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MINISTRY OF AGRICULTURE

Flood-based Farming

Training, Teaching, and Learning Material
First Edition

Contents

Instruction on how to use this learning and teaching material

This manual is one of several teaching and learning guides in a series focused on Water Spreading Weirs (WSW) Construction, Flood-based Farming, and Biological measures. The authors stress the importance of a comprehensive understanding of WSW construction and biological measures in effectively planning, constructing, and using WSWs for Flood-based Farming. This knowledge is essential for development agents/learners engaged in community development activities.

In addition to technical knowledge, teachers and learners should also cultivate ‘soft skills’. The first step is to familiarize oneself with the Teaching and Learning Guide on Flood-based Farming, WSW construction, and biological measures.

This guide is arranged into four sections or Learning Outcomes (LOs):

Learning Outcome 1	Introduction to the concept of Flood-based Farming
Learning Outcome 2	Water Spreading Weirs (WSW) based farming
Learning Outcome 3	Crop production using WSWs-based farming
Learning Outcome 4	Farming System Management

Each Learning Outcome section comprises:

- Introduction with specific learning outcomes.
- An instruction sheet for teachers suggesting a teaching methodology, the time needed, and guidance through all worksheets.
- An instruction sheet for learners
- Information sheets on the implementation steps, guiding questions for discussion, and self-check test questions.
- Operational sheet, explaining, how to proceed to implement, what is described in the information sheet, indicating the required resources. For the Operational Sheets, it is good to realize that they are not stand-alone

and can be combined with Learning Outcomes. For example, discussing farming management can be done together with crop selection and suitability.
- LAP-Test.

The guiding questions for discussion are designed to enhance understanding, learning, and reflection on the section's content as well as to serve as a form of self-evaluation. The guide is centred on the active participation of students, integrating what they already know by key adult learning principles and detailing each topic with discussions, outdoor sessions, and/or role plays. A glossary of technical terms at the end of the document explains technical vocabulary and phrases.

Also, since many students of the ATVET colleges are future Development Agents (DA), the Teaching and Learning Guide focuses on their roles and tasks. Content that is especially relevant to the Development Agents is marked throughout the document by this illustration of a meeting:

Hints and Tips for Training and Teaching

Adult Learning

Adults learn differently from children and so teaching techniques for adults, therefore, need to be different from those used with children. The main difference is that adults have considerably more life experience. As a result, adults are keenest to gain information that is most relevant to this lived experience and are inclined to be less interested in that which is not. Key points which help adults learn therefore include the following

Meaningful information	Starting by helping the learners understand why the topic is important and how it can help them – see also specific Learning outcomes
Experience	Recognizing that the learners already have considerable knowledge and life experience and drawing out this experience as often as possible during learning.
Respect	Adults respond best when they feel that they are respected and that they are part of the learning process. Talk with them, not at them.
Self-exploration	Provide time for adult learners to explore ideas (on their own or in small groups). Let them consider how they might use and apply the learning material.

Teaching through facilitation

Facilitation is an important skill that takes practice and patience to improve. It is much easier for teachers to lecture and give instructions than to facilitate. However, to make learning interesting and to get the best results, a teacher facilitates effectively by assuming the following roles:

- The role of a mentor: assist students with empathy, understanding, and encouragement.
- The role of a leader and organizer: initiates, demonstrates and set goals as well as boundaries.
- The role of a coach: listens, comment, gives feedback and inspires.

Conducting an activity

- Communicate clearly and confidently with your students by speaking and writing clearly.
- Make eye contact and try to be calm and confident with your body language.
- When a student asks a question or makes a point, listen carefully, do not interrupt them, and repeat or summarise what you have heard for everyone before responding or asking others to respond to it.
- When explaining ideas, regularly cross-check whether your students have understood what you have said by asking them to summarise, either as individuals or collectively by contributing points.
- As often as possible, elicit information from your students by asking open questions Why? What? How? rather than closed Yes-No questions.
- Try to encourage everyone in a group to participate and avoid individuals dominating.

Brainstorming ideas

A brainstorm is a bit like a real storm: it happens quickly. Participants pour out their ideas as soon as they come into their heads, like rain falling.

Brainstorming is a particularly effective teaching method for adults because it draws out students' existing knowledge and experience as a starting point for the learning exercise. It is student-centred and if it is a written brainstorming rather than a verbal one, all of the ideas that have been contributed can be ordered, prioritized, and/or reworked from their position on the blackboard or cards.

Group work

Some of the most productive adult learning takes place during group work. Working in groups places both responsibilities for learning and empowerment for self-discovery onto the student, making them active learners rather than passive consumers of information.

Before breaking into groups and starting a given task, it is essential to clarify both the objective and the time frame. Breaking into groups can be done randomly across the class (such as by using a counting system of say 1-2-3-4-5 or by height order), or in a more structured way by grouping friends, neighbours, or regular working partners.

Leaders almost always emerge from group work, and so it is often helpful to select a group moderator whose responsibility is to steer the work towards the objective as well as encourage all members, recording and summarising information.

Groups should never be left alone, rather the facilitator should circulate between groups, observing how each group manages the activity and making suggestions or asking helpful questions if necessary. If a group is off track from the topic, give support and guidance to try and lead the group back toward the objective.

Role Plays

A role play brings a slice of reality into a session. By directly simulating reality, the role-play discussion, drama session, or game raises questions that require discussion, assessment, negotiation, and understanding of real scenarios. In this way, role plays are learning experiences for both the actors and the observers.

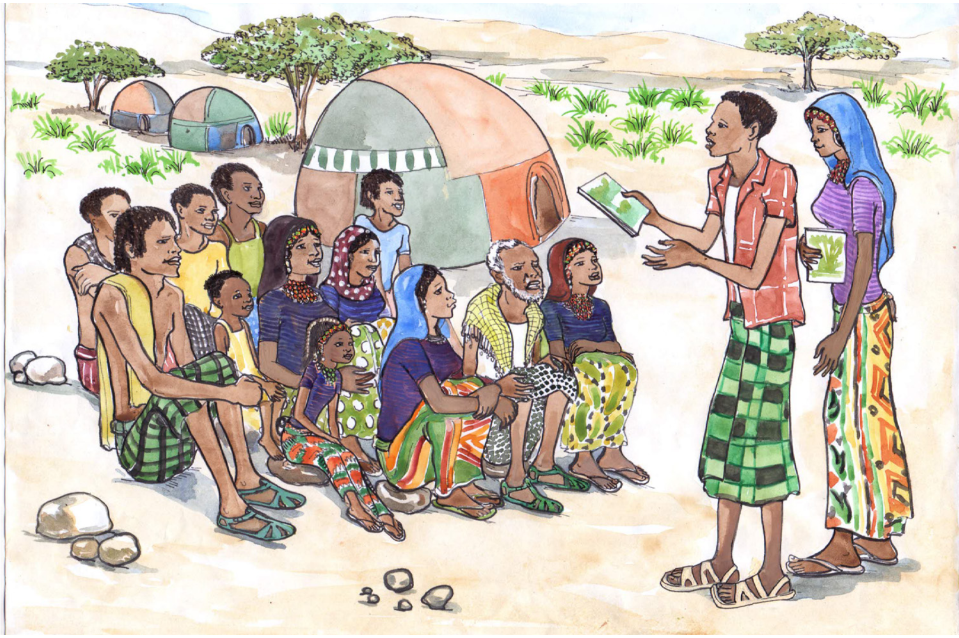


Figure 1: Presenting the discussed ideas to the group, as part of the group work

Evaluation

The Self-Check Test at the end of each Information Sheet, and the LAP-Test after each Operational Sheet of the Teaching and Learning Guide, are designed to help the student reflect on the overall content of a given section. Completing both Self-Check Test and LAP-Test will reinforce what is understood and learned as well as underline what needs further reflection, reading, discussion, or study.

Specific learning objectives

After you have finished working through this guide you should be able to:

- Explain the principles, functions, and importance of Flood-based Farming
- Internalize and enlist the tools and techniques of Flood-based Farming using the WSWs
- Describe the types of crops suitable for Flood-based Farming
- Explain the farmland and crop management practices of Flood-based Farming as part of DVRPU
- Facilitate the planning and implementation of fFlood-based Farming
- Execute the role of a development agent in the overall process.

You should also be fully aware of how to combine physical and biological conservation measures to maximize the livelihood benefits of Flood-based Farming using WSWs.

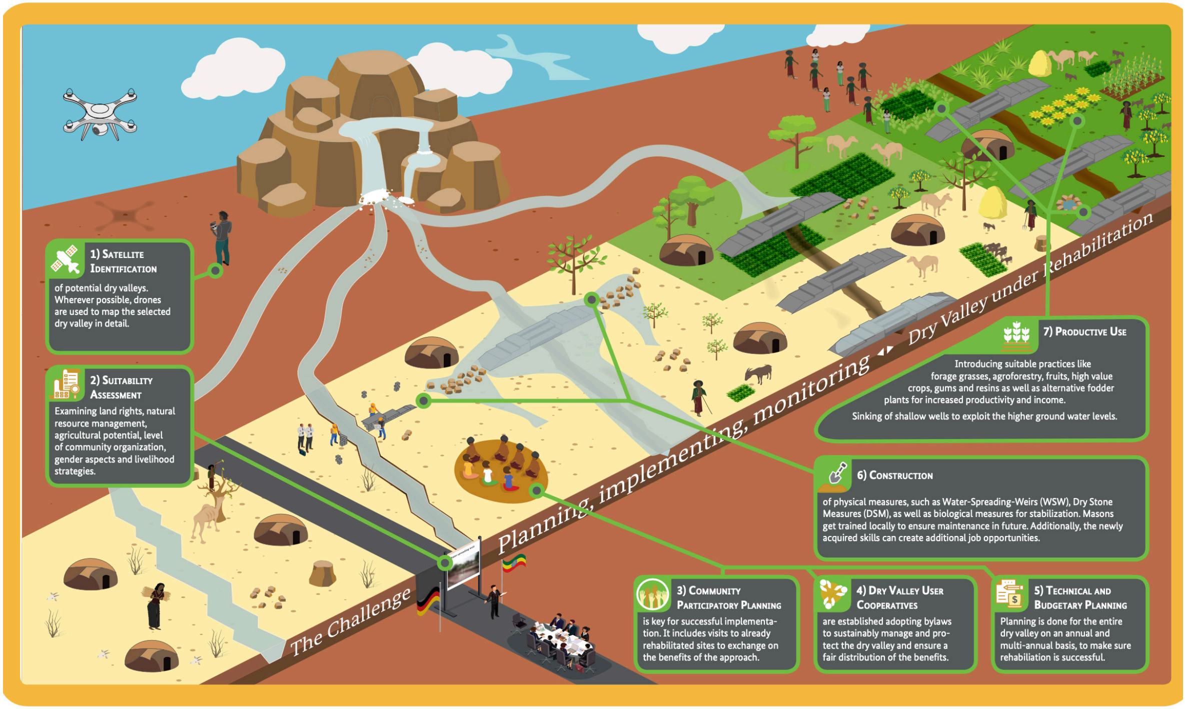
Figure 2: Growing fodder for livestock, using the moisture behind the Water Spreading Weir

Introduction to the DVRPU approach

The lowlands of Ethiopia are primarily inhabited by agro-pastoral communities. Climate change is causing longer drought spells and increased incidences of intense floods. This, combined with increased population pressure and intensified demand for livestock grazing land, has contributed to the overexploitation of natural resources. With the widespread degradation of the land now evident in poor vegetation cover and low soil infiltration capacity, the once-replenishing floods from the highlands have become a force of destruction. This is most apparent in the formation of deep gullies along the escarpment floor. The floods no longer nourish the earth but destroy it, along with the livelihoods of millions of people. This process has begun in most dry valleys, which used to be covered with tall grass in the past. They have lost their resistance to drought, and in most rainy seasons, water does more damage in the form of erosion than it contributes to regeneration. In this situation, Dry Valley Rehabilitation and Productive Use (DVRPU) is a game-changer. It has proven its potential to transform degraded dry valleys into flourishing fields that provide livelihoods for its people.

At the heart of DVRPU is a comprehensive set of measures that address multiple dimensions: social, technical, biological, economic, institutional, and governance, ensuring the successful rehabilitation of entire dry valleys. The core technology employed is a cascade of Water-Spreading Weirs (WSWs). These structures, combined with Dry-Stone Measures (DSMs) and biological measures, work together to slow down the flow velocity of floods. By doing so, water can infiltrate into the soils, increasing groundwater levels and allowing fertile sediment to settle, creating highly productive land and, thus, food security.
The DVRPU approach is defined in seven crucial steps for the sustainable rehabilitation of dry valleys:

1. Satellite Identification and Dry Valley Delineation
2. Suitability Assessment
3. Community Participatory Planning
4. Dry Valley User Cooperative Societies (DVUCS)
5. Technical and Budgetary Planning
6. Land Rehabilitation Measures
7. Productive Use



One of the key factors for success is the acceptance and active participation of local communities. Their engagement is supported by technical expertise and regulatory frameworks provided by local governments. This collaboration between communities, technical experts, and local governance is vital for the long-term sustainability of the intervention, fostering their active involvement in the planning, implementation, maintenance, and utilization of the rehabilitated lands.

The DVRPU approach offers a sustainable solution that not only rehabilitates the land but also empowers local communities to take charge of their own development and create prosperous futures for themselves.

This TTLM focuses on Flood-based Farming (FBF) system, a major contributor to the productive use (step 7) in successfully transforming previously unproductive areas into thriving productive land systems. FBF, following the DVRPU approach, recognizes that different zones within the rehabilitated area can be utilized in different ways, such as agricultural production, grazing land, and dry forests. By planting grasses, crops, and trees, agro-pastoralists can effectively prevent soil erosion, improve water retention, and enhance biodiversity. Trees play a crucial role in the productive use system by retaining soil moisture, providing shade and shelter, and creating favorable microclimates for both crops and animals.

The integration of trees, crops, and livestock offers opportunities for agro-pastoralists to diversify their income streams, reduce vulnerability, and enhance food security. Moreover, productive use can create job opportunities, particularly in the management of tree nurseries, agro-ecological practices, and value-added processing of tree products.

In summary, by rehabilitating these lands and effectively managing their diverse zones, FBF fosters increased agricultural productivity, ensures food security, and creates valuable opportunities for income generation within local communities, leading to a harmonious and resilient ecosystem.

Learning Outcome 1: Introduction to the concept of Flood-based Farming

Introduction

Every Learning Outcome has a similar structure (apart from an optional Operational Sheet). In this Introduction, you find the specific learning objectives of Learning Outcome 1. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test.

By the end of this Learning outcome section, you should:

- have a basic understanding of Flood-based Farming with its benefits and challenges
- know different types of Flood-based Farming
- be able to relate Flood-based Farming to the lowlands of Ethiopia
- be able to recognize productivity increase options in Flood-based Farming practices

Development Agents (DA)/ trainees need to be fully capable of overseeing independently the implementation of Flood-based Farming with their working communities. After working through this section, you must come to fully understand the objectives and benefits of Flood-based Farming.

Instruction Sheet for Teachers

- As you go through this Learning Outcome section together with your class, do not start by lecturing them about Flood-based Farming from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them and brainstorm ideas about farming practices that they already know.

- Work through the Information Sheet.
- Ask students/trainees to suggest examples of when and where Flood-based Farming might be most suitable. Ask them to explain why.
- Discuss the Guiding Questions.

Teaching methodology

Brainstorming, interactive teaching, and learning, group work (listing), and discussions.

Session Plan

- 20 minutes looking at the introduction, brainstorming, and listing differences;
- 30 minutes for the Information Sheet;
- 30 minutes for the Guiding Questions;
- Total time: 1 hour and 20 minutes.

Instruction sheet for Learners

1. Read the introduction with the specific learning objective for Learning Outcome 1. Familiarise yourself, as a potential future development agent, with your role in the process.
2. Read the Information Sheet on Flood-based Farming.
3. Write down any questions you have.
4. Ask your teacher for support and seek answers to your questions.
5. Try to answer the Guiding Questions and discuss them with classmates about the advantages, disadvantages, and other factors regarding Flood-based Farming.
6. Test your knowledge by completing the Self-Check Test.

