sanitation for people
3	Oromia Agriculture and Natural Resources Bureau (OANRB)	Increase in farm productivity; introduction new methods and techniques of farming, soil and water conservation	Need to have enough water and fertile soil suitable for agriculture
4.	Forest, Environment and Climate Change Authority (FECCA)	Forestation, controlling deforestation, research studies	Clean environment, reduced impact of climate change, carbon sequestration
5.	Oromia Forest and Wildlife Enterprise (OFWLE)	Provide seedlings, technical advice, awareness raising trainings	Afforestation and re-forestation, Reduced Deforestation and safe environment for wildlife
6.	Awash Basin Authority (AwBA)	Financing, catchment planning, providing materials and seedlings	Well planned & managed catchment to get enough water for sectors
7	Woreda Administration	Political intervention, community mobilization (in SWC, guard, planting and coordination)	Benefit for local community from well-maintained environment
8	Dire town Administration	Political intervention, community mobilization in environmental sanitation, hygiene, construction, settlement	water for local community, well planned and clean urban development
9	Local Farmers	Good farming practice, planting indigenous trees, environmental sanitation, participate in SWC	Benefit from water source, increase productivity, retain soil and economic benefit
10	Private Sectors	Financial contribution, technical and material support	Water access, expand investment, safe environment
11	Community Based Organizations (CBOs)	Communicate and mobilize the community	Benefit from the water resource, increase productivity, economic benefit, healthy social environment

- ***Earlier interventions related to priority problems***: in many catchment areas interventions may have already been made by different actors and with different levels of success. It is necessary to make a list of the main interventions and the level of success as this in part may determine the response and possible resistance of actors to go along with new interventions. Successful interventions provide for great learning and can be built upon. New interventions you may want to start through learning projects with local actors. Table 5.4 gives an example of a way to report on earlier interventions.

Table 5.4 Example of earlier interventions

Intervention	Lead actor	Effect
Forestation with indigenous trees, seedlings planted on common land through public campaign led by development team' members who encourage / enforce local participation.	• Woreda agriculture and natural resources office (WANRO), with support water company • Oromia Forest and Wildlife enterprise	The initial effect was good but due to limited follow-up many seedlings died, also because responsibility for maintenance on common lands was not established
Soil and water Conservation (SWC) awareness raising and training	Different organizations including WANRO, OANRB, FECCA, water utility	Effect is good in some locations which can be used for learning / demonstration and not effective in others
Gully protection with check dams construction	Bureau of Agriculture	Check dams construction by trained manpower are usually fine; those constructed in campaigns are of lesser quality

- ***The main solutions that will be introduced*** which should look at the priority problems, costs and benefits, experience with earlier interventions, and availability of actors to lead and implement the solutions. For each of the specific improvement actions that is developed it needs to be clear what benefit it may achieve, who will be the actor that will be responsible to implement the action, what budget is available and when the action needs to be completed. In Table 5.5 a few examples are presented of interventions that a water utility may want to take forward as to meet their specific interests in relation to water quality, water availability and mitigation against climate variation and climate change. Preferably the actions are listed in order of importance. Actions may be very diverse and may include technical interventions, action oriented information sharing, training, as well as setting up a good monitoring system. Feasibility of the interventions needs to be checked as will be indicated in section 5.3. A difficulty may be the availability of (financial) resources, but with a good plan in hand it may be easier to convince external actors that resources are needed. It will also be important to clarify the gains that may be obtained for local actors (e.g. less loss of fertile topsoil) as well as external organizations including the water utility (e.g. better water quality).

- ***The detailed plan***: can be put in the form of a bar chart in excel which shows the main activities and the time frame of their implementation (Table 5.6). In combination with this chart you can also connect the main actors with the activities (Table 5.7). You can make this chart more detailed adding more actors and including the time expected to be spent on each activity.

Table 5.5 Examples of catchment related interventions for a water utility

	Specific improvement action including goal	**Specific activities**	**Responsible person**	**Budget (Birr)**	**Due date**	**Status** *(not yet started, actions undertaken to date, etc.)*
1	Facilitating and financing of forestation to protect areas of relevance to water source(s)	• Contact WANRO and OANRB • Identify priority areas for the water utility • Help to develop detailed plan • Help organize local team • Facilitate access to seedlings and implementation • Encourage maintenance (arrange monitoring)	Mr. A	………	…… …….	………………

2	Stimulating Soil and Water Conservation (SWC) in areas that are most relevant for the water sources of the utility	• Contact WANRO and OANRB • Identify priority areas for the water utility • Help to identify most feasible solutions (find demonstration areas / good local practice) • Help to develop detailed plan • Support implementation • Encourage monitoring	Ms. B	………	…… …….	………………
3	Explore with OANRB which gullies are particularly important for the water utility and support interventions	• Contact OANRB • Identify the gullies that are most important • Identify good practices in the area (construction and maintenance) • Encourage developing plan with local actors • Co-finance interventions • Encourage monitoring	Mrs. C	………	…… …….	………………
4	Explore possibilities to pay (some) actors in the catchment to isolate and help regenerate	• Explore with management which actors to involve in discussion • Analyse possible resource available in the utility and elsewhere • Identify most strategic areas for intervention with OANRB and WANRO • Support implementation and monitoring	Mr. D			

