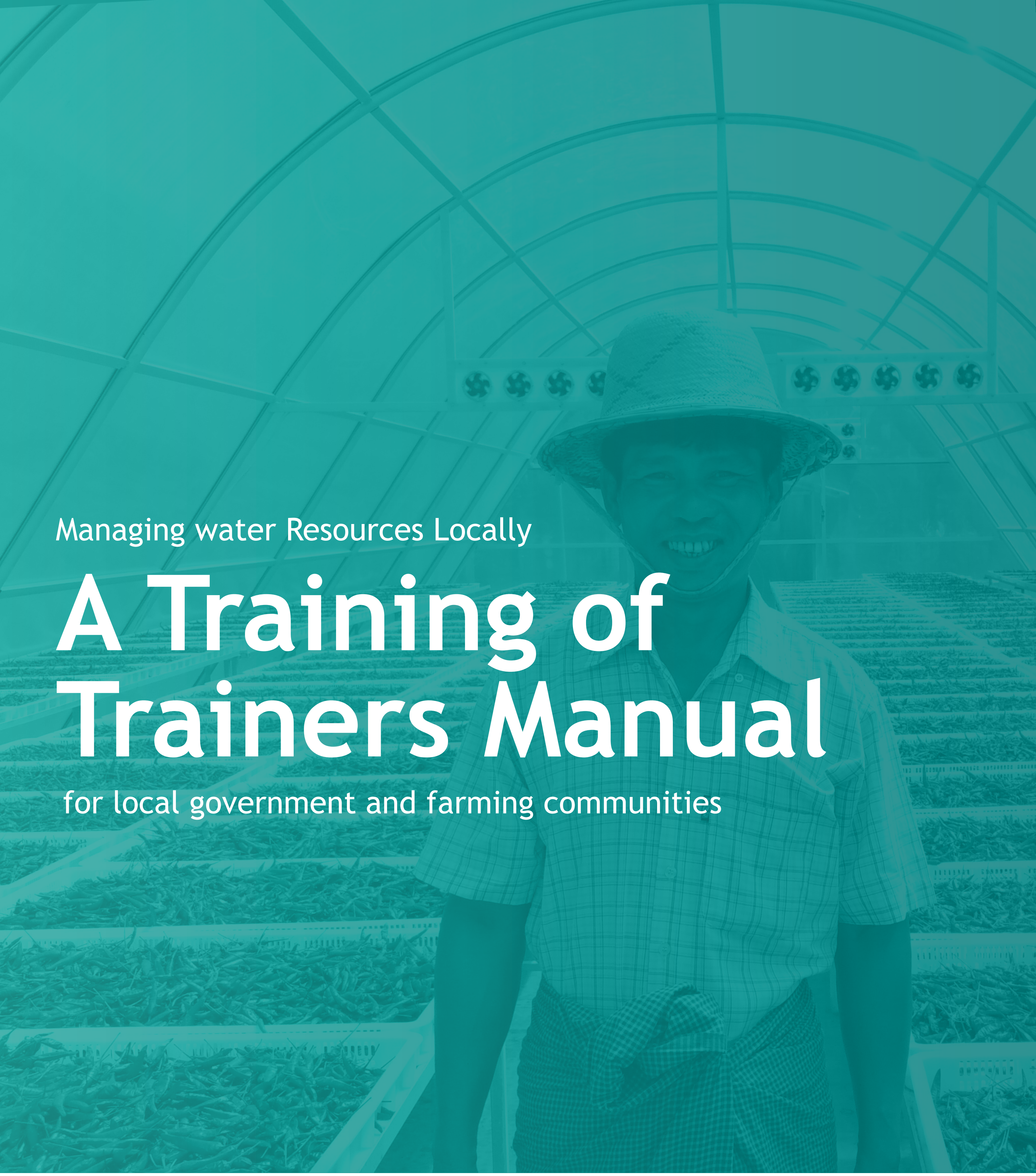

Managing water Resources Locally

A Training of Trainers Manual

for local government and farming communities

RAKHINE WINTER CROPS PROJECT

NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme

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Definitions

Community-based	Referring to activities undertaken by, or with the participation of, local communities.
Data, information and knowledge	Data are raw numbers derived from measurement or regular monitoring. When data is processed and interpreted, it becomes information. When that information is assimilated and used by individuals and organisations, it becomes knowledge.
Groundwater	Groundwater refers to water below ground, held in saturated bodies of rock or earth material. It can provide water to wells and boreholes. If the water table intersects the earth's surface, groundwater discharges naturally as spring flow and river base flow.
Hydrology	Hydrology is the study, measurement and understanding of surface water flows. Groundwater hydrology is the corresponding study of underground water.
Hydrometeorology	The study, measurement and understanding of surface and groundwater hydrology, together with the meteorology on which water resources depend.
Improved / unimproved water source	Improved water sources are those which are engineered and protected in such a way as to provide safe water, i.e. water free of, or low in, disease causing pathogens. Unimproved sources are unprotected from faecal contamination and so pose a risk to human health.
Meteorology	Meteorology is the study, measurement and understanding of weather.
National monitoring networks	Networks of rain gauges, river flow stations and groundwater data points designed to inform a nation of the spatial and temporal distribution of its water resources.
Water resources	Water resources are the streams, rivers, surface water bodies and groundwater stores which by their natural discharges support wetland ecosystems, and which can be exploited for water supply for many purposes.
Water security	Water security means different things to different water users. However, the common feature for all is the assurance of sufficient quantity and quality of water for all the uses to which water is put. This, combined with low risk from waterrelated hazards (floods and droughts) constitutes water security.
Water security planning	Water security planning is a structured participative process involving risk assessment, focused monitoring and action planning. It is an extension of the more narrowly focused approach known as water safety planning.
Water supply	Water supply is the act of harnessing, engineering and managing the delivery of water to water users, for domestic, agricultural and industrial (including electricity generation) uses.

Introduction

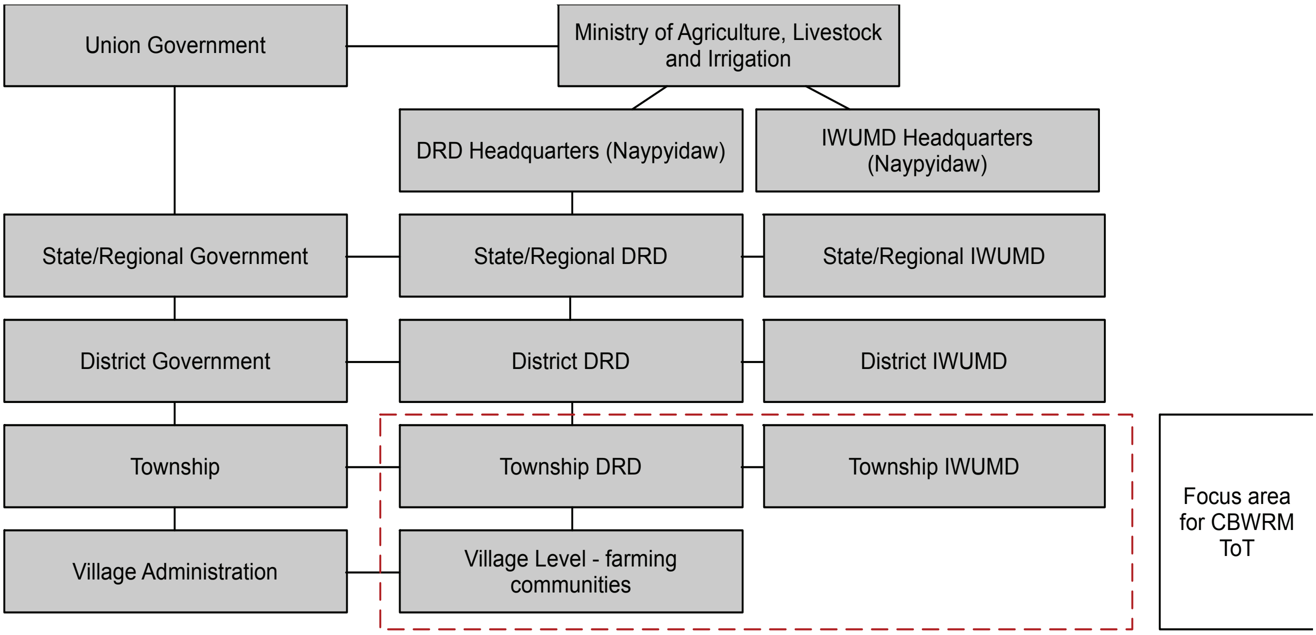
The Rakhine Winter Crop Project (RWCP) has been running since 2015. So far, it has primarily been concerned with the practicalities of delivering water supply for irrigation purposes to farming communities in the localities of Thandwe, Toungap and Gwa. This Training of Trainers (ToT) guide puts the spotlight on a different issue, namely water resources management, which is fundamental if water supply and food security systems are to be managed sustainably. Water is used for a wide range of competing purposes in the projects target villages. This includes domestic usage (such as drinking, cooking, washing laundry and bathing) as well as productive usage (irrigation, livestock watering and home gardens). These water supply systems need to be understood and managed well, and many institutions, from those at community level, local, township and national water management level all have a role to play.

Rakhine State is extremely well-watered, which may account for the reason that water resources management issues have not previously been addressed in detail. Government institutions have limited resources to carry out water resource assessment and management work. But, across Rakhine State there is a sense amongst some farming communities interviewed that water security conditions are changing. For example, people highlighted that rainfall patterns are more variable, with seasonal rains now ending earlier than in the recent past. This has resulted in reduced water access in the dry season months. This feedback is anecdotal and based on people's own observations, but it highlights that continuous changes are taking place. The pressures on water resources are many and include: population growth and demographic change, increased water demands, changes in land use and land degradation (such as deforestation); as well as increased climatic (rainfall) variability.

One of the first steps required to establish some form of water resources management in the RWCP is to build an appreciation and knowledge of water security matters. This would enable government institutions to incorporate activities into their current water supply work. This training guide sets out a method for achieving this aim. Its focus is on working with local and township authorities as shown in Figure 1. This guide has been developed and tested by Adam Smith International, with representatives from Department for Rural Development (DRD) and Irrigation Water Utilisation and Management Department (IWUMD), in RWCP target villages. The training sessions in this guide explain how the proposed water resources management approach can be applied.

1 82 people consisting of community members and government officials attended 9 Focus Group Discussions in Thandwe, Toungap and Gwa in Rakhine State over a six-day period from 13th to 18th inclusive. 35 were female, representing 42% of the attendees.

Figure 1: How WRM Trainer of Trainers guide fits into national context



About this guide

This document consists of ten session plans each with its own facilitation guide. Corresponding handouts, data record sheets, and two PowerPoint presentations are also included in the Annexes. The Power Point presentations have been developed specifically for Session Plans 1 and 2 and they are primarily for engagement with township offices. This training guide has also been translated into Burmese and provided to DRD and IWUMD on USB memory sticks.

Each of the ten session plans presents the purpose, key learning points, time required, materials required, methodology, session outline with a breakdown of core messages, notes and references. The accompanying facilitation notes provide a step-by-step guide so facilitators can familiarise themselves with the material, before running the session. Tips and questions to prompt discussion are also provided so the sessions can be maximised. The sessions can be run individually or combined into workshops of varying length. Table 1 below provides a "rule of thumb" guide for applying each session plan.

Table 1: Overview of session plans

Session Plans 1 and 2 are intended to serve as an introductory guide for staff at DRD and IWUMD at township level.
Session Plans 3, 4 and 5 will help to determine village-level water security problems.
Session Plan 6 is relevant for communities where hydrometric monitoring will take place.
Session Plans 7 and 8 are intended for communities that experience water scarcity problems and irrigate at scale into the winter and dry seasons.
Session Plans 9 and 10 aims to support township level planning within DRD and IWUMD.

Background

This ToT guide was designed, drafted and finalised over an intensive three week period in August 2019. The Session Plans were designed following a series of meetings, discussion and field visits with DRD and IWUMD staff in Thandwe, Toungap and Gwa. Multiple meetings were also held with farming communities in these localities.

Rakhine State is exceptionally well-watered receiving in excess of 192 inches of rainfall each year. Historically water resources have never been a serious constraint to development in the region and consequently no base currently exists for their management today. However, Rakhine States high annual rainfall should not give grounds for complacency. Farmers that irrigate at scale, typically work on an individual or household basis and there are few collective arrangements in place to monitor and manage local water resources.

When interviewed, rural communities clearly have some concerns over their water resources.

- Farming communities' express concerns that rainfall patterns are becoming more variable and the wet season has reduced in length.
- Communities express concerns over the seasonality of their water points, particularly springs and streams; as well as shallow hand dug wells.
- Communities can no longer take their domestic and productive water sources for granted and there is some concern that continuous change is taking place.
- For communities, generally water quality and their collective demands on dry season availability is the greatest concern.
- DRD and IWUMD are primarily concerned with extending access to new water supplies respectively for domestic and productive use.
- DRD and IWUMD acknowledge they have few systems in place to monitor and manage water resources – other than at major reservoirs.
- Government institutions are rightly concerned they have limited human, material and financial resources to engage in water resources management activities.

These pressing issues reflect some of the challenges that exist. A starting point therefore is to build an appreciation and knowledge of water resources management in Rakhine State. There is also the requirement to develop experience and ability in practical water management activities. This ToT guide therefore focuses on the development of good practice in identifying water security problems, mapping water resources locally, data collection and sharing, better decision-making and planning, follow up action and improvements in water infrastructure. It will require DRD and IWUMD to adopt a "leaning by doing" approach and to clearly identify the boundary between what issues rural communities and local farmers can address directly and those that require ongoing external support. Now on with the session plans.

Session Plan 1: An introduction to water resources management

Overview

At the end of this session participants will have appreciation and knowledge of water resources management and why the subject matter is important. They will also have been introduced to the concept of Community Based Water Resources Management, or CBWRM, which focuses on managing water at a local level.
The session plan could also be used as a basis for briefing national level authorities. This is required so local level initiatives are supported by "higher" level authorities in Naypyidaw (such as the National Water Resources Management Committee).

Session	An introduction to water resources management
Purpose	To ensure that all DRD and IWUMD focal persons have a shared understanding of water resources management, the key components of water resources management and how Government agencies and farmers groups can collaborate.
Key learning	• A sound conceptual understanding of water resource management and its different elements. • Knowledge and understanding how water resources management can be applied at village level.
Time allowed	55-60 min
Materials	• Flip chart, • Marker pens, • Power Point Presentation introducing water resources management or slide handouts if a projector is not available
Methodologies	• Plenary questions and discussion • Power Point presentation • Group discussion (Questions and Answers)
Session outline	• Welcome (5 min) • Introductions (10 min) • Instruction (25-30 min) • Questions (10 min) • Summing up (5 mins)
Key messages	• Water resources in Rakhine State face growing pressures. • Extended support should be provided to farmers that irrigate to help them manage their local level water resources. • DRD and IWUMD have limited resources and so water management approaches need to be practical and realistic in their scale and ambition. • Our focus should be on "starting small and starting something".

Facilitation note 1

This session will ensure technical staff in DRD and IWUMD possess an appreciation and knowledge of water resources management. For many, this may be a new area of learning and it is helpful to explain what water resources management is and the rationale for the approach presented in this ToT guide. We begin with an introductory meeting and a PowerPoint presentation.

Welcome (5 mins)

1. Thank each participant for attending the training session and record their names and job titles on an attendance sheet.
2. Introduce yourself and explain the purpose of the training session. Note that this is an introduction to water resources management and it aims to explain how water resources management can be applied in the Rakhine Winter Crops Project or RWCP.

Introduction (10 mins)

3. Ask the participants to introduce themselves one by one, saying their name, their organisation and their job title.
4. Ask them if they have any previous experience in monitoring or managing water resources? Do they feel this is a new subject area or is it something they have experience and expertise in? The reason for asking this is so you know the level of understanding within your audience.

Presentation (25 – 30 mins)

Now you can begin with the Presentation: Session Plan 1: An Introduction to Water Resources Management (see Annex A). If a projector is not available, then the slides could be printed and handed out before you start.

Slide 1: Presentation title page.

Explain the purpose of the presentation is to introduce the concept of water resources management so that “we” all have a common understanding. The presentation will also introduce how water resources can be managed at village level, termed Community Based Water Resources Management or CBWRM.

Slide 2: Summary

This slide helps to set the scene for the presentation. You should highlight that Rakhine State is well-watered receiving on average more than 192 inches of rainfall each year. This is based on rainfall information collected in Thandwe from 2015-2019. But also tell the participants that we should not be complacent about access to our water resources because conditions in the natural environment are changing. For example, water resources face growing pressures that include: an intense and variable wet season followed by a period (winter and dry season) when very little rainfall occurs. Other pressures include population growth, migration pressures and increased water demands; deforestation that results in changes in land use; and increased rainfall variability. Climate change will make this rainfall variability worse. So the key message is: **we have a lot of rainfall in Rakhine State, but we must still monitor and manage our water and land resources carefully. If we do not do this then we cannot know what changes are taking place.**

MANAGING WATER RESOURCES LOCALLY

Slide 3: People have concerns about their water resources

This slide shows some of the concerns people have about their water supplies. Talk though the points on the slide from the discussions held in Toungap, Thandwe and Gwa. It is important to note that these concerns are based on informal observations by community members and their experiences. Explain that what DRD and IWUMD need to do is to collect raw monitoring data that can be processed and analysed so the changes taking place can be quantified (measured).

