TRAINING PACKAGE ON BIOPHYSICAL SOIL AND WATER CONSERVATION MEASURES ON HILLSIDE/DEGRADED LAND

PART FOUR: TECHNICAL MANUAL ON MOISTURE HARVESTING STRUCTURES

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Table of Contents

List of Acronyms

CBPWSD	Community Based Participatory Watershed Development
Cm	Cent meter
EB	Eyebrow basin
Ha	Hectare
Km	Kilo meter
M	Meter
mm	millimetres
M^3	Cubic meter
PD	Persons Day
sq.ft	Square feet

MODULE 1: MICRO BASIN

1.1Concept

Description of a micro basin

Micro basins are small circular and stone faced structure for tree planting. Micro basins have sizes according to the requirement to conserve water. They can be small in moist and large in dry agro climatic zones.

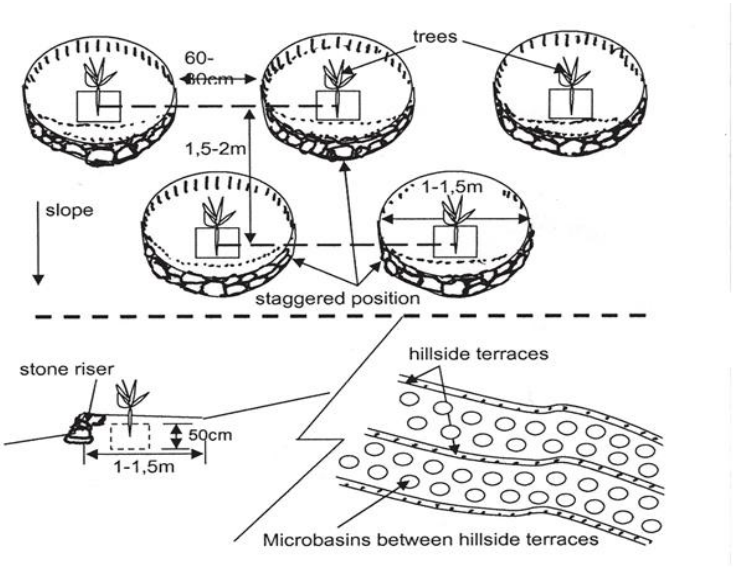


Figure 1: Micro- basin along the contours (CBPWSD guideline, 2005)

Purpose of constructing micro basin

Micro basin has a good potential to improve degraded and steep hillsides - mostly for area closure and multipurpose trees and fodder trees plantations. When combined with sound moisture conservation trenches and proper management, it will contribute to watershed rehabilitation, biomass production and recharging of water tables. Micro basin also have multiple effects in moist areas, which they provide a small platform for tree planting in dry areas and they are used to harvest water from a larger area with 3-10 m diameter on gentle slopes, sometimes with additional water collection ditches.

Time to construct micro basin

Micro-basins are mostly constructed during the dry season or after short rainy season for hard soil.

Suitability and agro-ecology

Micro basins are suitable for medium and slightly low rainfall areas, stony areas and shallow soils. Based upon experience they are not very effective in low rainfall areas where trenches and eyebrows are preferred. It is applicable in steep and degraded hillsides maximum slope 50% and for community closures. Micro-Basins need to be often combined with other measures such as hillside terraces, stone bunds, trenches, etc. It can also be applied inside large gully areas for tree planting.

1.2 Design, Layout and Construction of Micro Basin

1.2.1 Technical standards and Design steps

The minimum technical standard for micro basins is generally determined by the extra water required by the plant. Considering the water requirement of various plant species and elements of hydrology from different areas, agreement is made with the following standards and specifications of a micro

basin. It has a minimum 1 metre and maximum 1.5 metre diameter. Micro basins' also have stone riser of 0.2 metre foundation and 0.2-0.4 cm height above ground based on slopes. The size of micro basins' plantation pit is 40 cm diameter by 50 cm depth.

It is a prerequisite to know where to start the first line and the spacing between micro basins along and between the rows. The spacing is determined by the ratio of catchment to cultivated areas. the spacing between structure along and between rows are mainly depend on the objective of the plantation and the type of tree species to be planted, as well as, the number of structure to be constructed is highly depend on the spacing of the structures/ plants. The amount water harvested from a micro basin /micro-catchment should satisfy the extra water required by the plant. Accordingly, 3:1 catchment to cultivated area ratio is recommended for micro basins. The number of micro basins to be constructed is calculated using the following formula:

$N= 10{,}000A/4D^2$,
$\frac{C}{CA} = 3:1$
Where:
A= Catchments Area (ha)
D= Diameter of MB (m)
If there is hillside terrace,
$N = (10{,}000A-2m\ (W)*1000L)/4D^2$
W = Width of the trace (ditch + berm + embankment)
L= Length of Hillside Terrace
C is defined as catchments or runoff area depending on the land use system (C:CA= runoff to run on ratio)

Work Norm: 1Person Day /5Micro basin.

Micro basins can be modified and constructed using sods or soil in areas without stones and on maximum of 20% slope and stabilizing with plants. Micro basins can also be modified or improved by construction of water collection ditch in front of the planting pit similar to eyebrow basin. In moisture surplus area, it is recommended that water collection ditch for micro basin has to construct beside the planting pit, in such a way that runoff would slowly get in to the plant through subsurface flow

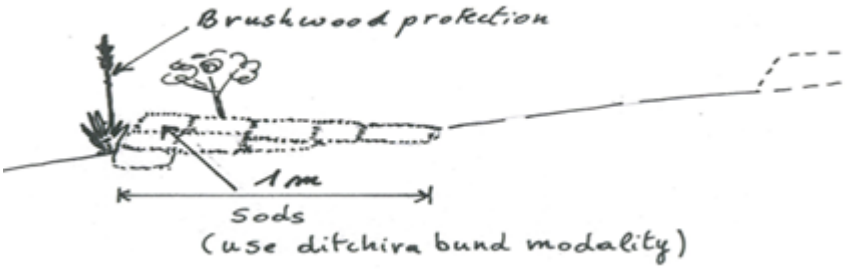


Figure 2: modifications to standard design of micro basin (CBPWSD guideline 2005)

1.2.2 Layout and Construct Steps

Based on the standard design micro basins have to be carefully lined out on the slope with staggered placements for runoff control and proper spacing. Their size should be small in moist (1 m diameter), and large in dry areas. The layouts also have to be undertaken by selecting the appropriate place where to start the first structure which shows steps or procedures to follow.

Layout Procedures:

- Mark contour line at the selected point to start by putting pegs every five meters.
- Put a peg at one point on the contour to use as a centre for the first structure (centre point = F) then put pegs at the ends (E and G).

E ——————————— **F** ——————————— **G**

- Take the center and mark half circle on the lower side of the contour using the radius of the micro basins. This marking is the line where the riser will be placed.
- Start layout and mark locations of each micro basin to be constructed along the first contour line following the spacing.
- Mark also the locations' for micro basins to be constructed in the next raw in staggered/ spread out position and then follow similar steps until the end.
- Repeat the same steps along the contour for the next structures in the same row and considering staggering with the other rows.

N.B. Whenever necessary provide with water collection ditch to the plant in the Micro basins

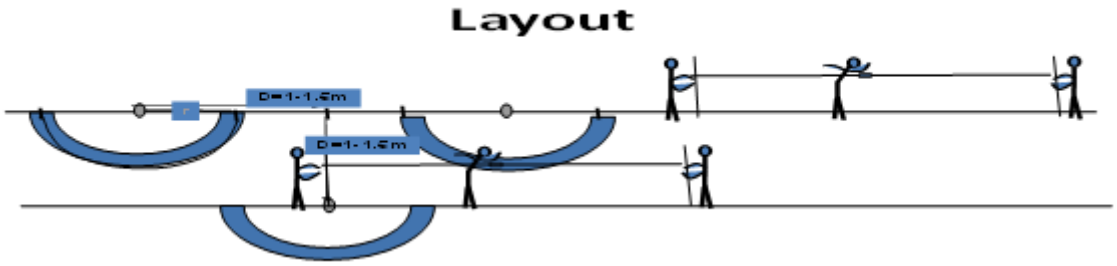


Figure 3: Micro basins layout (CBPWSD guideline, 2005)

The minimum surveying equipments used for layout are A-frame or line level with 5 meters string and two range poles. Tools required for the construction micro basins are crow bar, sledge hammers, shovels, and pick axes.

Construction Steps:

Before starting micro basin construction, experts need to prepare on the following technical issues.

- Assessment of soil depth and slope (5-50% max).
- Based the agreement made on the site selection and technical preparations;
- Soil excavated from cut area and pit is used as sealing material to internal wall of the micro basin.
- Construct in staggered or spread out position between rows and in rather close spacing within row in case of 1 metre diameter micro basins and some overlapping required between rows.