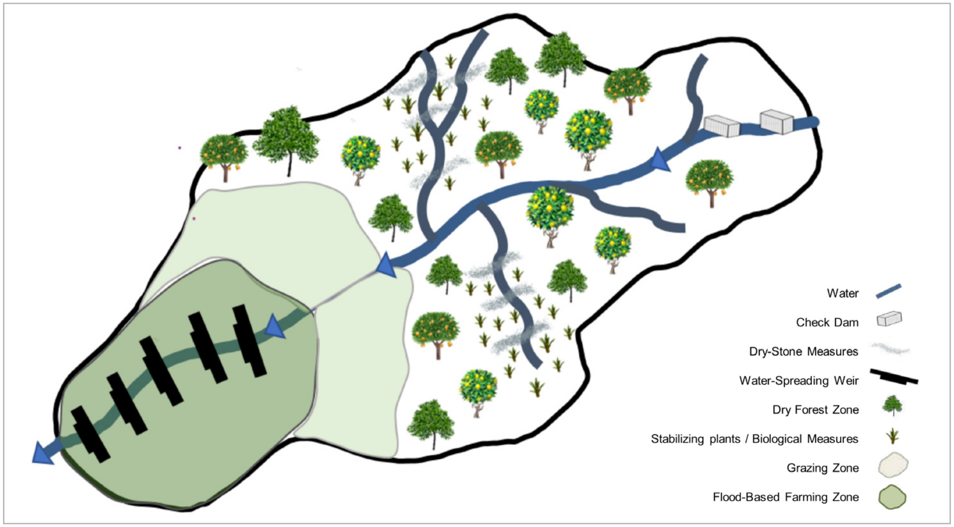
Flood-based Farming for Dry Valley Rehabilitation and Productive Use

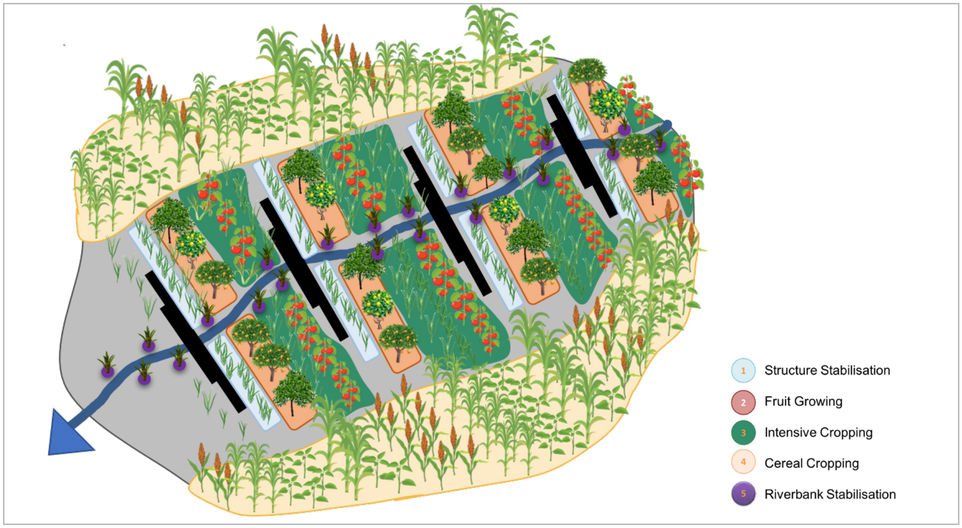
Flood-based Farming (FBF) system is a major component of the Dry Valley Rehabilitation and Productive Use (DVRPU) approach designed to transform dry valleys that rely on temporary floods into productive agricultural landscapes. FBF system within DVRPU offers a diverse range of characteristics and benefits that collectively make it a vital and sustainable system for dry valley agriculture:

- **Utilization of Floods:** FBF harnesses temporary floods and the sediments they carry to efficiently support agricultural production, making efficient use of these natural occurrences.
- **Improved Infiltration and ground water recharge:** The alluvial sediments harvested by FBF system enhances groundwater levels through improved infiltration. This groundwater resource is utilized for both domestic and irrigation during the dry periods when there are no flood events.
- **Diversified agriculture:** Due to its deep soil profile with good soil moisture holding capacity, FBF system is suitable for a variety of cereals, pulses, vegetables, and fruits. This diversity enhances food security and is quintessential adaptation to floodwater variability.
- **Nutritional Enhancement:** The diversified crop production systems under

FBF offers a variety of nutritious options for both human consumption and livestock feed. Trees like moringa and mango also provide high-quality fodder, improving livestock nutrition and productivity

- **Diversified Income Streams:** By integrating fruit trees into crop production, FBF provides multiple income streams for farmers, enhancing economic stability and fostering resilience against financial fluctuations.
- **Minimal External Inputs:** In contrast to conventional agriculture, FBF minimizes reliance on external inputs such as fertilizers and pesticides. Instead, it prioritizes the use of the often nutrient-rich sediments carried by floods. This approach is particularly advantageous in isolated dry valleys, where the risk of pests and diseases as well as accessibility to fertilizers at an affordable cost is limited.
- **Environmental Sustainability:** FBF contributes to environmental sustainability by managing weed growth through controlled grazing, promoting plant diversity, and creating habitats for beneficial insects, birds, and wildlife. This comprehensive approach conserves natural resources and supports biodiversity, aligning with broader environmental sustainability goals.





These benefits of FBF systems are realized by adopting the DVRPU multiple production zones that match plants and crops to the different moisture gradients caused by flooding:

- **Zone 1** serves as the foundational element, focusing on stabilizing physical structures with grasses. It occasionally experiences waterlogging, which is essential for flood mitigation.
- **Zone 2** thrives as a fruit-growing area, benefiting from abundant water availability, creating ideal conditions for fruit-bearing plants to flourish.
- **Zone 3** is an intensive cropping area characterized by ample water availability, making it a prime location for cultivating high-value crops.
- **Zone 4** functions as a cereal cropping area that is accustomed to intermittent dry spells. It is primarily utilized for growing crops like maize and sorghum.
- **Zone 5** plays a pivotal role in riverbank stabilization and features rich water availability. This zone encompasses a mix of grasses and fruit-bearing plants, contributing to both land stability and agricultural diversity.

Information Sheet

What is Flood-based Farming?

Flood-based Farming (FBF) is a traditional agricultural practice that involves using floodwaters for crop cultivation. This technique is typically used in areas with seasonal floods, such as river basins and floodplains, where the floodwaters can provide nutrients and moisture to support crop growth. Flood-based Farming relies on additional water from different kinds of floods in addition to rain-fed farming systems that are found in dryland locations.

In Flood-based Farming, crops are planted in low-lying areas that are prone to flooding, such as riverbanks or basins. When floods occur, the water covers the fields and deposits nutrient-rich sediment on the soil, which can help increase soil fertility. The crops are then able to grow using the moisture and nutrients from the flood water.

While floods are often framed as harmful and destructive, they also have many positive impacts and provide benefits for people and nature. Flood-based Farming has several advantages. It is a low-cost and low-input agricultural system that relies on natural resources such as rainfall and floodwaters, reducing the need for irrigation or expensive fertilizers. It also helps to improve soil fertility and reduce the need for synthetic fertilizers. In sub-Saharan Africa, an estimated 25 million hectares are already being irrigated with floods, in various ways. With a mean plot size of 0.5 hectares, it can be assumed that about 50 million people directly practice and benefit from Flood-based Farming (CGIAR, 2015).
Flood-based Farming is also common in Asia, where it yields greater productivity and supports larger populations than what is reported for Africa. This discrepancy is primarily due to better management and more diverse uses of floods in Asia.

Annual floods occur in different environments in Ethiopia. The existence of a distinct wet and dry season in Ethiopia allows these fluctuations of the water level in these areas. Floodplains of rivers, the margins of lakes, and (seasonal) wetlands are the environments where the water level changes over a year and are therefore suitable for the practice of flood-based agriculture. These environments exist in the high and lowlands of Ethiopia and are distributed all over the country. But, the use and management of floods can be improved, by implementing relatively low-investment and low-skill interventions, to boost agricultural productivity in Ethiopia.

Figure 3: Potential areas for DVRPU in the Horn of Africa.

Flood-based Farming can also help to mitigate the negative impacts of floods. By directing floodwaters into agricultural fields, the water can be absorbed by the soil and plants, reducing the amount of water that reaches urban areas and causing flooding. This can help to reduce the risk of property damage and loss of life from flooding.

However, Flood-based Farming is not without its challenges. In some cases, floods can be too severe and can lead to crop damage or loss. In addition, the technique may not be suitable for all crops or all areas, depending on factors such as soil type, crop type, and flood frequency.
Overall, Flood-based Farming is an important agricultural practice that has been used for centuries in many parts of the world. It can be an effective way to support crop growth, increase soil fertility, and reduce the risk of flooding in agricultural areas.

Occurrence of Flood-based Farming in Ethiopia

Ethiopia practices all major types of Flood-based Farming, including spate irrigation, flood inundation and recession, flood spreading weirs, and road water harvesting. The total area under Flood-based Farming, as compiled from various field studies, is approximately a quarter of a million hectares. However, the potential estimated using GIS and remote sensing ranges from 8 to 20 million hectares in Ethiopia alone. The significant difference is mainly because the former considers suitable areas to be those with rainfall of less than 300 mm, relying almost entirely on short-duration floods, while the latter includes areas with 500 mm of rainfall where floods could also serve as supplementary water resources. For this manual it is most relevant to look into the existing Flood-based Farming in Ethiopia, which can provide insights into the suitability and potential of Flood-based Farming in the lowlands of Ethiopia, and as part of the DVRPU approach.

Traditional Flood-based Farming, with limited area coverage within each system, have been in use for several generations in Ethiopia. The most significant development initiatives have taken place, recently in the last decade, particularly in the arid lowland areas (below 1500 meters above sea level). These are areas with hardly any perennial flows, but vast cultivable land. Perennial streams and springs exist primarily near mountains with an annual rainfall of over 1000 mm or near the outflow of lakes. Historically, government-sponsored irrigation development in Ethiopia concentrated exclusively on perennial streams, often overcommitting them while underutilizing the potential of seasonal rivers and short-duration flood flows. However, in recent years, this approach has changed, with several regional governments allocating budgets for Flood-based Farming.

The increasing focus on Flood-based Farming by public authorities and international development partners is part of a broader movement towards higher productivity farming systems, moving away from exclusively rain-dependent agriculture. The development of Flood-based Farming in the arid lowlands is closely linked to the increasing population in these areas and the growing variability of rainfall in highland regions. Previously, lowland areas were sparsely populated and mainly utilized by agro-pastoralists. In the past decades, due to population pressure in the highlands and advancements in controlling tropical diseases like trypanosomiasis and malaria, the lowlands have become more habitable. In some areas, Flood-based Farming has also emerged as a response to the trend of perennial rivers becoming seasonal rivers, a consequence of catchment degradation leading to shorter-duration but higher-peak floods, as situation where the DVRPU approach is highly relevant to reverse land degradation.

DVRPU is an innovative solution specifically designed to address the challenges and opportunities of lowland dry valleys, which are located in Ethiopia‘s transition zone between highlands and lowlands and are affected by seasonal flooding from the highlands. It identifies the zone suitable for DVRPU along the escarpment, which also happens to coincide with the areas with the highest food insecurity levels in Ethiopia.

This geomorphological gradient is not exclusive to Ethiopia alone - similar landscapes can be found throughout the Horn of Africa. This geographic region exhibits a broad spectrum of lowland dry valleys that share similar geographical and climatic parameters, making them ideal for the implementation of the DVRPU approach and the related Flood-based Farming under step 7. By acknowledging the broader scope of the potential application of DVRPU, we can recognize that the principles and strategies developed for Ethiopia lowland dry valleys can be adapted and utilized in other regions facing similar land and water management challenges. This broader perspective emphasizes the transferability and scalability of the DVRPU approach, enabling its implementation across the Horn of Africa to unlock the untapped potential in these diverse landscapes, from formerly degraded and underutilized areas into fertile islands of agricultural productivity fostering sustainable development, and making the available land- and water resources to use.

Developing this vast lowland potential is crucial for Ethiopia. Doing so will reduce dependency and ensure the food security of a continuously growing population with shrinking landholdings and limited access to perennial irrigation. The recent food crisis resulting from the Ukraine war and the subsequent spike in prices underscored the country’s vulnerability in this regard. Besides contributing to enhanced livelihoods, Flood-based Farming also serves as a buffer and protect communities and their environment from the devastating impacts of floods, especially within the broader context of the DVRPU approach. In 2020, for instance, floods wreaked havoc and devastated the lives of nearly 2.2 million agro-pastoral inhabitants.

Flood-based Farming differ significantly from conventional irrigation systems in various ways. In particular, standard design approaches cannot appropriately account for the level of uncertainty related to floods, the hydraulic challenge of guiding flood flows, the heavy sediment loads, the exceptional nature of water rights, or the management and maintenance models specific to flood-based irrigation. Therefore, dedicated training modules, such as this, are necessary. Flood Water Spreading Weirs are relatively new systems in Ethiopia and East Africa and are not adequately covered in the evidence-based documentation of Flood-based Farming facilitated by the Flood-based Livelihood Network in the past decade.

Types of Flood-based Farming

Flood-based Farming is possible in areas that regularly receive floods, which can form the basis for productive farming systems, such as crop cultivation, livestock grazing, or fishing grounds.

The main types of Flood-based Farming systems have been identified as:

1. **Floodplain agriculture:**- is agriculture practiced at an area of land adjacent to a river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge.
    - It is the most common type of Flood-based Farming in sub-Saharan Africa, where either receding or rising floodwaters provide water for crop cultivation.
2. **Spate irrigation:** - is a traditional method of water distribution and diversion that uses seasonal floods of brief duration that originate in the mountains that receive abundant rainfall to irrigate cascades of levelled and bounded fields in the coastal lowlands.
    - It helps in the improvement of grazing areas, filling of drinking water ponds, and groundwater recharge.
3. **Inundation canals:** - is a farming system in which canals located near rivers or floodplains are fed by water when rivers rise and used to divert water to nearby farmland for agricultural activities.
4. **Depression agriculture:** - is farming system rely on shallow depressions filled when the groundwater level rises on a seasonal basis.
    - They can provide enough moisture to support grazing in the dry season and crops grow without irrigation.

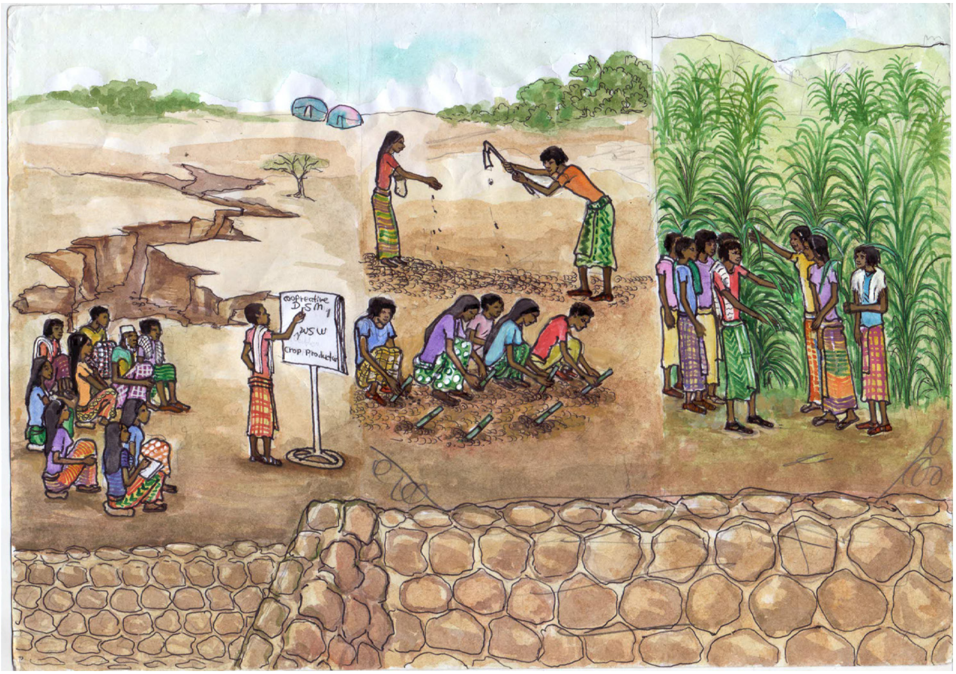


Figure 4: Generating an income through Flood-based Farming contributes to utilizing the benefits of the Water Spreading Weir construction and building a foundation for future maintenance of the WSWs

Flood recession agriculture is a form of agricultural cultivation that takes place on a floodplain and is practiced by successively planting in the flooded areas after the waters recede. It falls under the floodplain agriculture (type 1).
Flood recession regions receive a seasonal flood that brings fertile topsoil from the upper catchment, contributing to the soil composition in the flooded areas, which is typically fine-grained sediment that settles when water moves slowly across the floodplains. Additionally, floods can carry organic material from the upper catchment that settles in the flooded areas due to the slow-moving water.

- It is a resource management type of Flood-based Farming system that is often ‘forgotten’, even though the area covered by it is extensive – in Africa alone, it may amount to over 20 M ha.
- It serves as a rudimentary form of irrigation

Within the DVRPU approach, Flood-based Farming is an key element of step 7. The practice of Flood-based Farming using the water captured through WSWs, as practiced in the lowlands of Ethiopia, falls under the Flood recession agriculture. WSWs are masonry structures that span the entire width of a riverbed or large parts of a valley floor to spread floodwater over the adjacent land area.