Slide 4: Our observations

Explain the policy arena in Myanmar generally focuses on extending access to water supplies for domestic and productive use. This is important work and needs to continue. However, equally important is the need to ensure these services are sustainable. One aspect of this work is to monitor and measure water resources, which will strengthen DRDs and IWUMDs service delivery work. For example, if DRD are building a gravity-fed water supply system from a spring, "we" should know what the spring flows are in the rainy, winter and dry seasons, so we can provide adequate water storage and assess the adequacy of the spring flow. We also need to ensure that irrigation water management is sustainable.

Slide 5: Large scale water resources management

Explain that predicting the impacts of population growth and climate change is difficult work, which is full of uncertainty. In our own life times, some of our more experienced, senior colleagues may have seen significant changes in population growth or natural resources. But the changes taking place will have a significant impact on natural resources. This means it is essential to strengthen systems for monitoring and managing water resources.

Highlight that all countries need to invest in managing their water resources and typically they may have representative networks for monitoring rainfall, groundwater and surface water, with water quality surveillance at key locations. They may establish national agencies for managing water resources and try to establish mechanisms for managing water resources at river basin scale. This is expensive work and requires significant human, financial and equipment resources to establish these systems.

Slide 6: Thinking about Water Resources Management

Talk through the issues on the slide and highlight that Rakhine State is starting from a low base when it comes to issues related to water resources management. For example, to the best of your knowledge there is no state level water resources management strategy. Our departments also have limited (if any) resources to carry out water resources management work. This is why we should start by having a "localised" approach, that can feed in and support a regional and national system. Emphasise the priority now is to "start something" and "learn by doing" and the RWCP provides an opportunity for this to happen.

Slide 7: Dividing River Basins into smaller management units.

The following slides provide examples how this approach could be applied in practice. If we think about the river basin (or catchment) as the natural unit of water management, we should understand that river basins vary in size and complexity. It will be difficult for us to start straight away at this scale. However, emphasise that if we divide a river basin into smaller management units we can make some progress. For example, we may begin by working with single villages, and then progress to working with multiple village. Over time and with increased experience we can progress to work with upstream and down-stream water users and address problems at river basin scale. But this may well take some considerable time. In the future, it will be the responsibility of DRD and IWUMD to coordinate these interventions and to facilitate discussions as to how water should be shared between different users (upstream and downstream).

Slide 8: Supporting our communities directly

The RWCP has identified that a useful approach is to begin working with farming communities, because irrigation accounts for large water usage. It is also difficult to predict what is happening at local level if no monitoring is taking place. For example, even if we produce river basin maps using GIS or remote sensing we would still need to validate or “ground-truth” what is actually happening. This can only be achieved through monitoring.

Our proposed approach is to support farmers to monitor and manage their water resources. To do this we need to understand what actions they can fulfil and what tasks exceed their capacities. “We” must provide support to help them. When we refer to “water security” we mean that: **local communities have continued access to adequate water quantity and quality for domestic and small scale productive use, year round. We also want to strengthen their resiliance to water related disasters.** This localised approach is often referred to as: Community Based Water Resources Management or CBWRM.

Slide 9: Logic of CBWRM

This figure shows the logic of CBWRM. It emphasises that monitoring by communities and ourselves should lead to action – better decision making and improvements in water supply infrastructure. Explain that we should not monitor for its own sake and follow up action is very important as people want real water management problems to be addressed.

Slide 10: CBWRM has the following objectives

This slide explains what the objectives of CBWRM are. The first is strengthening the way communities manage their water resources. Second, acting as an early warning system if groundwater levels or stream flows are reducing. Third, using hydrometric data to inform the design of water supplies by DRD and IWUMD. Lastly, to help communities voice their concerns when “we” plan water supply interventions.

Slide 11: CBWRM activities consist of the following

Talk through each activity in turn. These activities follow a logical sequence and you can mention it links directly to Slide 9: Logic of CBWRM

Slide 12: Monitoring may include observations of

This slide highlights what water monitoring can be undertaken. It is an example of some of the monitoring DRD and IWUMD could focus on in the short to medium term (1-3 years).

Slide 13: Management decisions may include:

If communities collect monitoring data with government support this is an example of some of the better management decisions they could be taking. For example, if we know the range of groundwater variation between wet and dry seasons, we can better advise contractors and communities about what depth to dig hand dug wells.

Slide 14: Possible next steps

This slide puts forward some suggestions concerning next steps that we could focus on. It is intended to inspire senior managers and technicians to get behind the proposal to engage in water resources management activities. Support can also be provided by RWCP to DRD and IWUMD to complete these activities in the coming months.

Questions (10 mins)

Following the presentation ask the participants if they have any questions. Such as:

- Do people think water resources management is important in Rakhine State?
- What are the consequences if we do not engage in water resources management?
- Do we think the CBWRM approach is realistic?
- What support do we need to carry out the next step actions?

Summing up (5 mins)

Following the questions, sum up the presentation focussing on the key messages and next steps. Try to encourage your managers to set some actions for follow up and assign responsibilities to team members.

Session Plan 2: The water balance and water security

Overview

This session will help technicians and engineers working in DRD and IWUMD increase their own understanding of the water balance and water security. If individuals feel confident they may choose to deliver the session to their colleagues. Alternatively it could be used as a private study session.

It is not advised this session be provided to village communities, but some simple messages from the presentation can be discussed.

Session	**The water balance and water security**
Purpose	To ensure that all DRD and IWUMD focal persons have a shared understanding of the hydrological cycle and understand what factors affect groundwater and surface water recharge and recovery.
Key learning	• A sound conceptual understanding of the water balance. • Understanding of what happens when rain falls and how it divides between (rapid) runoff and infiltration. • Knowledge and understanding of key water resource management terms.
Time allowed	45-60 min
Materials	• Flip chart, • Marker pens, • Power Point Presentation or printed handouts if no projector is available
Methodologies	• Plenary questions and discussion • Power Point presentation • Group discussion
Session outline	• Preparation (5 min) • Introduction (5 - 10 min) • Presentation (25 -30 min) • Questions (5-10 min) • Summing up (5 min)
Key messages	• Assessing the local water balance is complex and depends on a number of inter-linked variables. • There is often anecdotal evidence of changes in the local water balance, but hydrometric monitoring (measurement) needs to be carried out to help us understand current trends.

Facilitation note 2

Preparation (5 min)

1. If DRD or IWUMD staff members plan to share this session with their colleagues, they will need to read through the slides and facilitation notes carefully to familiarise themselves with the material.
2. Set up the PowerPoint presentation or print out the handouts so they can be distributed.
3. Record the names, organisations and job titles of all participants attending the training session.

Introduction (5 – 10 min)

4. To start the session, ask the participants what knowledge they have of the hydrological cycle. Ask them whether they are confident in describing how the process works. This includes:
   1. Do they know how to calculate the local water balance?
   2. Are they familiar with technical terms such as rainfall intensity, surface runoff, infiltration, evapotranspiration and field capacity?
   3. Do they know the difference between groundwater recovery and groundwater recharge?

Take a note of the answers on flip chart paper or ask a colleague to help you.

5. Do not say whether the information is correct or not, but think about what DRD and IWUMD staff know or think they know. Note down any questions that people ask or whether there are any disagreements. It you feel confident try to address some of these issues in the presentation.

Presentation (25 – 30 min): The Water Balance and Water Security

6. Talk through the slides using the facilitation notes below. If the participants knowledge is limited then move through the slides steadily to ensure understanding.

Slide 1: Session Plan 2: The Water Balance and Water Security

Explain that the purpose of the presentation is to help people think about the water balance. It its simplest form this refers to the balance between water supply (annual rainfall) and water demand (collective usage of water). Clearly if water demand exceeds water supply then problems may occur. Explain that as DRD and IWUMD "we" need to have a common understanding of the water balance because we will need to advise and support farmers and community water user groups to manage their water resources.

Slide 2: The water balance

Ask the group what happens when the rain falls and where does the rain go? Explain that some rainfall will act as (rapid) runoff and enters streams and rivers. Other rainfall will enter land depressions (small ponds) and some will infiltrate into the ground.

Slide 3: Thandwe Rainfall: 2015-2019

Explain the graph shows rainfall from a monitoring station in Thandwe. It covers the period 2015-2019. It shows that Thandwe receives high annual rainfall, around 192 inches each year. The right-hand "y axis" shows monthly rainfall totals. While the left "y axis" shows the cumulative rainfall totals. This is also represented by the red line on the graph. The x axis shows the time period Jan 2015 to June 2019. Explain that some of these rainfall events are intensive (measured in mm or inches/hour) and other rainfall falls steadily.

Slide 4: Daily rainfall varies greatly over short distances

Explain that rainfall totals can vary significantly over short distances, even in a catchment area with the same topography. Thus, when they start to measure rainfall they may see significant spatial variation occurring. This slide shows an example from a small catchment area in Iowa in the United States. The catchment area is small (roughly 4 miles x 2 miles) but rainfall variability is high.

Explain that climate change is likely to increase the variability of rainfall further. Rainfall events may be more intensive, resulting in flooding or rainfall may reduce.

Slide 5: What factors determine the division between rapid runoff and infiltration?

The way in which rainfall divides between (rapid) runoff and infiltration depends on a number of factors. Explain what these are using the slide provided.

Slide 6: Soil texture and infiltration

Explain the way in which rainfall infiltrates into the ground also depends on soil types and texture (class of soil). It is worth highlighting that clay soils generally restrict infiltration, while sandy, loamy soils will support infiltration.

Check there is no confusion at this stage of the presentation. Also highlight that human activities (such as construction or farming) will clearly impact on land properties and in turn this affects the local water balance.

Slide 7: Other factors that affect the division between (rapid) runoff and infiltration.

Explain how vegetation is generally good for infiltration, because it slows down runoff; while bare soil often leads to greater runoff. Therefore, if we remove vegetation or cut-down forests we may see increased surface runoff and less groundwater infiltration. Rainfall intensity also affects the division between infiltration and (rapid) runoff. If the rainfall is very intense it may exceed the absorptive capacity of the soil. This results in runoff. Low intensity rainfall therefore is more conducive to infiltration.

Slide 8: What happens to rainfall that runs off the land as surface runoff?

Explain that some rainfall will find its way to rivers and streams. Some passes over soil (such as sands or loams) that allow it to infiltrate.

Slide 9: What happens to rainfall that is held in surface depressions or which infiltrates?

Explain that rainfall held in land depressions will evaporate from either bare soil or "depression storage." Water that is held in the soil can be taken up by crops and plant roots and transpired. Some of the participants may be familiar with the "evaporation" and "transpiration" from school geography lessons and you can check with them if this is the case. Together these two terms are called evapotranspiration and it can account for a high percentage of water that is removed from the surface.

Slide 10: Evapotranspiration

This slide highlights evaporation and transpiration.

Slide 11: What determines the rate of evapotranspiration?

This slide explains the four factors that affect the rate of evapotranspiration.

Slide 12: Potential ET and actual ET.

This slide introduces two new terms Potential ET (ETo) and actual ET (ETa). ETo refers to the potential of the atmosphere to remove water from the surface through processes of evaporation and transpiration. ETo can be determined from weather data collected by the Meteorological Department. ETa refers to the quantity of water that is actually removed. As the slide shows actual ETa can be less than or equal to ETo. For example, in a dry (desert) environment ETa will often be less than ETo.

Slide 13: Water is temporarily stored in the soil.

This slide continues to refer to water that has infiltrated into the soil. Talk through the main points on the slide to help people understand. Ask the participants to think of the soil as a sponge. If you hold a sponge in a bucket of water all the pores will fill with water. If there is heavy or continuous rainfall, pores in the soil structure may also completely fill with water and the soil is referred to as being “saturated.” This means it can hold no more water. If it continues to rain intensively then flooding will likely occur.

If the soil is allowed to drain freely then after 1-2 days it will reach field capacity (FC). This refers to the amount of water held in the soil once excess water has drained freely. Once the processes of evaporation and transpiration have used up all the water, the soil will reach Permanent Wilting Point (PWP). This refers to the minimum amount of water in the soil that a plant will require not to wilt. If water levels decrease further the plant will wilt and may not recover. Further water losses will result in the soil being “oven dry.”

Slide 14: Following heavy rain

This slide shows how field capacity is reached after free draining for 1-2 days.

Slide 15: Water holding capacity of soils

Explain that water that is held in the soil above FC (Field Capacity) can recharge groundwater resources.
Water that is held between FC and PWP is available to crops and vegetation.
At this stage it may also be useful to introduce two new terms: Recharge and Recovery.
You can explain that: imagine the aquifer is a large reservoir of water. When you pump from a well or borehole, you create a drawdown curve – the drawdown is greatest in the pumped well, and it reduces as you move away from it. It’s sometimes referred to as a cone of depression. When you stop pumping, the water levels return to something near horizontal. This redistribution of water levels is described as **recovery**. You can draw this on a flip chart to demonstrate recovery.
Recharge is something different. Recharge is new water entering the aquifer. Recovery takes place even in the absence of any new water entering the system. Recharge is necessary to sustain long-term abstractions. In the absence of recharge, pumping leads to progressively falling water levels – slowly if the aquifer is very extensive and it contains a lot of water, or quickly if the extent or storage volume is low. This is why monitoring groundwater levels is important because DRD and IWUMD need to know the long term groundwater trends.

Slide 16: Surplus in excess of field capacity

Explain that if there is a surplus of water above field capacity level then it can recharge groundwater levels beneath the root zones of crops and plants.

Slide 17: Review of water balance so far

This slide helps participants to conceptualise how rainfall divides and it gives an example as to how the water balance may be calculated. Remember that rainfall is divided between infiltration and (rapid) runoff. Infiltration is then divided again between water that is used by crops, plants, trees and vegetation and water that recharges the aquifer.

Slide 18: Groundwater recharge

Groundwater recharge is often a difficult subject for people to understand. In simple terms some water is lost through evapotranspiration. In Myanmar this may typically be in the order of 2-6mm per day, which may reduce in the dry season. Over the course of a year this may equate to between 730mm to 2190mm (29-86 inches). Other soil water will be extracted by plant roots, while excess water (above field capacity) will recharge the aquifer. Ask the audience whether they know the ET rates for Rakhine State?

Slide 19: What happens to recharge

Recharge will help groundwater levels to rise in the wet season and in the absence of interference from humans it will naturally discharge to low points in the dry season – for example serving springs as base flow.

Slide 20: A note on aquifer storage

Explain this slide, highlighting the importance of understanding aquifer properties in Rakhine State.

Slide 21: The final water balance looks like this

This slide provides an indicative example as to how the water balance may be derived in Myanmar. It assumes that ETa may account for about 30% of rainfall. Further monitoring and research is required to determine actual percentages but this provides an indication. As a comparison in West Africa ETa may account for 60% of rainfall. It is understood that ETa has often been assumed to be around 10% in Myanmar, which equates to around 1mm per day. This may well be an under-estimation and it would result in an over-estimation of available renewable water resources in Myanmar.

Slide 22: Green water and blue water

The final slide brings to people's attention some new terms for water resources. Explain that water that is available to crops and vegetation is often referred to as **green water**. Water that feeds rivers and streams is referred to as **blue water**. **Grey water** refers to water that may have been used by agriculture or industry that is discharged to the environment. It is possible to treat and reuse this water.

Discussion (5-10 mins)

7. Check with participants on their level of understanding. Ask them if they have any questions. Such as:
   - Do they understand the technical terms, such as recharge, recovery, Field Capacity and so on?
   - Was there any aspect of the presentation that is new for them?

Summing up (5 mins)

8. Following the questions, sum up the presentation. The key message is that assessing the local water balance is difficult and we need to monitor water resources to understand what changes are taking place.

Session Plan 3: Identifying local level water security problems

Overview

Session Plan 3 now focuses on engagement with communities and will help to determine what water security problems people experience. In particular it tries to identify what water quality or quantity (access) issues people experience across the year. We need to understand this to design the correct response.

Session	**Identifying local level water security problems**
Purpose	To explain the importance of water resource management to farmers and understand the water security challenges people experience.
Key learning	• Deeper understanding of the water resource problems that people experience across the year. • Understand the specific challenges faced by women and girls. • Understand the level of demand or interest from farmers to engage in water resources management activities.
Time allowed	60 – 70 min
Materials	• Flip chart, • Marker pens, • Power Point Presentation or printed handouts if no projector is available
Methodologies	• Plenary questions and discussion • Group exercise – divided male and female • Group discussion
Session outline	• Preparation (10 min) • Introductions (10 min) • Group work (25-30 min) • Discussion (10 -15 min) • Summing up (5 min)

Facilitation note 3

Preparation (10 min)

1. Before the session starts create two large charts divided into nine sections each, with headings as below. This can be laid be laid on the floor during the meeting with community members. The structure of the chart is shown below. For a group of ten people one page of flip chart paper should suffice.