Tools/equipment needed for construction

A-frame or line level with five meters string and two poles, Crow bars, sledge hammers, shovels, and pick axes.

1.3 Management and Maintenance Micro Basin

Besides construction of micro basin based on the required technical standard, micro basin requires regular follow up for maintenance and upgrading until structural stabilization**.** Area closure must be organized by the community. Preparation of follow-up plan for management and maintenance of the structures and planted species is critically important.

To stabilize micro basin structure fodder legumes and shrubs such as Pigeon peas, Tree Lucerne, etc can be planted along the filled area in smaller planting pits instead of a tree. Manuring and mulching

of plantation pits is important to decrease evaporation and enhance growth. Control grazing is a precondition for micro basins as even light trampling will hinder their function. Fodder growing on micro basins should not be uprooted but cut and carried.

1.4 Major issues not to forget and Common mistakes

Don't forget to:

- discuss and agree with farmers on type, spacing and integration with other physical structures as required or needed.
- conduct training on layout and construction and preparation of follow-up plan.
- Pay due attention to management and protection and maintenance of the structure.

Common mistakes:

The following mistakes are often made**:**

- spacing between the micro-basin is not appropriate.
- appropriate standard is not followed. For example often berm is very small,
- foundation depth of the riser is not according to the standards,
- stones placement is not always done appropriate when the riser is constructed,
- Free grazing.

MODULE 2: EYEBROW BASIN

2.1Concept

Description of eyebrow basin

Eyebrow basins are larger semi-circular structure made out of stones and stone faced soil structures constructed along the contours for tree and other species planting. Eyebrow basins replace micro basins in low rainfall areas (Dry, Weyna Dega and Kolla). With little modification on the planting pit and collection ditch orientation, the measure can also be implemented in moisture surplus area for growing plants and ground water recharging.

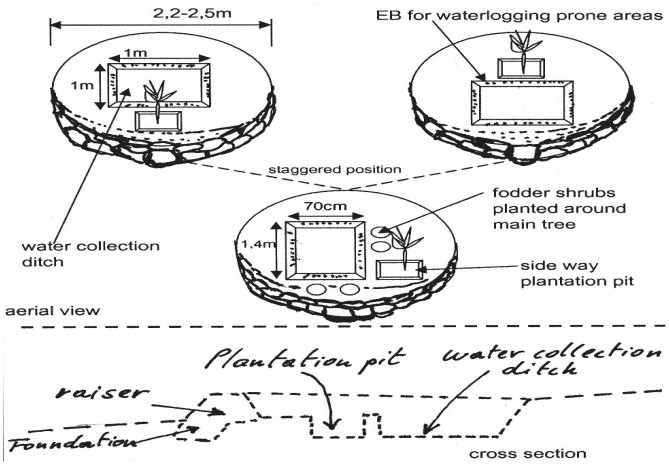


Figure 1: Eyebrow basin with various orientations of the pits& collection ditch (CBPWSD guideline January 2005)

Purpose of constructing eyebrow basin

Eyebrow basin is a good potential/possible to improve degraded and steep hillsides, growing multipurpose tree and fodder trees in closed areas. It can also be used to plant a mix of trees, shrubs and cash crops. Together with other measures, eyebrow basins can significantly improve watershed rehabilitation, biomass production and recharging of water tables. Based upon experience eyebrow basins are also effective in low rainfall areas to grow trees and harvest moisture. Eyebrow basin also helps to control runoff which contributes to recharge of water tables.

Time to construct eyebrow basin

Eyebrow basins are mostly constructed during the dry season or after short rainy season for hard soil.

Suitability and agro-ecology

Apart from other water harvesting measures, eyebrow basin structure is appropriate in degraded areas, mainly in semi-arid and medium rainfall areas with shallow soils and stony soils commonly practiced in dry and moist weyna dega areas for the growth of trees and support for plantations in area closure. Eyebrow basin could be constructed on side of gullies not too steep and where stones are available as well as on steep and stony portions of forest land which can be enriched.

Eyebrow basin is applicable in steep and degraded hillsides where the maximum slopes of the land ranges 5-100%, shallow soils with minimum depth of soil 25 cm and rocky areas. Eyebrow basin can be combined with other measures such as hillside terraces, stone bunds, and trenches based upon soil, slope and stoniness.

The spacing is determined by the ratio of catchment to cultivated areas. The amount water harvested from an eyebrow basin /micro-catchment should satisfy the extra water required by the plant. Usually, 2:1- 3:1 catchment to cultivated area ratio is recommended for eyebrow basins.

2.2 Design, Layout and Construction of Eyebrow Basin

2.2.1 Technical standards and design steps

Eyebrow basin has size: 2.2-2.5 m diameter; and a solid and well constructed stone riser (or stabilized by brushwood or life fence):

- With 0.2 m depth of the foundation, and height 0.4-0.6 m(based on slops) stone riser sealed with soil excavated from water collection area.
- Water collection area: dug behind the plantation pit: 1 m width x 1 m length by 20-25 cm depth (lower side); Plantation pit (s) of 50cm depth x 40cm diameter dug between riser and water collection area.
- Water collection ditch can be placed sideways or in front of plantation pits depending on soil type.

The spacing between structure along and between rows are mainly depend on the objective of the plantation and the type of tree species to be planted, as well as, the number of structure to be constructed is highly depend on the spacing of the structures/ plants.

The number of eyebrow basins to be constructed is calculated using the following formula:

$$N=\frac{A*10,000}{4D^2}$$

Where,

N= Number of eyebrow bassins in a given catchments

A= Catchments area (ha),

D= Diameter of eyebrow bassin (m)

$\frac{C}{CA}$ = 3:1

W = Width of the trace (ditch + berm + Embankment)

If there is hillside terrace,

$N = A*10,000- (W*L*100)$

$$N=\frac{A*10,000-2000m*L}{4D2}$$

Where, L= the length of hillside terrace (km); C is defined catchments or runoff area depending on the land use system (C:CA= runoff to run on ratio).

The number of person per day required for construction of eye brow basins is calculated using this formula. Work Norm: 2 eyebrows per day.

Modification to Standard

Modification of eyebrow basin in different soil type and for different plant species can be done by changing the position of the planting pit around the water collection ditch. The standard eyebrow basin has planting pit at the lower side of the water collecting ditch as in the figure below. However, In place where there is excess water and expected to cause water logging at the lower side of the ditch, the planting pit will be taken to the sides as in the figure 3 below. In this case the dimension of the water collecting ditch is changed so that the space at the side will accommodate the planting pit and at the same time the overall volume of the ditch and the diameter of the eyebrow basin remain the same.

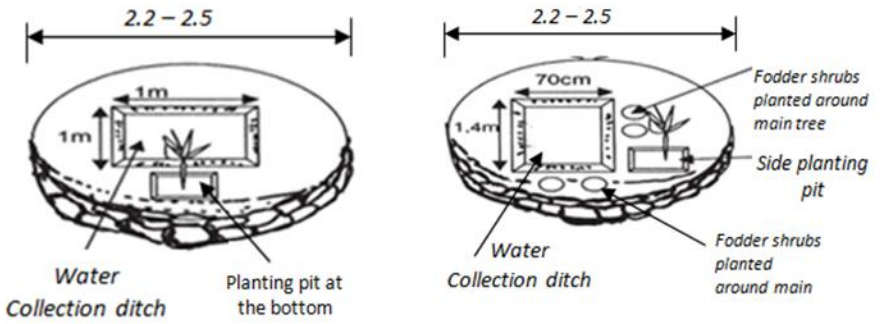


Figure 2: Modification in Eyebrow basin (CBPWSD Guideline January 2005)

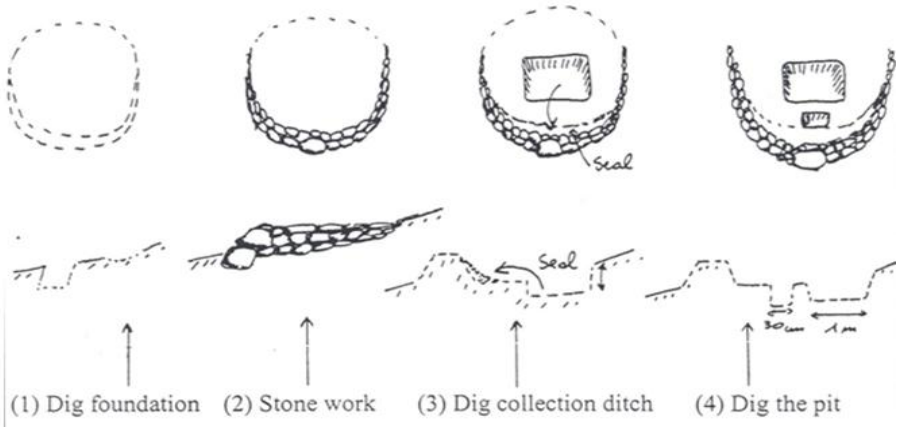


Figure 3: Eyebrow basin design and construction (CBPWSD Guideline January 2005)

2.2.2 Layout and construction steps

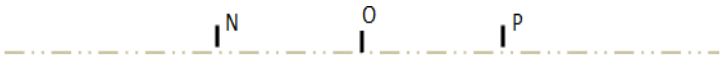
Before conducting the layout, it is a prerequisite to know where to start the first line. Determining spacing between eye brow basins along and between the rows is important in eye brow basin construction. However, this computation requires calculation of extra water requirement of specific plant. Thus it is easier to use the design eye brow diameter as spacing. The layout of the eyebrow basin is undertaken using water level, with five meters string and two range poles.

