Wet Watershed Management Guide

Water Harvesting and Soil Conservation in High Rainfall Areas

N.Mahapatra

North Bengal Terai Development Project

Government of West Bengal

ARCADIS EUROCONSULT

Centre for Development of Human Initiatives

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1. Why this guide?

An assumption of water managers is that one only needs to manage water, when it is scarce. This unconscious assumption has had far-reaching consequences. It has made one to assume that water management in humid areas is less important than in arid environments and more important in dry than in wet seasons. It has triggered tremendous interest in water demand management in times of scarcity, but far less in improving water management and increasing agricultural productivity when water is plentiful. And yet there is large scope for the latter too. As this guide shows the returns to investment in wet watershed management can be very high – even higher than the investments in dry season irrigation at times.

This guide discusses the process and type of interventions that come with wet watershed management or wet water harvesting and soil conservation in plain high rainfall areas. The guide is based on wet watershed management, as it is time-tested in the North Bengal Terai Region of India.

Wet watershed management has been implemented in North Bengal under the name 'soil conservation', but this name does not cover adequately what is being done. Wet watershed management or 'soil conservation' in North Bengal helps retains sheet flows and maintain groundwater levels, apart from avoiding soil erosion and gully formation.

To put wet water shed management in North Bengal Terai in perspective it is important to describe the distinct features of area. North Bengal is perched in the middle of the large Terai zone that immediately borders the Himalayan range and forms the beginning of the sub continental plains. The North Bengal Terai has a number of distinct features:

- The terrain is generally flat, but with a subtle micro-relief with the higher areas occupied by villages or tea gardens and the lower areas used for crop cultivation and ponds. In the cropped area the slope seldom exceeds 2%.
- Rainfall in the area is very high. - and exceeds 3500 mm annually. It mainly falls in the monsoon period May-October. Rainfall moreover comes at high intensities, with 250 mm in 24 hours not being exceptional.
- Soils in the area – due to its proximity to the Himalayas - are generally coarse. Loamy soils have only developed in the top 50 cm. A consequence of the coarse soil is that excess rainfall is relatively quickly absorbed, disappearing in a number of days, particularly in the early period of the monsoon when the soils are not completely water logged. Yet floods occur in the area, especially in the later part of the monsoon period. River floods at times deposit coarse sand. Sheet flows remove topsoil and lead to gully formation. The floods are sometimes caused by man-made action, such as the construction of bridges and roads
- Rain-fed paddy is the main crop in the area, with almost uniform coverage in the monsoon period. This cultivation can however be severely effected by gully formation, as water tables drop too low to assure high paddy yields.

Hydrogeology of North Bengal Terai
The Terai Belt is marked by thick alluvial deposits, consisting of sand with occasional layers of rocks and/or clay. In the monsoon these alluvial deposits completely fill due to the incessant rainfall and the large discharges from the Himalayas. Towards the end of the monsoon large parts of the area are covered in a sheet of water. In the dry season when agriculture depends to a large extent on groundwater and river lift pumping water tables are lowered, though not dramatically (5-10 feet). Water levels then again rise during the rainy season till they fill the basins to the brim. (*Kundu and Soppe 2002*).

For whom is the guide meant?

This guide is meant to familiarize new staff of local government and Agricultural Department in North Bengal with the process and techniques of wet watershed management. Besides

these, we also hope that the guide is of use to development workers in other parts of the world with similar environments: high periodic rainfall, flat terrain and coarse soils with the constant danger of gully formation and sheet erosion.

The guide first gives a background into wet watershed management. It next discusses the measures in wet watershed management (section 3). Section 4 discusses the main steps in the process of wet watershed development.

Man-made flood, Gadherkuti (Dhupguri)
The bridge on the Jaldhaka created a chicken neck and caused a flood immediately upstream of the bridge. As a result a large area to the east became sand-laden. After the main protection bund along the river was restored, the following measures were undertaken: the construction of a protection bund alongside the new arm of the river to retain water behind the bund rather than ending up in the new arm; the construction of a cross bund in this branch to allow it to silt up again; and the construction of small field bunds to bring land back to productivity.

The annexes contains a number of exercises – to help develop wet watershed development concepts and identify the overall set of measures that are appropriate. Annex 2 gives a more detailed description of the menu of measures that are applied in wet watershed management.

