# Agricultural TVET College

# Small Scale Irrigation Development

## Level III

## MODEL TTLM

## Learning Guide#18

**Unit of Competence:** Apply Watershed Management Principles

**Module Title:** Applying Watershed Management Principles

**LG Code:** AGR SSI3 M18 LO1-LO5

**TTLM Code:** AGR SSI3 TTLM18 1218V$_2$

**Nominal Duration:** 50 Hours

| Instruction Sheet | Learning Guide #18 |
|---|---|

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:–

- Understand basic watershed processes and their interrelated nature
- Consider the principles of long term watershed management
- Outline the elements of successful watershed management framework
- Design appropriate benefit sharing mechanisms among stakeholders

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- ✓ Understand basic watershed processes and their interrelated nature
- ✓ Apply watershed management principles according to enterprise guidelines and industry best practice
- ✓ Apply watershed management principles to a range of work environments and contexts
- ✓ Consider the principles of long-term watershed management
- ✓ Outline the elements of successful watershed management framework
- ✓ Design appropriate benefit sharing mechanisms among stakeholders

**Learning Activities**

1. **Read the specific objectives of this Learning Guide.**
2. **Read the information written in the "Information Sheet"**
3. **Accomplish the "Self-check".**
4. **If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your facilitator for further instructions or go back to Learning Activity.**
5. **Submit your accomplished Self-check. This will form part of your training portfolio.**
6. **Read and Practice "Operation Sheets".**
7. **If you think you are ready proceed to "Job Sheet".**
8. **Request you facilitator to observe your demonstration of the exercises and give you feedback.**

| INFORMATION SHEET#1 | Understand basic watershed processes and their interrelated nature |
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## 1.1 Introduction

The concept of watershed management was originated from the “torrent control” work in European Alps. Torrent refers to the swift and violent stream in mountainous terrain. At the turn of the last century, the concept was adapted in N America, first in research and then in practice, and gradually “torrent control became known as “watershed management”. At the same time, this work was introduced in Japan as “SABO work”, which means sand, debris, and erosion control in streams and hill slopes.

The protection, improvement and rehabilitation of mountain and/or upland watersheds are of critical importance in the achievement of overall development goals. Recognizing this, many developing countries are turning increasing attention and resources to the field of watershed management. Initial efforts have often been "fire-fighting" in nature, i.e. an immediate but isolated response to a perceived problem. However, in many if not most developing countries, the nature and magnitude of the problem of watershed degradation, and the scarce availability of resources mandate a comprehensive long-term approach.

Critically reviewing in Ethiopia past attempts and efforts to development, one can realize that the firm, non-participatory discipline oriented, multidimensional and poorly coordinated and synchronized development activities have brought threatened to the productivity of the natural resources base. Currently, the community at large is already facing crisis of a major dimension. Reports indicate that the Ethiopia highland where over 85% of the population and arable lands of the country situated in one of the most disturbed Eco-system in Africa, if not in the world. These frustrating problems need to be tackled socially, ecologically, and economically. It is therefore, a high time to move from dispersed technical assistance that addresses individual procedure to more holistic view of natural systems, processes and interrelationships that sustain life. This requires fundamental changes in both the philosophy and the approach to development. Recognizing that sustainable management and development implies proper balance between improving land-use and land productivity, the focus on watersheds as basic planning,

coordinating, and implementing unit can help the efficient use of land resources within their capability and create sustainable production system.

**Watershed is thus defined as:**

- Technically, a watershed is the divide (line) separating one drainage from another. But, the term watershed is commonly used to refer to (not to a line separating one drainage from another but) an area; especially to topographically delineated area in which all surface all surface water flows to a common point.
- A watershed is a topographically delineated area that is drained by a stream system, i.e. the total land area that is drained to some point on a stream or river.
- A watershed is a hydrological unit that has been described and used as a physical-biological unit and also, on many occasions, as a socio-economic-political unit for planning and management of natural resources. Catchment is often used as a synonym for watershed.
- Watershed is defined as a geo-hydrological unit draining to a common point by a system of drains.