	Rainy Season	Winter Season	Dry Season
Water Quality			
Water Quantity			

Introduction (10 min)

2. Introduce all team members that are facilitating the exercise and ask participants to introduce themselves also.
3. Explain the purpose of the meeting. Highlight that we are keen to learn about the water situation in the village and people's experiences year round. The exercise should take about 45 mins to complete.

Exercise - developing the water security problem analysis (25 - 30 min)

4. Ask the participants to divide themselves into two groups – male and female respectively. The reason for this is so women have a voice and can raise any concerns they have.
5. Ask both groups to gather around their respective flip charts and think about the water security problems they face. This is for both domestic and productive water usage.
6. Explain to both groups what the headings mean and explain water quality and quantity:
   • **Water quality** – safe water free from biological and chemical contamination, poor taste, colour and odour.
   • **Water quantity** – adequate quantity of water (gallons) for their essential domestic and productive water requirements.
7. Provide both groups with sticky notes of one colour for water quality. Ask them to write on the notes the water quality problems they face, and place it on the chart in the relevant box (rainy, winter or dry season). Continue with this process until both groups have identified all the key water quality problems they face. People may not know the specific issues, but they can identify "poor taste or colour."
8. Invite one participant from each group to come up and explain the examples from each box.
9. Next, give both groups a set of sticky notes from another colour, representing water quantity. Ask them to place on the chart any examples of when they experience water quantity issues. Encourage them to try to be specific about what the problem is (for example: low yield, seasonality, increased demand).
10. Invite another participant from each group to come up and explain the examples from each box.

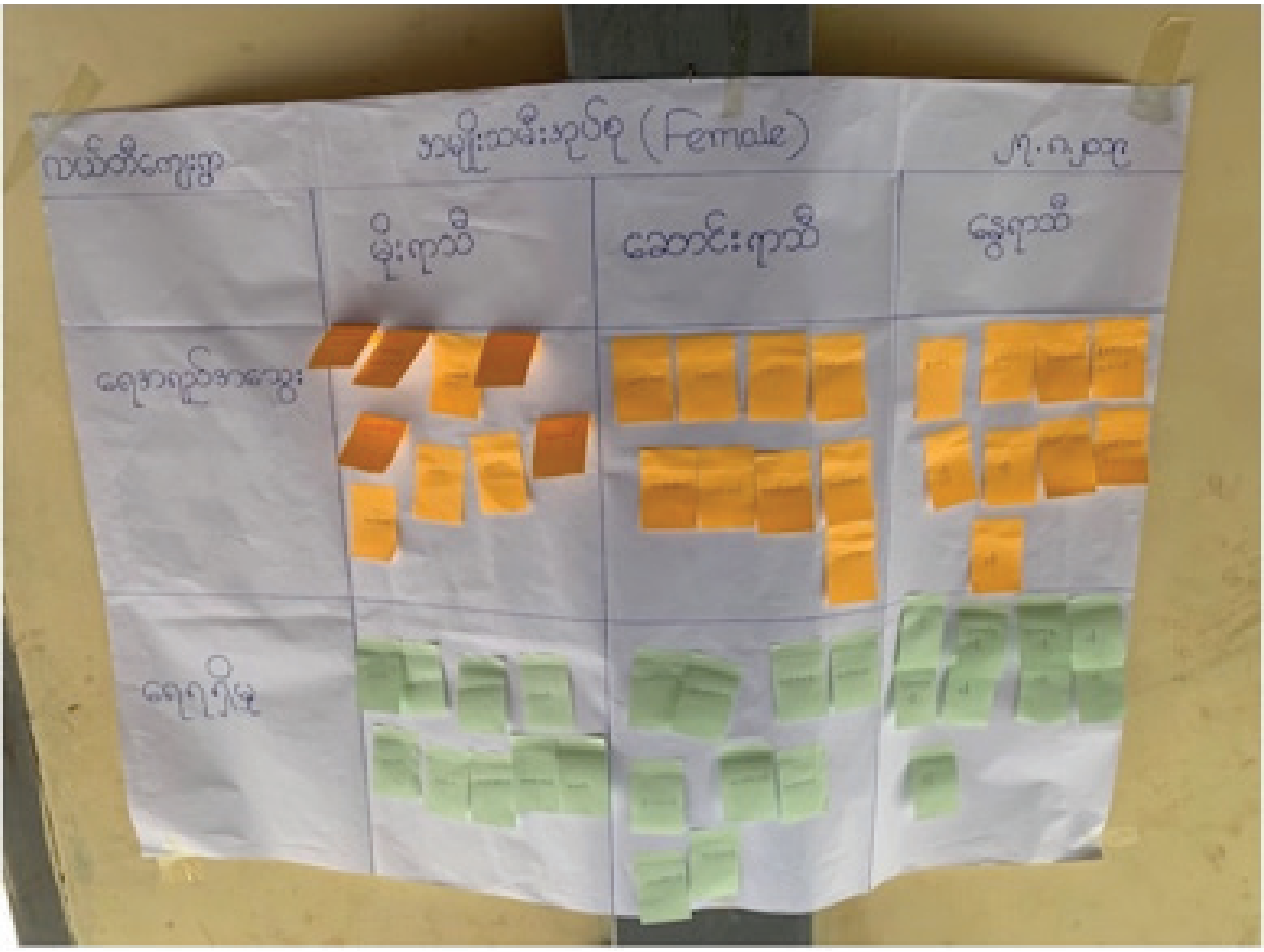


Figure 1: Example from Lel Di Village, Thandwe

Discussion (10-15 min)

11. Ask the participants to reflect on both group examples. Do they have any observations as to why these problems occur?
12. Questions to prompt discussion:
    - How long have these problems persisted?
    - Do they know what causes these problems and is it related to the practices of the community?
    - What are the consequences for the community – particularly women and girls?
    - Does the community have any suggestions how these problems could be addressed?
    - Is water a priority issue in the village?

Summing up (5 min)

13. Summarise the main points raised by both groups and share the key message with the community.

RAKHINE WINTER CROPS PROJECT

NEW ZEALAND FOREIGN AFFAIRS & TRADE Aid Programme

Session Plan 4: Mapping community-level water resources

Overview

Session Plan 4 focuses on participatory mapping of community water and land resources. Facilitators familiarise themselves with the target village and the map is produced by the community. It is a simple, participatory approach for identifying natural resources, and assets, within the community's boundary area. It can support future decision-making by communities with regards to their water management. It also enables DRD and IWUMD to collect information regarding the performance of water supply systems and determine where monitoring stations should be sited.

Session	Mapping community-level water resources
Purpose	To identify and create a map of community assets and water resources within a defined boundary.
Key learning	• Detailed understanding of community level natural resources (water, forests and farming land). • Identify major water users within the community (such as farmers or private well owners) • Knowledge of village boundaries and adjacent upstream and downstream communities. • Knowledge of how water resources perform year round.
Time allowed	100 – 120 min
Materials	• Mapping materials • Flip chart, • Marker pens, • Notebook and pens • Camera
Methodologies	• Observation • Groupwork and discussion • Key informant questions
Session outline	• Preparation and site walk (30-35 min) • Group exercise (60-70 min) • Questions (5-10 min) • Summing up (5 min)

Facilitation note 4

Preparation (30-35 min)

1. On arrival representatives from DRD and IWUMD should familiarise themselves with the village by walking around it with a member of the community. This will provide them with a basic understanding of the area to be mapped and it helps to establish a rapport with the villagers.
2. Next a suitable site needs to be selected to prepare the map. This could include a communal meeting area or monastery. If the meeting area has an unobstructed view of the village this will be ideal.
3. Before the session starts check with the group whether they are able to identify all the local natural resources (land, forestry and water) in and around their village. If the response is positive then begin. Prior to the meeting taking place the facilitator should ensure that key informants (male and female) will be invited.
4. The facilitation team should also bring with them a range of materials that can be used in the mapping exercise. This could involve using coloured powders to represent rivers, streams, forests and irrigation fields, as well as objects to represent domestic and productive water points.
5. The facilitation team should also organise their own roles and responsibilities. Such as: facilitator (who leads discussion), scribe (recording verbal information provided by the community) and someone that can re-draw the community map. Alternatively the map could be drawn directly on flip chart paper.

Exercise (60-70 min)

6. Depending on the number of participants the exercise could be completed in two groups - male and female. This is required to ensure women have a voice, as they are haulers and collectors of water. If the exercise is completed as one group, the facilitator should try to ensure women are active participants.
7. Explain to the group(s) that you would like them to map the key features of their village and surrounding area. This includes the following:
   - Village boundaries
   - Topographic features
   - Location or water points (hand dug wells and tube wells)
   - Type and location of farmland
   - Types of land use
   - Local, springs, ponds, streams and rivers
   - Local forests
   - Key buildings in the village, such as schools and monasteries
   - The number of households and population - this can be written on slips of paper and placed on the map.
   - Irrigation area and crop type
8. The list above does not have to be prescriptive and if community members want to add other information they think is important this should be encouraged.
9. Information regarding the performance of water points can also be recorded on slips of paper and placed on the map. For example the facilitator should identify the performance of water points with regards to: water quality, access, reliability (year round) and yield.

10. The facilitator or scribe should encourage participants to discuss the map in detail until they are satisfied that all information is correct. The team facilitating should then sketch the map onto a sheet of flip chart paper so that a paper copy can be retained. If possible, larger size paper could be used (or multiple sheets joined together) and it should be laminated or stored for safe keeping by the village community.
11. Any questioning about the map should be done in a non-intrusive manner so that people feel comfortable to share information. For example, the facilitator should discuss how water access changes between rainy, winter and dry seasons. This information can also be validated against information provided in Session Plan 3.

Questions (5-10 min)

12. At the end of the mapping exercise the facilitator should ask participants if they are happy with information provided:
    - Do they agree the map is accurate?
    - Is there any additional information they wish to add?
    - Does the map reflect the variation in access to water across the year (wet, winter and dry seasons)?
    - Are all the key water management issues represented on the map?

Summing up (5 min)

13. Thank them for attending and stress the exercise allows DRD and IWUMD to collect reliable information that can be used for planning purpose.

Session Plan 5: Field surveys

Overview

This Session Plan sets out an approach to gather a significant amount of information with which to start to develop a better understanding of community water supplies and irrigation systems. The general approach is to carry out a field survey that observes and records the status of domestic and productive water supplies and the irrigated area in use by the community. The method is used to help identify where subsequent improvements in water supply infrastructure are required and to identify locations for hydrometric monitoring. It is inter-linked to the mapping information recorded in Session Plan 4.

Session	**Field Surveys**
Purpose	To identify and create a map of community assets and water resources within a defined boundary.
Key learning	• Triangulating data collected in Session Plans 3 and 4. • To better understand the water and land resources in target villages. • Identifying and recording total irrigated area. • Better understanding of the status of water supply systems. • Identifying cause and effect problems related to human activities and local water resources. • Identifying where monitoring instruments should be sited.
Time allowed	120 – 180 min
Materials	• Notebook and pens • Measuring tape • GPS • Camera • Printed copies of functionality sub categories (Table 2)
Methodologies	• Transect walk and observation • Key informant interviews • Groupwork and discussion
Session outline	• Preparation (15 min) • Transect walk (90-120 min) • Review (5-10 min) • Summing up (5 min)

Facilitation note 5

Preparation (15 min)

1. The transect walk should only be carried out if there is cooperation and support from the community. The data collected should also correspond to the problems highlighted earlier by the community in Session Plans 3 and 4.
2. Prior to leaving the office ensure you have all necessary equipment, such as note book and pens, tape measures, water level dip tapes, GPS and camera.
3. Identify key informants from the community that are willing to walk some distance around the village and share their observations. The walk may take 90-120 mins, but can be used to enhance the knowledge of the local community.
4. Prior to commencing the transect walk the aims of the walk should be discussed and agreed by the team. Such as:
   a. Agreeing on the route the team will follow.
   b. What specific information the team will collect. This can draw on information collected during the community mapping exercise (Session Plan 4).
   c. Whether the team should be divided into more than one group to maximise the time available.
   d. Confirming what information is already held by RWCP.

Transect walk (90 – 120 min)

1. Examples of data to collect during the transect walk include the following:
   a. Recording the geo-location and owner of all water points in the village;
   b. Recording village boundaries;
   c. Carrying out an inventory of water points and identifying their status.
   d. Area of irrigation (acres) for individual farmers and the crops being grown.
2. Other information to collect could include the following:
   a. Identify potential hydrometric monitoring sites (raingauges, v-notch weirs). A monitoring form is provided in Annex C;
   b. Measuring depth of well, diameter, and static water level. This will be particularly important when selecting groundwater monitoring wells;
   c. Identifying any potential sources for water contamination – through vertical and horizontal pathways;
   d. Water quality samples;
   e. Status of water supply infrastructure (see description below).
3. If there are many water points in the village then the team may choose to focus on a select number – such as those water points that function year round and those that are seasonal. An example of how water points can be categorised is explained below at the end of this section.

Review (5 -10 min)

1. On completion of the transect walk the team should review the information they have recorded, capturing any key insights while they are still fresh in the mind.
2. Explain your observations to the community representatives to ensure this is a fair representation of the survey.
3. On return to the office data can be downloaded.

Summing up (5 min)

4. Thank the community members for their time and assistance. If the site visit is incomplete you will need to arrange another time to return.
5. Depending on the time spent completing the transect walk this may also require some contribution-in-kind if appropriate to the local context.

Notes: A closer look a functionality

If communities are to be water secure their water points should retain a number of core attributes. Such as:

- First water points should be mechanically sound. When breakdowns occur (as inevitably they will one day) communities should be able to either repair the water point directly or with external support (for example from DRD) in a timely manner (days).
- Second, the water point should have adequate yield year-round to meet user water requirements.
- Third, the water point should not be seasonal (dry up).
- Fourth water quality should be acceptable to the community. These attributes apply to both domestic and productive water points (albeit with possible variations in water quality requirements depending on usage).

The transect walk will provide an opportunity to record the status of water points in the target village. Water points are often classified as being functional or non-functional, but this binary description tells us very little about the actual condition of the water point. Table 2 on the next page unpacks functionality in more detail to help DRD and IWUMD understand what are the most prevalent issues to address.

Categories F1, F2, F3, F4, F5, NF1, NF2, NF3, NF4 will probably of most interest for the team to visit during the transect walk - if time allows. Category NF5 can be disregarded if the community has abandoned the water point completely. These can be identified on the community map at the beginning. Categories NF3 and NF4 can be recorded but will also need further follow up diagnostic work by DRD if the water user committee is unable to resolve the problem. F4 and F5 has been added to this table because these are specific problem raised by various communities during earlier Focus Group Discussions.

As the team records the geo-location of water points in the village (such as tube wells, hand dug wells, spring sources) they should determine what category of functionality is applicable. This can be recorded by hand or input directly into the GPS.

Table 2: Categories of functionality (source Carter, R.C. And Ross, I. 2016).

ID	Description	Mechanical	Yield/quality	Seasonality
Functioning water points				
F1	Functional year round and has no yield, seasonality and quality issues.			
F2	Functional at the time of monitoring and no yield, seasonality or quality problems but have experienced mechanical failure in the past year.			
F3	Functional at the time of monitoring but dries up in the year. Good yield and quality when functioning.			
F4	Functioning year round, no yield or seasonality problem, but is considered to have poor quality (colour, taste, smell)			
F5	Functioning year round but has low yield at certain times of the year. No reported quality issues and does not dry up completely			
Non-functioning water points				
NF1	Water point non-functioning at the time of monitoring due to mechanical issue, but yield, quality and seasonality normally good.			
NF2	Non-functioning due to water resource limitations. Yield and quality acceptable when working but seasonal.			
NF3	Non-functional and abandoned. Poor quality, yield or mechanical problems	Could be any		
NF4	Abandoned and decommissioned. No plans to reuse.	Could be any		
NF5	Abandoned and forgotten by community.	Could be any		

Session Plan 6: Monitoring water resources

Overview

This session plan provides practical guidance on water resources monitoring. It explains how DRD and IWUMD can establish local level monitoring sites and it explains some of the practicalities they will need to address in order to assess water resources availability. The practicalities for water resources monitoring can be discussed with volunteer observers when monitoring sites are being established.

Government engineers and technicians should familiarise themselves with the information contained in this section. They will then be in a position to provide education and guidance to volunteer observers. The table below shows a recommended training session for volunteer observers.

Session	Monitoring water resources
Purpose	To introduce the practicalities of hydrometric monitoring at community level
Key learning	• Knowledge and appreciation of hydrometric monitoring • Siting and Installation of monitoring devices • How to provide training and support to volunteer observers • How data should be processed
Time allowed	6-8 hours introductory session – longer if monitoring equipment is to be installed
Materials	• Raingauge • Dip tapes and pocket dippers • V-notch weirs • Construction materials • Camera • Note book and pen
Methodologies	• Site visit • Groupwork and discussion • Practical training
Session outline	• Typically 3 hours classroom based followed by 4-5 hours practical work in target villages. It is recommended that DRD and IWUMD familiarise themselves with this material first, before engaging with communities to identify, select and train volunteer observers

Facilitation note 6

This section provides practical guidance for establishing monitoring sites for rainfall, groundwater levels and surface or spring water flows. This will provide farmers with information to improve their own water management.