2. What is wet watershed management?

Watersheds divide one drainage basin from another. Within each watershed all water drains off to a common point. That may be a gully, small stream or big river. These natural units have evolved through the interaction of rainwater with land mass and typically comprise of arable land, non-arable land and natural drainage lines.

Watershed management aims to balance development within a watershed. It is the analysis, protection, repair, utilization and maintenance of drainage basin for optimum control and conservation of water with due regard to other resources, in particular soil, vegetation, biodiversity and manpower. It primarily addresses adequate resource use to bring about socially acceptable, economically gainful, ecologically balanced yet sustainable best land and water use system for sustainable production.

In the wet environment and on the flat sandy soils of the North Bengal Terai watershed management differs from watershed management in dry or in hilly environments. With the abundant and high intensity rainfall in the Terai much of the lower lying areas are temporarily inundated and large volumes of water are drained away through gullies and as sheet flows. Gully formation is a constant threat. By improving drainage patterns the run-off can be slowed down, water can be retained and soil erosion reduced.

In other parts of the North Bengal Terai river floods have deposited large quantities of coarse sand and distorted drainage patterns in the process. Such sand-laden areas are regenerated with a series of measures that retain sheet flows and allow cultivation. Because of this soil profiles will slowly built-up and over a period of 5-8 years soil fertility will restore.

All these measures are essentially what wet watershed management is all about in the high rainfall region of North Bengal. In short wet watershed management are a series of landscaping measures to break the speed of run-off, spread and retain water over larger areas, avoid unwanted deep drainage. Wet watershed management serves several objectives:

- Reduce the velocity of sheet flow and run-off. This avoids the loss of the thin fertile topsoil through rill erosion and the scouring of drainage gullies.
- Avoid or reverse gully formation, as uncontrolled gully formation will make it impossible to retain water in the watershed
- Retain water tables at high level, thus improving the reliability of cultivating rain-fed amon paddy. In essence this is done by increasing the period with assured soil moisture. This is an important difference with watershed improvement in dry areas. In wet watersheds the objective is to avoid overdrainage from gullies and retain water to improve the reliability of rain-fed farming, whereas in dry watersheds run-off infiltration and recharge for water supply in the dry season is the prime purpose.
- Restore flood-damaged, sand-laden land – by allowing cultivation and restoration of soil fertility
- Trap eroded materials and thus reduce sediment production into the streams
- In some areas to provide temporary irrigation by diverting sheet flows and gully flows into irrigation channels.

The ultimate aim is to provide remunerative crop based agriculture and generate regular and casual jobs.

Soil erosion
Gully formation and soil erosion
Soil erosion is the detachment of soil particles (and plant nutrients) from its original location and transportation to a new location through the action of rain, wind, flowing water or other forces. In Terai region of North Bengal rainfall and sheet flows are the main agents in soil erosion. It is the combined effort of rainfall erosivity, soil erodibility, slope steepness, slope length, ground surface cover and conservation practices. Soil erosion reduces the soil depth faster and faster if no protection is in place – and may go to a sequence of splash effects, sheet erosion, rill erosion, gully formation (as in picture) and ravines.

If done properly, the impact of wet watershed improvements can be very significant. An evaluation was done of six sites in North Bengal. In all these sites a number of wet water management improvements were undertaken (Despande and Dey 1999). The results of this study are given in annex 1. They show an extremely high return to investment. Against an average investment of INR 3960/ha (US $ 90/ha):

- average cropping intensity increased from 90% to 201%
- on average the gross value of production increased almost ten-fold. It was INR 17600/ha (US $ 370/ha) on average after completion
- assured soil moisture availability during the rain fed cropping season increased from 2 days to 10.9 days on average; besides the interventions reduced soil erosion and gradually increase water retention capacity, a.o. by increasing the organic content of the soils
- land value increased from INR 30750/ha to INR 84300/ha.