- They are designed to spread and redistribute as much floodwater – including its sediment load – as possible, as well as to reduce soil erosion.
- Water Spreading Weirs are low-based structures made of natural stones and cement.
- Each weir consists of a spillway, one or more basins in the riverbed itself, and lateral abutments or ‘wing walls’ which decrease in height away from the spillway.
- WSWs Flood-based Farming is different from a dam, which is designed to retain water, a WSW is not blocking the water flow completely but spreads water and its sediments, reducing the velocity of water flow by enhancing the length of the waterway.
- The areas upstream and adjacent to a weir are temporarily flooded, allowing water to infiltrate into the soil and sedimentation to accumulate, thereby recharging groundwater stores, increasing vegetation, and creating favourable drainage patterns.
- It is the focus of this Teaching and Learning guide and further details will be discussed in the coming learning outcomes

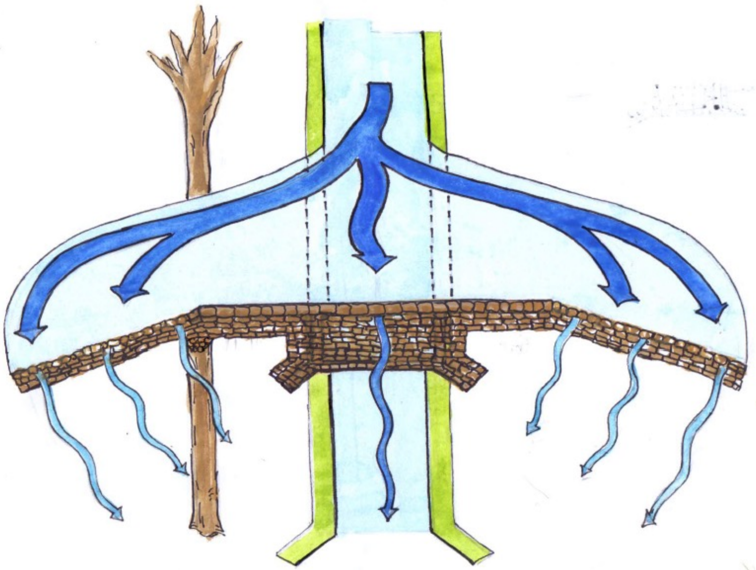


Figure 5: Water Spreading Weirs force the water to spread over a larger area, contributing to sedimentation of soil particles and increased infiltration of moisture, which provides a basis for Flood-based Farming.

Integrated Sediment and Catchment Management

Fine sediments are of very important to Flood-based Farming systems, second only to floods themselves. These sediments play a crucial role in developing the soils that sustain crops in these systems, characterized by their loamy and silt loam textures. These specific soil characteristics are essential for rapid water infiltration and moisture retention, both critical factors in Flood-based Farming where crops rely heavily on residual soil moisture throughout their growth cycle. Moreover, these fine sediments are often rich in nutrients, facilitating organic

Flood-based Farming practices that significantly contribute to both human and environmental well-being. However, the preservation of these positive contributions of fine sediments and the overall sustainability of Flood-based Farming systems call for several important measures:

1. Coarse sediment control: Efforts must be made to limit the entry of coarse sediments into the area behind the Water Spreading Weir, which are often brought in by large floods. Implementing can help achieve this goal in Flood-based Farming systems. Coarse sediments have the potential to significantly reduce both infiltration and soil moisture retention capabilities.
2. Balancing Conservation: Striking the right balance between introducing upstream soil and water conservation measures and ensuring that these measures do not overly restrict downstream floodwater and sediment supply is crucial. An excessive focus on upstream conservation can inadvertently harm the Flood-based Farming system.
3. Assessing Upstream Impact: Careful analysis is necessary when considering agricultural activities in upstream catchments. While some areas may be unsuitable for agriculture due to their steep terrain, others are actively cultivated. Decisions to intensify agricultural activities upstream should take into account potential negative impacts downstream. Several real-life examples underscore the importance of this approach:
    - In the Mekong Delta, extensive upland rice cultivation has reduced downstream floodwater and sediment influx considerably, resulting in a significant shrinkage of low-lying flood-based irrigated areas.
    - The Fogera flood-based livelihood systems in Lake Tana, Ethiopia have experienced moderate soil fertility stress, attributed to inadequate upstream soil and moisture conservation practices.
    - Yemen faces issues related to the extensive plantation of the high water-demanding Qat (also spelt Khat or Qaat) plant, which is widely chewed by both men and women as a social activity. It is already having a negative impact on both sediment and floodwater flow downstream, affecting flood-based livelihood systems.

Recognizing the interdependence between upstream and downstream areas, flood-based farmers should be well-organized and possess the collective institutional strength to influence upstream developments. This ensures that extreme interventions that could negatively impact their lives and livelihoods are avoided thereby strengthening the DVRPU approach. Furthermore, it is important for governments and international partners to ensure that development programs are well-informed, taking into account how interventions in one section of the catchment affect and are affected by initiatives in other areas. This holistic perspective is essential for sustainable and integrated catchment management.

Linking Flood-based Farming to the DVRPU approach

Within the DVRPU approach, the implementation of productive use form an important building block and the final step. The productive use of the valleys, mainly through Flood-based Farming, is one of the ways of harvesting the benefits of the rehabilitation efforts (step 7 in the DVRPU approach). In the next section, measures to increase the productivity within Flood-based Farming are laid out, to further strengthen step 7 of the DVRPU approach.

Six Ways to Increase the Productivity of Flood-based Farming Systems

Improving the following aspects has the potential to drastically increase the productivity of these Flood-based Farming systems:

1) Water distribution

- Floods may vary in intensity and duration, from a few hours to a period of months, and may also at times be forceful and unpredictable.
- Improving water distribution, by putting in place water control structures, can allow better control of water and reduce erosion, water logging, and other risks.
- Dividing the floodwater into smaller portions and avoiding steep slopes where water can pick up speed, can help safely steer water.
- Other relevant flow diversion structures can be put in place, including drop structures (to transition between levels), flood bed stabilizers (to prevent uncontrolled runoff), and water-spreading weirs (to reduce erosion).

2) **Field water management**

- Being able to manage the rise and drainage of floodwater within a field is also essential to be able to use the water productively.
- Several mechanisms can help in this matter: Dikes and soil bunds can help protect fields from unexpected floods and they can also allow farmers to drain or retain water as needed; drainage ditches can be used to channel away excess floodwaters, and reuse agreements can enable farmers to take turns using water from the same source.

3) **Groundwater use**

- In most areas where Flood-based Farming can be practiced, groundwater is shallow, meaning it is close to the surface.
- This means that potential exists to access and use groundwater to extend the cropping season.
- Several approaches can be considered, including accessing groundwater through hand-drilled tube wells, which can be established for low costs and using only local labor.
- Other groundwater-lifting technologies include rope pumps, treadle pumps, motor pumps, and solar-powered pumps.
- Most importantly in assessing and mapping groundwater resources to avoid over-exploitation.

4) **Agronomic practices**

- Introducing improved crop varieties and changing agricultural practices can also help realize potential production gains. Good agronomic practices such as intercropping, crop rotation, and mixed cropping are also helpful.
- Some crop varieties are better suited for Flood-based Farming systems, such as early maturing crops (climate-smart crops).

5) Multi-functional use

- The productivity of Flood-based Farming systems can also be boosted by considering the multiple ways that floodplains provide benefits, such as through fishery, flood pastures, fuel wood collection, and water supply. For example, fishponds and aquaculture can supply local communities with protein, while requiring fewer inputs than other agricultural practices.

6) Internal governance

- Flood-based Farming systems are underappreciated and poorly understood by governments, donors, and development agencies.
- To realize the full potential, governance must be improved, including by familiarizing policy makers, extension workers, academics, and other water professionals with the potential for and benefits of floods-based farming

Figure 6:Discussing the potential use of Flood-based Farming with community members

Guiding questions for discussion

1. How are the farming practices in the lowlands of Ethiopia?
2. What is the understanding of the community regarding floods in the lowlands?
3. Benefits and challenges of floods in lowlands
4. What is Flood-based Farming?
5. Why is Flood-based Farming important for the lowlands of Ethiopia?
6. What are the (four) types of Flood-based Farming?

Self-Check-Test

Name	
Date	
Time started	
Time finished	

Instructions

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

Short answers

1. What is Flood-based Farming (2pnts)?
2. List three types of Flood-based Farming more appropriate for your area (3pnts).
3. List 4 ways to increase the productivity of Flood-based Farming systems (4pnts).
4. How can Water Spreading Weirs (WSWs) have a role in Flood-based Farming (3pnts)

Rating

Note Satisfactory rating points 7 and above. Unsatisfactory points below 7.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Learning Outcome 2. Flood-based Farming as part of DVRPU

Introduction

In this Introduction, you find the specific learning objectives of Learning Outcome 2. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an Operational sheet tells you how to proceed with the implementation of what is described in the information sheet.

By the end of this Learning outcome section, you should:

- understand the basics of the Flood-based Farming as part of DVRPU
- understand the benefits of Flood-based Farming as part of DVRPU
- be familiar with the tools and technologies required for Flood-based Farming as part of DVRPU

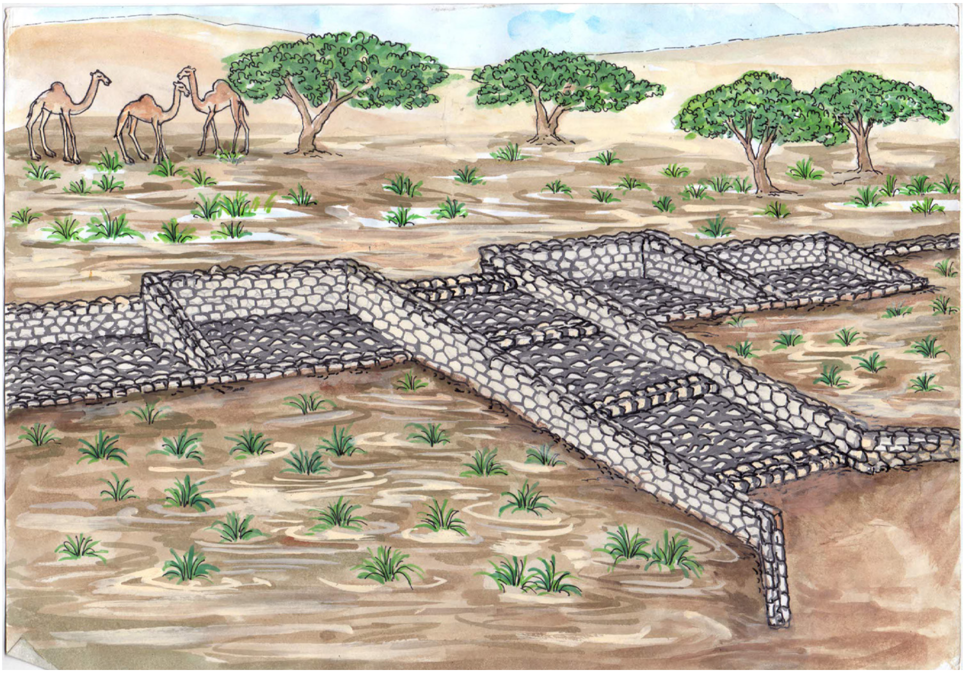
Instruction Sheet for Teachers

As you go through this Learning Outcome section together with your class, do not start by lecturing them about Flood-based Farming from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them and brainstorm ideas about Flood-based Farming as part of DVRPU practices that they already know.

- Work through the Information Sheet.
- Ask students/trainees to suggest examples of when and where Flood-based Farming as part of DVRPU might be most suitable. Ask them to explain why.
- Discuss the Guiding Questions.

Teaching methodology

Brainstorming, interactive teaching, and learning, group work (listing), and discussions.



Session Plan

- 20 minutes looking at the introduction, brainstorming, and listing differences;
- 50 minutes for the Information Sheet;
- 30 minutes for the Guiding Questions;
- Total time: 1 hour and 40 minutes.

Instruction sheet for Learners

- Read the introduction with the specific learning objective for Learning Outcome 2. Familiarise yourself, as a potential future development agent, with your role in the process.
- Read the Information Sheet on Flood-based Farming as part of DVRPU.
- Write down any questions you have.
- Ask your teacher for support and seek answers to your questions.
- Try to answer the Guiding Questions and discuss them with classmates about the advantages, disadvantages, and other factors regarding Flood-based Farming as part of DVRPU.
- Test your knowledge by completing the Self-Check Test.

Information Sheet

- WSWs are low retention walls designed to dissipate flash floods into rangelands and farms while also reducing runoff and soil erosion.
- They are made of natural stone and cement and consist of a spillway in the dry riverbed itself, lateral abutments for stabilization, and wing walls that span the width of the valley perpendicular to the dry river on both sides of the spillway.
- WSWs may alter flood course and the distribution of fertile sediments and nutrients.
- Sedimentation could improve the physical, biological, and chemical properties of soils; builds up soil depth, increases crop production, and keeps production costs low as no cost of fertilizer is involved.
- This would create a spatial difference in soil moisture and soil fertility that could determine the area of land to be cultivated and crop productivity and production.
- The governing principle in this approach is that WSWs alter flood velocity, direction, and spatial pattern of moisture and sediment deposition modifying spatial distribution of soil moisture, soil chemical characteristics, and thereby productivity depending on how effectively water and sediment load from flood events are spread over the command area.
- Within the DVRPU approach, the implementation of productive use form an important building block and the final step. The productive use of the valleys, mainly through Flood-based Farming, is one of the ways of harvesting the benefits of the rehabilitation efforts (step 7 in the DVRPU approach).

Information Required for Practicing Flood-based Farming as Part of DVRPU

1. Climate data in the Ethiopian Lowlands

The lowlands of Ethiopia have a hot and dry climate, with significant regional variations due to differences in elevation, topography, and latitude. Generally, the lowlands are classified as arid or semi-arid, with very low annual rainfall.

The climate of the lowlands of Ethiopian is typically divided into two main seasons: a dry season and a rainy season. The dry season, which lasts from October to May, is characterized by hot and dry weather, with very little rainfall. Temperatures during this season can reach highs of 40°C (104°F) or higher, particularly in the eastern and south-eastern parts of the country.

Figure 7: Water Spreading Weirs spread the water over a larger area, contributing to sediment deposition and build-up of shallow aquifers, as well as soil moisture in the top soils.

The rainy season in the lowlands of Ethiopia usually occurs between June and September, and it brings brief, intense rainfall. The amount of rainfall varies widely depending on the location, with some areas receiving less than 200 mm (8 inches) of rainfall per year, while others may receive up to 900 mm (36 inches) of rainfall annually.

The lowlands of Ethiopia are home to a unique array of wildlife and plant species, many of which have adapted to the harsh conditions of the arid and semi-arid environments. The regions are also known for their diverse pastoralist communities, who have developed innovative ways to manage and survive in this challenging environment.

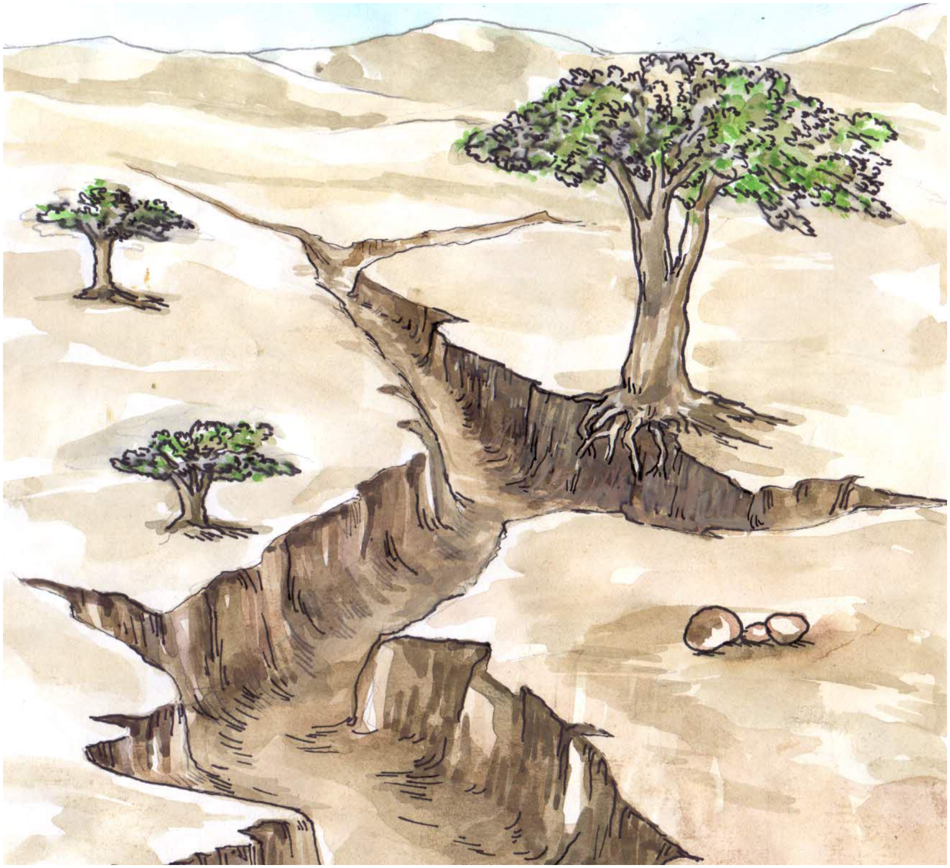


Figure 8: Strong rainfall together with lack of land cover and soils which are susceptible to erosion can contribute to gully formatting.