Accordingly, to layout the first line use line level, mark contour line at place where select the appropriate to start the first structure and follow the following procedures.

Lay out procedures for eyebrow basin:

Select the appropriate place to start the first structure and follow the following steps;

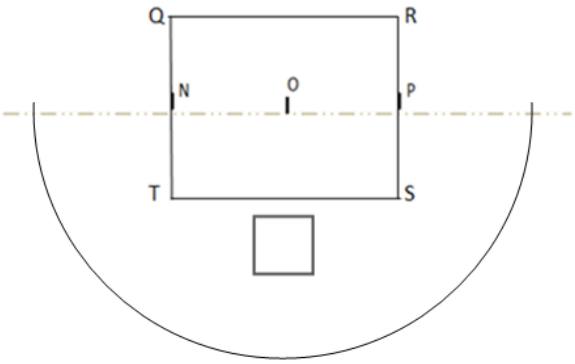
- Mark contour line at the selected point to start by putting pegs every 5 meters;
- Put a peg at one point on the contour where to start the first structure and use this point as a centre for the first structure; say “O”;
- At point “O” measure half the length of the water collecting ditch to both direction on the contour and put pegs on the ends; (N,P)



- Measure half the width of water collecting ditch at “N” and “P” perpendicular to the contour and put pegs at all 4 corners; (Q, R, S, T) is then the water collecting ditch.

- On the lower side of the ditch mark plantation pit according to the sppecies requirement leaving the recommended berm size between the ditch and the pit as shown on the next figure;

- Taking the centre “O” again mark half circle on the lower side of the contour using the design radius of the eyebrow basin. This marking is the line where the riser will be placed; the final result looks like the figure below;



Now complete the lay out over the whole area by repeating the above steps. The spacing between the centers of the eyebrow basins within the row and between the rows is 2 times of its diameter for 3:1 catchment to cultivated area (C:CA) ratio;
the over all lay out looks like the figure below;

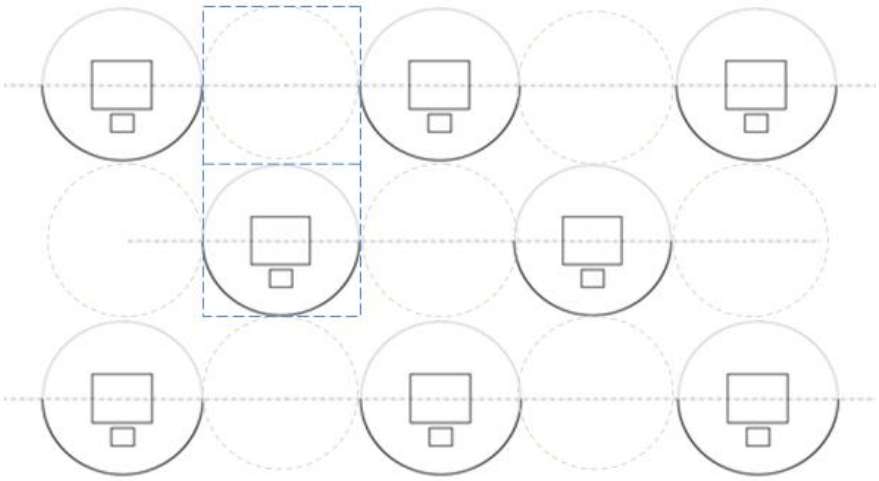


Figure 4: Eyebrow basin lay out with C: CA ratio 3:1(Shiferaw, GIZ SLM Oromia)

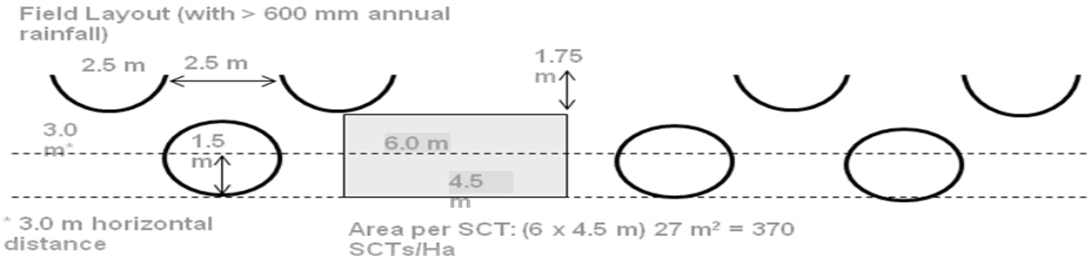


Figure 5: View of eyebrow basins layout (CBPWSD guideline January 2005)

NB. While laying out such structures preparing simple wooden or iron bar framed according to pre determined design standards that can make easier and time saving.

Construction Steps:
Estimating the quantity per eyebrow structures per given plot of land is important to plan the target. After knowing the quantity per given plot of land, manpower required to construct the structures is calculated by multiplying with the norm per unit of structure. The norm for eyebrow basin is two eye brow basin structure can be constructed per person per day. Accordingly, eyebrow basins are constructed using sods and stabilized with plants up to 20% slope.

(1) Construction start by digging a foundation of the riser about 20cm deep x 30cm wide at its lower point and decreasing uphill
(2) Place large stones in the center of the foundation for maximum stability.
(3) Dug Water collection pit behind (or side of) plantation pit: 1 m width x 1 m length x 20-25 cm depth (lower side). Depth and size of water collection area may change based on available soil depth.
(4) Prepare plantation pit 30cm by 30cm by 30cm.

Tools/equipment needed for construction
Tools such as crow bars, sledge hammer, shovels, and pick axes are used for construction of eyebrow basins.

2.3 Management and Maintenance of Eyebrow Basin

Maintenance and management of eyebrow basin structures is very important that it needs to arrange working groups for maintenance. Control grazing on eyebrow basin is a precondition for even light walk on could make to be damaged. Besides, fodder/cash crops growing on eyebrow basin should not be uprooted but cut and carried.

Fodder, legumes, shrubs and cash crops can be planted along the filled area to stabilize the structure plants such as Pigeon peas and Sesbania. Manuring of plantation pits and mulching is required to decrease evaporation and to enhance the growth of plants.

2.4 Major issues not to forget and Common mistakes

Don’t forget to:

- discuss and agree with farmers on type, spacing and integration with other physical structures as required or needed.
- conduct training on layout and construction and preparation of follow-up plan is important.
- pay due attention to management and protection and maintenance of the structure.

Common mistakes:
The following mistakes are often made:

- appropriate spacing is not maintained,
- appropriate standard is not followed. For example often berm is very small,
- foundation depth of the riser is not according to the standards,
- stones placement is not always done appropriate when the riser is constructed.

MODULE 3: HERRING BONE

3.1Concept

Description of herring bone

Herring bones are small structures constructed like a bone of herring fish combined with water collection pit. They are small trapezoidal structures (called also A structures) constructed along the contours on gentle slopes for tree and other species planting. Between the water collection pit and the herring bone structure there are small pit(s) for planting valuable cash crops, shrubs and trees.