Animatie Dohani
In Nimati Dohani a protection bund was made and gullies were plugged. Whereas previously there was hardly ever assured soil moisture, this improved significantly after these measures. This allowed extension of cultivation and even double cropping in part of the area. Earlier only one third of the land was cultivated. Land prices increased more than ten-fold. (Despande and Dey 1999)

After – soil fertility restored

Before – field bunding in sand-laden area

3. What do we do in wet watershed management?

The main repertoire in wet watershed management consists of four elements:

Gully plugging – this is done by blocking gullies with relatively large earthen bunds or alternatively construction small concrete overflow weirs in natural drains. The earthen gully plugs cause run-off water to spread and are only made when there is room to spread water. Otherwise concrete overflow weir are preferred. As with earthen gully plugs, concrete gully plugs prevents that local water tables are lowered because of deep gullies in the freely draining sandy soils.

Graded bunds – these are low bunds that are built on the contour in order spread and retain water over a large area

Location of bunds
Sketch resource map (by farmers) of wet water shed area indicating roads and houses as well as the preferred location for graded bunds, that will slow down sheet flow and prevent gully formation in this otherwise plain (but sandy) area. Some of the bunds were planned to plug existing gullies and spread the water sideways. Plugging such gullies will avoid that water tables become too deep – jeopardizing rain fed rice cultivation. The location of road bunds is very important as they define the boundaries of the micro watershed and because culverts are the points to which excess water is removed.

Field bunds – raising field bunds avoids that water gushes from field to field but instead fills a field basin before it neatly topples over to the next field basin.

Protection bunds – built along rivers and gullies. The protection bunds have two functions – first is to prevent uncontrolled flooding from the streams. But equally important is the second function – avoiding that water gathers in the rivers and gullies too quickly and gathers large quantities.

Land reclamation and vegetative measures – uprooting of wild vegetation to make sand-laden suitable for cultivation as well after field bunding vegetative measures to prevent soil erosion and accelerate the restoration of soil fertility

The set of specific measures is summarized in table 1. A detailed description of the various measures is given in annex 2. What is important is to study an area and together with land owners and farmers identify what can be done and jointly develop the concept prior to

starting further activities. To help guide in developing wet watershed improvement concept, annex 3 gives a number of study cases. The starting point in developing the concept for an area is to see first where the existing ridges and drainage channels. The ridges are in most cases road bunds in the flat terrain of North Bengal. Road bunds de facto often define the borders of the watersheds and hence the natural unit for wet watershed planning. Equally important is to study the existing drainage paths, as ultimately the excess water from the unit will have to be removed through the drainage canals. In some cases this may require the construction of additional drainage channels linking up with the existing ones or the construction of additional culverts in the road bunds.

Table 1: Wet watershed measures

Wet watershed measure	Purpose
Graded bund	Spread sheet flow to reduce erosive effects of high velocity flows that will otherwise lead to gully formation. Also retain water behind bunds and increase soil moisture reliability.
Field bunds	Retain rain water in farm plots to improve soil moisture, reduce rill erosion and mitigate sheet flow peaks – will ultimately help rebuilt soil fertility
Earthen gully plug	Increase groundwater tables and avoid further gully formation, even reverting it (in case of cross bunds); spreading sheet flows over large areas
Concrete gully plug	Increase groundwater tables and avoid further gully formation
Protection bunds	Protect land and property against floods as well as retain sheet flow behind bunds so as to increase groundwater levels and mitigate river flood peaks
Farm ponds	Create water resource for irrigation or fishery and increase flood water storage capacity
Drainage channels and culverts	Avoid water logging and controlled removal of excess water
Diversion channels	Provide supplementary irrigation
Reclamation of sand laden area	Prepare land for cultivation by removing wild vegetation such as cassia grass
Supporting agronomic measures	Reduce the splash effect of rain, help improving soil structure, help in retarding and reducing overland flow

4. What are the steps?

To implement the wet water harvesting and soil conservation activities, a number of steps are important:

I) Survey and investigation.
II) Planning.
III) Implementation and subsequent appraisal of the total effect.

Survey and investigation:

After identification of possible locations: demarcation/ delineation of watershed in mouza maps and field verification are pre-requisites. After delineation of watershed area in mouza maps with the help of topo sheets, the same needs be verified in the field.