2. Meteorological Data:

Historical rainfall data from previous years and forecasts for the upcoming season in the Ethiopian lowlands and nearby highlands are essential for understanding the frequency and intensity of rainfall, which determine the flood situation in the lowlands, and thus aid in planning agricultural activities.

- Rainfall Forecasts in the Highlands: Rainfall in the adjacent highlands serves as the primary source of floods in the lowlands. Analysing rainfall characteristics in these highlands can help predict the likelihood of floods and serve as a proxy to assess the potential for Flood-based Farming in the lowlands.
- Rainfall Forecasts in the Lowlands: While the amount of rainfall in the lowlands is often limited, when substantial, it plays a significant role as a supplementary water source next to floods and can be an important factor in determining farming schedules and crop selection.

This type of data can be accessed through regional/Woreda-level Disaster Risk Reduction Management and other related offices.

Frequency and intensity of rainfall:

- The quantity and intensity of rainfall received in the command area and adjacent highlands define the potential for Flood-based Farming. The effectiveness of Flood-based Farming practices hinges on how frequently high-intensity rain events occur, leading to floods in the lowlands.
- Low to medium-intensity rains in the highlands can also contribute to flood generation if there is already substantial soil moisture storage from preceding rainfall and flood events.

3. Flood Occurence Information Sheet

A flood occurrence information sheet is a document that provides details about A flood occurrence information sheet is a document that provides details about the occurrence of a flood event in a particular location. It typically includes information such as the date and time of the flood, the location of the flood, the severity of the flood, the type of flood (e.g. flash flood), the duration of the flood, the impacts of the flood (e.g. property damage, loss of life), and any relevant warning or evacuation orders issued by local authorities.

Flood occurrence information sheets are useful for emergency response and management, as well as for proper planning of Flood-based Farming. By providing accurate and up-to-date information about flood events, these sheets can help agropastoral communities to make informed decisions about how to protect themselves and their property during and after a flood as well as using the flood for Flood-based Farming.

Figure 9 shows the occurrence of major flood events in Ethiopia in the period 1950 – 2020. It can be seen that the lowlands are more susceptible to floods as some parts have received major floods on 10+ occasions during the period. It is important to note here that the annual floods, which are used for the Flood-based Farming behind WSWs, are not taken into account in this illustration.

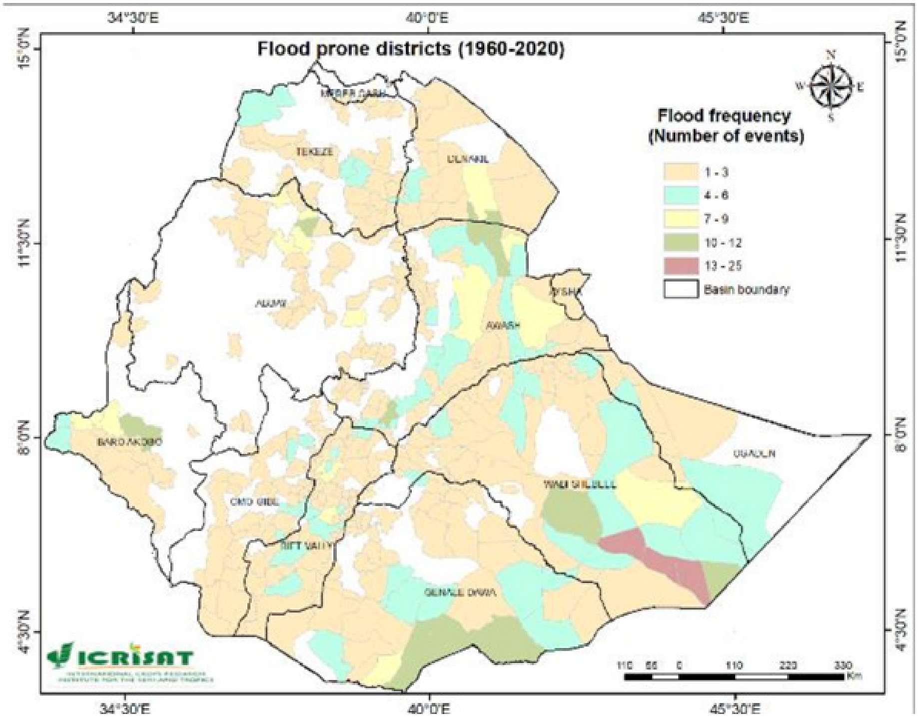


Figure 9: Flood frequency/number of observed events in Ethiopia (UNOCHA, 2019 in ICRISAT, 2021)

4. Moisture Zonation

Soil moisture zonation is an important factor that determines the type of crop selection for the appropriate area of land/zone. Due to the variability of soil properties such as topography, vegetation, and climate change, this important factor varies over time and place. The measurement/zonation method can provide soil moisture information over a wide range of short intervals with reasonable accuracy.

Suitability of crops for the different Moisture Zones

In Figure 10, three moisture zones have been identified for the case study area in Chifra Afar, namely:

- Low moisture zone (VWC <13,5%)
- Medium moisture zone (VWC: 13,5 – 18%)
- High moisture zone (VWC >18,5%)

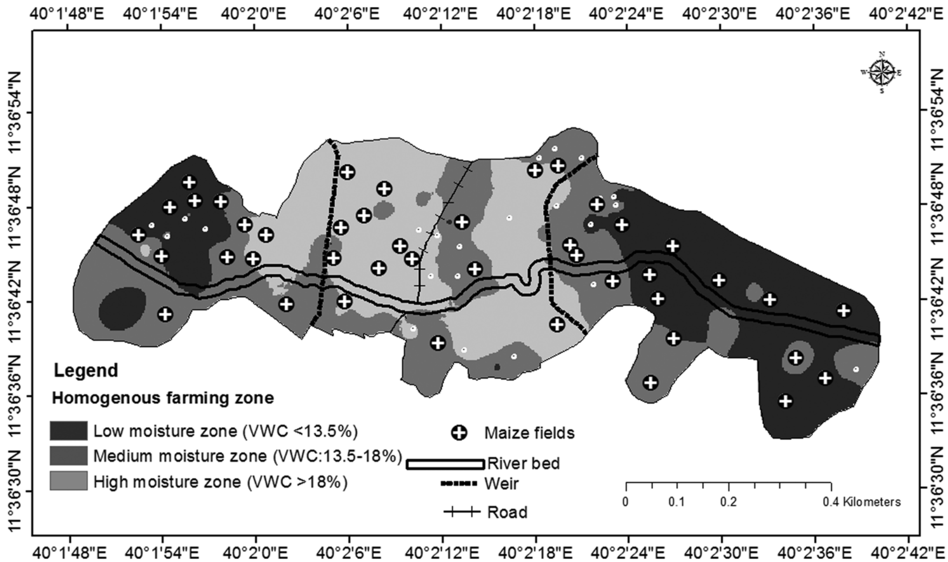


Figure 10: Map of homogeneous farming zones based on soil moisture gradient at the start of the Meher season of 2017 at Shekai Boru site of Chifra in Afar.

(Note: VWC is Volumetric Water Content, the ratio of the volume of water to the unit volume of soil, a higher the percentage means a higher moisture content)

Table: Suitability of common crops in the lowlands related to moisture zonation

Crop	Category	Moisture zonation
Lowland wheat	Cereals	Low to moderate
Lowland rice	Cereals	Moderate to high
Maize	Cereals	Low to moderate
Sorghum	Cereals	Low
Pearl millet	Cereals	Low to moderate
Haricot bean	Pulses	Moderate
Soya bean	Pulses	Moderate
Mung bean	Pulses	Moderate
Cow pea	Pulses	Low
Pigeon pea	Pulses	Moderate
Sesbania	Pulses	Moderate
Ground nut	Oilseeds	Moderate
Sun flower	Oilseeds	Low to moderate
Sesame	Oilseeds	Low
Onion	Vegetable and fruit	Moderate to high
Tomato	Vegetable and fruit	Moderate to high
Citrus fruit	Vegetable and fruit	Moderate to high
Papaya	Vegetable and fruit	Moderate to high
Guava	Vegetable and fruit	Moderate to high
Elephant grass / Napier Grass	Fodder	Moderate
Desho grass	Fodder	Moderate
Sudan grass	Fodder	Low
Buffle grass	Fodder	Moderate
Moringa	Multipurpose Tree	Low
Neem tree	Multipurpose Tree	Low to moderate

In other areas where flood-based farming can take place behind Water Spreading Weirs, a similar zonation for moisture can be developed. In the table below, the suitability of common crops in the lowlands is presented.

Planting zones in the DVRPU FBF system

In the DVRPU FBF system, the planting area is divided into multiple zones that match plants and crops to the different moisture gradients caused by flooding. This enhances productivity and maximizes the benefits derived of the rehabilitated areas. In figure 11 the zones and their respective planting area are presented schematically and in the table below, the zones are matched to crop categories.

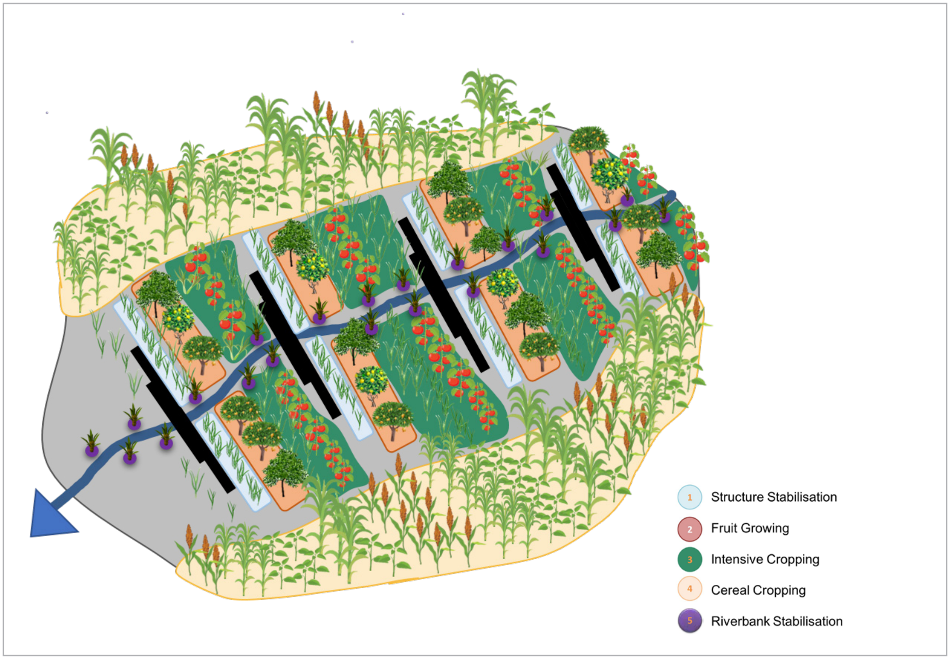


Figure 11: Planting zones identified within the DVRPU FBF system

Table: Crops and crop categories suitable for flood-based farming system across the five DVRPU zones

Cereals (zone 4)	Pulses (Zone 3)	Oil Oilseeds (zone 3)	Vegetables and fruits (Zone 3)	Fodder (zone 1 & 5)	Multipurpose trees (Zone 2)
Lowland wheat	Haricot bean	Ground nut	Onion	Elephant grass / Napier Grass	Moringa
Lowland rice	Soya bean	Sunflower	Tomato	Desho grass	Neem tree
Maize	Mung bean	Sessame	Citrus fruit	Sudan grass	
Sorghum	Cow pea		Papaya	Buffle grass	
Pearl millet	Pigeon pea		Guava		
	Sesbania				

Exceptions: Rice, which is more adapted to water logged condition and Mung beans, which is resistant to waterlogged situation are more suitable to the well-watered zone 3.

The land classification is based on the soil moisture regime and previous crop performance as input data. A similar classification can be made for other sites with Water Spreading Weirs, providing insight in the potential for Flood-Based Farming.

Soil moisture: refers to the entire quantity of water in the ground's pores or on its surface.

- The moisture content of soil depends on such factors as weather, type of land, and vegetation coverage.
- Soil moisture determines the field's readiness for agricultural processing.
- Ultimately, the soil moisture effect on plant growth and yield is vital.
- Soil moisture also affects the Physical, chemical, and biological properties of the soil.

Factors Affecting Soil Moisture

This parameter depends on various indicators such as topography, vegetation cover, and climate. The main soil characteristics are:

- **Texture:** the finer it is, therefore, better moisture retention.
- **Structure:** porous structure with a high level of aggregation improves water retention.
- **Organic matter content:** The more organic matter there is, the more significant the water-holding capacity.
- **Density:** The higher it is, the less water penetrates inside.
- **Temperature:** moisture content is higher at lower temperatures.
- **Salinity:** the higher the salt content, the less water the plants can absorb, as salt is a natural absorbent.
- **Depth:** This factor affects the amount of water available, i.e., the deeper the soil is, the more water and nutrients the plants can get.

The Optimum Moisture Content (OMC) or Optimum Water Content (OWC) is the moisture content at which the soil attains maximum dry density.

- The desired soil moisture content depends on the Field Capacity (FC) and the Permanent Wilting Point (PWP).
- FC means how much water the soil can hold after the excess drains off. It displays the balance of water and air in the ground's pores. There is not enough oxygen if the moisture percentage is too high.
- PWP reflects the temperature threshold below which plants begin to wither and die because they don't receive enough water.
- Both depend on the type of soil, so it is critical to conduct an appropriate analysis to specify the optimal soil moisture range.

The suitability of crops for the moisture zones, their capability to handle different levels of moisture, is included in the overview of crops in Learning Outcome 3.

Moisture deficiency

- It is the difference between the exact water content in the ground and the water it can hold.
- Also, an important indicator is Total Available Water (TAW), i.e., how much of it plants can get.
- It is the contrast between the moisture content of the ground according to FC and PWP.
- Above FC, crops can take it only for 1-3 days; below PWP (Permanent Wilting Point), crops cannot absorb the needed water anymore and they wilt.

It is good if there is a datasheet available gathered from the previous water-spreading weirs with soil moisture measurements. It will help to take the average estimate of the land area adjacent to the structure. Otherwise, it is good to create a traditional way of measuring/identifying the moisture level of the soil, it can be a stick method or taking a sample of soil around 20cm deep at different parts of the land. Deciding the crop type suitable for such moisture zones can be done after the zonation of the moisture level around the WSWs.

Techniques to identify soil moisture levels around the WSWs

Soil moisture can be measured using various technologies, like the ones mentioned below. However, if the tools are not available/accessible agropastoral community can use their experiences and the following tips to identify soil moisture in their land.

- Slope/elevation: when the slope increases towards the wings of the WSWs the moisture level of the soil will generally decrease
- Feel method: compressing soil samples by hand. The compactness of the soil after releasing the hand that compressed the soil shows the availability of moisture. If the soil crumbles after releasing, it is a sign of dryness.
- Physical methods:
    1. Soil samples: soil samples at different depths and locations can be sampled and tested for moisture, to find out the moisture at different depths. This testing requires an auger or drill tool to be able to take the samples.

Alternatively, you can dig a small pit (± 30cm deep) with a how to check the soil moisture in the upper layer, just below the surface.

2. Visual observation: This method mainly applies for inherently light coloured soils. The texture and colour of the soil can also indicate the availability of moisture or the capacity of the soil to hold the moisture for a certain period. If you observe a darkening in colour, it is a sign of soil moisture availability. The darker the colour, the higher the soil moisture content.
3. Stick method: insert a small stick into the soil for 10 – 15 centimetres. Remove it after 30 seconds and the extent to which the soil clings to the stick and the change of colour of the stick is an indication for the soil moisture.

Once identified the moisture content level of the area/land plots with sufficient moisture content can be allocated for maize and sorghum while plots with low moisture content can be allocated for early maturing crops (cereals, legumes, or grasses).