Preparation

1. From the outset, it is important to explain why the DRD and IWUMD want to start monitoring water resources.

> Begin by discussing in your groups what these key messages could be.

Key messages (some examples)

- Water resources face many pressures. If we do not monitor (measure) our water resources we cannot manage them.
- We need to understand "what works" and "what does not work" when it comes to hydrometric monitoring. This is a new area of work for many staff.
- We also want to collect a significant amount of data to develop a better understanding of groundwater and surface water hydrology in Rakhine State.
- Some of this important work can be carried out by farmers and volunteer observers, with ongoing government support.

2. Before meetings are held with farmers and community members it will be necessary for DRD and IWUMD to prepare thoroughly. A number of general issues need to be discussed from the beginning. These are as follows:
   - Where should monitoring take place?
   - How will monitoring equipment be chosen?
   - Who will operate the monitoring instruments?
   - How should data be recorded?
   - How should date be collated?
   - How will data be cleaned (or validated)?
   - How will data storage be undertaken?
   - How will data be shared?

> These important questions are each discussed in turn below. But before we continue write down some of the practical issues you think DRD or IWUMD need to consider. Discuss these in your groups, then continue.

Where should monitoring take place?

The RWCP aims to establish a small number of monitoring sites in target villages near each of the three townships (Toungap, Thandwe and Gwa). The aim will be to build experience in hydrometric monitoring and understand "what works". Inevitably the number of monitoring sites depends on the budget available, but initially it makes sense to establish at least 2 village-level monitoring sites in each Township.

3. At each monitoring site the following information should be recorded:
   • GPS Coordinates of each monitoring location. This can be achieved using GPS devices such as Garmin Etrex10 or an iPhone app Motion X GPS. GPS accuracy is estimated to be ±10m.
   • Ground elevations can be derived by comparing GPS recordings with online terrain contour maps (e.g. Google maps with contour interval of ±20m and "Motion X GPS" terrain map with contour interval of ±10m). If there is discrepancy then it makes sense to record and note down the GPS elevation.

How will monitoring equipment be chosen?

4. Ideally monitoring equipment selected should meet national Myanmar standards – where they exist. If they do not then equipment selection could be aligned to World Meteorological Standards (WMO). However, local level monitoring equipment does not necessarily need to be so high-tech or stringent. There is a trade-off between cost and accuracy and low-tech instruments can also provide accurate results. Plastic rain-gauges, for example, give more than adequate results at a far lower cost than high specification equipment.
5. Automated instruments will require programming, calibration and support for downloading data. Furthermore, electronic systems can also malfunction and it will be more expensive to replace equipment if damaged or lost. This is an important consideration when Government institutions have limited equipment budgets. It will also be important to ensure that Government agencies accept the monitoring equipment selected and do not disregard the data collected by volunteer observers.
6. Operation and maintenance costs are an important consideration for DRD and IWUMD. Often, when establishing monitoring networks, projects tend to think only about the capital cost for purchasing equipment and much less about the ongoing recurrent costs for collecting and analysing data and maintaining a monitoring network. These, recurrent costs may account for 10-20% of the capital cost each year.

Who should operate the monitoring instruments?

7. It is envisaged that monitoring will be carried out by DRD and IWUMD, with the support of volunteer observers in the farming communities. Government institutions should be responsible for more technical instrumentation, maintaining monitoring networks and processing data. However, the division of responsibilities between DRD and IWUMD needs to be clarified.
8. Involving volunteer observers will be one method for keeping monitoring costs down. DRD and IWUMD will need to identify and select competent and willing individuals that are literate and able to do basic maths (addition).
9. Where data needs to be downloaded from specialist instrumentation then trained technicians will need to do this work.

How should data be recorded?

10. Data should be recorded using simple paper-based and electronic forms. If national forms already exist these can be used, if not they can be designed. An example of a rainfall data collection form is provided in Annex D.

How should data be collected?

11. Data should be collected by DRD and IWUMD staff so they can identify any problems with the data in-

situ and discuss with the volunteer observer. This can be carried out more frequently at the beginning of the project and as experience grows, data forms can be collected monthly. These forms then need to be transcribed and entered in the selected software. – such as excel – so they can be stored in a safe place.

What is data cleaning?

12. Data cleaning is a process for identifying any obvious errors. It requires an individual with an interest in data, an "eye for detail," and someone that has a basic knowledge of the likely data ranges – such as daily rainfall data.

How should data be stored?

13. Data should be stored in a simple software package – such as MS Excel or a generic database such as MS Access if there is knowledge how to use the software. Over time and with experience more expensive software options could be selected.

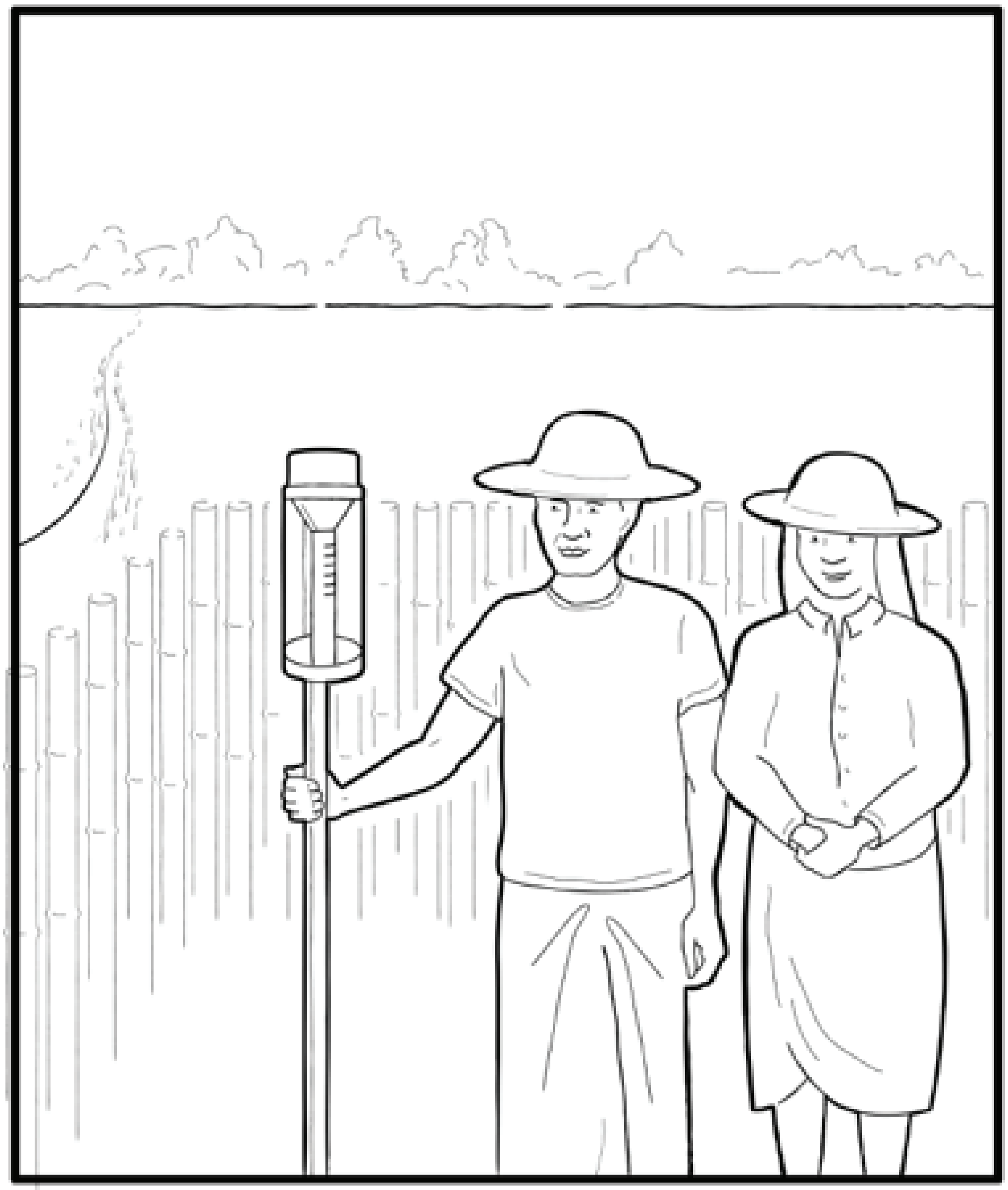
How should data be disseminated?

14. There is little point in collecting hydrometric data if it is not used to inform decision-making or trigger appropriate follow-up action. In the RWCP it is most likely that farmers will want to receive analysed data, so they can understand what is happening to their water resources. However, other Government departments or Universities may be interested in raw or cleaned data if they have capacity to carry out their own analysis.

Monitoring rainfall

15. The following guidance is relevant for the installation of mounted simple raingauges suitable for use in community villages (Figure 4).
16. The first requirement is to understand what is the maximum probable daily rainfall in Rakhine State, so the raingauge is large enough to record all daily rainfall. Given the intensity of the rainfall in the coastal region, monitoring sites will probably need a standard 8 inch raingauge to ensure they can record high or extreme rainfall events. 8 inch refers to the diameter of the raingauge, but the instrument can typically hold around 20 inches (500mm) of rainfall.

Figure 2: Installation of a raingauge in a local community



Site location

17. The raingauge should be sited away from buildings and trees (or any other tall object) at a distance equal to twice the height of the nearest tall object. It should be placed on level ground wherever possible and the vegetation around the raingauge should be removed – cut back. Alternatively position the gauge on a post at 3.0 - 4.5 ft above ground level with the rim of the funnel above the height of the post. A fence should be constructed around the raingauge, enclosing an area of about 12ft x 12ft and about 5 ft high. Naturally the raingauge also needs to be sited in a convenient location for the observer to access.

Hours of observation

18. The rainfall is to be measured at 0900 each morning and the amount of rainfall entered on the record sheet against the date the reading was taken. During the analysis of the data, the values will be ‘thrown back’ to the previous day, on the assumption that most of the rainfall measured at 0900 today actually fell yesterday.

Reading the raingauge

19. If all the rainfall is contained in a central graduated measuring cylinder, read the level of water in the cylinder by bringing your eye directly opposite the level of water and reading the position of the bottom of the curved surface of the water to the nearest 0.01 inch on the scale.
20. If rainfall has overflowed into the outer container, then carefully remove the entire rain gauge from its mounting bracket. Remove the central graduated cylinder and pour water from this into a separate large storage vessel. Take care not to spill any water. Next pour the contents of the outer container into the vessel.
21. To measure the rainfall amount, fill the graduated cylinder and note the reading. Pour this water back into the main rain gauge container. Repeat this process until all the water is measured.
22. The totals should be added together, for example: 2.00” + 2.00” + 1.50” + 0.75” = 6.25”.
23. Recheck the measurement if necessary by repeating the process. When satisfied with the result, write the total rainfall value onto the rainfall form and empty the rain gauge by pouring water onto the ground. Carefully return the rain gauge back to its mounting bracket taking care not to damage the bracket.

Small amounts

24. If it has rained a small amount but the water does not rise above 0.01” in the graduated cylinder, record the word “trace” or “T” on the rainfall form.

Large amounts

25. If it has rained very heavily and the outer cylinder has overflowed, record the word “overflowed” on the rainfall form. (Note: when full the recommended rain gauge has a capacity of 20 inches).

Missed reading

26. If a reading is missed for any reason, then when the raingauge is next read, record the total rainfall amount on the day of measurement. Record the words “no data” or “nd” in the missing days prior to this. If you know there was no rain on any of these days, record these as 0.00.

Mode of entry

27. The rainfall result is always to be entered in 0.01 inch units (100th of an inch). When writing down readings the decimal point is always inserted even for zero values of whole numbers. Do not write “inch” on the form. Examples of the correct style for numbers include: 1.00 or 0.50 or 2.55.
28. When identifying and selecting volunteer rainfall observers DRD or IWUMD will need to ensure people are trained thoroughly on steps 19-29 inclusive.
29. When working with volunteer observers think about what aspects will need to be considered to ensure they remain motivated? Recognising the work of volunteer observers as well as providing small incentives will help to maintain their motivation.

Monitoring groundwater level

30. It is recommended that monitoring initially takes place using simple dip meters and pocket dippers (Figure 3). Over time it may be possible to install automated level loggers in wells and tube wells, but DRD and IWUMD will need additional training.

Figure 3: Water level meter and pocket dipper

31. Many hand dug wells in the RWCP do not have covers and water level dip meters or pocket dippers can be used to record groundwater levels periodically.
32. Once permission has been obtained from the well owner the following information should be recorded: date and time of visit, GPS coordinates, depth to the base of the well, depth to static water level, height of the measuring point above the ground.
33. Also record the method for abstracting water (pumped or use of buckets), type and status of well and pumps. Also determine whether the well is seasonal and take a photograph of the well and its environs.
34. Ideally the well will be sited in relatively close proximity to the raingauge, wherever possible. This should enable a better understanding of how groundwater levels respond to rainfall.

Monitoring stream flows

In the RWCP it is assumed it will not be possible to monitor large surface water discharges for reasons of cost. The National Water Resources Management Committee will most likely be responsible for measuring rivers and major water courses. However, it is still valuable for the RWCP to enhance its understanding of local catchments and how they respond to rainfall. V-notch weirs can be installed in target villages to help DRD and IWUMD assess spring and stream flows.

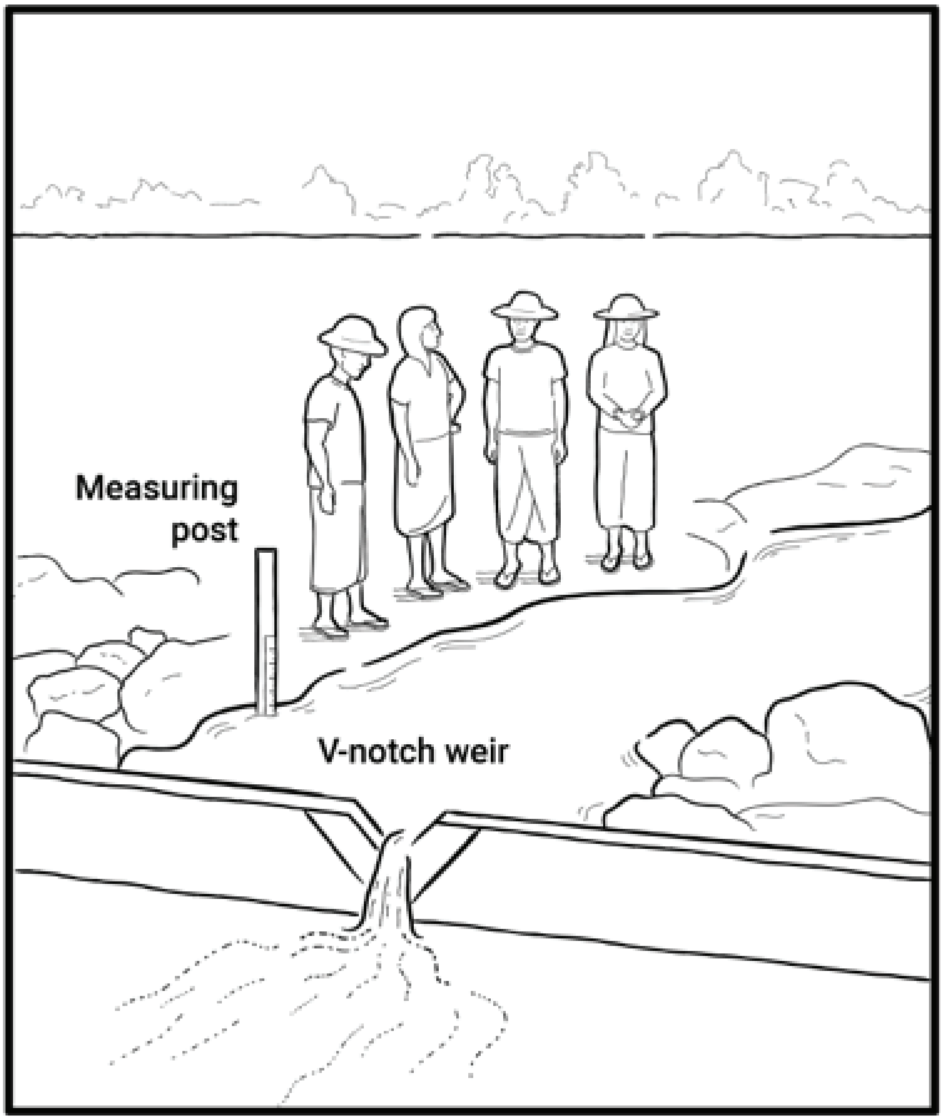
What is a v-notch weir?

A v-notch weir is an accurate and simple device for measuring low surface water flows. Since RWSP is most interested in low flows in the dry season, v-notch weirs are a useful method for measuring spring and stream flows.

V-notch weirs are available in various sizes. The angle of the “V” ranges from 90o down to 22.5o. The vertical height of the “V” determines the range of flows which can be measured. The height (or head) of water above the vertex (or point) of the “V” is used to determine the flow through the weir. The head needs to be measured a little way (a minimum of 3-4 times the maximum head) upstream of the weir itself.