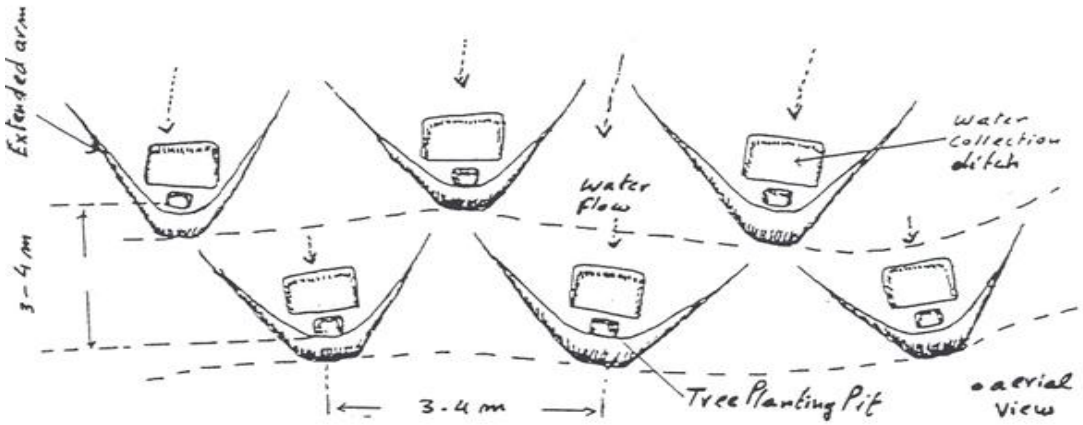


Figure 1: Herring Bones along contours (CBPWSD guideline 2005)

Purpose of constructing herring bone

Herring bones are constructed to collect and store runoff water for growing trees, shrubs and valuable crops**.** A herring bone also helps to control runoff which contributes to recharge of water tables.

Time to construct herring bone

Herringbone has to be constructed during the dry season. For hard soils, it is easier to dig the herring bones after short rainy season.

Suitability and agro-ecology

It is applicable in gentle slopes less than five percent and where the layer of the soils is at least 50cm deep. Besides it could be applicable on degraded lands and gullies. It is also applicable with portions of gentle slopes on small plateaus where soil is not too hard and rocky or lower sections of community closures areas. Herring bone is mostly recommended on gentle slope for fruit tree plantation, or cash crops, not for tree seedling.

It is appropriate to make the herring bones structures around homesteads for valuable trees and cash crops. Also herring bones are appropriate in abandoned lands to restore or re-establish growing of trees. Mostly suitable in semi-arid and medium rainfall areas for medium textured and drained soil such as sandy loams and sandy clay loams soils.

3.2 Design, Layout and Construction herring bone

3.2.1 Technical standards and Design steps

The structures are placed 3 m apart (maximum 4meter in very dry places) along the contours and have extended arms conveying water towards the planting area.

A water collection ditch is dug 1m by 1m by 0.3 m depth at lower side behind the planting pit and 40 cm diameter by 50 cm depth. The tips of the extended arms are 2.5-3 meter long. The embankment of the herring bone maximum height down slope is 0.4- 0.5 meter and decreases to 20 cm at the end of the side arms. The spacing between structure along and between rows are mainly depend on the objective of the plantation and the type of tree species to be planted, as well as, the number of structure to be constructed is highly depend on the spacing of the structures/ plants.

The number of herring bone to be constructed in a given area can be calculated using the following formula:

$$N = \frac{A*10{,}000}{21}$$

Where,
N= Number of herring bone in a given catchments
CA= Area of the catchments (ha)
C: CA=1:1
C is defined catchments or runoff area depending on the land use system (C:CA= runoff to run on ratio)

The number of person per day required for construction of herring bone is calculated using this formula. Work Norm: 4 herring bone per person per day**.**

Pits can also be placed sideways to the water collection ditch. One pit can be planted with fodder trees such as Sesbania and the second pit with fruit trees like coffee and other valuable trees.

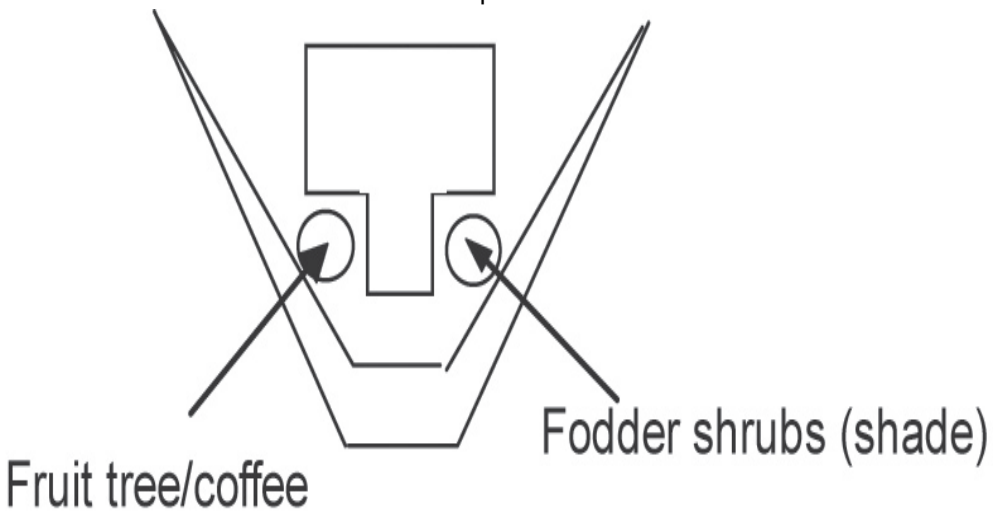


Figure 2: Design Modification double pitting (CBPWSD guideline 2005)

Herring bone for multiple purposes: Similar to the one above, the herring bone can be planted with fodder shrubs mixed with cash crops and a slow growing tree planted behind the water collection pit. Or, Herring bones along the contours planted alternatively with cash crops mixed with fodder plants and herring bones with trees only.

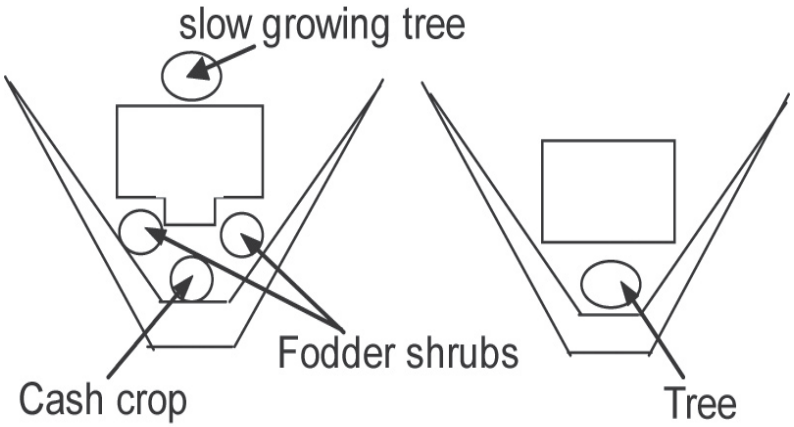


Figure 3: Design Modification more than two pitting (CBPWSD guideline 2005)

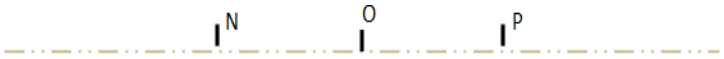
3.2.2 Layout and construction steps

The layout of the herring bones is the main precondition using A frame which can directly provide the shape of the herring bone when laid down at ground level. Besides, water line can be used for marking major contour lines and then proceed with direct assessment by sight and adjusting orientation of herring bone based on micro slopes. Accordingly, select the appropriate place to start the first structure and follow the following steps/procedures.

Layout Procedures:

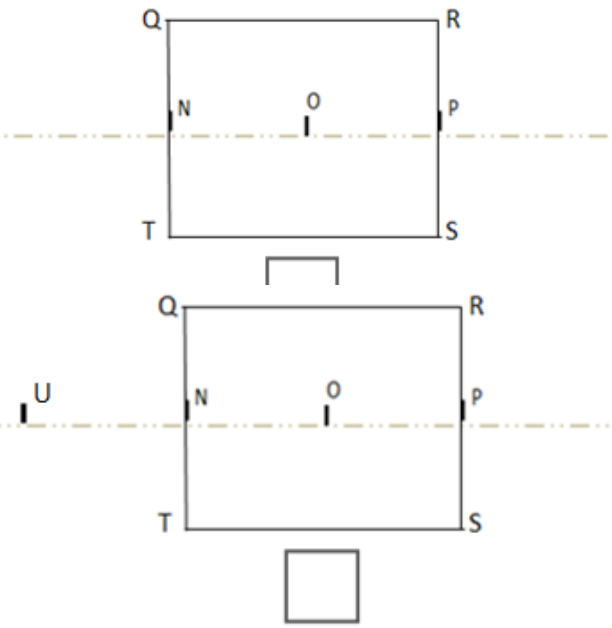
- Mark contour line at the selected point to start by putting pegs every 5 meters;
- Put a peg at one point on the contour where to start the first structure and use this point as a centre for the first structure; say “O”;

- At point “O” it measures half the length of the water collecting ditch to both direction on the contour and then put pegs on the ends; (N and P)



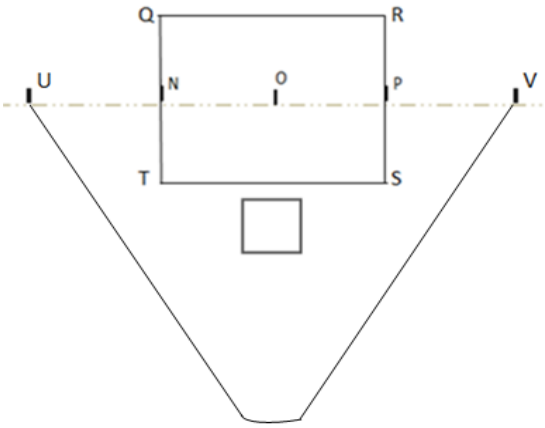
- Measure half the width of Water collecting ditch at “N” and “P” perpendicular to the contour and put pegs at all 4 corners; (Q, R, S, T) is then the water collecting ditch.