*What is watershed management?*

Watershed management is the organization of land use (forests, grazing, agriculture, roads, footpaths, houses, irrigation schemes) in a watershed in such a way that the erosion is controlled and the land quality remains good, for you, your children and grand-children.

*Why watershed management?*

Proper management of soil, water and forest resources will mean more food for all and fewer landslides, gullies and other erosion types. For example, soil erosion techniques such as terracing and fodder plantation in landslide-prone areas, prevent nutrient-rich topsoil from being washed away. With careful watershed management, you will grow more and better crops, therefore you can earn extra income, irrigate your fields, improve your trails and participate in other activities you yourselves design. Consequently, the overall living standard will improve and at the same time, the condition of the environment will be maintained.

## 1.2 Understanding basic Watershed Processes and their interrelated Nature

### Watershed Delineation

The delineation of priority area can be performed to some extent by reconnaissance survey and study of toposheets. However, this technique is not providing very accurate information. Demarcation of priority areas and improving the quality of such work can be achieved in better way by using the aerial photograph. Normally, the photographs of 1:60,000 scale serves more efficient but photographs of larger scale such as 1:15,000 can also be used for the purpose.

For demarcating priority areas on watershed basis, the preparation of framework of watershed delineation over the entire watershed is an essential requirement. Furthermore, it is also necessary that, the size of watershed to be delineated should be range from 10,000-20,000 hectare, because for small watersheds the formation of soil conservation working plans and their execution over a reasonable period is practically possible and easy, too.

The steps for demarcation of small size watershed are described as under:-

1. Divide the entire watershed in to different sub-watersheds following important tributaries. The size of the sub-watershed should be counted as few hectares.
2. Again, divide each sub watershed in to small size following distinct tributaries and streams passing through respective sub-watersheds. The size of these small watersheds should be in the range of 50,000 to 1,000,000 ha.
3. Further, sub divide each small parts of watershed (as obtained in step two0 in size ranges from 10,000to 20,000 ha.
   This work should be started from down-stream and proceed to upstream side.

### Natural processes in watershed

**Rainfall:-**in small watersheds intense rainfall causes rapid peak runoff, where as in large watersheds it is not so.

Over land flow is more predominant in small watersheds as there is less network of drainage system in large watersheds channel flow is predominant.

**Hydrology:-**

Water Occurs in many phases; liquid, solid, Agas phases. It also occurs in many places: in oceans, rivers, in soils, plants etc….

Hydrologists study basic processes governing the occurrence, distribution and movement of water over on and under the earth, its variation from time to time and from one place to another.

Experts in the area of Natural resources are more concerned regarding the interrelationships among the water, climate, vegetation, soils etc. and their impact on production and productivity. In order to understand phenomena lets first of all:-

- Simplify and generalize the broad concept of hydrologic cycle
- Assume a smooth, un interrupted sequential movement of water
- Considering these we may say that:-

The transformation from one phase to another and the motion from one location to another constitute the hydrologic cycle which is a closed system having neither beginning nor end.

Atmospheric moisture reaches the earth's surface in the form of rain, hail and snow.

**Soils: _**

For hydrologic analysis of watershed the hydrologic properties of a soil or a group of soils are essential factor. Soils can be classified to their hydrologic properties provided that they must be independent of watershed slope and cover, both. Normally, the following four major soil groups are recognized for primary classification of watershed.

1. Group A: soils having high infiltration rate when thoroughly wetted are kept in group A. these soils involve low runoff potential. Usually sands or gravel that are deep and well to excessively drain are the main soils of this group.
2. Group B: soils having moderate infiltration rate, when thoroughly wetted. Mainly, moderately deep to deep, moderately well to well drained and moderately fine to moderately coarse textured soils are counted under this group of soils.

3. Group C: this group contains the soils involving slow rate of infiltration when thoroughly wetted. The soils with a layer that impedes the downward movement of water and moderately fine texture soils.
4. Group D: the infiltration rate of this group of soils is very slow when thoroughly wetted as a result they have high runoff potential.