Typically the v-notch plate could be made of stainless steel and bolted to a timber structure across the watercourse. The steel plate is sharp edged and chamfered (angled) on the downstream side. The water must drop freely over the weir, so that the nappe (or waterfall) has air behind it (it is then referred to as being ventilated). If the nappe clings to the weir (typically at very low flows), then the measurement will be inaccurate. The water level is measured on a graduated rule attached to a stable post (Figure 6).

Figure 4: Installation of a v-notch weir and measuring post



V-notch weir calibrations

The general equation describing the relationship between head and discharge for a v-notch weir is:

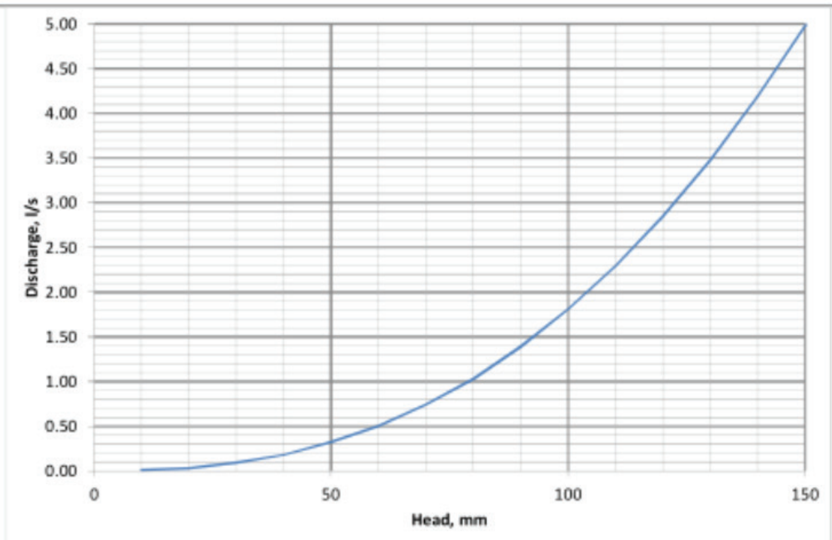
$$Q = 0.533\sqrt{2g}\,.\,C\,.\,\tan\left(\frac{\varnothing}{2}\right)h^{2.5}$$

where g is the acceleration due to gravity (9.81m2); the coefficient C is assumed to take a value of 0.59; θ is the angle of the v-notch and h is the head over the weir (m). V-notch weir rating curves are shown below.

Figure 5: Rating table curves for 45 and 60 v-notch weirs

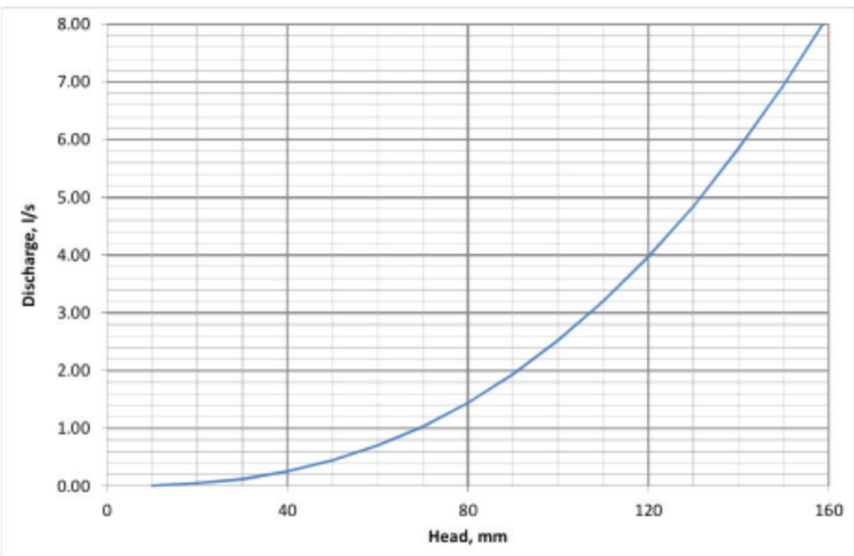
45° v-notch

Head (mm)	Discharge (l/s)
10	0.01
20	0.03
30	0.09
40	0.18
50	0.32
60	0.51
70	0.75
80	1.04
90	1.40
100	1.82
110	2.32
120	2.88
130	3.52
140	4.23



60° v-notch

Head (mm)	Discharge (l/s)
10	0.01
20	0.05
30	0.13
40	0.26
50	0.45
60	0.71
70	1.04
80	1.46
90	1.95
100	2.54
110	3.23
120	4.01
130	4.90
140	5.90
150	7.01
160	8.24

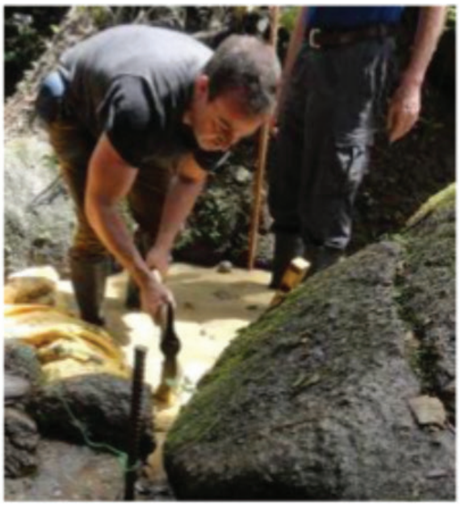


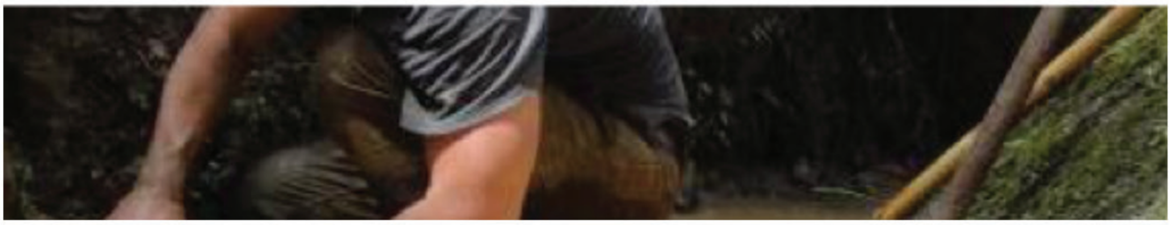
Siting and installing a v-notch weir

Think about what factors need to be considered when siting and installing a v-notch weir?
Write them down and discuss within your group.

35. Some important considerations are as follows:
    - Finding allocation that is safe and easy for the observer to access. Safety next to open water courses should be paramount.
    - Locating the weir on a relatively flat and straight section of the stream channel (not on a bend) so the flow in the stream will be more uniform.
    - Measuring the cross section of the river.
    - The ability to work in the stream channel and keep the site dry. Naturally it makes sense to install the v-notch weir in the dry season period.
    - How much underlying bedrock is in the channel – as some of this will need to be removed.
    - How much fall there is downstream of the weir to take the water downstream.
36. The photographs below show an example of a v-notch weir being installed. Here the weir is assembled and mounted on a wooden board before being fixed in the stream.

Figure 6: Installation of v-notch weir

RAKHINE WINTER
CROPS PROJECT

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Session Plan 7: Water efficiency

Overview

Agricultural irrigation constitutes the largest user of water in Rakhine State. In the Rakhine Winter Crops Project farmers, who were previously reliant on rainfed agriculture are now irrigating into the winter and dry seasons. Many farmers will also be keen to extend their irrigation areas and diversify the crops they are growing. This means increasing water efficiency and saving water in agriculture also need to be priorities for both farmers and government authorities. This session plan focuses on identifying areas where water savings can be made and it is relevant for DRD and IWUMD staff. It is inter-linked to Session Plan 8 that focuses on water efficiency and management at village-level.

Session	**Water efficiency**
Purpose	• To identify opportunities for saving water in irrigated agriculture. • To explore technological and management approaches. • To explore actions that could be taken by government agencies and farmers.
Key learning	• Knowledge of the main areas of water use in irrigated agriculture. • Understanding the interdependencies in supplying water to farmland. • Appreciation and knowledge of the main areas where water savings could potentially be made.
Time allowed	95-110 min
Materials	• Flip chart and marker pens • Notebook and pens • Printed copies of framework for identifying options to save water
Methodologies	• Groupwork and discussion • Follow up transect walk
Session outline	• Welcome (5 min) • Introduction (10 min) • Opening briefing (10 min) • Group work (50-60 min) • Feedback to group (15-20 min) • Summing up (5 min)

Facilitation note 7

Welcome (5 mins)

1. Thank each participant for attending the training session and record their names and job titles on an attendance sheet.
2. Introduce yourself and explain the purpose of the training session. Note that this is an introduction to water management and it aims to assess technology and management options to reduce water losses.

Introduction (10 mins)

1. Ask the participants to introduce themselves one by one, saying their name, their organisation and their job title.
2. Ask them if they have any previous experience in identifying water efficiency savings? Do they feel this is a new subject area or is it something they have experience and expertise in? The reason for asking this is so you know the level of understanding within your audience.

Opening briefing (10 mins)

3. Explain that water saving in agriculture often refers to reducing the amount of water that is abstracted or diverted. However, water savings can also be achieved through a number of other ways.

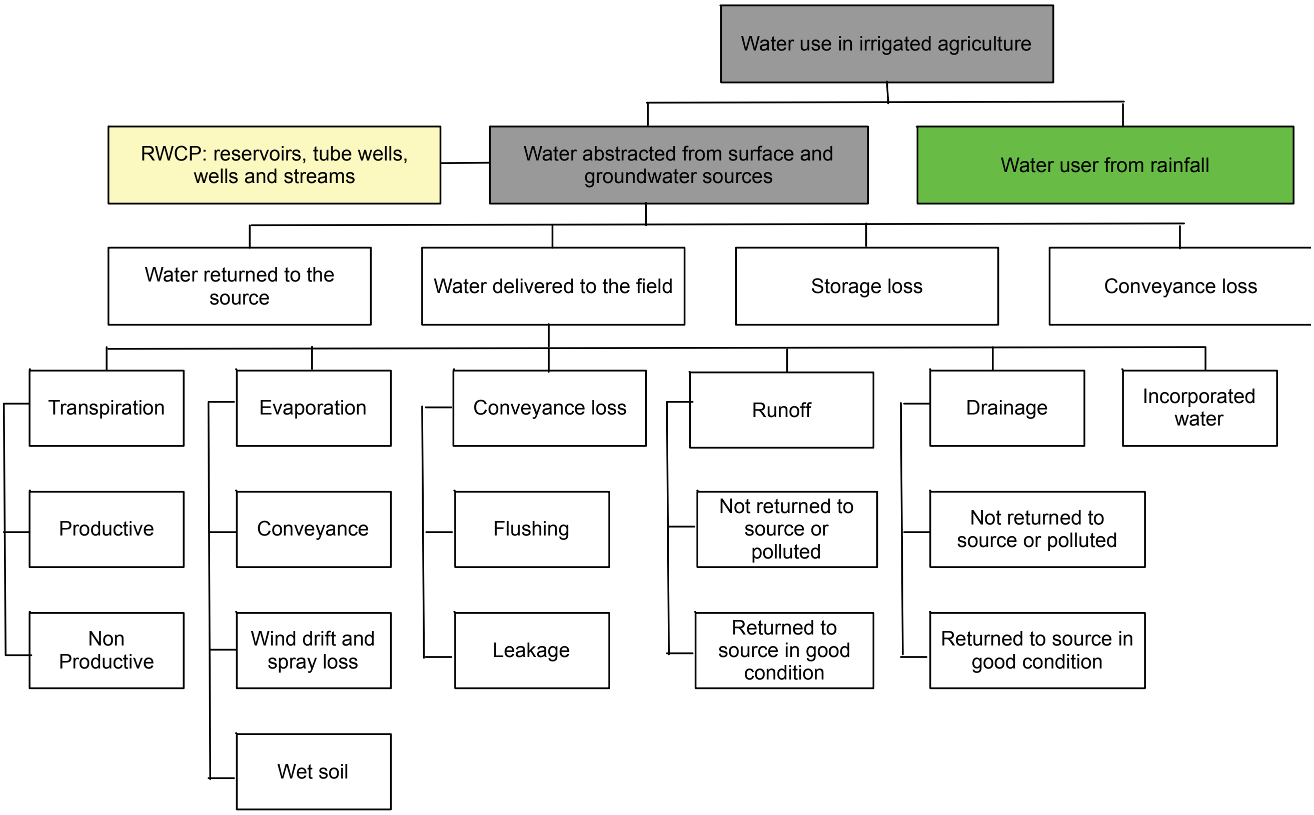
> Ask participants if they are aware what some of these water efficiency options are and record their responses on a flip chart.

4. Explain that other options for saving water include the following:
   a. Appropriate techniques for irrigation
   b. Applying relevant management practices
   c. Using water from alternative sources
   d. Influencing farmer behaviour
   e. Providing education and training to farmers
   f. Reviewing the wider water supply system and identifying options for water efficiency savings
5. Explain Option F is the focus for this session plan. Depending on the number of participants divide people into groups of 3-5 people.

Group work (50-60 min)

6. Provide each group with a printed handout of the framework for identifying options to save water in irrigated agriculture (Figure 9)

Figure 7: Conceptual framework for identifying water savings in irrigated agriculture (source Hess, T. M. and Knox, J.W. (2013))



7. Explain that in Myanmar farmers make use of both rain-fed agriculture, but in the RWCP farmers now irrigate using "blue" water. This refers to water that is abstracted from surface water and groundwater sources.
8. Explain that the conceptual framework aims to show potential opportunities for saving water.
9. Ask each group to identify areas where they think water efficiency savings could potentially be made. Give them 25-30 mins to discuss and highlight on the printed handout.

10. Once the group has identified areas on the handout ask them to write down how these water efficiency savings could be achieved. For example, is this through technological managerial improvements and what would this look like? Give the group another 25-30 mins to record these on a flip chart.
11. Ask one member of each group to present their findings. Ask each group where they think the most efficient water savings could be made.
12. Record on a flipchart all the key responses from each group.

Feedback to group (15 – 20 min)

13. Next, proceed to a plenary discussion and share a second handout (Figure 10). This handout is "shaded" to explain some examples where cost-effective water efficiency savings could be made.
14. Explain, in Figure 8 the "orange" shaded boxes represent non-productive water losses. Such as storage losses and conveyance losses and leakage. Technological and management interventions could result in water savings in these areas.

15. Explain, the white boxes refer to water that is not consumed but is returned to the environment in good condition and is available once more to the resource. In the long term, there may be limited value in trying to reduce these losses, but there may be value in reducing these losses in the peak irrigation periods.
16. Now explain some of the ways in which non-productive water losses could be reduced. These are explained in Table 3. This can also be shared as a handout.

Summing up (5 min)

17. Conclude the session by asking people if they have any further questions and highlight the key areas for water saving interventions. All of the options presented here represent sensible practices for farmers and decision-makers to apply.