- On the lower side of the ditch mark plantation pit according to the sppecies requirement leaving the recommended berm size between the ditch and the pit as shown on the next figure;
- The next step is to lay out the arms of the herring bone. To do so two options among others are as follows:



Option 1: Measure half the length of the herring bone arms from the center point (“O”) to both directions on the contour line and put pegs at the ends; (U, V) – line segment UOV is the base for the arms of the haring bone;

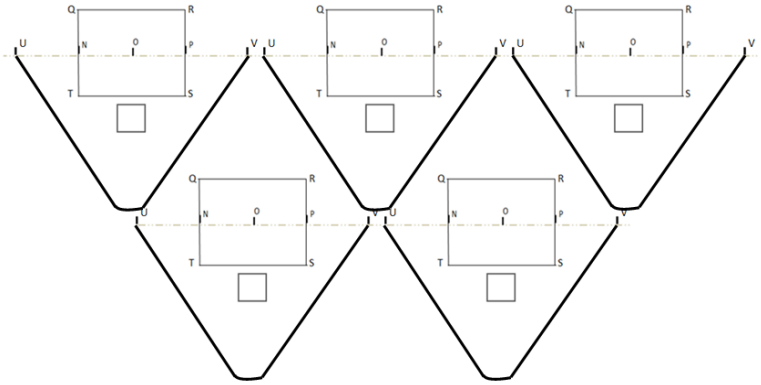
- Now extend a string of length equal to the length of the arms from both “U” and “V” points and find the intersection at the lower side of the contour and put a peg at the point; “W”. This point is then the tip of the herring bone riser commonly named the nose of the herring bone. Avoid the sharp angle of the nose by making a slight curve to put off easy damage. The final result looks like the figure below;



- Now complete the lay out over the whole area by repeating the above steps. The spacing between the rows of the herring bones is equal to the height of a triangle formed by the two arms and baseline of the herring bone for 1:1 catchment to cultivated area (C:CA) ratio. The hegiht can be calculated using pyitagoress theorem i.e $\mathbf{a^2 + b^2 = C^2}$. The over all lay out looks like the figure below;

Option 2: Using an A-frame the same size of the herring bone (3 - 4m large) outer tips level and mark the position of the herring bone.

- Then, rest down to the soil the A-frame and mark the shape of the herring bone by using the shape of the A-frame
- Continue marking more herring bones with your frame adjacently and below the first one. The over all lay out looks like the figure below;



NB. While laying out such structures preparing simple wooden or iron bar framed according to pre determined design standards that can make easier and time saving.

Construction steps:

Before constriction start the excavation of the collection ditch which used for planting pit and embankment building and compaction of the soil undertaken with the following steps.

Construction starts by digging a 30cm x 30cm x 30cm tree planting pit. Then dig the water collection ditch 1m x 1 m x 30 cm deep and behind the pit (15cm tie). Keep some top soil aside for filling the plantation pit. Use the rest of the soils to construct the embankment which it has to be well shaped and compacted. The side of herring bone arms should be well shaped and sufficiently strengthen with stone riser. The soil should also be well compacted.

Tools/ equipment needed for herring bone construction

- A-frame used for layout of the herring bone structure.
- String and meter, shovels and pick axes are used.

3.3 Management and Maintenance of Herring Bone

Arranging working groups for maintenance and sustain the structures is very crucial. It can be maintained by individuals/groups or community. Also it needs the commitment of Keble watershed committee, Keble leaders and communities.

To stabilize herring bone structures plantation or re-vegetation with fodder legumes, shrubs and cash crops is very important. Besides, Plantation of plants such as pigeon peas, tree Lucerne, sesbania along the embankment is considerably helpful for structure stabilization.

3.4 Major issues not to forget and Common mistakes

Don't forget to:

- use A frame for proper layout of the structures,
- carry out appropriate site selection including recommended slope and soil conditions,.
- maintain appropriate compaction level for the arms of side herring bone arms,
- integrate with other soil and water conservation technologies such as stone faced soil bund,
- exclude animals
- carry out appropriate selection of plant species planned to be grown/planted in the structure
- carry out close technical monitoring and undertake maintenance.
- implement cut and carry system for fodder crops growing on herring bones.

Common mistakes:

The following mistakes are often made:

- appropriate layout and technical design is not implemented accordingly,
- allow free grazing on the area of herring bones structures,
- herring bones are constructed on steep slopes and areas with rugged topography,
- stone placement on the riser and soil compaction is not accordingly.

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MODULE 4: MICRO TRENCH

4.1Concept

Description of micro trench

Micro trenches are rectangular and deep pits constructed along the contours. They are large and deep pits constructed along the contours. The main purpose and effects of micro trenches are the same as other moisture harvesting structures. It can support the growth of trees, shrubs, and cash crops.

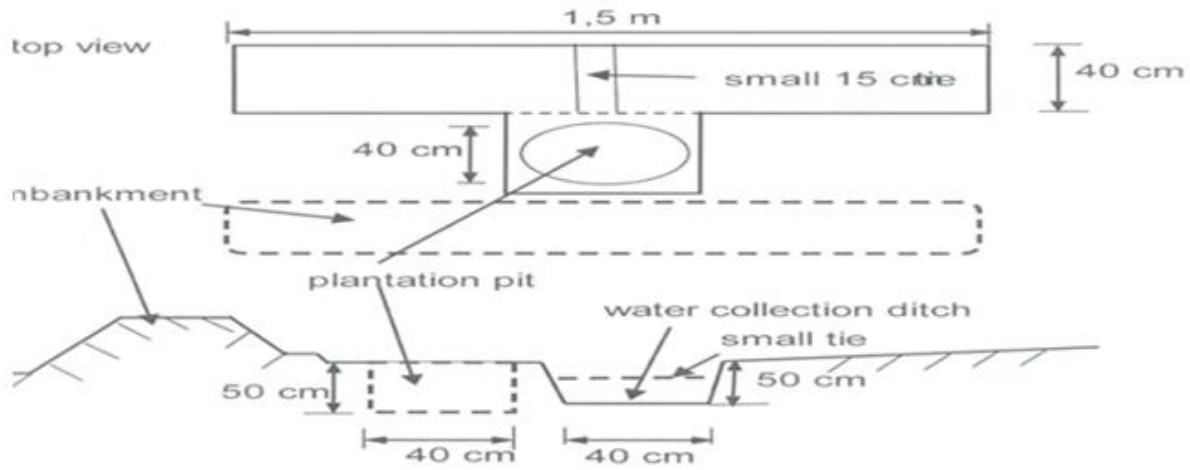

Figure 1: Micro trench (CBPWSD guideline, 2005)

Purpose of constructing micro trench

Micro trenches have good potential to improve degraded areas; they can also construct for enhancing production of trees and homesteads fodder and trees/shrubs. Micro trench harvest less water compared to large trenches (average maximum water holding capacity of each Micro trench is around 0.3m³ of water but allows for denser plantation of lower water demanding trees/plants.

Time to construct micro trench

The micro trenches are constructed after short rainy season, during dry season and immediately after short rainy season for easy of work labour availability and stability.

Suitability and agro-ecology

Micro trenches are suitable mostly in semi-arid and medium rainfall areas (600-900 mm). Micro trenches have introduced recently in Ethiopia, and it has the potential to expand in many areas, including pastoral areas for improving grazing reserves. Micro trenches could be a better option than micro-basins as they can collect and conserve more moisture. It is applicable in a broad range of soils and slopes of less than 30%, on degraded lands, widespread gullies, hillsides, and within homesteads for planting trees and fodder species along fences and backyards. Based upon soil and slope, it can be often combined/mixed with other measures such as larger trenches, soil and stone bunds, and hillside terraces.

4.2 Design, Layout and Construction Micro Trench

4.2.1 Technical standards and Design steps

An average size of the trench is 1.5 meter length by 0.4 meter width by 0.5 meter depth. Except for very permeable soils, trenches are provided with a small and low tie in the middle to regulate water flow (15 cm width). In this type of design trees are not planted in the middle of the trench but in front

of it. The spacing between two micro trenches is 1.5 - 2meter along the slope and 30-50 cm along the contour. The plantation pit is 50cm depth by 40 cm width and it is also possible to make a larger pits.