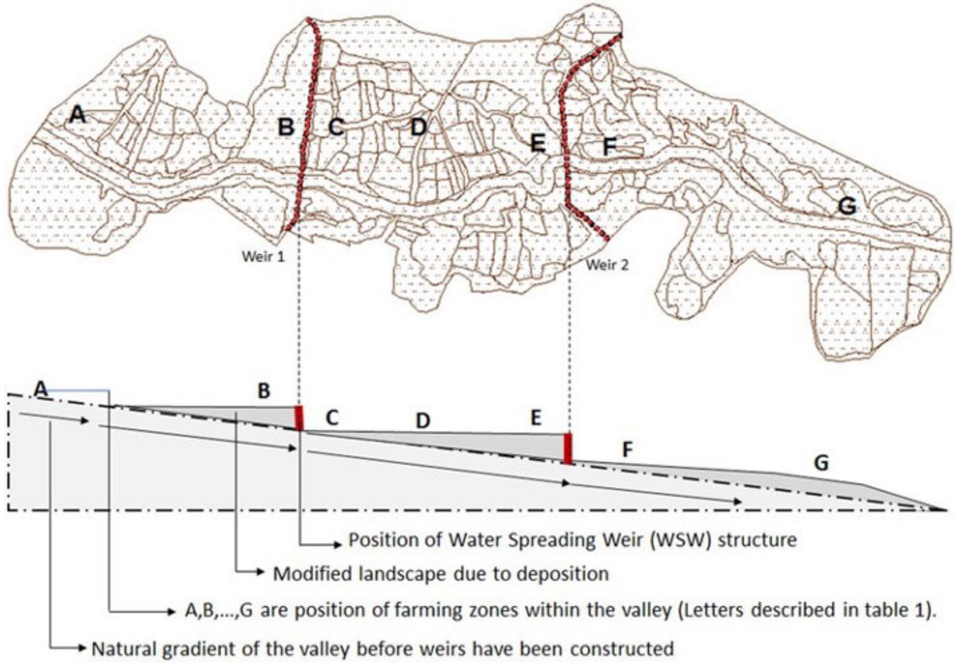


Figure 12: Schematic representation of the orientation of WSWs and locations (A–G) within the study site.

Table 1: Description of the locations relative to the WSWs in the study site

Locations	Description	Suitability for Agriculture/Flood-based Farming
Location 'A'	Far upstream of the weir 1 constructed at the end. It is less impacted by the WSW.	This part of the farm was found to be highly suitable for agricultural production.
Location 'B'	The upper side of weir 1.	Reduced suitability. In this zone, crop and fodder choices were highly limited by waterlogging after floods and sediment loads afterwards.
Location 'C'	Located in the downstream side of weir 1, the excess water that jumps over weir 1 floods into this location	The zones were mostly well-drained, shallow and suitable only for drought-resistant and early-maturing crops as well as grasses
Location 'D'	Farm fields located approximately midway between weir 1 and weir 2 it usually receives the excess water flowing from location 'C' and the flash back of downstream weir 2	This part of the farm was found to be highly suitable for agricultural production.
Location 'E'	Located at the upper side of and close to weir 2. Fields in this location get moisture from the flash back of weir 2	Reduced suitability. In this zone, crop and fodder choices were highly limited by waterlogging after floods and sediment loads afterwards.
Location 'F'	Located close to weir 2 the downside. The excess water jumping over weir 2 irrigate this area	Not suitable, Any crop or forage planted in this parcel could be washed away.
Location 'G'	Fields in the eastern extreme end of the site far from weir 2.	The zones were mostly well-drained, shallow and suitable only for drought-resistant and early-maturing crops as well as grasses

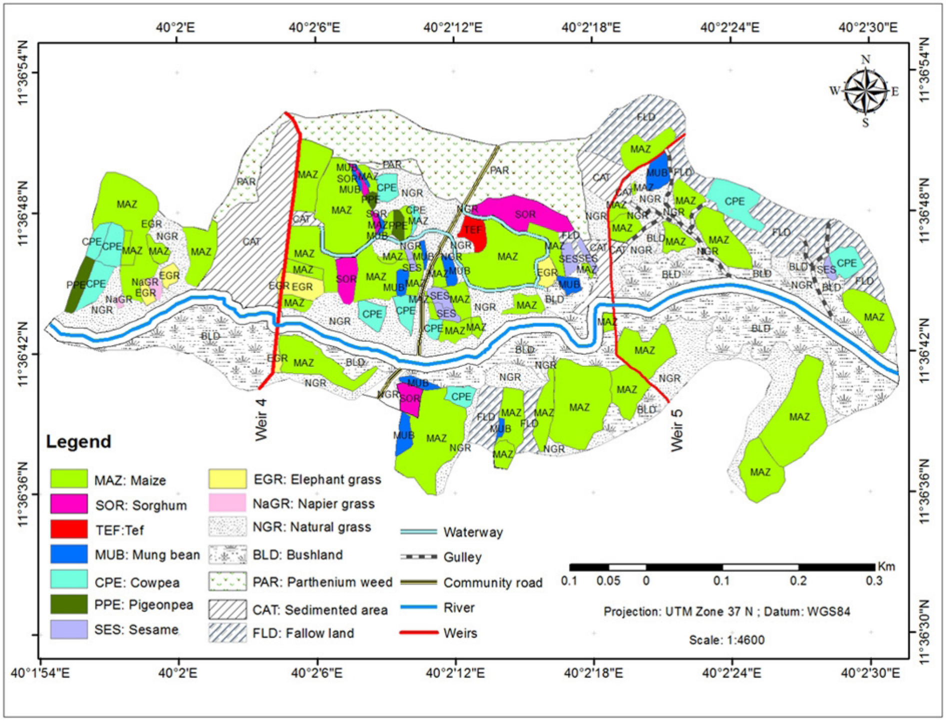


Figure 13: Map of crop and forage production and productivity in Chifra, Afar

In this information sheet, part of Learning Outcome 2, use is made of a case study in Chifra, Afar. While some of the findings are site specific, the approach in identifying the suitable plots within the areas where Water Spreading Weirs have been constructed can be applied in other areas in the lowlands of Ethiopia. In this approach use is made of data on flood occurrence, rainfall and moisture zonation.

The availability of data for each specific site will determine whether the specific type of data can be taken into account as part of the identification.

Guiding questions for discussion

1. What is your understanding regarding WSWs?
2. How are the Flood-based Farming as part of DVRPU practiced in the lowlands of Ethiopia?
3. What are benefits and challenges of Flood-based Farming as part of DVRPU?
4. Why is Flood-based Farming as part of DVRPU important for the lowlands of Ethiopia?

Self-Check-Test

Name	
Date	
Time started	
Time finished	

Instructions

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

Multiple choice
On what source of water does farming in the lowlands depends the most?
A. Groundwater
B. Floodwater
C. Rainfall
D. Dew water

What does Field capacity mean

Short answers

1. Explain what WSW is. (2 points)
2. What is the main difference between WSW and a dam? (2 points)
3. Explain Flood-based Farming as part of DVRPU. (3 points)
4. What is the most essential information required for practicing Flood-based Farming as part of DVRPU? (2 points)
5. Explain soil moisture and its importance in Flood-based Farming as part of DVRPU (2 points)
6. List factors affecting soil moisture (2 points)
7. List 3 ways you can use to identify soil moisture around the WSWs (3

points)

Rating

Note Satisfactory rating points 10 and above. Unsatisfactory points below 10. You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Learning Outcome 3: Crop production using Flood-based Farming

Introduction

Every Learning Outcome has a similar structure. In this Introduction, you find the specific learning objectives of Learning Outcome 3. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an Operational sheet tells you how to proceed with the implementation of what is described in the information sheet.

By the end of this Learning outcome section, you should:

- know characteristics that crops require to be of use in the lowlands of Ethiopia
- have an overview understanding of the crops that are suitable for production in Flood-based Farming systems in the lowlands of Ethiopia
- have a basic understanding of a few seasonal cropping patterns

Instruction Sheet for Teachers

- As you go through this Learning Outcome section together with your class, do not start by lecturing them about Flood-based Farming from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them and brainstorm ideas about Crop production using Flood-based Farming practices that they already know.
- Work through the Information Sheet.
- Ask students/trainees to suggest examples of crop types that are most suitable in their areas. Ask them to explain why.
- Discuss the Guiding Questions.

Figure 14: Harvesting the maize after a productive season of Flood-based Farming

Teaching methodology

Brainstorming, interactive teaching, and learning, group work (listing), and discussions.

Session Plan

- 20 minutes looking at the introduction, brainstorming, and listing differences;
- 45 minutes for the Information Sheet;
- 30 minutes for the Guiding Questions;
- Total time: 1 hour 35 minutes.

Instruction sheet for Learners

- Read the introduction with the specific learning objective for Learning Outcome 3. Familiarise yourself, as a potential future development agent, with your role in the process.
- Read the Information Sheet on Crop production using Flood-based Farming as part of DVRPU.
- Write down any questions you have.
- Ask your teacher for support and seek answers to your questions.
- Try to answer the Guiding Questions and discuss them with classmates about the Crop type selection criteria.
- Test your knowledge by completing the Self-Check Test.

Information sheet

Crop type selection

Crop type selection in semi-arid areas can be a challenging task because of the unique environmental conditions of these regions. Pastoral communities rarely practice farming, there are very limited crop type choices in the system. The choice of appropriate varieties is very important for the success of Flood-based Farming and its sustainable uptake by the community.

The following are some factors to consider when selecting crop types for semi-arid areas:

1. Water/moisture availability: Water is often the limiting factor in semi-arid regions, so crop types that are drought-resistant and can tolerate low moisture conditions should be selected. Some examples of crops that can survive in low-water conditions include millet, sorghum, and legumes.
2. Soil type: Soil type is also an important consideration, as semi-arid areas often have sandy or loamy soils that are low in nutrients. Crops that can thrive in these soil conditions include sunflower, pearl millet, and cowpea.
3. Temperature: Semi-arid regions have high temperatures during the day and cold temperatures at night. Crops that can tolerate extreme temperatures, such as maize, beans, and cassava, are good options.
4. Market demand: The selection of crops should also take into account market demand. The selected crops should have a market value and should be profitable for agropastoral communities. Some crops that have a high market demand in semi-arid regions include cotton, sesame, and groundnuts.
5. Pest and disease resistance: The selected crops should also be resistant to pests and diseases that are common in the region. Some crops that have good resistance to pests and diseases include cowpea, sorghum, and groundnuts.
6. Community or personal preference for the use of the crop, will influence the demand for the crop, besides the market demand.

7. Distance of the fields from the home. This will influence the time available for the cultivation of the field and the management of the crop. With a greater distance, there will likely be a preference for a crop which is less requiring demanding.

In summary, the selection of crops in semi-arid areas should be based on water/moisture availability, soil type, temperature, market demand, and pest and disease resistance.

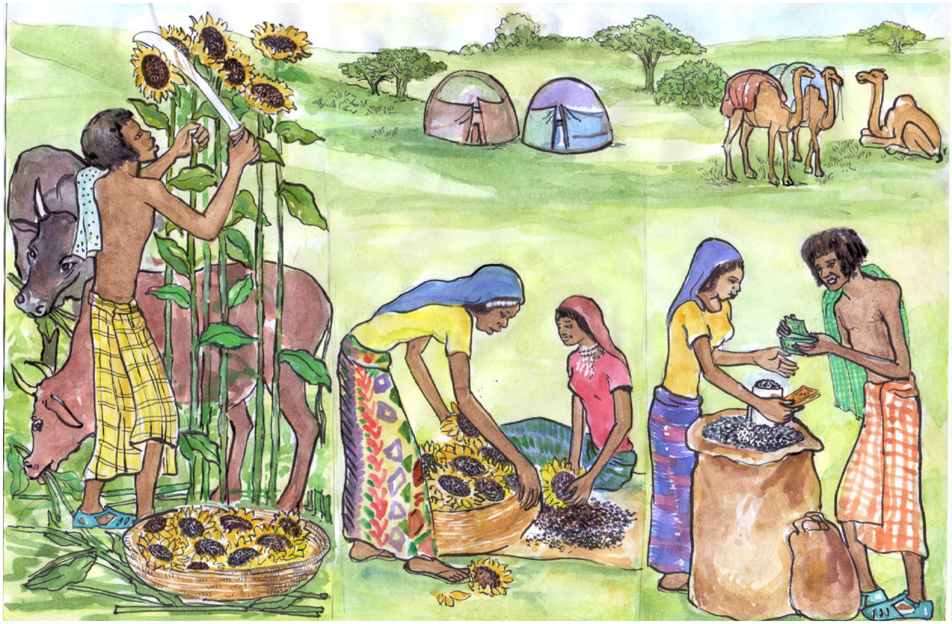


Figure 15:Selecting the right crop helps to benefit from the Flood-based Farming, through being able to sell to the market.

Crop type selection criteria for WSWs Flood-based Farming

The following summary of major criteria serve to identify crop types for WSWs Flood-based Farming in the lowlands of Ethiopia

- Biomass productivity
- Less nutrient-demanding crop
- Short maturity (2-3 months)
- Drought resistant varieties
- Pest and disease resistance
- Adaptability to dry climates/heat tolerance
- Multi-purpose crops
- Community preference
- Availability of market for the produce

Proposed crop types suitable for the lowlands

Maize (variety Melkassa 2 and 4, 110 days of maturity), Sorghum (variety Melkam and Girana, about 130 days of maturity), Mung beans (variety N-26), and Napier grass, Lablab (variety Acc147) are usually recommended for the lowlands of Ethiopia. Other types of crops which are getting attraction in the areas are:

Cereals	Pulses	Oil Oilseeds	Vegeta-bles and fruits	Fodder	Multipur-pose trees
Lowland wheat	**Haricot bean**	**Ground nut**	Onion	Elephant grass / Napier Grass	Moringa
Lowland rice	**Soya bean**	**Sun flower**	Tomato	Desho grass	Neem tree
Maize	**Mung bean**	**Sesame**	Citrus fruit	Sudan grass	Neem tree
Sorghum	**Cow pea**		Papaya	Buffle grass	
Pearl millet	**Pigeon pea**		Guava		
	Sesbania				

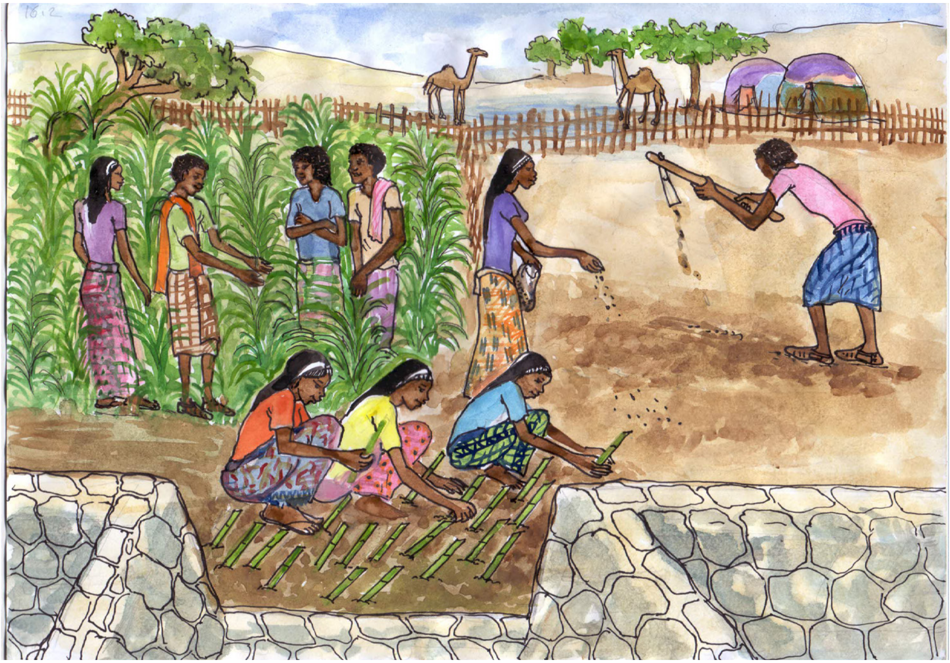


Figure 16: Growing crops and preparing the fields for the next harvest

Guiding questions for discussion

1. Which crops are commonly (if any) produced in your area/region?
2. What are the benefits and reasons for the production of this particular crop?
3. Do you see the potential for another crop? Which and why?
4. Are there any other criteria, not listed in the Information Sheet, that you can think of?

Self-Check-Test

Name	
Date	
Time started	
Time finished	

Instructions

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

Multiple-choice question

How do you recognize when maize is ready for harvest (2pnts):

A. The cops (maize fruit) fall on the ground
B. Blackened at the top of the cop
C. Leaves turn yellow
D. The leaves around the cop open up

Which of the following characteristics is not a criterion for the crop in the lowlands of Ethiopia (2pnts)?