Figure 8: conceptual framework for identifying water savings in irrigated agriculture

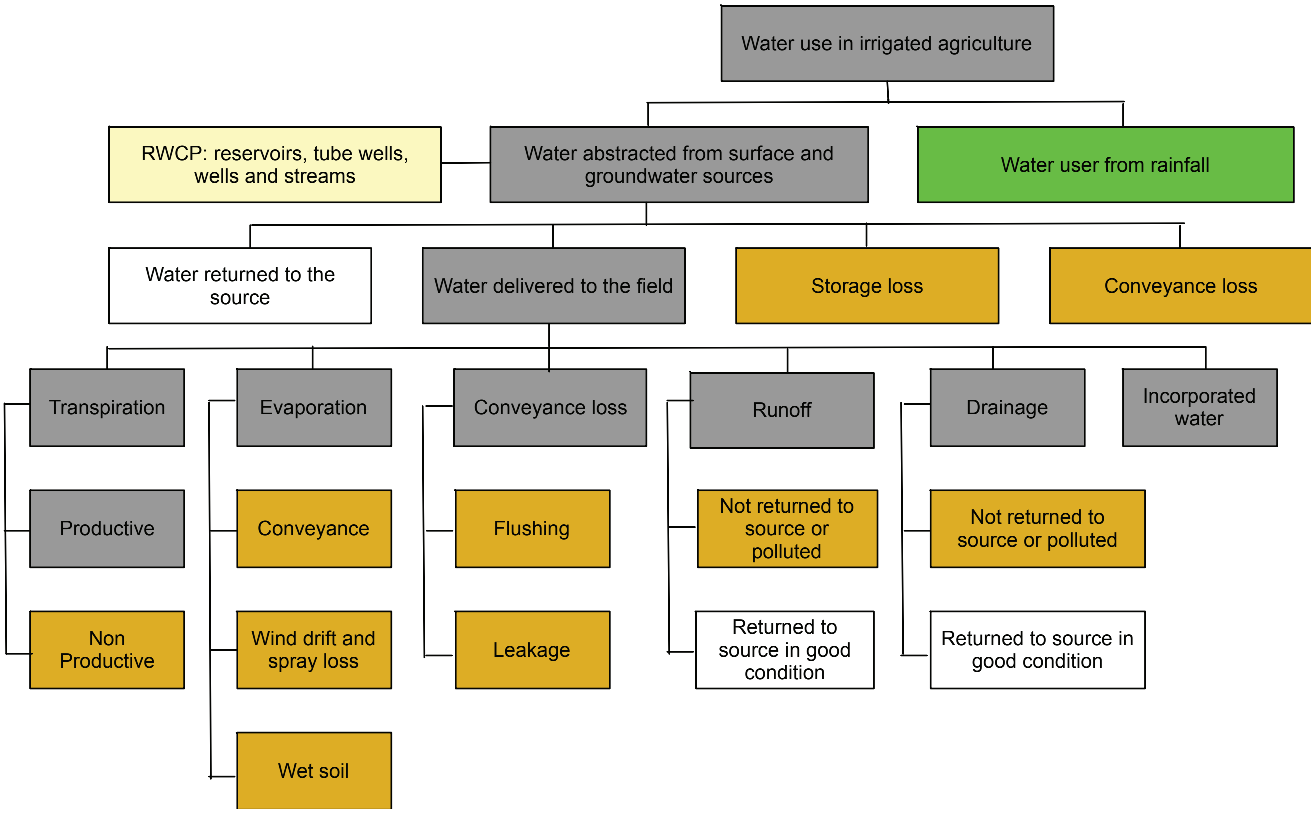


Table 3: Possible water saving interventions

Water Saving Area	Description	Possible intervention
Storage Losses	Water loss from storage reservoirs ponds through evaporation will be inevitable and can be significant - in the order of 30% in Rakhine State. Water evaporates from water bodies faster than surrounding areas, due to lower surface resistance. Water from smaller water bodies evaporates faster than larger water bodies due to turbulence and edge effects. So farms ponds will evaporate at a faster rate than larger reservoirs.	Applying covers and shades (such as military netting) or floating covers or objects can reduce evaporation losses and prevent algal growth. Windbreaks or areas of shade can also have beneficial impacts.
Conveyance Losses	Water losses can occur from unlined canal systems; or over-pressurised and leaking pipes. These losses can be significant	Regular inspection of pipe networks and water (hydraulic) control structures. Repairing leaks Lining of conveyance channels to prevent seepage losses.
Transpiration	This refers to non-productive transpiration on irrigated areas, such as water that is transpired by unwanted vegetation (such as weeds). Transpiration will increase if unwanted vegetation develops roots.	Removal of unwanted vegetation, soil tillage or use of weed control may have benefits. Soil tillage may have unintended consequences if wet soil is brought to the surface and results in greater evaporation.
Evaporation	Evaporation can be lost through conveyance systems. Wind drift and spray losses can occur with sprinkler and hose systems. Water can be lost in the air or evaporate from the crop canopy. When soil is wet, evaporation and transpiration can happen simultaneously. When plants are small evaporation may be the dominant process, but this can change as plants mature (grow).	When designing conveyance systems it may be more effective to use low pressured pipe systems rather than open channels. But, potential for higher capital costs. Switch to drip irrigation systems where efficiency may reach 90%. Mulching (covering the soil with permeable materials) can help to reduce ET rates from wet soil. Mulching helps to retain moisture and reduce surface runoff.

Conveyance	This refers to on-farm conveyance systems and losses that can occur if irrigation equipment is damaged or not maintained.	Regular maintenance of pipelines, back flushing of drip irrigation systems to reduce sediment build up.
Run-off	Refers to run-off that occurs when the rate of irrigation exceeds the soil infiltration rate or when irrigation occurs on soil that is already wet. Therefore, the rate of irrigation should be matched to soil infiltration rates.	Improved irrigation and field management (scheduling) and improvements in technology can help to reduce run-off risks and save water. Techniques to prevent run-off, such as blocking furrows. Maintaining good soil structure to ensure good infiltration – for example minimising soil compaction.
Drainage	Poor drainage can result in increased surface runoff. Over-watering can also result in increased drainage.	Try to ensure good drainage, through soil management and ensuring some storage capacity within the soil if rainfall events are unpredictable.

Session Plan 8: Operating Principles

Overview

This session focuses on working with farmers to improve irrigation efficiency. It is most relevant for farmers who are irrigating at scale into the winter and dry seasons. Agricultural irrigation accounts for significant water usage in Rakhine State, probably in the order of 70%. If farmers expand their irrigated areas then water demands will increase and there will be competing demands for water driven by farmers wanting to maximise their profits. Population growth and other competes uses will add to these pressures. Water management is essentially a social and moral challenge rather than a technical one. This session explores ways in which farmers can establish operating principles for water management.

Session	Operating principles
Purpose	• To unpack existing community-based management systems. • To explore opportunities to establish or strengthen management systems. • To identify some key principles of water management that share the same characteristics across different communities. • To understand the limits of community-based management.
Key learning	• Knowledge of existing community-based management systems. • Understanding whether these systems are robust to cope with water stress. • Appreciation and knowledge of collective action to strengthen water management.
Time allowed	70-80 min
Materials	• Flip chart and marker pens • Notebook and pens • Printed copies of handouts contained in this section
Methodologies	• Groupwork and discussion
Session outline	• Preparation (10 min) • Introduction (10 min • Icebreaker (15 min) • Discussion (30-40 min) • Summing up (5 min)

Facilitation note 8

Preparation (10 min)

1. Before travelling to the village make sure the key handouts contained in this session plan have been printed. Also determine who will be the facilitator and scribe for the session.

Introduction (10 min)

2. Introduce all team members that are facilitating the exercise and ask village-level participants to introduce themselves also.
3. Explain the purpose of the meeting. Highlight that we are keen to learn about the water management practices in the community. In particular how they organise themselves to manage irrigation water.

Icebreaker Quiz (15 mins)

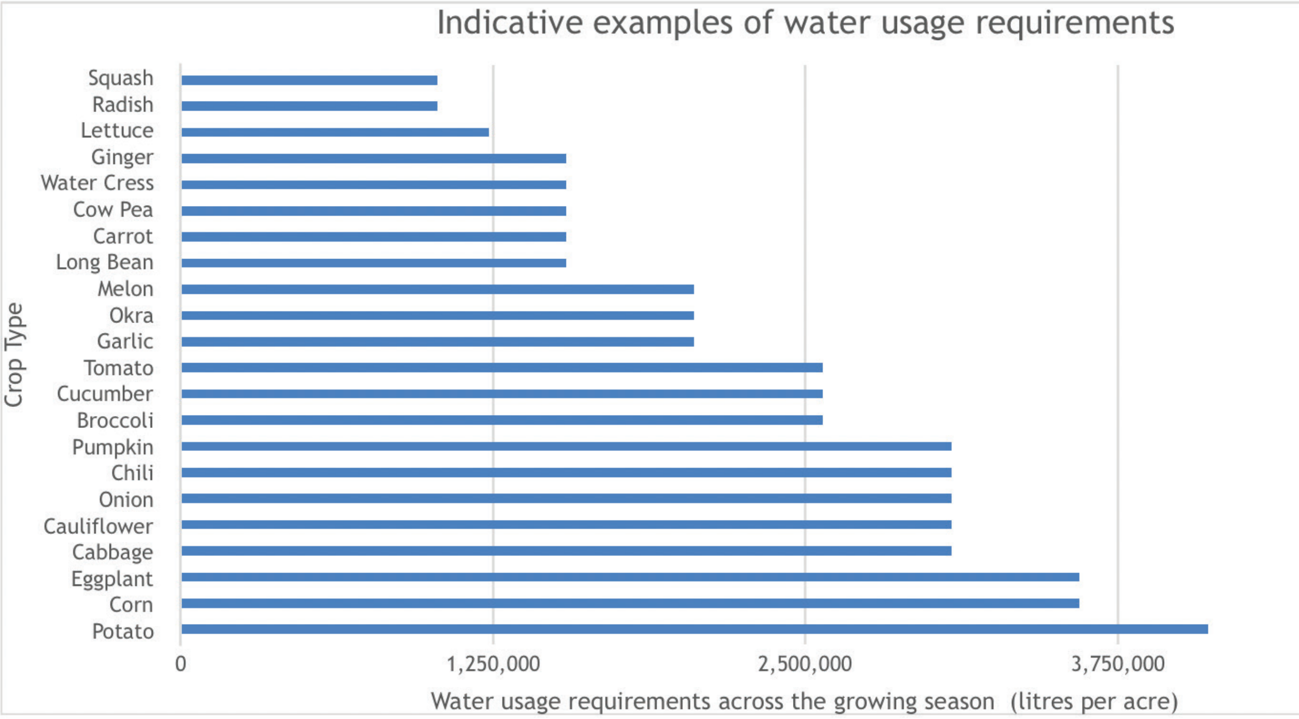
4. Ask the participants to complete a short quiz (Annex E). Explain the purpose of the quiz is to see how efficiently community members believe they are irrigating. If necessary the team can work with the participants to complete exercise.
5. At the end of the exercise one member of the facilitating team can quickly collate the responses and score them. You do not have to use individual names but instead show the collective responses and whether people think there is high, moderate or low possibility to improve irrigation efficiency.
6. Note that when testing this approach we have found that communities often think their own irrigation practices are reasonably good. But some participants may have different positions. Regardless of the responses, do not say whether you think they are correct or not. The responses can be categorised as follows:

- There is high potential to improve irrigation efficiency.
- There is moderate potential to improve irrigation efficiency.
- There is limited or low potential to improve irrigation efficiency.

Discussion (30-40 min)

7. Next, ask people to think of their groundwater and surface water resources as a large reservoir. Each day they are all drawing on these water resources and using water for many different purposes. Explain that irrigation will account for the largest use.
8. Show the handout below (Figure 11) to help people picture the potential water usage requirements.

Figure 9: Crop water requirements



9. Explain the graph (Figure 11). For example, show that potatoes and corn account for significant water usage, while squashes and radishes use around 75% less water.
10. The group should discuss what crops they grow and the potential risks if they all choose crops with high water requirements.
11. Next, ask the groups to think about some of the issues that may increase these risks. Examples include the following:

- No measurement of water usage or abstraction
- Farmers working individually rather than collectively
- Poor irrigation practices – no scheduling of water use or over watering
- Inefficient irrigation systems
- Uncontrolled boundary expansion of irrigation areas
- No collective rules or operating principles

12. Ask the group if they have reflections on these risks. Record their responses.
13. To help the group think more about operating principles ask the group to think about the following examples. Ensure each operating principle is explained clearly.

Operating Principles	Description
Autonomy	Encouraging communities to set their own rules for water usage, rather than having rules and laws imposed by Government.
Contiguity	If irrigated land is fed from a central reservoir controlled by IWUMD then irrigation plots are watered in a fixed sequence, depending on crop requirements. Thus people know when irrigation will take place.
Uniformity	Encouraging famers to irrigate with the same frequency, depending on crop type. Second, everyone is encouraged to irrigate in the same way – using the most efficient techniques.
Proportionality	Imposing an upper limit on the amount of time or volume of water that should be used, which is relative to the size of their irrigated area.
Transparency	All farmers should know whether neighbouring plots are obeying the collective rules. If farmers exceed the irrigation schedule or over-abstract they can be reported to the village-level committee.
Boundary maintenance	Any expansion of the irrigation area should be agreed by committee members first as this will increase water demands and may increase water stress.
Graduated sanctions	Penalties can be imposed if farmers break the agreed rules. For example, if irrigation continues into the dry season months and reduces access for some community members if shallow wells run dry.

14. Ask the group to discuss each of the operating principles and record their feedback or thoughts. Ask the group to reflect on these operating principles.
15. Now ask the group to reflect on their original quiz responses and see whether their original responses on irrigation efficiency have altered.

Summing up (5 min)

16. Summarise the discussion and key messages. Tell the group this is an issue DRD and IWUMD would like to keep discussing to see how water management can be improved.

RAKHINE WINTER CROPS PROJECT

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Session Plan 9: Who does what in water resources management?

Overview

This session aims to identify “who does what” on water resources management issues. It aims to identify what institutions are currently doing and identify any major gaps or areas of duplication. The session should be run internally involving DRD and IWUMD staff.

Session	**Who does what in water resources management?**
Purpose	To identify what activities institutions are currently undertaking and pinpoint gaps in roles and responsibilities.
Key learning	• Better understanding of institutional mandates • Identify the boundaries between activities that can be completed by communities and areas for external support.
Time allowed	60-70 min
Materials	• Flip chart, • Marker pens, • Notebook and pens
Methodologies	• Groupwork and discussion
Session outline	• Preparation (10 min) • Group exercise (40-50 min) • Summing up (10 min)

Facilitation note 9

Preparation (10 min)

1. Before the session starts print off copies of Table 4.

Discussion (40 – 50 min)

2. Participants should be drawn from representatives of DRD and IWUMD.
3. Explain to the group you are keen to identify roles and responsibilities for all the different components of water resources management. Work through the Table 4, as a guide. New activities can be added by the group as required.
4. In plenary, try to distinguish the boundaries between the roles of different groups.
5. Once the participants have completed the exercise as a group, ask them for their reflections on the exercise. Are there any gaps in defining roles and responsibilities?

Summing up (10 mins)

6. Conclude the session with key messages.

Table 4: Who does what in water resources management?

	Communities	DRD	IWUMD	Other
Hydrometric monitoring				
Rainfall				
Meteorology				
River flows				
Spring and stream flows				
Groundwater levels				
Monitoring Abstractions				
Water Quality Monitoring				
Water allocation				
Prioritising water use				
Bargaining between water user				
Allocation (Sharing)				
Water Rules and Laws				
Setting rules and laws (Regulation)				
Day-to day water management				
Resolving water-related disputes				
Infrastructure				

Service delivery – domestic water supply				
Service delivery – irrigation water supply				
Minor operation and maintenance				
Major operation and maintenance				
Finance				
Financing Capital Expenditure				
Financing recurrent cost				
Water scarcity or flood response				
Monitoring domestic water supply				
Monitoring productive water supply				

Session Plan 10: From local level to basin wide

Overview

This session helps to identify what arrangements need to be in place if water resources management activities are to transition from village-level, to multi-village and river basin scale.

Session	**From local level to basin wide**
Purpose	To identify different stages of development for establishing and expanding water resources management activities.
Key learning	• The importance of staring small and starting something • Working and planning in an incremental manner • The resources an competencies required to upscale water resources management activities
Time allowed	Welcome (5 min) Introduction (10 min) Discussion (60 min) Summing up (5 min)
Materials	• Note book and pen • Flip chart • Marker pens • Printed handout
Methodologies	• Groupwork and discussion
Session outline	• Classroom based

Facilitation note 10

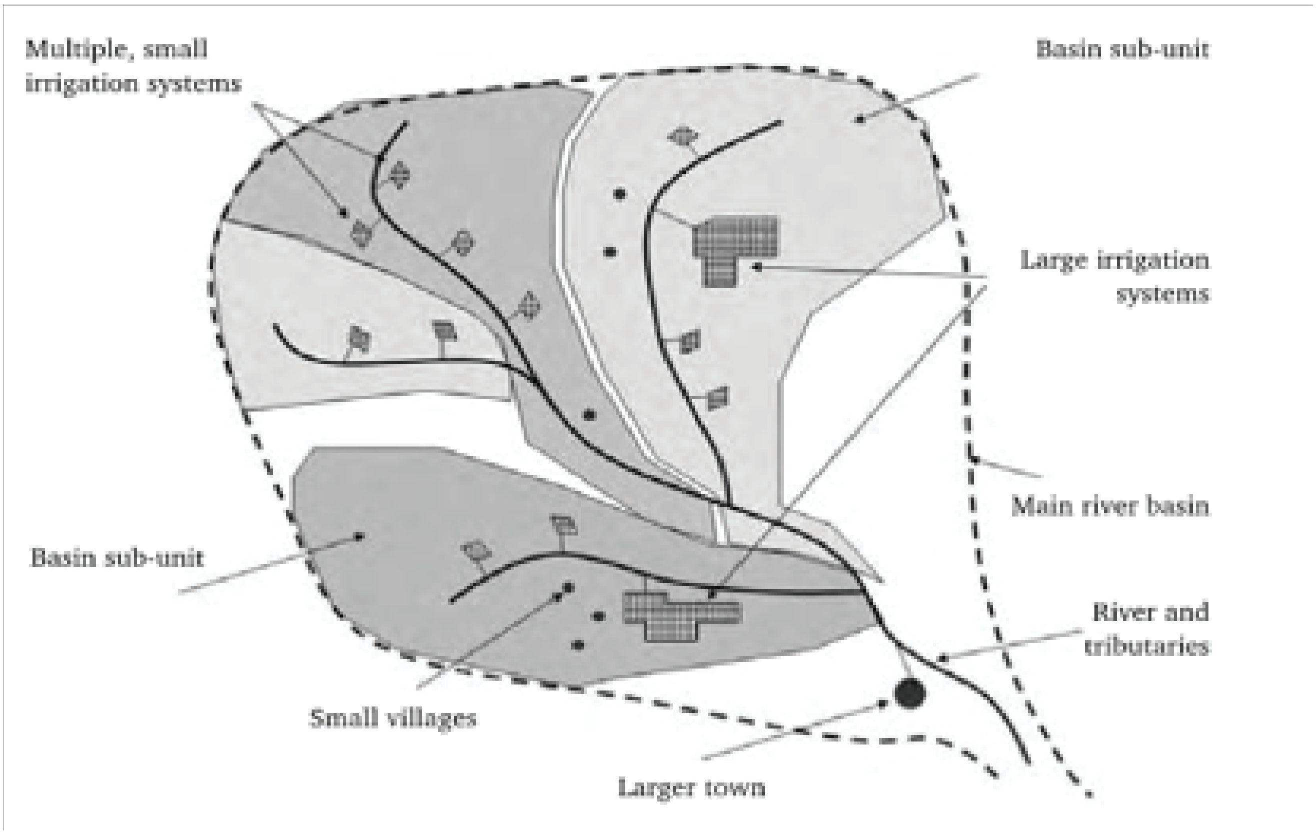
Welcome (5 mins)

1. Thank each participant for attending the training session and record their names and job titles on an attendance sheet.