Micro trench also could be modified and constructed using sods and stabilized with plants. Two trees one for fodder and one for wood can be planted in one or two which 40cm x 40cm x 40cm deep plantation pit (s) in front of the micro-trench.

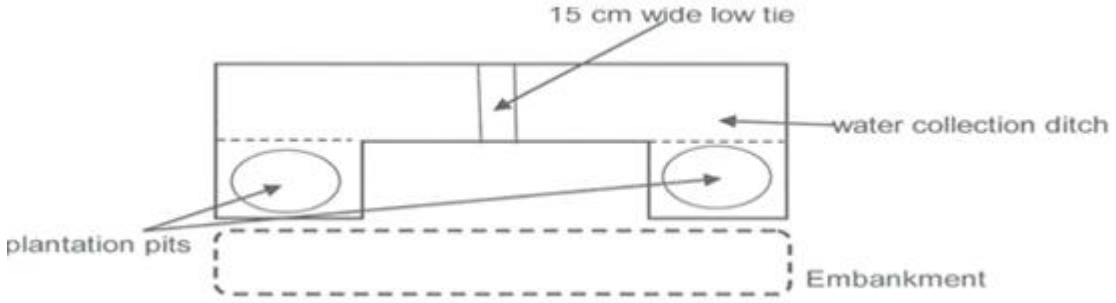

Figure 2: modifications standard design of micro trench two trees can be planted in plantation pits (CBPWSD guideline, 2005)

4.2.2 Layout and construction steps

The layout of the micro trench is undertaken using an A-frame level or the water level hooked to a string linked to range poles placed at five meters distance and orient the micro trenches along the contour line to address possible traverse/pass through/ microscopes. Accordingly, to layout the first line using line level, mark contour line at place where select the appropriate to start the first structure and follow the following procedures.

Layout Procedures:

- Select the appropriate location/place to lay-out the procedure.
- Mark the contour line at the selection point to start.
- Put pegs at every 5 meters on the contour line.
- Based on the design standard, prepare wooden or metallic moulded frame to mark the actual structure on the ground including the tie.
- Repeat or continue the same procedure to lay out structures on the next contour line till the end.
- N.B to mark the structure on the ground using a moulded wooden or metallic make the lay out easier and maintaining the standard.
- After lay out start digging the soil up to 1.5 length metre 0.40 metre and width 0.50 metre.
- Dig the planting pit at the middle of the trenches or immediately at the lower of the trenches depending on the climatic condition; (inside the trench for moisture stress areas, while below the trenches for medium rainfall areas).

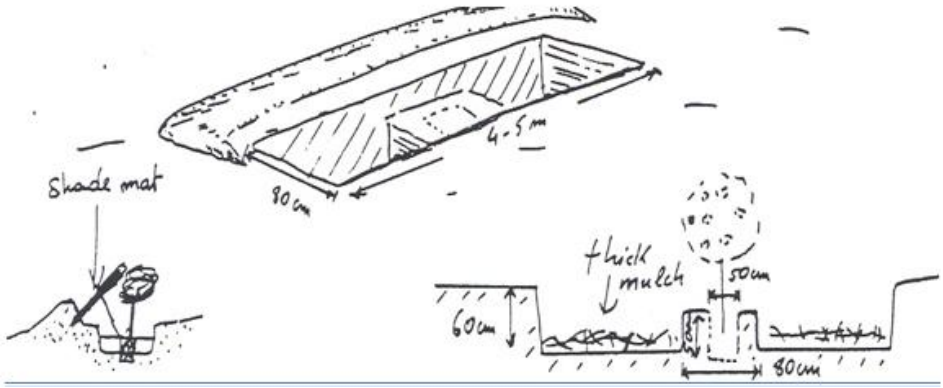

Figure 3: Layout of micro trenches for fruit tree growth (CBPWSD 2005)

Construction Steps:
After layout has completed, dig out the trench up to 25cm depth by 50cm width and 2.53m length**.** Then a 30cm by 30cm pit is dug in the middle of the trench. Deepen the collection ditch around the ties up to the required depth of 50cm. The piled soil of the embankment must be shaped level and well compacted. In general, the construction steps include excavation of soil, embankment, compaction and digging of plantation pit.

Tools/equipment needed:
Tools to be used are crow bars, pick axes and shovels, crow bar, pick axes Shovels.

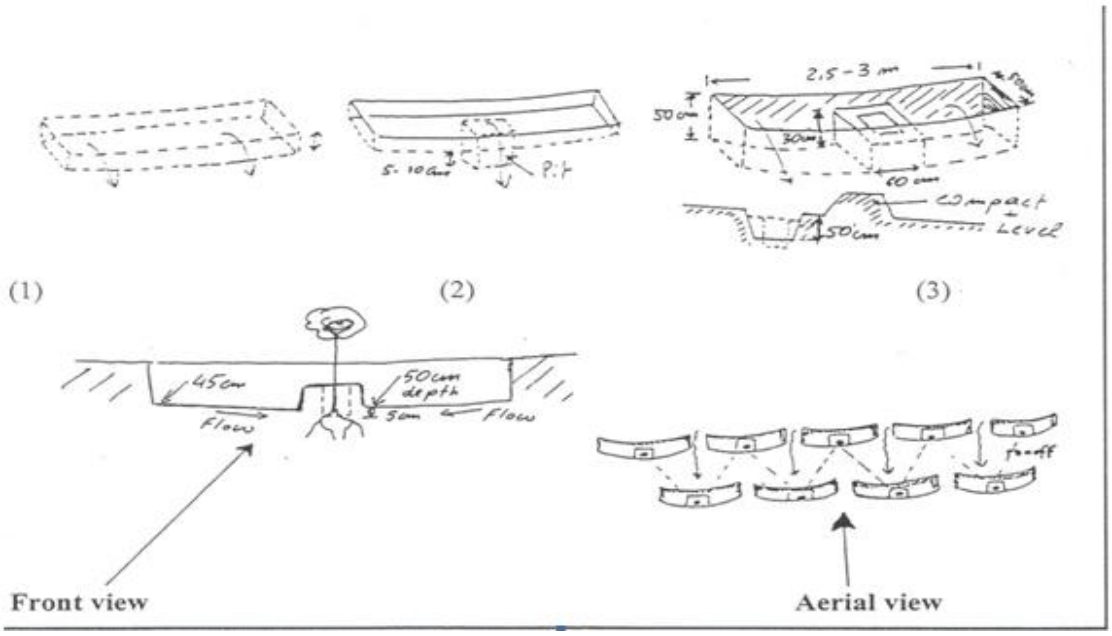

Figure 4: Construction sequence (CBPWD Guideline, 2005)

4.3 Management and Maintenance of Micro Trench

Control grazing is one of the preconditions for micro trenches as trampling of animals will compromise its function and also technical supports for structural maintenance is important by arranging working group and give technical advice how to maintain is important.

Integration with other physical soil management measures mainly help for stabilization of the structure. Fodder legumes, shrubs can be planted along the filled area such as pigeon peas, tree Lucerne, in smaller planting pits instead of a tree is important for stabilization of structures. Besides manuring of plantation pits and mulching decrease evaporation and enhance growth.

4.4 Major issues not to forget and Common mistakes

Don't forget to:

- Integrate micro-trench with larger trenches and other structures
- to protect free grazing,
- implement cut & carry system for fodder crops growing on micro tranches.

Common mistakes:
The common mistakes are often made:

- broken structures during heavy storms are not repaired,, gap filling, patching of tree seedlings, de-siltation and improvement of filled trenches, cut and carry, mulching, are not practiced accordingly,
- training for layout, construction and management/maintenance operations and group formation/consolidation are overlooked.

MODULE 5: WATER COLLECTION TRENCH

5.1Concept

Description of water collection trench

Water collection trenches are large and deep pits constructed along the contours to collect and store runoff water on the spot.