A. Short maturity
B. Pest and disease tolerant
C. Profitability on the market
D. Drought tolerant
E. Water intensive

Short answers

1. Explain the importance of crop type selection for Flood-based Farming as part of DVRPU in the lowlands (3pnts)

2. List 4 Crop type selection criteria for Flood-based Farming as part of DVRPU in the lowlands (4pnts)
3. What crop types are proposed for Flood-based Farming as part of DVRPU in the lowlands (3pnts)

Rating

Note Satisfactory rating points 8 and above. Unsatisfactory points below 8.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Learning Outcome 4: Farming System Management

Introduction

Every Learning Outcome has a similar structure. In this introduction, you find the specific learning objectives of Learning Outcome 4. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an Operational sheet tells you how to proceed with the implementation of what is described in the information sheet.

Figure 17: Flood-based Farming, using the moisture stored behind the Water Spreading Weir, allows for the cultivation of a variety of crops.

By the end of this Learning outcome section, you should:

- have an understanding of how to prepare farmland
- be able to align the cropping calendar with the sowing date and the right timing
- have the knowhow of crop and farmland protection
- understand how to apply horizontal learning

Instruction Sheet for Teachers

- As you go through this Learning Outcome section together with your class, do not start by lecturing them about the management of Flood-based Farming from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them and brainstorm ideas about what they expect to learn from this Learning Outcome. Ask them question, e.g., what does the word management means, especially in the context of Flood-based Farming?
- Work through the Information Sheet.
- Ask students to explain Farming System Management now that they have read the Information sheet.
- Discuss the Guiding Questions.
- Go through the Operational Sheet together with the students. To make sure that everyone understands the content of the Operational Sheet, stop at a few points to discuss the content and ask what students think is meant with the content, in their own words. Focus in your discussion on the Operational Sheet on your role as Development Agent, what is important, and how to approach this.

Teaching methodology

Brainstorming, interactive teaching, and learning, group work (listing), and discussions.

Session Plan

- 20 minutes discussing introduction, brainstorming, and listing differences;
- 40 minutes for the Information Sheet;
- 30 minutes for the Guiding Questions;
- 20 minutes for the Operational sheet
- Total time: 1 hour and 50 minutes.

Instruction sheet for Learners

- Read the introduction with the specific learning objective for Learning Outcome 4. Familiarise yourself, as a potential future development agent, with your role in the process.
- Read the Information Sheet on Farming System Management.
- Write down any questions you have.
- Ask your teacher for support and seek answers to your questions.
- Try to answer the Guiding Questions and discuss them with classmates about Farming System Management. Do not hesitate in the discussion as this helps you to stimulate the understanding of the content.
- Test your knowledge by completing the Self-Check Test.
- Together with the Teacher, go through the Operational Sheet. Make the LAP test to get a full understanding of the implementation process. Discuss any questions or remarks immediately with the Teacher.

Information sheet

Flood-based Farming is an intensive but rewarding operation. Therefore, proper management of the system is important. Armed with the knowledge of technologies and crops from Learning Outcomes 2 and 3, one should not just start Flood-based Farming without preparing the basic needs and management considerations. This Learning Outcome will familiarize you with the managemental duties that need to be fulfilled when practicing a successful flood-based farm. So, the management focuses on all the side activities that need to be done next to the farming itself. This helps in expectation building.

Farmland preparation

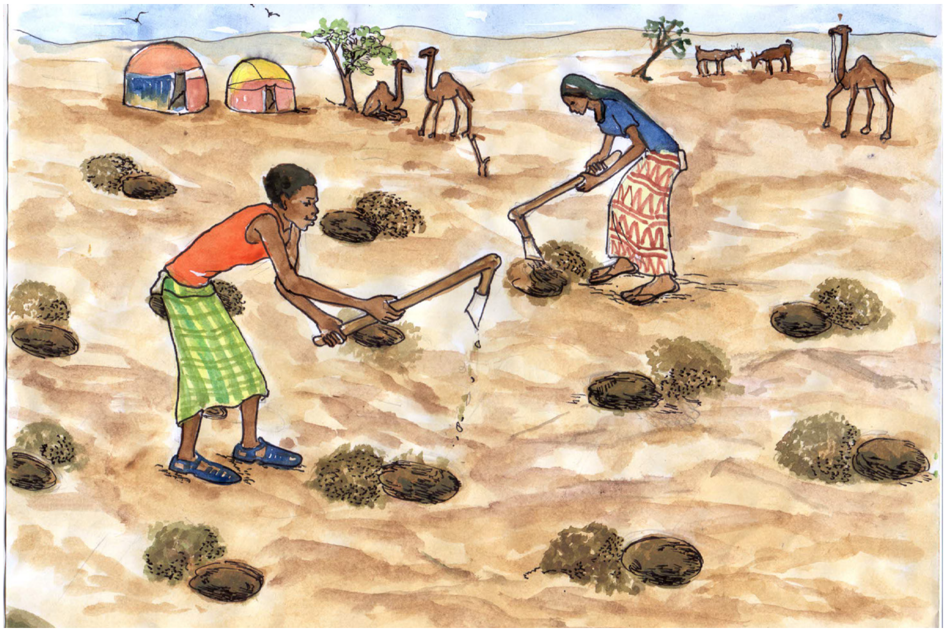


Figure 18: Preparing the land by making small pits

Figure 19: Growing elephant grass for fodder and soil protection

- Taking care of the right sowing dates and accompanying soil preparation is essential. Learning Outcome 2 discussed the different seasons, so to get a basic understanding of the sowing dates, go to this Learning Outcome.
- The (semi-) arid lowlands of Ethiopia are highly diverse, meaning that matters like water (both precipitation and floodwater) amount, timing, and availability of fertile soils differ from place to place.
- Based on this, one should identify the growing seasons that have a sufficient length to mature the target crops.
- In the Afar and Somali regions, generally, 1 or 2 flood-based growing seasons are possible, depending on the amount and timing of flood flashes.

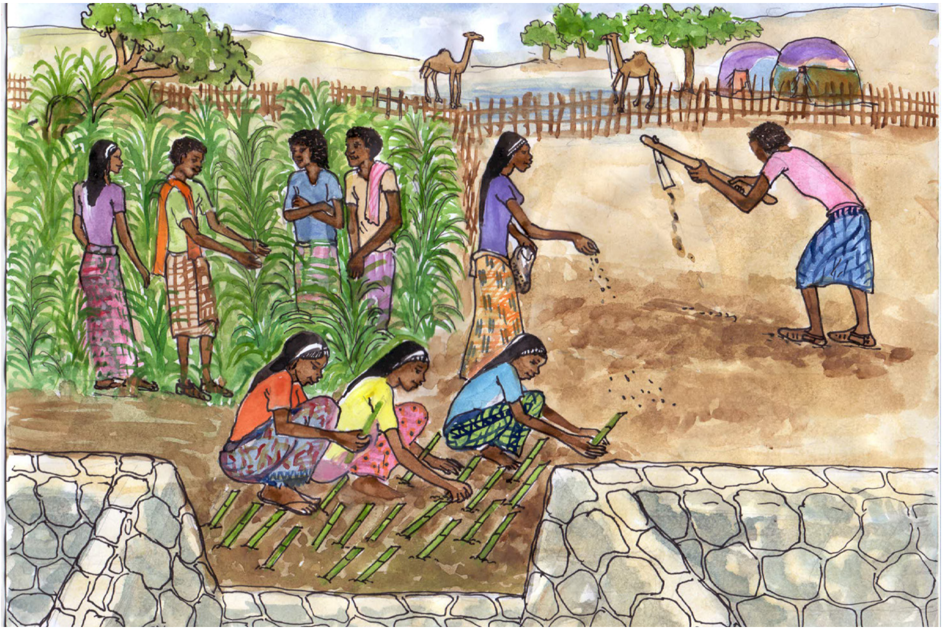


Figure 20: Preparing the cultivation of elephant grass for fodder and soil protection, using the moisture stored behind the Water Spreading Weir.

To know what areas are suitable in which are not you can prepare farming suitability maps. With different classifications (good, medium, poor), you could indicate how many growing seasons are possible on specific patches of land (for example, look at Figure 2). More information on how to prepare a suitability map can be found in the Operational Sheet.

As mentioned in Learning Outcome 2, Flood-based Farming depends a lot on the available moisture left in the ground after the flood. Therefore, it is essential to preserve moisture by preparing the land. The aim is to reduce evaporation from the soil as much as possible.

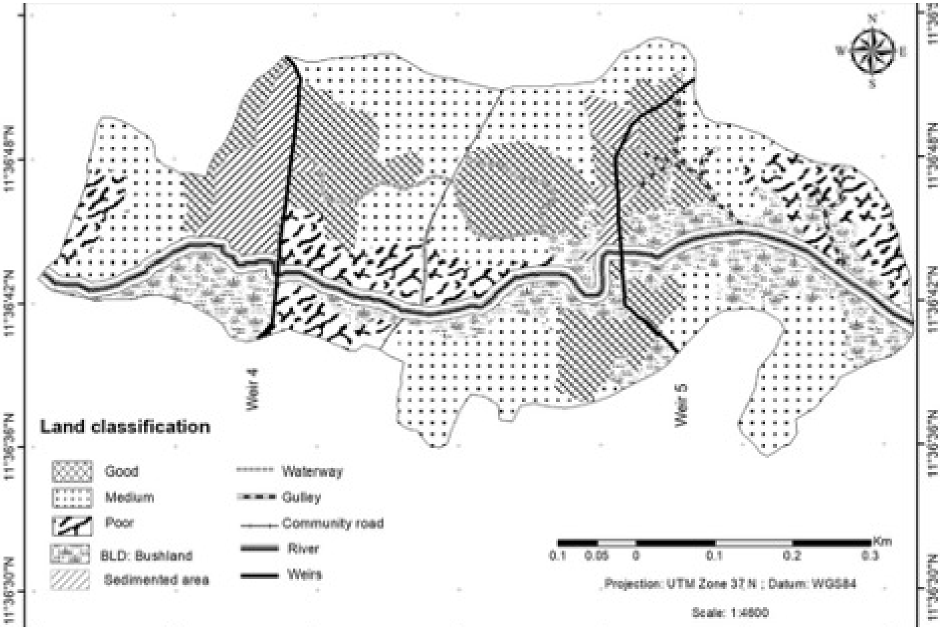


Figure 21: Land use suitability maps using soil moisture regime in Shekayboru, Chifra, 2017.

With the available livestock present among agropastoral communities, farmland preparation has large potential.

- Ploughing before floods to stimulate infiltration (applicable for low infiltration rate soils). For ploughing use can be made of livestock or single axle tractors or 4-wheel tractors, depending on the availability of the machinery.
- Conservation agriculture (Minimum/zero tillage farming)
- Mechanized agriculture
- Mulching

The first flood improves the workability and increases the moisture content of the dry soil that resulted from the preceding dry periods. The alluvial nature of the soil near the WSWs does not require multiple ploughs, ploughing can be done during sowing/planting using a pair of oxen. Or through making use of machinery like the ‘single axle tractor’ or ‘two wheel tractor’ (see box) or other types of tractors.

Box: Single Axle Tractor or Two Wheel Tractor and its use in Flood-based Farming

Two-wheel tractors are sources of power designed to perform most field operations. Due to the size of two-wheel tractors, they have become an economic alternative for smallholder farming. In addition, two-wheel tractors are also more productive than animal traction and they require less time for attendance and preparation, giving the individual farmer more independence and contact with modern technology.

A single axle tractor is powered by a fuel-efficient water-cooled diesel engine and can be used for multiple purposes within the context of Flood-based Farming. The single axle tractor is compact, robust and easily maintained. The tractor can be fitted with metal paddle wheels for working in wet conditions, as they will prevent slipping.

The equipment is suitable for both traction and stationary drive. This means the machine is able to undertake multitask agricultural operations when the appropriate tools and attachment are used. The tractor requires proper maintenance and care to expand its shell life beyond 10 years.
In traction mode it can be used for:

- Ploughing
- Rototilling
- Towing trailer

In stationary mode, as a power source it can be used for:

- Water pumping
- Grain threshing

- Flour milling
- Fodder cutting
- Food oil pressing

Manuals are available that explain the various benefits of the two wheel tractor and the different functions it can have in the agricultural context. One example is the manual developed as part of the Africa Rising programme, titled Training Manual For Two-Wheel Tractor And Ancillary Equipment For Operators, Service Providers, Extension Experts And Workshop Owners.

Single Axle Tractor in operation (source: Greentree)

Two-wheel tractor

Conventional plough

Wheat planter

Maize planter

Reaper harvester

Wheat thresher

Maize planter

Water pump

Tools that can be used together with a two wheel tractor (source: AfricaRising, 2023)

Cropping patterns:

- Include both the cropping calendar & different practices of farming (intercropping/rotation)

To keep soil fertility in cropping fields or even enhance it, a range of cropping practices can be executed. Consider the following practices and carefully decide which practice might be suitable for your specific region/area:

- Crop rotation: Growing different crops every year on the same patch of land. This practice is old but still relevant, as it increases soil fertility and simultaneously decreases the change of pests/diseases. The same crop develops similar rooting depth which could deplete natural resources in this layer, while different crop after another competes less for the same nutrients. In the cropping rotation, consider the use of legume fodder (grasses, peas, etc.).

- Intercropping: two (or more) crops grow at the same time on the same patch of land. Important for intercropping is to use crops with different rooting systems as this can maximize the use of soil moisture and nutrients in the soil. In systems where large stable crops like maize or sorghum row grow, soil erosion continues to happen. Besides, with harvest, often the whole plant is removed from the field, leading to a depletion of nutrients. To counteract this, legumes (nitrogen fixation crops) can be planted in the lines between maize, sorghum, and millet. Be sure to apply intercropping in areas where there is sufficient soil moisture (after floodings).

- Strip cropping: On gentle slopes, contour strip cropping can be an effective way to create crop production and soil and water conservation at the same time. Be sure to vary the types of strips, first the main crop (maize, sorghum, and/or millet) and the next strip down a soil-conserving crop (legumes, e.g., cowpea, mung bean, etc.). The steeper the slope, the closer the strips should be.

Figure 22: Intercropping of beans with maize to make optimal use of the soil moisture and to maintain fertility.

- Ley cropping: In areas that are heavily depleted fallow land with only a shallow soil surface layer, legume-based pastures should be grown for a few years before using it for other crops. In these years, the legumes restore nutrient levels, increase surface soil depth, and prevent evaporation due to dense ground cover. A mix of legumes and grasses can be applied. Consider the following legume crops in the lowlands of Ethiopia: Siratro, Lablab, Stylosantheshamata (VaranoSylo), and Desmodium uncinatum

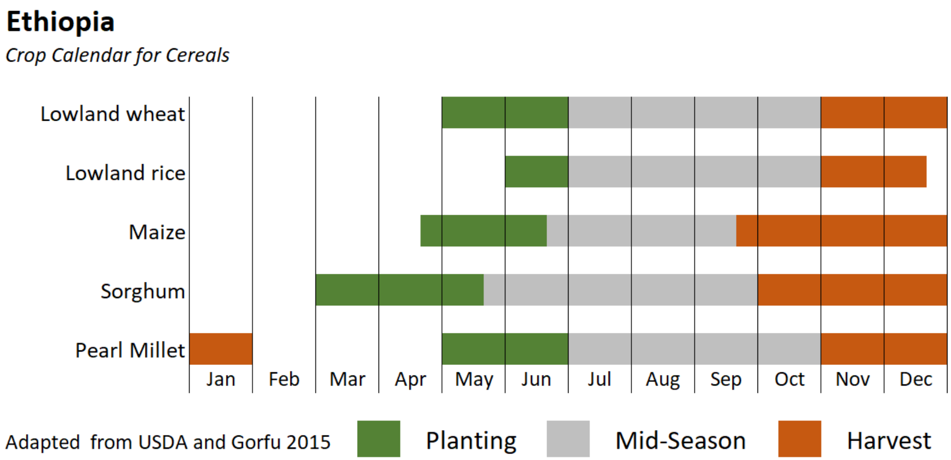
- Combination of food crops with forage crops: In the livestock intense lowlands of Ethiopia, combining food crops with forage crops helps in the current shortage of feed. Again, this can be done in lines, for example in the Afar region combining haricot beans with maize or sorghum.