Cover: any material can be used for covering the soil surface to protect the soil against impact of rain fall. Normally, vegetative materials are commonly used to cover the soil. Usually the detail information's about the cover, such as: density of plant. Height, root depth and its density, extent of plant cover and extent and amount of litter are seldom available. Due to this for hydrologic analysis of watershed it is always relied largely on the land use as an index of cover conditions. The various covers which are common are:-

- Fallow
- Row crops
- Small grains
- Closed seed legumes
- Pasture or range
- Wood lands
- Farm steeds
- Meadow
- Roads etc.

**Geology:** -geological formation and rock types affect the disposition of water erosion channel erodibility of hill faces etc. apart from it the physical and chemical properties of soil such as, texture, structure and depth are also significantly affected by the geological formations causing to affect the degree of water disposition by the way of infiltration, storage over the soil surface and runoff.

In addition, the erodibility, transportation and deposition of soil particles in erosion process are also influenced by the soil properties in precedential magnitude.

**Topography**: - the topography of a watershed is studied by determining the degree and length of slope and slope uniformity. The topography affects the time of concentration and infiltration opportunity tine of the area.

Furthermore, topography also regulates the drainage capability of the watershed. The drainage capability of an area is assessed by the term "drainage density", which is defined as the ratio of total length of the stream to the watershed area.

The length, width and depth of main stream and subsidiary channels, elevation of main outlet also depend on the topography of the watershed.

### 1.3 Human factors

**Land use**:-

It affects the overland flow, hence significant to small watersheds, while in large watersheds there is channel flow predominant, therefore the land use in large watersheds is not effective.

### 1.4. Size of the watershed

The size of the watershed has significant effect on its function. A small watershed is pronounced by over land flow which is main contributor to result on peak runoff. Land use plays key role to affect the over land flow significantly but channel flow is main. Large watersheds are also affected by basin storage.

The soil maps, Arial photographs or country maps are useful to determine the size of watershed. Occasionally, a field reconnaissance survey is necessary to define the non-contributing areas, which must be excluded from the area considered to compute the surface runoff or quick return flow.

| SELF-CHECK # 1 | Written Test |
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**Name:** _____ **Date:** _____

*Directions:* **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.**

1. Define watershed?(5pts)
2. What is the need of watershed management?(5pts)
3. What are the characteristics of watershed? (5pts)
4. What is watershed delineation? (3pts)

*Note:* **Satisfactory rating - 15 points and above** **Unsatisfactory - below 15 points**

You can ask your teacher for the copy of the correct answers

| INFORMATION SHEET#2 | Consider the Principles of Long-term Watershed Management |
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## 2.1. Multidisciplinary watershed management

Integrated watershed planning and management requires application of knowledge of various disciplines. The multidisciplinary planning team may include; land resource management and planning, agronomy, agro forestry, socio-economics, hydrology, geology, soil and water conservation, livestock development and etc……

It is therefore necessary that we need to coordinate our planning activities with the similar activities of other government and non-government agencies and obtain the necessary information required for planning.

## 2.2. Data collection and analyzing

### 2.2.1. Data collection

It accomplishes under the following heads

A. Watershed description:-

i. Location: - the information such as name of river basin, tributary, physiographic region, and principal communication lines associated attitude and longitude of watershed are collected.

ii. Size and shape: - the size of water shade either $km^2$ or and shape of watershed is long and narrow, or fan shape whatever those are should be mentioned.

iii. Climate:- the following details are usually collected

- Precipitation
- Temperature
- Evaporation
- Relative humidity
- Wind velocity and its distribution
- Solar radiation

iv. Geology: - it includes the geological information such as nature of parent rock, fractures, faults, weathering ground water recharge and extent of out crops.

v. Surface drainage

- Nature of stream flow

- Drainage net work
- Morphological characteristics of streams

vi. Soil: - the information about major groups exists in the watershed, physical and chemical properties of the soil, etc.

vii. Physiographic: - it consists nothing the details of evaluation of different parts of watershed mountainous range etc.

viii. Watershed need:- under this the contents such as source of surface and subsurface water, water use for domestic, irrigation ,power generation and recreation, future needs of water exploration ,etc. are recorded

ix. Land use and cover condition:-
- Existing land use and cover conditions
- Forests
- Range lands
- Agricultural lands
- West lands
- Habitation lands
- Miscellaneous

x.Economic data: - the economic and social data are needed to be determined. Under this the following data are collected.
- Economic condition of the population.
- Profession and dependent on resources.
- Market and market practice.
- Return from various resources.