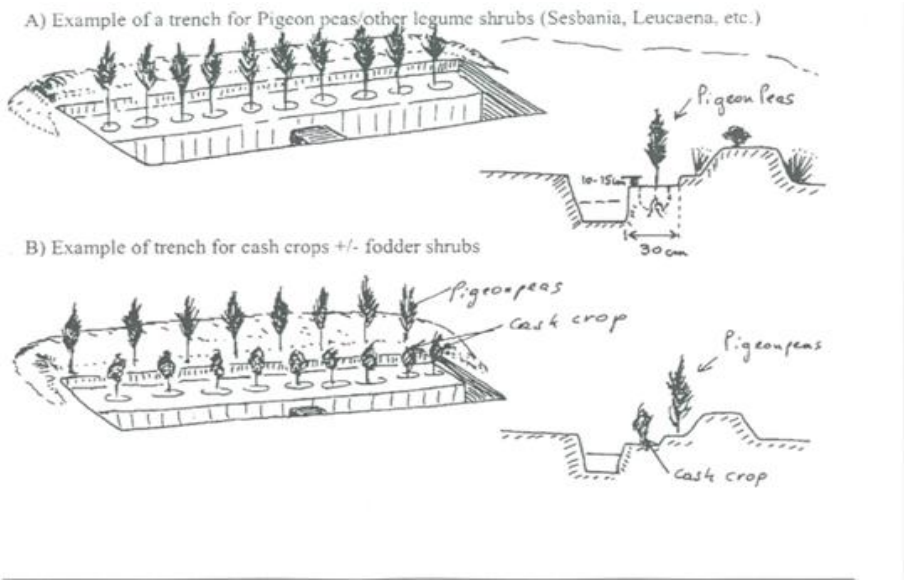

Figure 1: (A and B) trenches used for pigeon peas/ other legumes and cash crop trees (CBPWSD guideline, 2005)

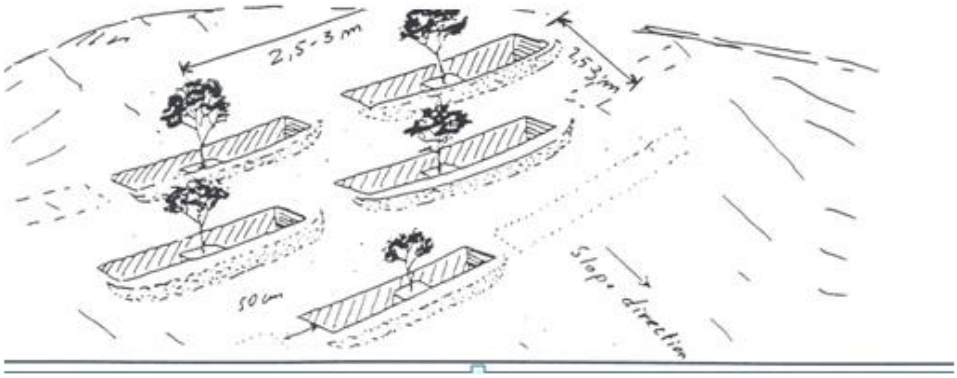

Figure 2 water collection Tranches (CBPWSD guideline, 2005)

Purpose of constructing water collection trench

The main purpose of constructing trenches is to harvest and store runoff for the growth of trees, shrubs, cash crops and grass or various combinations of those species in moisture stressed areas as well as in moisture surplus areas with short raining seasons/months.

Due to structural stability and wide applicability, a trench has multiple benefits:

- protects cultivated fields and gullies located downstream from flood and erosion,
- raises the water table and thereby increases the yield of water sources(spring, river, wells) in the downstream area ,and
- effectively rehabilitate degraded areas integrating/in combination with other biophysical measures.

Time to construct water collection trench
Water collocation trenches are constructed during dry season when the working labour is available. The plantation pit needs to be prepared one month before the rainy season for enabling favourable conditions for plant growth.

Suitability and agro-ecology
The water harvesting structures used for plant growth including trench are primarily meant for implementing/are primarily expected to be constructed/ in moisture deficit areas so as to fill the water requirement gaps of plants. However, experiences from the field have also shown that trenches are also highly suitable in many areas in the highlands/relatively moisture surplus area/ to improve closures and plantations. In pastoral areas, trenches are used to improve grazing reserves, aerial pasture, etc.

It is applicable in all land uses and topography. Trench is used to rehabilitate very steep and degraded hillsides. A water collection trench can be combined with other measures such as hillside terraces, stone bunds, and other moisture harvesting structures based upon soil, slope and stoniness. A water collection trench can also be applied inside large gully areas for tree planting.

5.2 Design, Layout and Construction of Water collection Trench

5.2.1 Technical standards and Design steps
The spacing, standard design and specifications of water collection trenches is determined by the ratio. Recommended ratio between catchment and cultivated area ranges from 4:1 to 6:1... Spacing between trenches is 50cm laterally and 2.5-3m vertically. The size of each trench is commonly 2.5-3 m long and 50cm deep. They are constructed in a staggered position one from another.

The number of water collection trenches to be constructed can be calculated using the following formula.

Work Norm: 3 trenches per 2 Person per day.
N= (10,000A)/16
(Catchments/cropping area C/CA or runoff/run-on area ratio is 2:1)
Where:
A= Catchments Area (ha)
If there is hillside terrace,
N= (10,000A-2000L)/16
L= Length of hillside terrace

Modification to Standard
Designs and specifications of the trench depend on the type of soil, rainfall, and the type and position of trees. A water collection trench can be used to grow one up to three/many plants as possible. Considering the immediate as well as long time benefits, it is important to take advantage of the water harvesting effect of the trench. This can be done by planting fast growing trees and one or two additional slow growing trees that require less water.

A modified design from the previous standards design for water collection trench for growing a tree can be:

- Trench with two trees planted on pits dug in two ties
- Trench with 1 tree planted in a tie & 2 trees on pits dug in front of trench
- Trench with 2 trees planted in two ties & 1 tree planted in front of the trench

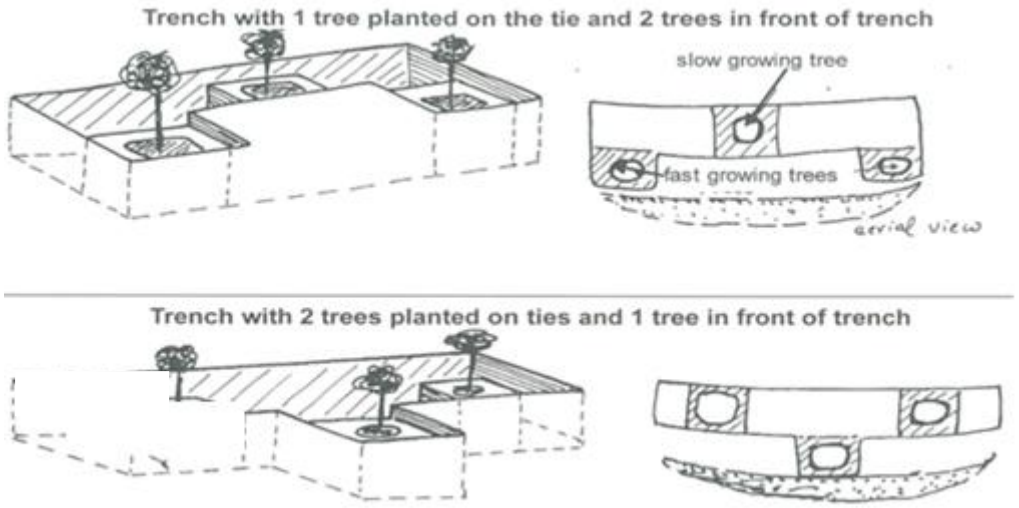

Figure 3: Tranches with 1 and 2 trees planted (CBPWD guideline, 2005)

5.2.2 Layout and Construction steps

It is a prerequisite to know where to start the first line and the spacing between the water collection trenches along and between rows. The spacing is determined by the ratio of catchment to cultivated areas. The amount of water harvested from a water collection trench /micro-catchment should satisfy the extra water required by the plant.

The layout /marking of the place where trenches are constructed starts from the top of the hill or field. It is defined by using an A-frame level or water tube level linked to two poles placed at three meters distance. If both are not available use the normal line level hooked to a string linked to range poles placed at five meters distance.

Using an A-frame/line level the same size of the trench (2.5-3m long) level the two tips of the frame and then mark the shape of the trench. Continue marking more trenches with your frame adjacently and below the first one. The trenches are placed/constructed in a staggered position one from another.

Tools/equipments needed

Tools needed include crow bars, pick axes and shovels.

Construction steps

- Select hillsides or abandoned areas that you wish to restore for growing tree/shrubs or other crops.
- Design of a trench with ties placed up to the ground level and a 50cm x 50cm x 50cm pit is dug between the tie and the berm.
- Prepare a proper lay out of the trenches
- Establish with the soil dug out an embankment at the lower side of the water collection trench.
- Properly mulch the water collection trench and the pit after construction.
- Apply manure or compost to the pit and to the side ditches of the trench one month before the rainy season.
- .Plant suitable grasses on the trench embankment after the first effective rain shower.
- Make the trench soaked with water and fill up with some silt for an entire season.
- After two months from the end of the rainy season cut and mulch the grasses which have grown inside and around the trenches.