Figure 23: Harvesting of fruits grown behind the Water Spreading Weir

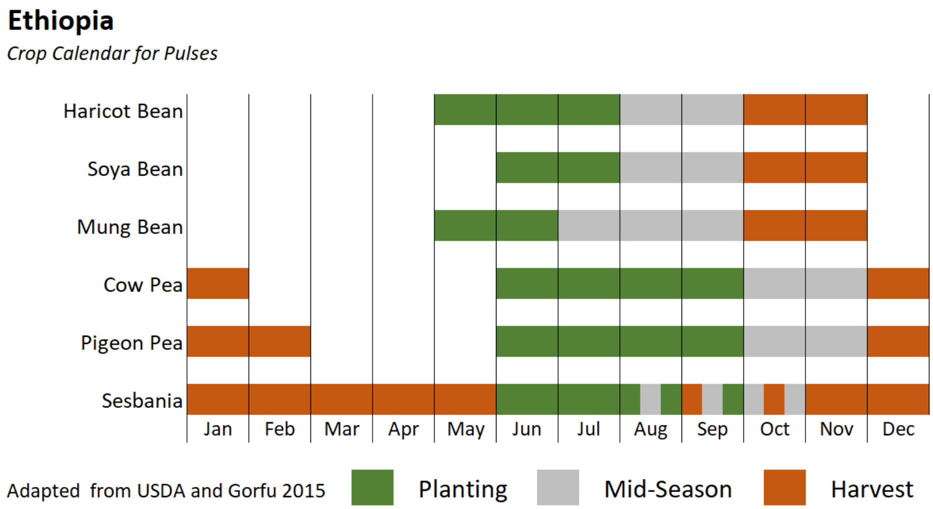
As you can see from the list above, there is a range of different cropping practices that can be done. Although they might look similar, careful decision-making should be done according to the needs of the community.

Crop calendar

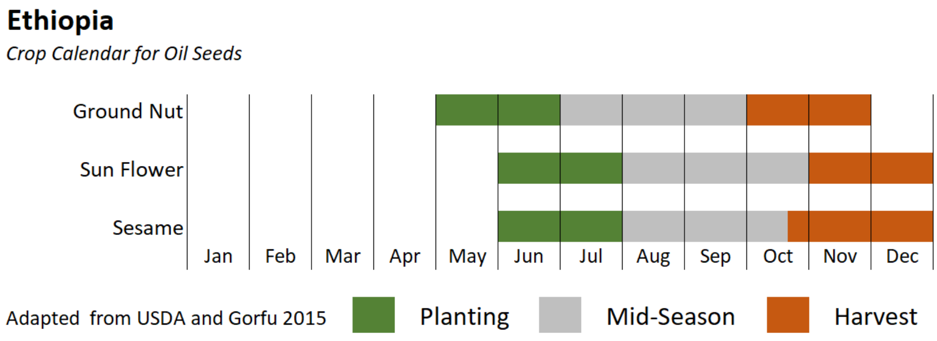
The crop calendars on the next pages can help you to determine the growing seasons for common crops in Ethiopia. Do take care to ensure the seasons also take into account the lowland specific context in terms of moisture availability and temperature.



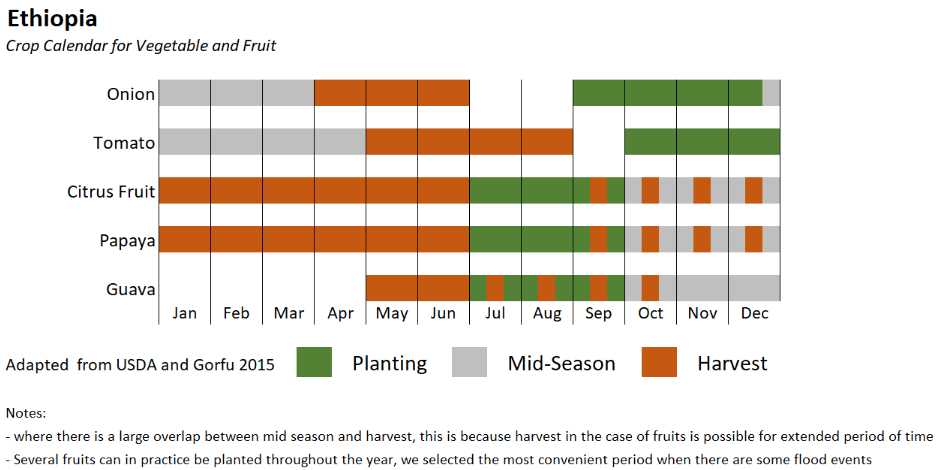
Crop calendar for cereals for Ethiopia (source: USDA/FAO/GIEWS/Corfu, 2015)



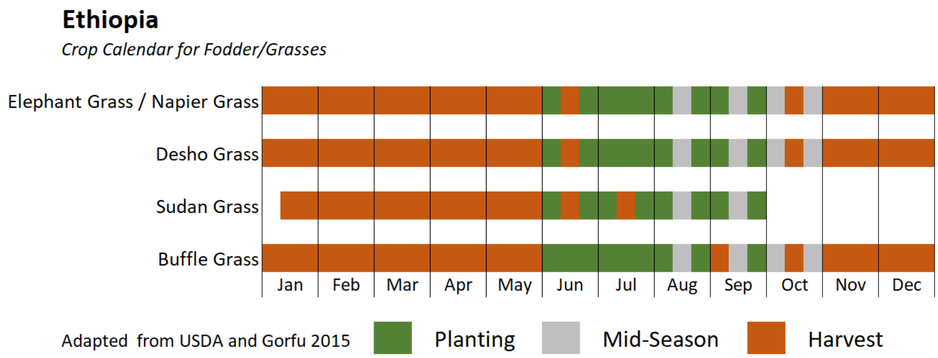
Crop calendar for pulses for Ethiopia(source: USDA/FAO/GIEWS/Corfu, 2015)



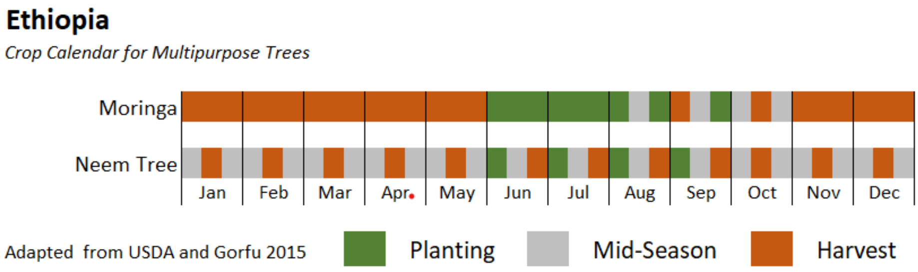
Crop calendar for oil seeds for Ethiopia(source: USDA/FAO/GIEWS/Corfu, 2015)



Crop calendar for vegetables and fruits for Ethiopia(source: USDA/FAO/GIEWS/Corfu, 2015)



Crop calendar for fodder/grasses for Ethiopia(source: USDA/FAO/GIEWS/Corfu, 2015)



Crop calendar for Multipurpose Trees for Ethiopia(source: USDA/FAO/GIEWS/Corfu, 2015)

Crop protection and management

During the full growing period, good crop protection is essential in order to not lose high-valuable production.

The main hazards that should be considered and cared for are:

- Pests (eg. Locust, Quilla Quilla, Armyworm, termites, etc)
- Diseases (rusts, blight & rotting)
- Weeds

Be aware, it is possible that before the farming practices started in the area, these hazards did not have distinctive impacts. However, you should realize that with the production start of nutritious crops, these hazards have the opportunity to benefit from it the crops as well. Weeds for example, everywhere where crops can grow and weeds are present as well. Fast-growing weeds compete with crops for highly valuable natural resources, like water (soil moisture) and nutrients.

All factors can ruin harvest and potentially jeopardize food security for (agro-) pastoralists that started Flood-based Farming around the WSW. To make yourself familiar with some management techniques, some crop protection strategies are addressed in the next section. Always realize that every crop is different and therefore requires different techniques to protect the crops from hazards and there can be a difference from year to year in the extent to which a hazard manifests itself.

Overview of hazard control measures in Flood-based Farming:

A. Pests:

- Removal of dead crop material (e.g., maize) residues to reduce the possibility of pests. Near the end of the flooding season, make sure to keep the residues somewhere, as these can be used to cover the soils to retain moisture for a short second growing season of pulses and legumes.

- Locust outbreaks
- No barns close to the fields, as they attract rodents (rats).
- Integrated Pest Management (IPM) instead of using chemicals.
- Inter-cropping with sunflower and pigeon peas can reduce the pest white grub.
- Place a stock with some old clothing on to scare birds

B. Disease:

- Inspect the crop regularly for diseases. If you spot one, collect the infected plants and burn them away from the field so that the disease does not have a chance of spreading. Be sure to check more often after the identification of a disease, as it might have spread to other crops.
- Dead crop material is attractive for diseases to form. Therefore, make sure to remove and process the dead crop material safely, for example through composting.

C. Weed:

- Especially in the early stages of crop growth, the crop needs enough moisture, nutrients, and light.
- To avoid the competition for these resources, make sure that the fields are weed-free during this period.
- Afterward, weed by hand regularly.
- A general scheme for cereal crops (maize, millet, sorghum) can look as follows (could be altered for specific crops).
    1. First weed control around 2-3 weeks (15 - 25 days)
    2. Second weed control after 5 weeks (35 - 40 days), and
    3. Third weed control after 7 weeks (50 - 55 days).
    4. For weed control, field cleaning before planting is a smart additional practice.

Farmland protection

Figure 25: Growing indigenous grasses behind the Water Spreading Weir as fodder for livestock

- Farming in pastoral areas brings challenges to the free movement of livestock.
- Between clans, proper management is required to avoid conflicts between livestock grazing and crop production.
- Two management strategies are central, protection of farmlands (fencing) and by-law creation among community members.
- Always look for the option to implement the two strategies together, as one functions less without the other.
- In practice, this means that you cannot expect the livestock owner to keep his animals away from the field without proper protection of the field.

- There should be a two-sided understanding. Important in the creation of by-laws is that they are developed among the communities themselves, as they are the ones who set the fines and penalties when violating the rules.
- The PADO should function as a mediator in these meetings. For more information about fencing, see Theme 3 (biological measures) of the Teaching and Learning Guide.

Harvesting

The right moment to harvest the crop depends on factors (e.g., seed variety choice, water availability during the growing season) and therefore can vary from season to season. Some appearance characteristics of crops can help you in identifying crops that are ready for harvest.

Harvesting can involve several steps, depending on the type of crop and the method used. For crops such as grains or oilseeds, harvesting may involve using machinery such as combined harvesters. For other crops such as vegetables, fruits, or nuts, harvesting may be done by hand, using tools such as knives, clippers, or pruners.

Once the crops have been harvested, they must be cleaned, dried, and stored. This can involve additional tools such as dryers or storage bins. In some cases, crops may also need to be processed, such as milling grains or pressing oilseeds before they can be sold or consumed.

Harvesting crops is an important and time-sensitive process, as crops must be gathered at their peak maturity to ensure maximum yield and quality. Weather conditions, such as rain or wind, can also impact the harvesting process, as they can delay or damage the crops. Therefore, farmers must carefully monitor their crops and plan their harvesting operations accordingly to ensure a successful harvest.

Figure 26: harvesting the grasses using the Cut and Carry method, to increase the quality of the fodder provided to the livestock, as compared to free grazing.

Figure 27: Harvesting the different fruits that can be grown behind the Water Spreading Weir

Post-harvest management:

Storage and transportation management

After harvest, an important task lies in the careful but efficient storage and (potential) transport of cereals, grains, fruits, etc. With all the hard work done, this is important as it can minimize unfortunate losses of the products.

For storage, a few important points to take into account:

- Use a clean storage place
- Dry, both the storage plain as the moisture in the grain
- Well-ventilated
- Packed carefully (multiple layers) so that there is no pest damage (for

example hermetic bags)
- If possible, the sacks are placed free from the floor, for free flow of air to be possible under the sacks.

Figure 28: Harvesting the crops after a productive season.

Community mobilization and horizontal learning:

- Communities living in the lowlands are predominantly pastoralists, they have limited experience in farming.
- This can be a major bottleneck to Flood-based Farming, which will halt farmer innovation and learning.

- Therefore, continuous capacity-building activities through community mobilization and horizontal learning are very crucial for the adaptability of Flood-based Farming practices.

Figure 29: Joint landscape planning on the use of the lands behind the Water Spreading Weir

The risk of not having a broader collective agreement on how the land would ultimately be allocated would still be controversial as de facto use of a plot of land translates very easily into long-term occupation and ownership—impacting a communal territory that was subject to other collective choice rules. However, there were also complimentary between individual and collective processes.

These included new ways of introducing Byelaws, collective removal of sediments from selected spots, establishing social organizations to derive greater benefits from food and fodder farming, but also accessing better fodder market opportunities through economies of scale and collective lobbying for new schooling and other social benefits.

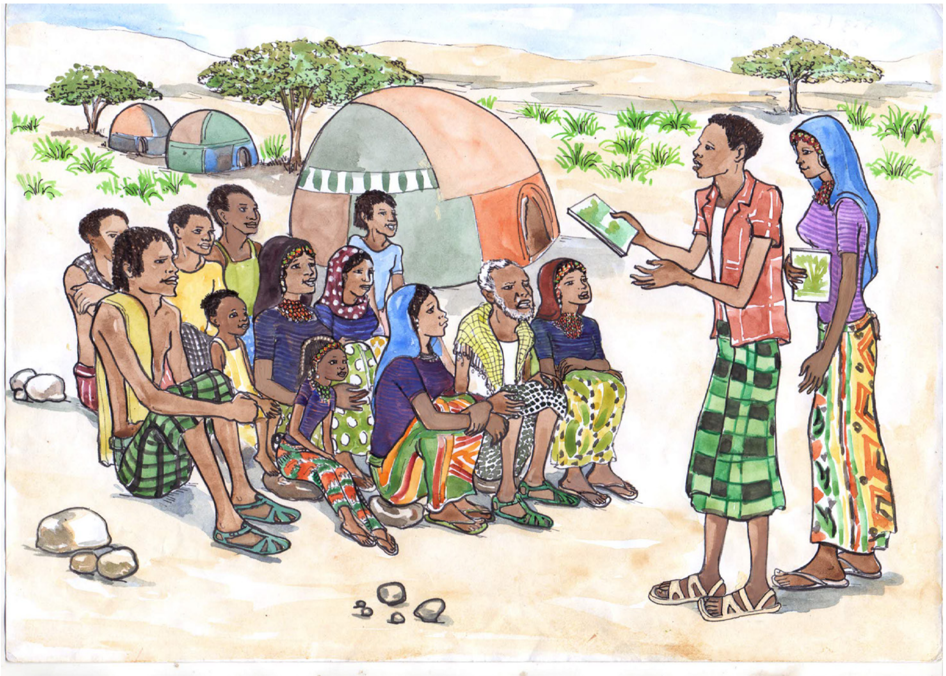


Figure 30: Introduction of the possibilities of Flood-based Farming to the communities

Guiding questions for discussion

- What does Farming System Management include and what is the importance?
- What is generally the understanding of the community regarding farming?
- What do you think are the benefits and challenges of farming in the pastoralist community?
- How do you think communities would participate in farming?

Self-Check-Test

Name	
Date	
Time started	
Time finished	

Instructions

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

Multiple choice questions:

Which of the following is not necessarily important in the storage of crop harvest: (2 pnts)

A. Dry space
B. Well- ventilated
C. They are transported within 1 month
D. Use of multi-layer bags
E. Free from the floor

What is essential in horizontal learning practices? (2 pnts)

A. Peer-to-peer learning, no hierarchy
B. Communities have shared meetings
C. There needs to be someone who supervises all the time
D. Scientific proof for good practices

Short answers

1. Explain farmland preparation and how it can be done. (3 pnts)
2. List crop protection and management hazards that should be considered in Flood-based Farming as part of DVRPU and explain the prevention mechanisms. (4 pnts)
3. List methods of farmland protection. (2 pnts)

Rating

Note Satisfactory rating points 8 and above. Unsatisfactory points below 8.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Operational sheet

Flood-based Farming management includes many different topics and activities that must be undertaken to have successful farming systems. Key in this is preparation, meaning that all community members (elders), PADO, kebele leader, and/or clan leader are on the same page and know what needs to be done before starting/shifting to Flood-based Farming. If right, you have developed good connections with all stakeholders and they know the idea and benefits of Flood-based Farming. Make sure to explain all the steps, as for pastoralists, farming practices might be new. If there are any doubts among the community, PADO, kebele/ clan leader, take time to explain. Do not rush through the steps, often it is better to have unclarities clear for everyone, instead of going quick and fast implementation. During the management procedure, always stay positive and listen carefully to the needs of the different stakeholders.

Objective

All community members (women, men, and young adults) are aware of the management procedures of Flood-based Farming.

Expected outcome

- Suitability map of the area (digital or drawn), which indicates the grow-

ing season potential and what kind of land preparation needs to be done
- A suitable crop calendar for the specific area (use the crop calendar in the Information Sheet as inspiration). This crop calendar must match the needs of the community
- A written-out strategy to manage and control hazards (pests, weeds, diseases) and farmland protection. If needed, include by-laws.

Requirement

- Venue and materials to hold community meetings
- Communities that are willing to participate actively in discussions and transect walks
- Pen and paper for mapping and strategy planning

Procedure

1. As soon as the WSW structure (or DSM) is ready, discuss the options of Flood-based Farming in the area around the structures (see Operational Sheet of Learning Outcome 2)
2. What was decided and agreed on in the by-laws around the WSW? What do these by-laws mean for Flood-based Farming practices? Who will use which land? Is there common land? Etc.
3. Make a transact walk with everyone and develop a resource map indicating which patching of land is suitable for Flood-based Farming.