B. Watershed problem: - the entire problem such as flood, drought, erosion, sediment damage and other problems related to conservation, utilization, and disposal of water in the watershed should be identified.

C. Proposed management programs: - All the management activities (physical and Agronomic/ biological management) should be included.

### 2.2.2. Data organization and analyzing

Analysis and formulation of the project proposal may have the following nine sections.

**Section 1**:- Brief report about project area is cited which include.

- General features
- Demography
- Economy
- Geology
- Climate
- Water resource
- Land resource

**Section 2**:- in this section the present status of development potential of the area are defined, which are:-

a) Present status
   i. Power supply
   ii. Land use
   iii. Agricultural production and availability of imputes such as seeds fertilizer money, etc.
   iv. Government policy
   v. Infrastructure for transport, etc.

b. Future development

i. Land preparation
ii. Irrigation and drainage requirements
iii. Reclamation of saline and alkaline soils
iv. Farm requirement and supply
v. Land forms required

a. Development potential
   i. Potential according to land use
   ii. Arial photograph for project planning
   iii. Land use capability, etc.

**Section 3:-** preparation of development plan

**Section 4:-** cost estimation criteria, capital cost foreign exchange requirement and equivalent annual cost.

**Section 5**:- the benefits are computed from following sources

i. Improvement in water quality
ii. Improvement in water quantity
iii. Increment in agricultural production
iv. Environmental control and recreation, etc.

**Section 6**:- Economic analysis

- Criteria
- Project cost
- Indirect benefit
- Agricultural and other benefits
- Benefit cost analysis
- Equivalent annual benefits
- International rate of return

**Section 7**:- Financial analysis

- Cost allocation
- Payment capacity

**Section 8:-** program implementation techniques.

**Section 9:-** conclusion and recommendation

### 2.3 identifying and prioritizing watershed problems and possible solutions

#### 2.3.1. Identifying and prioritizing watershed problems

The problems such as flood, drought, erosion and sediment damage and other problems related to the conservation, development, utilization, disposal of water originating in the watershed etc are discussed, identified and prioritized under this section of watershed plan. The major problems are outlined as under:-

- Amount and value of land improvement and other properties exposed to the flood hazards in the watershed
- Frequency of flood occurrence
- Significance of small frequent flood or large infrequent floods in total flood problems
- Limitations

Other pertinent problems

- Sediment damage:- the problems exposed by sediment deposition is considered in following cases :
    - ☞ Problem of reservoir sedimentation
    - ☞ Problem of channel silting
    - ☞ Drainage problem
    - ☞ Loss of agricultural lands
- Erosion damage:- the problems of erosion damage is studied under the following contents;
- Extent of sheet erosion, gully and channel erosion
- Downstream damage due to sediment deposition
- Effects on agricultural production due to erosion
- General effects on watershed economy

- Water management problems:- it includes the details on irrigation needs, water supply required for agricultural and non-agricultural uses and other management needs.
- Special problems:_ the problems such as land slip, land slide. Torrents, highway erosion, mines etc. are counted for preparation of watershed works plan.