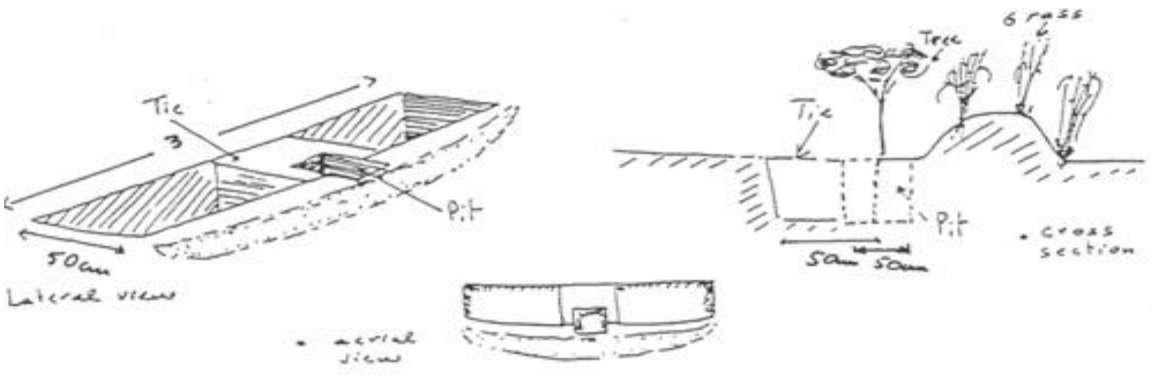

Figure 4: Trench constructions in severe water logging areas (CBPWD guideline, 2005)

5.3 Management and Maintenance of Water Collection Trench

- Compact and restore breached embankments after each rainy season
- De-silt the trench regularly
- Check for dead seedlings or plants and replant or re-sow regularly.

5.4 Major issues not to forget and Common mistakes

Don't forget to:

- integrate water collection trenches with stabilization and soil management practices,
- mulching is in dry areas,
- put a cut-off drain above the area treated with trenches if the top portion of the catchment is not included.

Common mistakes:

The following mistakes are often made:

- staggered position is not practiced,
- diverting & allowing flood more than capacity of water collection trench,
- Water collection trenches are not repaired after a heave storm or rain,
- Carrying out plantation without manuring the pit,
- exclusion human and cattle not implemented,
- thinning of the dense planting not regularly implemented.

MODULE 6: IMPROVED PITS

6.1Concept

Description of improved pits

Improved pits are square shaped water collection pits constructed along the contours with a plantation pit in front of the main water storage pit. Its main purpose is similar to micro-trenches which it serves for tree, shrubs, and cash crops planting.

Purpose of constructing improved pits

Improved pits support the growth of trees and fodder shrubs, and can be used for cash crops like coffee. Also improved pits have good potential to improve parts of hillside areas with gentle slopes and better soils. In homesteads improved pits can support fodder production and trees/shrubs. Improved pits allows for denser plantation of lower water demanding trees/plants. Other effects are same as micro basins that it contributes to watershed rehabilitation, biomass production and recharging of water tables**.**

Time to construct improved pits

Improved pits mostly constructed during the dry season or after short rainy season for hard soils and when labour is available.

Suitability and agro-ecology

- Improved pits suitable mostly in gentle slopes of semi-arid and medium rainfall areas.
- Improved pits is a better option than normal pitting in degraded and moisture deficit areas and easy to replicate.
- They are suitable for species that can be planted in denser spacing or higher density per hectare.
- It is applicable on slopes up to 8% maximum gradient or inclines and soils at least 50 cm depth on degraded lands, gullies, and hillsides.
- Improved pits could be also applicable within homesteads for planting trees and fodder species along fences and backyards.

It can be constructed by combined/mixed form with other measures such as trenches, soil and stone bunds, hillside terraces, etc, based upon soil and slope of the land.

6.2 Design, Layout and Construction of Improved pits

6.2.1 Technical standards and design steps

Dimension: 0.6m lengths by 0.6m widths by 0.5 m depth or other shapes equivalent to the pit volume are also possible.

Spacing: the distance between pits is 30-40cm along the contour and 1.5 - 2 meters along the slope. A 40cm by 40cm by 50cm deep or wider plantation pit is constructed in front of the pit in the middle of a shallow platform. The distance between planting pits should be 2-3 times denser as for trenches. The number of improved pits to be constructed in a given area can be calculated using the following formula:

$$N = \frac{10{,}000 * A}{5}$$

Where:

A= Catchments area (ha)

If there is hillside terrace,

$$N = \frac{10{,}000A - 2000L}{}$$

5

Where:

L= Length of Hillside (km)

Work Norm: 5 improved pits per person per day

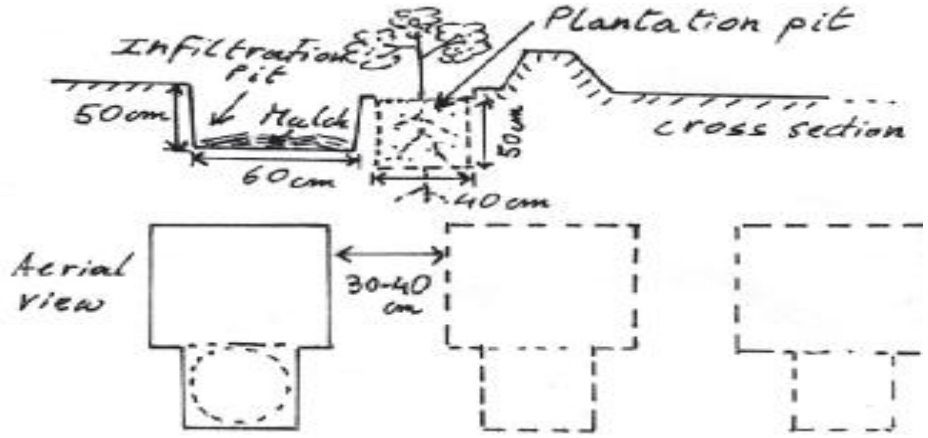

Figure 1: Variations in design/shape (CBPWD guideline, 2005)

Modification to Standard Design

- The shape can be rectangular - similar to a micro-trench: 1 m length by 0.4 m width by 0.5 depth
- The type of trees and shrubs can be selected to avoid competition for water and soil (for example: 1 improved pit with tree and 2-3 improved pits with fodder shrubs)

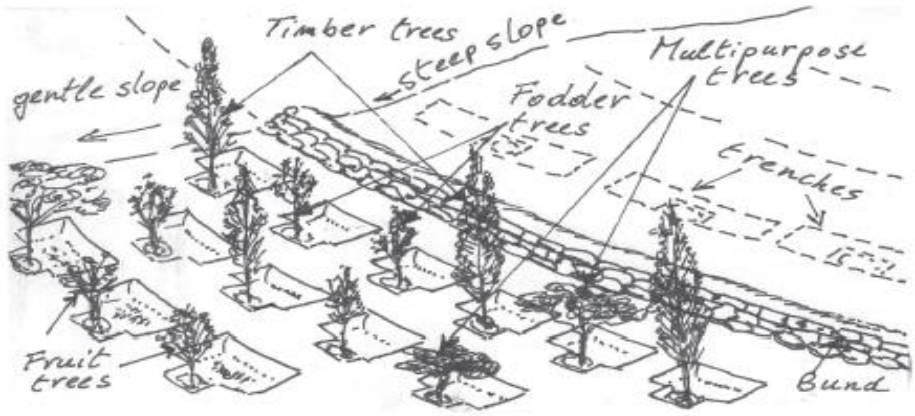

Figure 2: combination of species in Improved pits (CBPWD guideline, 2005)

6.2.2 Layout and Construct steps

Layout:

Improved pits can be lay out using a water line level hooked to a string attached to range poles placed at 5-10 meters distance and adjust the improved pits along the Contour line. Tools pick axes and shovels can be used to lay out the structures.

Tools/equipment needed: crow bars, pick axes and shovels (one crow bar: two pick axes and two shovels ratio).

Construction Steps:

- Site selection
- Layout and marking
- Dig the pit and place the soil down the slope (keep the top soil separately for the plant).

- Dig the plantation pit in either of the following positions: (1) front, (2) at its sides, (3) in the middle or (4) at the bottom of it.

6.3 Management and Maintenance of Improved Pits

- Arranging working groups for maintenance of the structure is very important
- Control grazing is a pre-condition for improved pits as cattle trampling will compromise their functions,
- Improved pits need to be spaced with care as overtopping can create series of breakage down the slope,
- Fodder/cash crops growing on improved pits should not be uprooted but cut and carried

6.4 Major issues not to forget and Common mistakes

Don't forget to:

- construct improved pits on steeper slopes as the soil embankment may slide downwards and fill the next trench,
- construct the improved pits in staggered position.

Common mistakes:

The following mistakes are often made:

- Not to integrate improved pits with larger trenches and other structures as the slope increases,
- Not to control free grazing and not implementing area closure.