Introduction (10 min)

2. Start the session, tell the participants we are going to think about the different transitions for up-scaling water resources management from village, to multi-village and river basin scale (Figure 10). Explain that no-one is expected to be an expert and this is chance to discuss the issues.
3. Figure 10 can be shared as a handout and will help the group to visualise these transitions. The facilitator should spend a few minutes explaining this handout.

Figure 10: Sub dividing river basins into smaller management units (source Lankford and Hepworth 2010)



Issues to consider

- How will monitoring sites need to evolve?
- What additional resources will be required for processing monitoring data?
- How will the role of local communities evolve, between upstream and downstream communities?

- What external support and assistance will they require?
- What national policies and strategies need to be in place?

Discussion (60 min)

4. In the first phase we are focussing on working at village level. This means water resources management may be confined to individual villages and the focus is on supporting communities to monitor and manage their water resources with external support from DRD and IWUMD. Explain that typically this may focus on efficient irrigation practices and solving real water management problems that people experience.
5. On 1 sheet of flip chart paper ask participants to write down what the water resources management activities may look like at village level. Identify tasks that will be completed by communities, DRD and IWUMD. Give them 15 mins to complete the exercise.
6. Next, in Phase 2 ask the group (s) to write down how they think activities would evolve if they were working with multiple-villages (upstream and downstream users) that are sharing water resources. Ask how would the WRM system need to evolve and what additional resources may be required. Allocate 15 mins once more for this exercise. Responses can be written on a new sheet of flip chart paper.
7. In the third phase ask the group(s) how the system would evolve once more if activities were up-scaled to river basin scale. Give the group 15 mins and provide a third sheet of flip chart paper for each group.
8. After this third phase ask each group to select one person to provide feedback – 5 min per group.

Summing up (5 min)

9. Summarise the key issues raised by the group and recap on some of the key issues to consider.

Annex A: Power Point Presentation slides:
An introduction to water resources management

INSERT FINAL HANDOUT SLIDES HERE

Summary

- Rakhine State is well-watered, typically receiving in excess of 4500mm (192 inches) rainfall each year during the period May to October.
- However, this should not give cause for complacency, as water resources face many pressures.
- Problems include a long dry period when there is limited or no rainfall, population growth, increased water demands, deforestation, land degradation and increased climatic (rainfall) variability.

People have concerns about their water resources

"Rainfall patterns are changing...less predictable"

"Some water points are seasonal and low yielding"

"More wells experience sea water intrusion"

"Population growth and demographic change"

"We experience water quality problems – such as high iron content"

"Deforestation is reducing our spring flows"

"No water management systems exist in our village"

Our observations

- The policy environment in Myanmar, generally focuses on providing water supplies for unserved communities. This is important work...
- ....but, efforts are also required to monitor and manage water resources.
- This is because water supply systems and food security can only be sustained if water (and land) resources are understood and managed well.

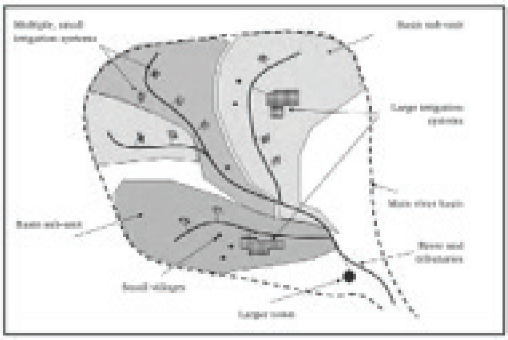
Large scale Water Resources Management

- WRM activities often focus on managing water and land resources at river basin scale.
- National monitoring networks are also established with data collected and analysed by technical government agencies.
- However...these systems take years to establish and require considerable skills, knowledge and resources (financial, equipment and human)

Thinking about Water Resources Management

- Rakhine State does not have a WRM plan or strategy.
- DRD and IWUMD have limited resources to allocate to WRM activities. – our focus is on domestic and productive water supply.
- A starting point for us is to begin monitoring and managing water resources at community level.
- The justification for this is we need to build experience and expertise in DRD and IWUMD, while also addressing real water management problems that people experience.

Dividing river basins into smaller management units

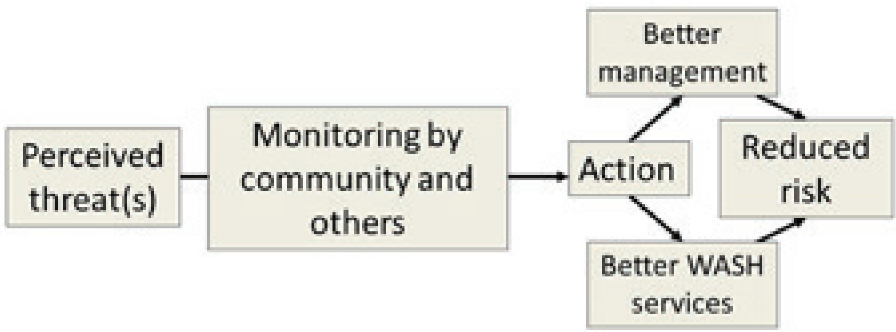


- Dividing the river basin into smaller management units
- Moving from village scale to multi-village scale
- Increase the interaction between different sub-units – as experience and expertise grows

Supporting communities directly

- The pressures on local water resources are difficult to predict accurately.
- Careful monitoring is required so that water management decisions can be taken and operating principles can be established.
- Our aim is to improve "water security" and ensure water is shared equitably.
- Some monitoring can be carried out directly by communities, with external support by DRD and IWUMD.
- This approach is referred to as CBWRM or Community-Based Water Resources Management.

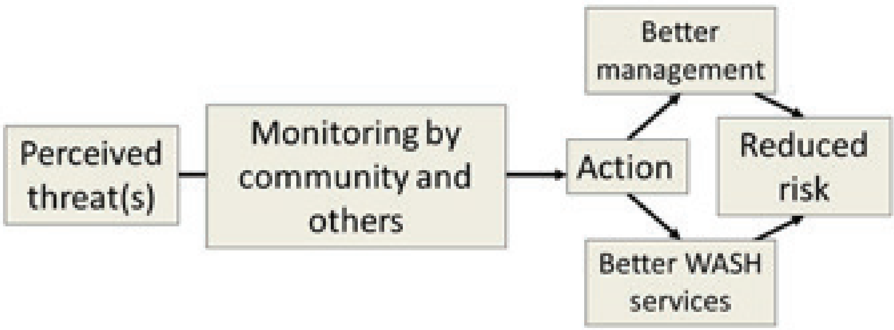
Logic of CBWRM



CBWRM has the following objectives

- Strengthening community operating principles for managing water usage (domestic and productive)
- Acting as an early warning system, alerting communities to water security threats
- Informing the design of water supplies to meet user needs
- Strengthening the voice of communities to call for assistance, when access to water is threatened

Logic of CBWRM



CBWRM has the following objectives

- Strengthening community operating principles for managing water usage (domestic and productive)
- Acting as an early warning system, alerting communities to water security threats
- Informing the design of water supplies to meet user needs
- Strengthening the voice of communities to call for assistance, when access to water is threatened

CBWRM activities consist of the following

- Understanding the key water security problems, and where CBWRM can add value
- Helping communities to understand their collective water needs
- Collectively understanding potential threats to water resources and water supplies
- Monitoring water resources by communities and specialist institutions (DRD, IWUMD)
- Planning and management decisions to mitigate risks
- Corresponding improvements to water supply services

Monitoring may include observations of..

- Rainfall, usually on a daily basis by community volunteers
- Groundwater levels, on a weekly basis, usually carried out by community volunteers
- Spring or stream flows, usually carried out weekly by community volunteers with technical support
- Groundwater levels in tube wells, often monitored hourly using data loggers managed by government agencies
- Water abstractions, carried out by government agencies on a periodic basis
- Water quality surveillance at key locations by government agencies
- River Basin activities (usually upstream) by technical agencies using remote sensing

Management decisions may include..

- Enforcing protection of water sources, such as springs
- Agreeing to allocations for different water users
- Establishing operating principles for irrigation
- Prioritising water usage during the dry season months
- Follow up improvements in water supply infrastructure


Possible next steps
• Engagement with Government to secure support
• Securing funding from external donors
• Developing implementation plan
• Procuring equipment through Rakhine Winter Crops Project
• Training and Capacity Building for DRD and IWUMD
• DRD and IWUMD training farmers and communities

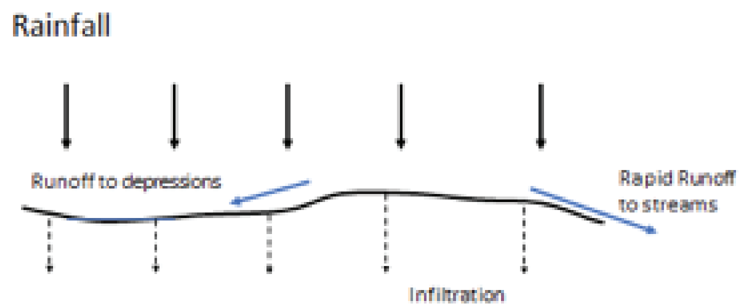
Annex B: PowerPoint Presentation slides: The water balance

Session Plan 2: The Water Balance and Water Security

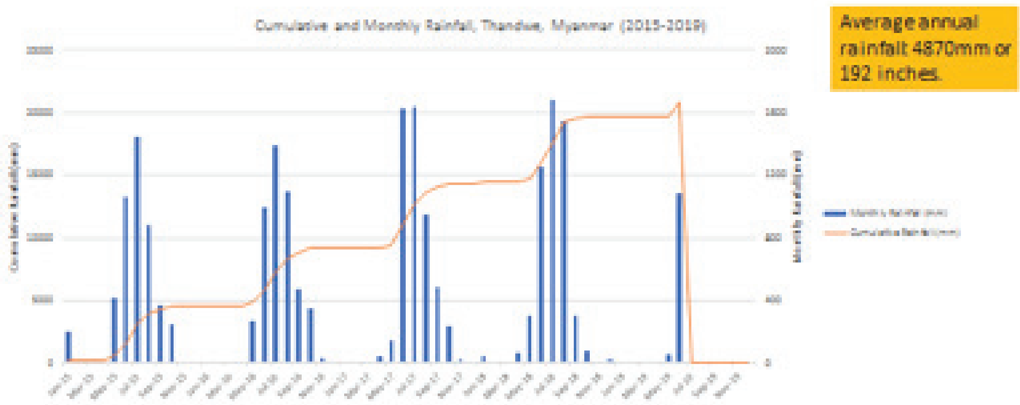
Rakhine Winter Crops Project
Rakhine State, Myanmar

The water balance

When rain falls ... where does it go?

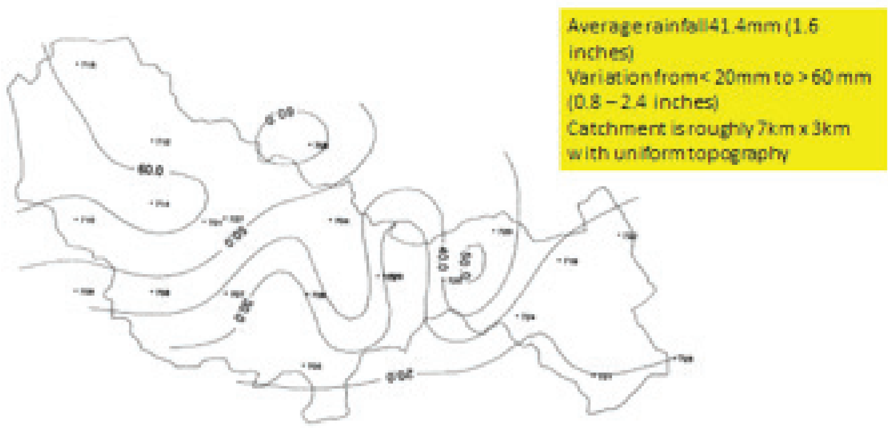


Thandwe Rainfall: 2015-2019



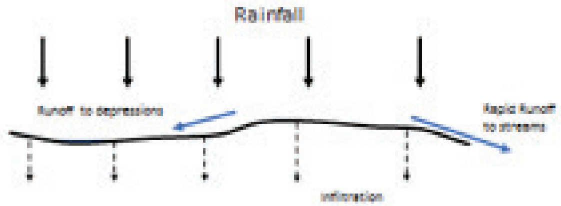
Daily rainfall varies greatly over short distances

[Walnut Creek watershed, Iowa, 22 rain gauges, 16 June 1993, Hatfield et al 1999]



What factors determine the division between (rapid) runoff and infiltration?

- The properties of the land surface
  - Soil texture
  - Soil structure
- Rainfall intensity
- (Slope)



Other factors that determine the division between (rapid) runoff and infiltration

- **Soil structure, root channels, other openings**
  - More vegetation generally encourages more infiltration.
  - Bare soil often leads to more runoff.
- **Rainfall intensity (*rate* of rainfall)**
  - High intensity exceeds ability of soil to receive water, so we get runoff.
  - Low intensity is more conducive to infiltration.

Soil texture and infiltration

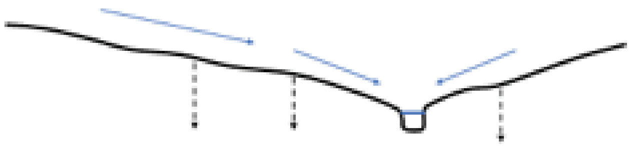
- **Soils which are rich in clay**
  - Low infiltration
  - High runoff
  - [exception: cracking clays]
- **Soils which are sandy / silty**
  - High infiltration
  - Low runoff
  - [exception: soils which develop *crusts*]

Other factors that determine the division between (rapid) runoff and infiltration

- **Soil structure, root channels, other openings**
  - More vegetation generally encourages more infiltration.
  - Bare soil often leads to more runoff.
- **Rainfall intensity (*rate* of rainfall)**
  - High intensity exceeds ability of soil to receive water, so we get runoff.
  - Low intensity is more conducive to infiltration.

What happens to rainfall that runs off the land as surface runoff?

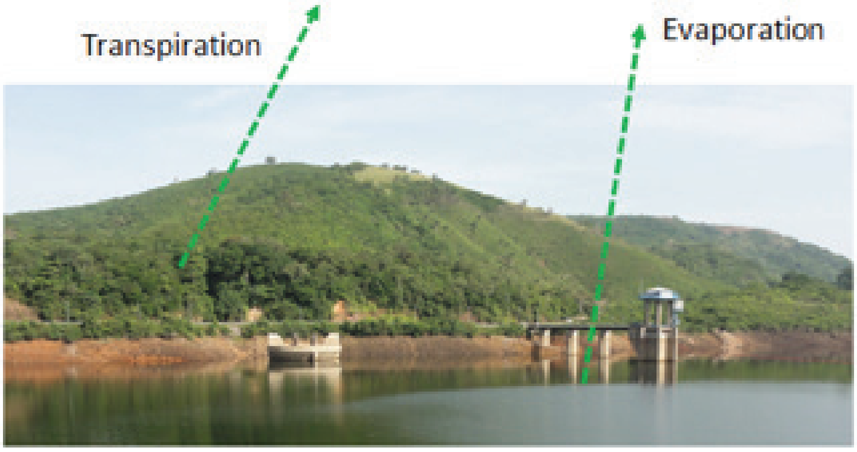
- Some finds its way to streams and rivers.
- Some passes over soil which allows it to infiltrate.



What happens to rainfall which is held in surface depressions, or which infiltrates?

- Some *evaporates* (from bare soil or from depression storage).
- Water in the soil can be taken up by plant roots, and *transpired*.
- Evaporation and transpiration both involve turning liquid water into water vapour.
- Together they are called *evapotranspiration*.

Evapotranspiration



What determines the rate of evapotranspiration?

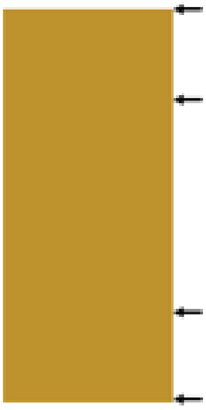
- Temperature
- Solar radiation (sunshine)
- Wind
- Humidity

Potential and actual ET

- Potential ET (ETo) can be estimated from weather data.
- Actual ET (ETa) may be less than ETo if the soil is dry and the crops or vegetation are under stress.
- In other words ETa ≤ ETo.