### 2.3.2. Proposed management programs

Under this section the management programs to be used for fighting against watershed problems encountered etc. are described. The different proposed management option is listed below:-

1. Management program for agricultural lands:- to control deterioration of agricultural lands the various control measures for them are divided in to the following two groups:-
    a. Agronomic measures
        - Crop proposed
        - Crop rotation
        - Cultural operations
        - Introduction of improved seeds
        - Use of manure and fertilizer
        - Plant protection me assures
        - Expected yield obtained
        - Expected cost invested
    b. Engineering measures
        - Proposed measures and their justifications
        - Specification of individual measures with plan and design
        - Cost estimation
2. Management programs for conservation irrigation
    - ✓ Selection and design of irrigation method for each parts of land
    - ✓ Irrigation duration
    - ✓ Conveyance system
    - ✓ Location and specification of system
    - ✓ Leveling and smoothening operation
    - ✓ Plan for drainage
    - ✓ Agronomical measures

3. Management measures for drainage
    - Types of drainage system
    - Specification
    - Location of outlets and their design
    - Intercepting and relief drains along with their design
    - Maintenance
    - Cost estimation
4. Management programs for flood protection
    - ❖ Channel improvement
    - ❖ Flood retarding structures; their design and cost estimation
5. Management programs for forest land
    - Management practices for existing forest. Degraded forest, shrubs and farm forestry
    - Engineering measures for forest and range lands
6. Management programs for grazing lands
    a. pastures
        - ✓ selection of grass species
        - ✓ raising methods
        - ✓ Mechanical practices e.g. Contour furrowing
        - ✓ management practices
        - ✓ yields and cost invested
    b. grass land
        - ❖ use of improved practices and grazing system
7. programs for special problems
    - land slide:- retarding wall or other structures
    - stream bank erosion :- vegetative or structural measures
    - erosion along the highway :- vegetative or revetment
    - gullies and ravines:- vegetative and gully control structures

## 2.4. Implementing, monitoring and evaluation of watershed management

### 2.4.1. Implementation and monitoring

The implementation strategy of integrated watershed management has clearly indicated the following aspects:-

- task sharing and cost sharing arrangements
- making implementation arrangements
- monitoring and evaluation
- phasing out strategy

The steps of watershed management can be classified as ***recognition***, ***restoration***, ***protection***, and ***improvement*** phases.

***Recognition*** phases, watershed problems, their probable causes and development of alternatives for the, are described, which is carried out by conducting several surveys, such as soil, land capability, agronomic, forest lands under permanent vegetation, engineering, and socio-economic surveys.

***Restoration*** phase covers the task of selection of best solution and their applications for watershed management. In this phase, treatment measures (biological and/or engineering measures are applied to the critical areas for the recognized problems, identified earlier during recognitions phase, so that these critical areas can be restored to the pre-deteriorating.

***Protection*** phase the general health of watershed is taken care of and its normal working is also ensured. In addition to this, the protection of watershed against all those factors, which causes deterioration, is also carried out under this management phase. The protection is preferably made on the critical areas, which are restored in the phase of restoration.

The improvement phase has a paramount importance in watershed management work. Under this phase, the overall improvements made during management of watershed are evaluated for all the lands covered. In addition, attention is also given to make improvement on agricultural land, forest land, forage production, pasture land and socio-economic status of the people.

### 2.3.2. Evaluation of watershed management

After implementation of watershed management measures to overcome the watershed problems or fulfill the objectives the next step comes as evaluation of results obtained through them. The evaluation of watershed management work should be accomplished under the following two terms:-

1. by achievement of watershed objectives
2. financial returns

Both of these evaluations are necessary for assessing the efficiency of management work applied to the watershed. Several times, it is observed that, the protective benefits safeguard against misery and losses, which cannot be easily evaluated in terms of money. Under this circumstance c e, some financial values to put on them is required.

The financial returns are evaluated interms of cost-benefit ratio, which is determined by accounting all the costs incurred for development work starting from survey work to implementation of the activities.

| **Self-Check 2** | **Written Test** |
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**Name:** _____ **Date:** _____

***Directions:*** **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.**

1. What is multidisciplinary activity mean?(5pts)
2. What is the need of prioritizing problems in watershed management?(5pts)
3. What is the purpose of monitoring and evaluation in watershed management?(5pts)

***Note:*** **Satisfactory rating - 13 points and above** **Unsatisfactory - below 13 points**

You can ask your teacher for the copy of the correct answers

| INFORMATION SHEET#3 | Outline the elements of successful watershed management framework |
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### 3.1 Framework/principles of watershed