For farming management, focus on the flexibility of the communities. If one year something does not work, reflect on it to improve the management the next year.

Figure 31: Joint planning of the management procedures of the Flood-based Farming

Do's and don'ts of Flood-based Farming

Do's:

Preparation

1. Do use rainfall forecasts to predict occurrence of floods and plan farming schedules and select appropriate crops.
2. Do provide accurate and up-to-date information about flood events to agropastoral communities for proper planning of Flood-based Farming.
3. Do use physical methods such as soil samples and visual observations to identify soil moisture levels.
4. Do analyse the soil moisture levels to determine suitable crop selection for each area/zone.
5. Do introduce low-cost post-flood tillage and soil mulching to reduce evaporation loss and preserve soil moisture.
   Residual soil moisture is the only major source of water available for the crops. After the floodwater has receded and the soil has some moisture but is not too wet, shallow-low-cost tillage helps close large soil pores and cracks created by the huge volume of floodwater harvested. When this post-flood tillage is complemented with soil mulching - covering the field with a thin loosely compacted top-soil layer – evaporation losses could be reduced by up to 40%, resulting in a higher availability of moisture for the crops.
6. Do ensure to take care of the right sowing dates and accompanying soil preparation to be prepared to plant, once the floods are occurring.

Crop selection

7. Do take the following factors into account when selecting crop types:
   - rainfall and flood season variability in timing,
   - water/moisture availability,
   - nutrient availability,
   - soil type,
   - temperature,

- market value and demand,
- community preferences as a staple food, and
- pest and disease resistance.

8. Do use the crop calendar to determine the growing seasons for common crops
9. Do make use of a many of crops for different growing periods to mitigate the variability of rainfall and flood events.
   These are becoming common phenomena. For Instance, flood-based farmers in the Aba'ala area of the Afar region in Ethiopia have adopted a sequence of crops and planting dates as follows: April 1 to May 10: Sorghum; May 10 to June 15: Maize; July 10 to 30: Teff and Barley; August 30 to September 15: Special beans locally called quaya or sebere. They have developed this agronomic package in response to the ongoing fluctuations in the timing of the flood events.
10. Do include short-duration varieties across your selection of crops.
    This provides good to have short-duration varieties and the flexibility of either adopting multiple harvests of these short-duration crops or opting for your preferred medium to long-maturity crops. In the event that floods arrive towards the end of the cropping season, short duration may be the only hope to prevent a complete harvest failure.
11. Do consider adopting 'improved varieties of local crops'.
    When dealing with water scarcity as a significant concern, it is advisable to consider adopting 'improved varieties of local crops' that can provide better yields while still retaining their natural adaptation to local climate and water availability conditions. This is preferable to shifting to 'high-yielding' crops, which are often highly susceptible to soil moisture stress. Improved varieties are available for various cereals, oilseeds, and pulse crops .
12. Do select drought-resistant and low nutrient-demanding crops such as millet, sorghum, and legumes for semi-arid regions.
13. Do choose crops that can thrive in loamy, silt loam or sandy loam soils that are low in nutrients, such as sunflower, pearl millet, and cowpea.
14. Do prioritize crops that offer a combination of high drought tolerance and a high fertilizer productivity index.

A breakdown of crops commonly grown under Flood-based Farming systems is provided: (a) Maize and all major oil crops (such as sunflower, rapeseed, and soybean), with the exception of cotton, have high fertilizer productivity indices and moderate drought tolerance; (b) wheat, sorghum, millet, and pulses (including beans, chickpeas, lentils, and peas) are more tolerant to water stress but exhibit only moderate fertilizer productivity indices; and (c) Rice has the highest fertilizer productivity index but is a very water-demanding crop.

15. Do choose crops that are resistant to pests and diseases that are common in the region, such as cowpea, sorghum, and groundnuts.
16. Do consider multi-purpose crops that can be used for different purposes.

Crop management

17. Do use Integrated Pest Management (IPM) instead of using chemicals, when dealing with pests.
    Instead of applying chemicals that offer a quick cure, but could be very harmful, adopt the above cropping system, which is a proven and low-cost organic pest and disease mitigation measure.
18. Do inspect the crop regularly for pests and diseases
    If the problem is identified too late it may not be possible or too costly to address it. The inspection will also allow to take simple but effective measures such as removing dead crop material to reduce infection and expansion of pests.
19. Do use cropping practices such as crop rotation, intercropping, strip cropping, ley cropping, and a combination of food crops with forage crops.

Besides spreading the risks, these farming practices replenish soil fertility, enhance yield and contribute to crop diversification, which is a quintessential adaptation to climate change and variability.

Other Do's

20. Do introduce measures that facilitate symbiotic co-existence between pastoralists and farmers.
    Examples are having a buffer zone where livestock could graze and also giving priority to the local herders for in-the-field grazing of the crop stocks after the harvest. Yet, it may also be necessary to protect farmlands through (live-)fencing and by-law creation among community members.
21. Do continuously carry out capacity-building activities through community mobilization and horizontal learning, to ensure support and participation.
22. Do regularly monitor the condition of the water-spreading weirs to ensure they are functioning properly.

So set aside adequate resources for annual routine maintenance before, during, and after the flood season. This not only facilitates the efficient harvest of floodwater but also reduces the risk of major damages and significant repair work, which requires significant effort and funding that may not be readily available. Also it ensures continuity in the availability of soil moisture for productive Flood-based Farming.

Don'ts:

Preparation

1. Do not assume that all areas are suitable for Flood-based Farming as part of DVRPU without analysing soil moisture levels and other factors.
2. This will avoid planting crops in areas that are not suitable for the specific crop.
   Do not start Flood-based Farming without preparing the basic needs and management considerations

Crop Selection

3. Do not forget to consider the lowland-specific context regarding moisture availability and temperature.
4. Do not plant shallow-rooted crops at the start of the season if you cannot afford deep tillage
   At the start of the season as the soil moisture often migrates to the deeper soil profiles and then gradually travels upwards in the later stages of the cropping season through capillary movement and root absorption pressure. This is why, for instance, farmers first grow sorghum and maize (effective root depth can reach 1.5 m) and then fruits and vegetables such as watermelon, which need less water and have shallow roots.
5. Do not select crops that cannot tolerate extreme temperatures in semi-arid regions.
6. Do not select crops that are not resistant to pests and diseases that are common in the region when mono-cropping is practised.

Crop Management

7. Do not ignore the risks associated with floods and implement good water management practices to avoid waterlogging and crop loss.
8. Do not allow excessively weedy fields to develop.
   While there is a tendency among agro-pastoral communities who depend on Flood-based Farming systems to keep some weeds in the field as this could be used for fodder, excessive weeds will negatively

affect farming in several ways. For example, fertilizers applied might not increase yields because weeds absorb nitrogen more effectively than many crops. Weeds may also become alternate hosts for insect and disease pests of the main crop. Additionally, excessive weeds also reduce yields by competing with the plants for sunlight, moisture, and soil nutrients

9. Do not ignore the hazards such as pests, diseases, and weeds. Always monitor your crops and plan the harvesting operations accordingly
10. Do not practice mono-crop farming, particularly in a continuous manner. Mono-crop farming is not only a recipe for nutrient-depleted soils and low yields down the road, but such a farming system is the most susceptible to pests and diseases.
11. Do not expect the livestock owner to keep his animals away from the field without proper protection of the field

Other Don’ts

12. Do not neglect the importance of soil fertility and incorporate organic matter and nutrients to maintain soil health.
    This will ensure a healthy soil life for the future years.
13. Do not use synthetic fertilizers, as this may harm the environment and reduce soil fertility.
    If possible do not use synthetic fertilizers, otherwise, avoid excessive application especially of nitrate as this could cause soil acidification depriving the farmers of further crop production and harming the environment along the way.
14. Do not practice poor storage of organic manure as this will release huge amounts of nitrogen and cause toxicity while incomplete composting also often becomes a breading place for harmful bacteria and fungus.
15. Do not store crops in unclean, poorly ventilated, or damp spaces.
    This will lead to post-harvest losses and reduces the proceeds of the Flood-based Farming.
16. Do not forget that farming in pastoral areas brings challenges to the free movement of livestock
17. Do not forget to continuously involve and mobilize the community to achieve successful Flood-based Farming

Glossary of the technical terms

Alignment	An adjustment in straight line
Area under rehabilitation	An area where interventions are implemented designed to improve soil, water and vegetation conditions by reducing land degradation.
Area under protection	Defined as area, which is managed by a community under the governance of a participatory land use plan at community level with corresponding by-laws. The adherence should result in observable improvements of used natural resources, e.g., through cultivation area.
Backfilling	The process of replacing the soil removed during foundation or related earthwork
Bare land	It is land of limited ability to support life and in which less than one third of the area is covered by vegetation or other cover. It may be constituted of bare exposed rock, strip mines, quarries and gravel pits. In general, it is an area of thin soil, sand or rocks.
Basin	Any area draining to a point of interest
Cascade	A cascade is a series of Water-Spreading Weirs that reinforce themselves creating optimal growing conditions over an area of 200 to 800 hectares by increased infiltration of flood waters and the sedimentation of fertile sediments from the highlands. The area of a cascade is measured from the first upstream weir up to the last downstream weir. The upstream weir will be located in an area where erosion of the dry valley starts. The final weir will be at the area where there is no longer a change for high erosion (i.e. relatively flat areas, rocky areas, etcetera).
Catchment area	The area from which rainfall flows into a river, lake, or reservoir.

Climate	Also known as the "average weather" over a long period of time (generally 30 years). Within climate different variables (temperature, precipitation, and wind) can be identified.
Community	People who are living within or outside of the dry valley and utilizing the available natural resources within that dry valley. The contribution of community be considered for developing sense of ownership and as a checkpoint to know how the system is functioning properly and necessary to the target communities.
Counter Wall	The end of the wall of water spreading weir; party wall
Cropland	is defined as land used primarily for production of food and forage whether rain fed or irrigated; this category includes both cultivated and non-cultivated lands.
Discharge	Runoff excluding offsite flows, leaving the proposed development through overland flow, built conveyance system or infiltration facilities
Downstream	The direction of a stream or river flows
Dry Forest	Any vegetation found in areas with limited water resources and low annual precipitation which fall within an altitude range of 500 to 1500 meters above sea level. These forests are composed of several tree species adapted to limited water conditions including forage, timber, charcoal and gums and resins producing species
Dry Stone Measures	are structures constructed from loose stones laid along the contour lines. They are constructed in a series, and the measures can be used to fill smaller gullies (up to 1.5 m depth) feeding into the dry valley and disperse runoff in flatter areas. They are designed to reduce the speed of water flow, retain organic matter and deliver a water-spreading effect (although less than a water-spreading weir). DSMs function best in combination with biological protection.

Dry Valley	A dry valley is defined as a segment of a dry river valley receiving seasonal floods from the highlands. The dry valley upper and lower boundaries are defined by a non-erodible base made up of stones or an intact floodplain. The dry valley includes all run-off areas within the upper and lower boundary towards the dry valley. It includes all the natural resources in a basin, especially water, soil, and vegetative factors. At the socioeconomic level a dry valley includes people, the farming system (including livestock) and interactions with land resources, coping strategies, social and economic activities and cultural aspects.
Flood-based Farming	the process of utilizing excess runoff (floods) for growing food, fodder or fuel in areas where no other options are possible
Gabion Check Dams	are placed and anchored in gullies, function similarly to masonry check dams but with some distinct features. These dams, reinforced by sturdy mesh wire known as gabion, are designed to be lower in height compared to traditional masonry check dams. They are particularly effective in stabilizing deeper gullies and controlling the flow of water. So that soil can settle behind the gabion wall, and allow water to flow over it, mitigating the force of floods.
Gully erosion	A gully is a landform created by running water eroding sharply into soil on a hillside or slope.
Infiltration	The penetration of water through the ground surface into subsurface soil
LAP-test	Learning Accomplishment Profile Test, examined by an assessor.
Live Check Dams	These are innovative structures designed to combat erosion while minimizing the costs of establishment. This method involves strategically planting suitable species to form a horizontal barrier across the gully bottom. By effectively reducing the velocity of flowing water in the gully, live check dams serve as a defence against erosion.

Maintenance	Making sure that over time the desired effect of a measure (in this case a water spreading weir) is still intact.
Masonry	Stone or other similar material normally bonded together with mortar to form a wall.
Masonry Check Dams	are a non-permeable, low-based masonry structure that span the entire width of a riverbed. Masonry check dams are constructed at deep, preferably stony gullies with a depth of up to four meters. If necessary, they can be increased in height after each rainy season to fill the gully. The final stage, once level, check dams can be upgraded to a WSW.
Mass excavation	The process of removing large volume of soil
Mortar In masonry	mortar is the paste that is used to bind stones and used to construct the wall
Pasture land	Pastureland/Rangeland: Extensive area of land on which the vegetation is predominantly grasses, shrubs and is managed as a natural ecosystem. It is a significant source of livestock feed and of livelihoods for stock raisers and herders.
(Agro-) Pastoralism	is a traditional system that combines agriculture and livestock management. Communities practice both crop cultivation and animal rearing for sustenance and livelihoods. This approach maximizes resource utilization and is commonly practiced in arid or semi-arid regions.
Primary users	People living within the delineated dry valley or using area within the delineated dry valley permanently
Productive Use	is the utilization of a delineated dry valley for biomass production like for food, fodder, fuel and fibre crops. Residual moisture for crop/fodder production and drinking water for livestock and humans.
Retaining wall	A wall that built to keep the land behind from sliding
River basin	The area drained by a river and its tributaries.

Runoff	Water that flows over the land surface entering rivers, lakes or other reservoirs.
Saturation	Soil's water content when practically all pore spaces are filled with water. This is a temporary state for well-drained soils, as the excess water quickly drains out of the larger pores under the influence of gravity, to be replaced by air.
Seasonal Grassland	Land covered the natural growth of graminea and herbaceous vegetation or a land sown with introduced grass and leguminous for the grazing of livestock. Generally open and continuous flat areas dominated by grass.
Secondary users	People living outside the delineated area but moving through and utilizing the resource temporarily. There might be a traditional resource use agreement with the primary users.
Sediment	Particles, derived from rocks or biological materials, which are suspended or settled in water, having been transported by a fluid or other natural process.
Setting out/ Lay Out	The practice of transferring the design onto the land itself.
Shrubland	is land with shrubs/bushes/combined canopy cover ≤ 10%. Shrubs and bushes are woody perennial plants with <2m in height at maturity in situ. Scrubs are low bushes and stunted trees, mostly spiny either deciduous or evergreen. On scrubland, more than half of the surface of the ground is bare of vegetation.
Slope	The side of a hill or mountain, the inclined face of a cutting, canal or embankment, or other inclination from the horizontal. The steepness of a slope can be expressed as a percentage, the term 'gradient' also being used.

Soil Erosion	The wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and / or remove soil or geological material from one point on the earth's surface to another. Soil erosion is normally a natural process occurring slowly over extensive geological timescales, but wherever the natural rate has been accelerated by anthropogenic activity, soil erosion becomes a process of rapid degradation and an immediate and identifiable threat to soil.
Spillway	A structure over or through which flood water or run-off is discharged. If the flow is controlled by gates it is called a 'controlled spillway'. If the elevation of the spillway crest is the only control, it is an 'uncontrolled spillway'
Stilling Basin	A basin constructed to dissipate the energy of fast-flowing water, such as from a spillway or outlet, in order to prevent undercutting of a dam or other structure and in order to protect the streambed from erosion
Transect	Also known as a 'transect walk'. This is a method used to explore the spatial dimensions of people's realities by factoring social aspects of a community into the layout of its natural and other resources. A transect is normally conducted following resource mapping the village in order to facilitate triangulation of the data generated on a resource map. The transect depicts a cross-section of agro-ecological zones and provides a comparative assessment of these zones in terms of topography, land type, land use, ownership, access, soil 104 type, soil fertility, vegetation, crops, problems, opportunities, solutions and other parameters.
Trench excavation	An excavation to open a narrow opening in the ground

Upstream	Opposite direction from the direction in which a stream or river flows.
Vegetative strips	planting of grasses and bushes in line along WSW or DSMs structures. Example: Elephant grass strip is highly suitable for WSW. Sisal and Sansevieria are also suitable for DSM by integrating additional physical structure like trench.
Water Spreading Weir (WSW)	are masonry structures constructed in a dry valley which spans the entire width of a dry river to spread floodwater over the adjacent land area. Water encounters the weirs and spreads off its side wings onto a larger surrounding area, overflow is channelled through a spillway and can be caught by the next weir. WSWs are constructed in cascades to increase the flood spreading effect and to reinforce each other against unseasonable floods etc.
Watering/ curing time	Refers to the length of time needed for curing the construction work

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