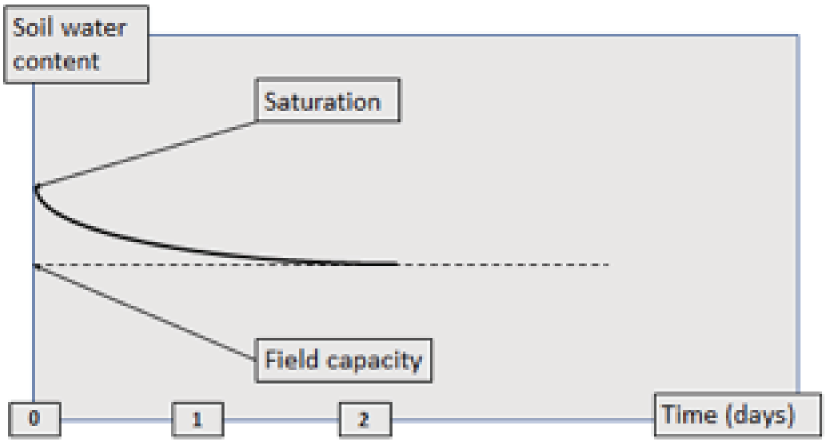
Water is temporarily stored in the soil

Think of the soil like a sponge ...



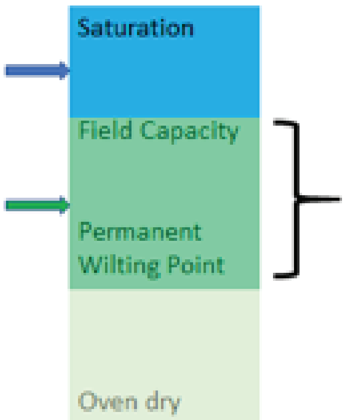
- Maximum water content – *saturation*
- After free drainage – *field capacity*
- When E and T have used up all the water – *permanent wilting point (PWP)*
- Completely dry – *oven dry.*

Following heavy rain…

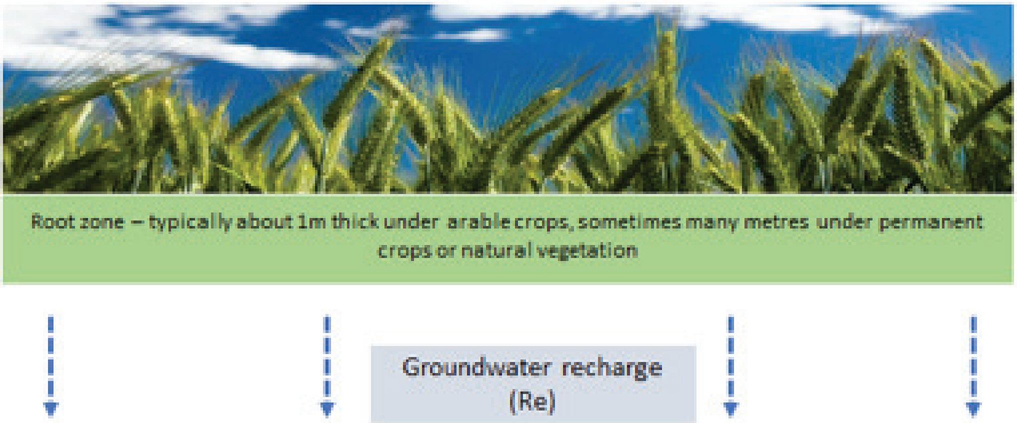


Water holding capacity of soils

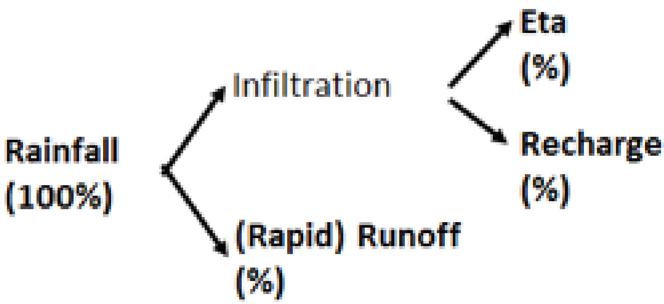
- Water temporarily held above FC can recharge the groundwater (Re).
- The water held between field capacity (FC) and permanent wilting point (PWP) is available to crops and vegetation.



Surplus in excess of field capacity

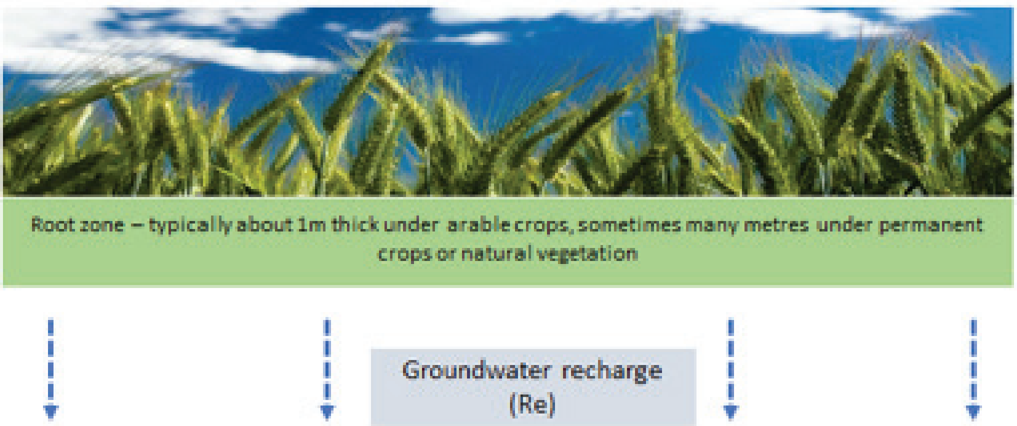


Review of water balance so far..

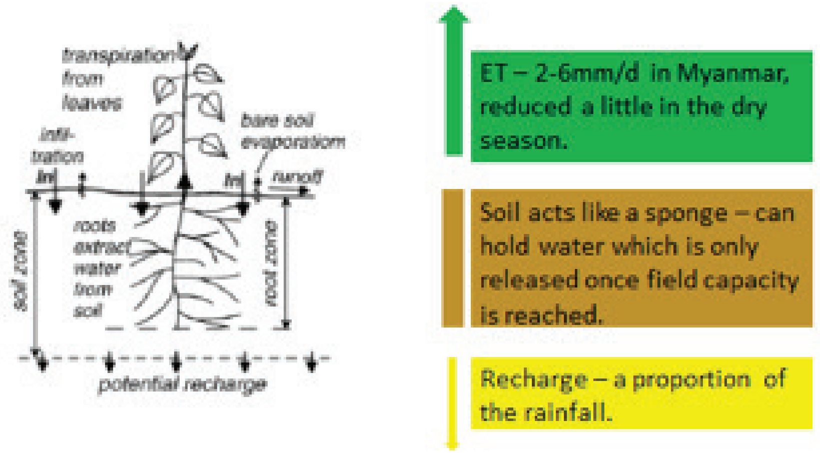


Rainfall = Rapid Runoff + Eta +Recharge

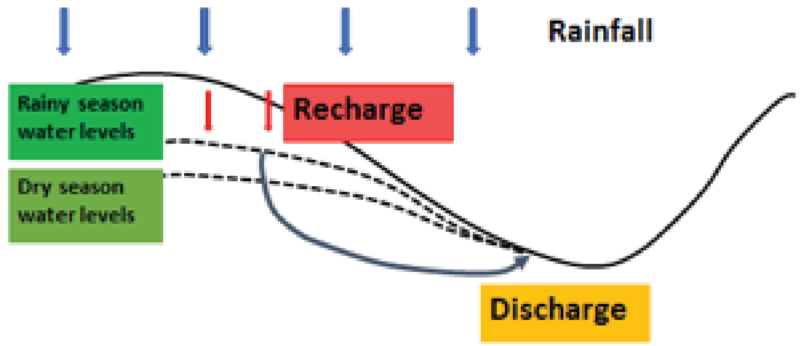
Surplus in excess of field capacity



Groundwater recharge



What happens to recharge?



In the absence of interference by man, groundwater recharge must discharge naturally to low points.

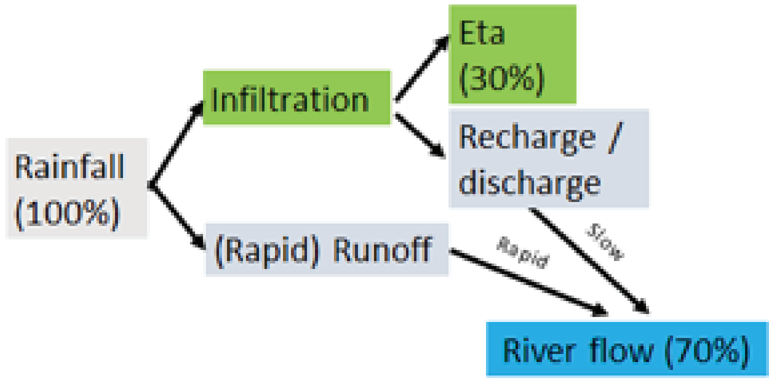
A note on aquifer storage

If the aquifer is thin and has limited storage capacity, it will discharge quickly in the dry season – so it is important

a) to know whether the aquifer has been fully recharged by the end of the rains, and

b) to ensure that wells (Hand Dug Wells and Tube Wells) exploit the full thickness of the aquifer.

So the water balance looks like this..

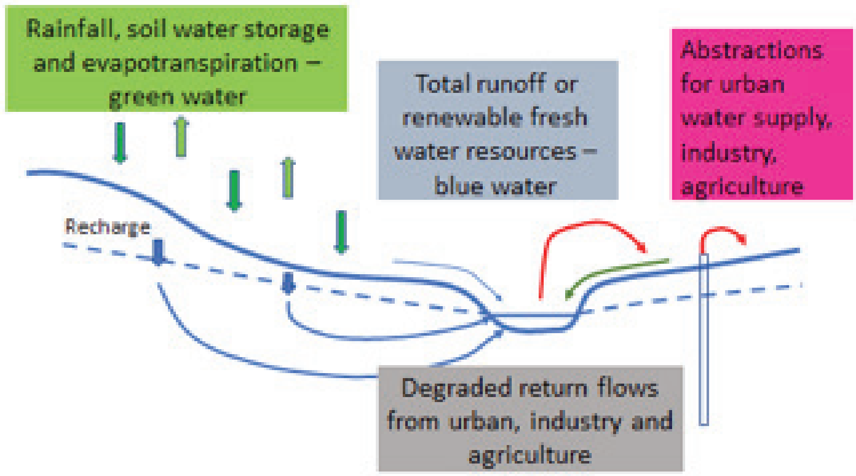


Rainfall = River flow + Eta

4500mm = 3150mm + 1350mm

Rainy season – rapid runoff dominates
Dry season – supported by baseflow

Green water and blue water



Annex C: Monitoring site information sheet

Monitoring Site Number	Photo
Monitoring Location	
GPS Coordinates	
Latitude	
Longitude:	
Well data	
Depth to bottom of well	
Datum height	Date:
Depth to water level	Time:
Groundwater monitoring equipment used	
Raingauge model	
Installation date	
First recording date	
Observer name	
Observer contact details	

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Annex D: Rainfall Data Form

Rainfall recording form

Location	District	Month and Year
Observers name	Title	Telephone

All readings to be recorded on the day they are taken. This will be adjusted to the preceding day during the data cleaning process. The rows below can be used if the measuring cylinder has overflowed to the outer cylinder.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1

Daily rainfall total

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1

One copy is to be retained by the village and one copy to be retained by DRD or IWUMD.	Total rainfall for the month (01st to 31st)	

Annex E: Irrigation Efficiency Quiz (source Knox J.W. and Kay, M. (2007))

As a first step to improving water management, try this short performance assessment with farmers. It is subjective but will help people assess how well they are irrigating and identify opportunities for improving water management.

Q1: Do you have enough water in the dry season to meet your total crop irrigation demand?

1. Don't know
2. Inadequate volume
3. Adequate in an average rainfall year
4. Adequate in all years

Q2: Can you abstract enough water to meet your crop water requirements in a peak month?

1. Don't know
2. Inadequate volume
3. Adequate in an average rainfall year
4. Adequate in all years

Q3: Do you have a strategy for managing periods of limited water availability?

1. No Plan
2. Limited consideration
3. Some consideration
4. Detailed strategy

Q4: How efficient is your on-farm water storage and distribution system?

1. Don't know
2. OK
3. Good
4. Excellent

Q5: How uniformly does your system apply irrigation water within the field?

1. Don't know
2. Large variations
3. Some variation
4. Only minor variations

Q6: Do you know the rate of water applied (m3/hour) by your system?

1. Don't know
2. Based on external information/recommendations received
3. Measured some time ago
4. Measured routinely

Q7: What is the current physical state of your irrigation system?

1. Don't know
2. Major repairs required
3. Minor repairs required
4. No repairs required

Q8: Do you compare your crop returns (yield) against the volume of water applied?

1. Not measured
2. At individual farm or plot level only
3. Sometimes at field level
4. Routinely at field level

Q9: Do you receive external support to schedule your irrigation practice?

1. No external support provided
2. Some external support
3. External support for all crops

Q10: Do you modify your irrigation in response to weather forecasts?

1. No
2. Sometimes (irregular)
3. Often
4. Always

Q11: Do you modify your irrigation in response to measured water availability?

1. No
2. Sometimes (irregular)
3. Often
4. Always

Q12: What is the quality of water you use for irrigation?

1. Don't know
2. Marginal
3. Satisfactory
4. Good

Q13: Do you think you would save more water by becoming more efficient?

1. Yes definitely
2. Maybe
3. Don't know
4. No

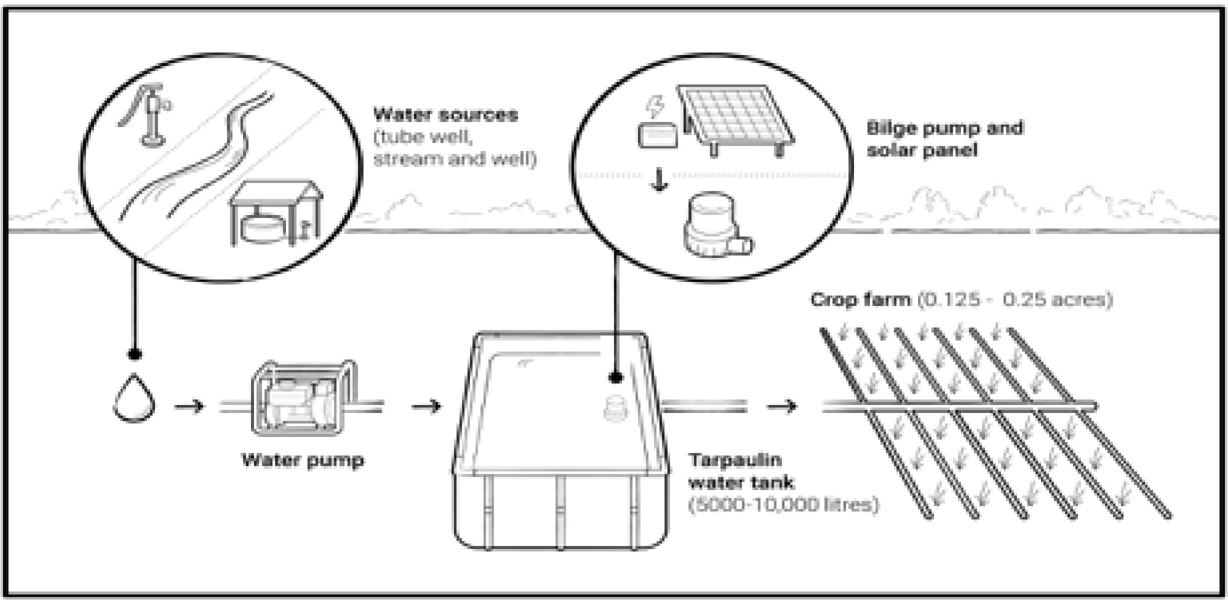
Scoring

Now add up the scores of each participant to assess the opportunity to improve irrigation efficiency and water management.

0-17 Major; 18-34 Moderate; 35-51 Minor

If the scores are low then revisit the questionnaire to see where people think improvements can be made.

Annex F: Baker Irrigation System



Annex G: Indicative equipment list

The following list is an indicative equipment list for three DRD Township offices (Thandwe, Toungap and Gwa) and an example for six village level monitoring sites.

Equipment	Unit cost ($)	Quantity	Indicative cost ($)
Delaqua Water Quality Test Kit	$1800	3	5400
Dip meter (100 feet)	525.00	3	1575.00
Rugged Troll Level Logger (100feet)	595.00	3	1785.00
Rugged Troll Baro logger (For use with level logger)	420.00	3	1260.00
Suspension wire (150 feet)	142.00	1	142.00
Programming cable for level loggers	695.00	1	695.00
Raingauge	120.00	6	720.00
Pocket dipper	60.00	6	360.00
v-notch weir	150.00	3	450.00
Construction materials and costs local	500.00	Lump sum	500.00

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Acknowledgements

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