Sound watershed management means improved overall productivity of an area. Improvement of livelihoods, controlling floods and reducing erosion as well as sediment accumulation are results of watershed management. Some of the basic principles are:-

1. utilizing the land according to its capability
2. Adequate vegetation cover during the rainy season
3. Conserving as much rain water as possible at the place where it falls
4. Draining out excess water with safe velocity and diverting it to storage pods/ recharge pods for further use
5. Effective utilization of surface water and ground water resources
6. Avoiding gully formation and checking at suitable interval to control soil erosion and recharge ground water
7. Optimizing productivity per unit area, per unit time and per unit of water
8. Adopting integrated soil, water, nutrient and pest management options
9. Increasing cropping intensity and land equivalent ratio through intercropping and sequential cropping
10. Safe utilization of marginal lands through alternative land use system
11. Ensuring sustainability of the ecosystem benefiting the man-animal-plant-land –water complex
12. Stabilizing total income and cutting down risks during aberrant weather situation
13. Improving infrastructure facilities, storage, transport, marketing etc….

| Self-Check 3 | Written Test |
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**Name:** _____ **Date:** _____

*Directions:* **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.**

1. What are the results of watershed management?(5pts)
2. State the frameworks of watershed management?(5pts)

*Note:* **Satisfactory rating - 10 points and above Unsatisfactory - below 10 points**

You can ask your teacher for the copy of the correct answers

| INFORMATION SHEET#4 | Design appropriate benefit sharing mechanisms among stakeholders |
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### 4.1 Benefits of watershed management

Water shed management is the development activities at watershed basis by consulting the community so as to achieve conservation based developments. The general objective of watershed management is to conserve natural resource of the area to the maximum sustained benefits of the inhabitants and to improve living standards of the community.

The specific objectives of watershed management are:-

1. protect, conserve and improve the land resources for efficient and sustained production
2. protect and enhance water resources, moderate floods and reduce silting up of resources, increase irrigation and conserving rain water for crops and thus mitigate droughts
3. Provide biomass for economic use of communities and their animals, like fodder, timber, firewood, straw, fiber….
4. Providing basic infrastructure for improving efficiency of produce marketing and services like water supply, road, etc…..
5. To promote the local people to regard the development plan as their own and be more willing to participate in its design, implementing and monitoring.

### 4.2. Benefit sharing approach

Integrated Watershed development should have a benefit sharing approach. This means it involves integration of all stakeholders in all implementation stages. Thus, Watershed development should be benefited equally to all members of the community.

These benefits may include environmental / ecological, economic benefits and social benefits. Sound Benefit sharing approach demands the engagement of watershed stakeholders.

**Engaging Watershed Stakeholders'** …

- Perform a careful and inclusive stakeholder analysis early in the project. …
- Identify target beneficiaries based on transparent criteria, distinguishing clearly between direct and indirect beneficiaries. …
- Identify specific actions with each group of beneficiaries under each relevant output. … Foster inclusion of young people as key project beneficiaries. …
- Engage field facilitators or community mobilizes to ensure continuous engagement of local populations. …
- Involve students from local universities in field activities for mutual benefits and to cultivate future watershed management champions and leaders. …
- Where the socio-political environment is conducive to a formalized governance structure, establish watershed management committees (WMCs) to foster multi-stakeholder participation.
- They should be a product of stakeholder negotiation and should build on existing structures, without duplicating their functions.

| **Self-Check 4** | **Written Test** |
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**Name:** _____ **Date:** _____

***Directions:*** **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.**

1. What are the expected results of watershed management?(5pts)
2. What is the need of benefit sharing mechanisms in watershed management?(5pts)

***Note:*** **Satisfactory rating - 10 points and above** **Unsatisfactory - below 10 points**

You can ask your teacher for the copy of the correct answers

## REFERENCE

Watershed Management in Action Lessons learned from FAO field projects; Food and Agriculture Organization of the United Nations Rome, 2017

Identifying and Protecting Healthy Watersheds; United States Environmental Protection Agency; February 2012

Getting to Know Your Local Watershed; A Guide for Watershed Partnerships, 2016