Table 5.6 Example of a plan with time line

	Item	**Months**							
		1	2	3	4	5	6	7	8
1	**Facilitation forestation**								
1.1	Contact WANRO and OANRB	x							
1.2	Identify priority areas for the water utility		xx						
1.3	Help to develop detailed plan		xx						
1.4	Help organize local team			x					
1.5	Facilitate access to seedlings and implementation					x			
1.6	Encourage maintenance (arrange monitoring)						x	x	x

Table 5.7 Example of a plan with overview of actors involved

	Item	**Actor**				
		Mr. x*	Ms. Y*	WANRO	OANRB	CT**
1	**Facilitation forestation**					
1.1	Contact WANRO and OANRB	x	x	x	x	
1.2	Identify priority areas for the water utility	x	x			
1.3	Help to develop detailed plan	x	x	x	x	x
1.4	Help organize local team	x	x	x	x	x
1.5	Facilitate access to seedlings and implementation	x	x	x	x	
1.6	Encourage maintenance (arrange monitoring)	x	x	x	x	x
	* Mr X and MS Y from water utility; ** CT = Community Team					

5.3 Checking the feasibility of solutions

After selecting and learning more about possible interventions it is essential to explore the technical and socio-economic feasibility.

5.3.1 Technical feasibility

The technical feasibility depends to a large extent on the local physical context. Hence it is essential to understand the requirements of each intervention and to explore whether local conditions are favourable for its implementation. Aspects that are of particular importance for many interventions include:

- Slope which determines the stability of the soil and the possibility to collect runoff.
- Soil texture as the soil characteristics have a great influence on how water moves throughout the landscape. It is a property that indicates the amount of particles of different sizes such as sand, clay and silt in the soil and this in turn determines the possibility to infiltrate water (coarser material allows faster infiltration in the soil whereas clay for example is quite impermeable and excellent for generating runoff and for lining of ponds.
- Groundwater characteristics which may require in depth analysis but you may get information by talking to local actors about the situation. For example the presence of springs, hand dug wells and scooping holes in dry riverbeds are an indication that groundwater is shallow or emerging at that specific point. If these sources reduce or dry up in the dry season then infiltration measures may be quite relevant.
- Presence of suitable construction material is very important as many interventions will require materials and if these are not readily available this may have important cost implications. If a gully plug cannot be built from locally available stones than these may have to be brought by truck from a distance. So you need to have an understanding of the main materials to be used and ask the local community members for potential sources. Nevertheless, some of the materials such as gabions, iron bars and cement are only available on the market.
- Experience with specific interventions is also very important as it may be a very important source of information about what is really feasible and it may generate possibilities for local actors to see for themselves and talk to their peers about the suggested interventions.

5.3.2 Socio economic feasibility

The socio economic feasibility is essential but is often insufficiently addressed in the design phase of interventions. Main question to be addressed are:

- Will the intervention be acceptable to the community? This is an important question as people may not be prepared to participate in implementation of some interventions if, for example, they were involved in similar activities before and did not receive benefits or they may not be willing to close areas for their cattle as this may reduce their income.
- How will intervention benefit them? The answer to this question is important and may concern short or long term benefits. Tree nurseries for example may become a source of income, as are trees that are being planted but the latter often takes considerable time. Improved grass production (new varieties) may also be a benefit and may encourage farmers to plant grass on soil bunds.
- Will the interventions be affordable? The answer to this question may depend on availability of external resources for the initial implementation, but the bottleneck may be the cost of adequate maintenance

In exploring these questions it is also necessary to look at the different groups that may benefit which implies looking at gender equity and the effect for disabled people. In many places women traditionally are responsible to find and bring water to the household which may imply a big burden to them. The question is whether a possible intervention makes this task easier.

5.4 Monitoring implementation and follow-up:

The issue of monitoring of the implementation of interventions may be reasonably well established in most projects in terms of exploring the envisaged inputs and direct outputs for example in terms of km of constructed bunds or ditches. Yet what is also necessary is the effect of the interventions particularly in terms of changes in runoff patterns, extra volume of water retained in the area and reduction in suspended solid loads.

A related issue is to monitor follow-up setting some clear indicators which may include the three indicators mentioned above, but one can add also some practical indicators about the percentage of the structures that are being properly maintained.

An issue that is often not being considered is how to deal with conflict. This is unfortunate because conflicts are normal and in fact may be having a great potential for growth if the negative energy can be transferred into joint action (Visscher, 2008). So the challenge is not to avoid conflict but to manage it. Conflict avoidance and neglect can worsen the situation. Let's take an example. If water is retained by a farmer to encourage infiltration, the downstream neighbour will receive less water. This may be a benefit (less flooding) but also may be a problem that needs to be addressed. So perhaps the approach to take in this case is to establish who truly benefits from the situation and initiate a negotiation among the actors involved to find a way to share benefits.

Many conflicts can be dealt with in a positive way through negotiation and joint problem solving. A few key aspects include:

- All parties need to understand the conflict and gain insight in the (subjective) views of the other parties
- Dialogue as the basis for problem solving in which actors listen to each other
- Separating the people (emotions) from the problem, but dealing with both. This aspect may require the involvement of a mediator to facilitate the process. Actors need to learn how to jointly face the problem instead of each other
- Focus on interests instead of positions to open dialogue
- Can problems be turned into opportunities by the actors allowing benefits to be enlarged and better shared?
- Develop multiple solutions to choose from and insisting on using objective criteria, independent of the will of either side, to choose the solution.

If conflicts were identified in the assessment then it is important to include actions that deal with these conflicts and that may include seeking external support.

5.5 Self evaluation

This is an individual evaluation of your understanding of the information presented in this module. Answer the (multiple choice) evaluation questions and check your own answers. In case your answers had many mistakes it is suggested that you review the module again before doing the assignment.

Q1. Indicate which of the following statement is correct. (Several statements may be correct)

A: A water catchment management plan needs to be developed with the actors involved in the catchment area and also needs to look a long term maintenance

B: An action oriented approach is important for catchment management with quick results particularly for local actors to help sustain interventions

C: Understanding the positions and interest of all actors involved in catchment management is a necessity

Q2: Which of the following soils is usually the most impermeable?

a. Sandy soils
b. Clay
c. Sandy loam
d. Light Clay
e. Loamy sand

Q3. Indicate which of the following statement is correct. (Several statements may be correct)

A: Taking stock of earlier interventions is necessary and useful

B: The technical feasibility of an intervention is more important than the socio economic feasibility

C: The socio economic feasibility primarily depends on the financial situation

D: A water utility is the best organization to take the lead in water catchment management

Q4. A written report is the most important aspect of a monitoring system.

A: Yes

B: No

5.7 Assignment

Finalise with your team:

- The Water Catchment Management Plan for the water utility using the results from exercises in the earlier modules, assigning clear responsibilities, resources involved and timing
- A monitoring plan for NRW reduction

5.8 References and further reading

Desta, L., Carucci, V., & Wendem-Agenehu, A. (2005). *Community based participatory watershed development: a guideline*. Ministry of Agriculture and Rural Development.

Hatibu, N., Mahoo, H. F., Gowing, J. W., & Unit, S. R. L. M. (2000). *Rainwater harvesting for natural resources management*. a planning guide for Tanzania.

RELMA. (2005). *Water from ponds, pans and dams*. A manual on planning, design, construction and maintenance. RELMA, ICRAF.

Visscher, J.T. (2008) Conflict mediation in the water and sanitation sector: And how to reach solutions. IRC International Water and Sanitation Centre, The Hague, The Netherlands. http://www.irc.nl/page/46285

5.9 Answers to self-evaluation questions

Q1: Answers A, B and C are correct.

A: It is indeed necessary to develop a water catchment management plan with the actors involved in the catchment area as they will need to sustain the activities in future. This makes it essential to also look at long term maintenance

B: To adopt an action oriented approach is necessary for catchment management and obtaining quick results particularly for local actors will encourage them to help sustain interventions

C: It is essential to understand the positions of all actors involved in catchment management and it is even more important to understand their interests as these are the basis for sustained interventions

Q2: Answer B is correct: Usually the most water tight soils are clays as these have the finest particles. This also depends on other factors such as the presence of cracks. Then after clay there are: light clay, Sandy Loam, Loamy Sand, and Sand which has the largest grains.

Q3. Answer A is correct.

A: Taking stock of earlier interventions is indeed necessary to find out what has worked and what not and to identify possible demonstration areas where other actors can learn from positive experiences

B: Is not correct; the technical feasibility of an intervention is important but often the socio economic feasibility is more important as it essential that local actors embrace the interventions to ensure longer term sustainability

C: Is not correct; financial aspects determine in part the socio economic feasibility but in part can be solved with external resources. More important however is the attitude of local actors as they are crucial for local maintenance

D: Is not correct; A water utility in fact has a big interest in water catchment management as they may be directly affected by poor management but they do not have a clear mandate to lead interventions so they will need to collaborate with other actors to get things done

Q4. Answer B. In many locations reporting is strongly emphasized, but the main reason of a monitoring system is to generate action when needed. Recording of some data is useful, but it should not be made into a burden as many monitoring aspects do not need to be recorded. So the essence is to establish a monitoring system that clear shows which indicators need to be checked and depending on the results what action need to be taken.

If you failed to provide several of the correct answers, then review this module again.