Meeting with farmers, local government staff (panchayats), officers from soil conservation department need to be arranged for appraisal of soil and water conservation problems and their consequences, and discussion on role of the different parties

Formation of maintenance committees among landowners in the watershed area, who will have to look after the future management of the earth works. Any treatment whether it is a bund or a structure or a plantation will remain viable if it is looked after over the years. The formation of such committees will need a well-prepared meeting to which everyone is invited in time. On this occasion alongside the scope and implementation of the different activities, the need for future maintenance arrangements can be discussed, such as vigilance against encroachment of bunds and fundraising for maintenance (for instance by planting tree crops on commonly owned bunds)

Discussion with maintenance committee on the scope of works. For this a transect walk with members of maintenance committee should be organized. A field identification of issues needs to be made i.e. type of erosion hazards and land degradation; intensity of over or under drainage problem if any; type of water bodies available; scope for rainwater harvesting etc.

Topographical survey and land measurement, with dumpy levels, may be undertaken but as the slope throughout the North Bengal is uniformly gentle, this is not necessary.

Identification of causes of such damages/hazards i.e. climatic factors, man, animals may also be ascertained from the farmers for future interaction. Preparation of present land use map and resource mapping may also be done together with maintenance committee and other farmers.

Planning:

On the basis of survey and investigation findings and identified problems the integrated package of measures should be planned:

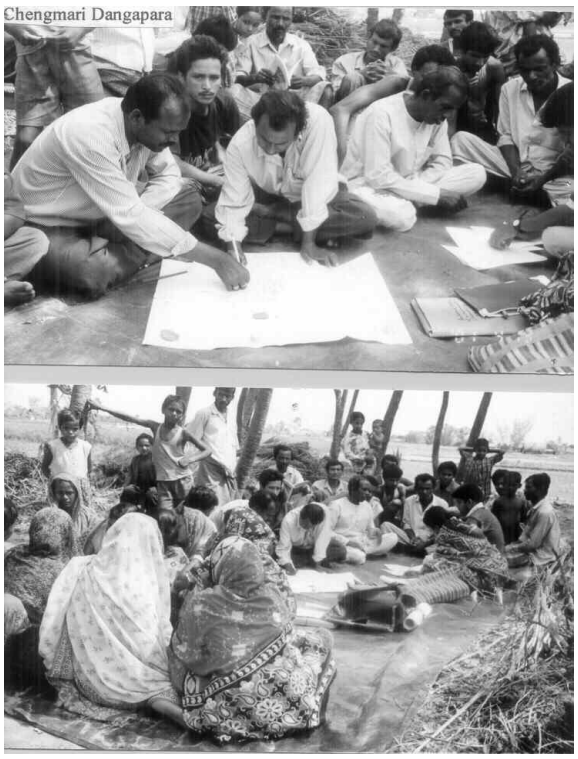
The plan should consist of:

- Water harvesting and soil conservation measures
- Supplementary measures (training, extension)
- Cost estimation of works on the basis of the accepted in view norms and regulations
- Phasing of activities. When finance is a constraint, work may be undertaken in a phased manner and to be completed within 2-3 years.

Preparation of proposed land use map is also a part of the planning process. Proposed measures should be recorded on the map

Micro-planning may be undertaken, to identify other steps to make use of natural and human resources beyond the watershed measures. Central to micro planning is the preparation of a resource map and action planning by the farmers of the area. The micro-plan may be presented in a meeting seeking support from the panchayat and others, for issues beyond the control of maintenance committee.

Implementation:



One great strength of the wet watershed programs is that they are very labour-intensive. Almost the entire budget is spent on labour, which is an important aspect of the watershed measures. Mechanical equipment is not used. Special attention is required in the program that child labour is not used.

Implementation of the conservation treatment according to the plan and estimates is the responsibilities of the soil conservation wing of the Department of Agriculture. In the current system the works are executed through a 'beneficiary committee' supervised by the engineering staff of the soil conservation wing. This committee should be formed amongst the farmers in a meeting in presence of panchayat bodies, departmental officers. Prior to that there should be discussion on their responsibilities. Preferably, the beneficiary committee and maintenance committee are one and the same. To avoid confusion – it needs to be explained that:

i. The executing agencies/ department or local governments have no provision of fund for future maintenance.
ii. The return to the investment is high but sustainability of the project works will much depend on proper and timely maintenance as and when needed.

In short, the function of the maintenance committee will be as follows:

- To look after the annual maintenance part of the project works before the monsoon starts/ at the onset of monsoon / and during the entire monsoon period as and where necessary.
- To sit together with others to assess the condition of the structures, preferably by an annual walkthrough/ inspection visit

- To seek technical guidance from for instance the Soil Conservation Wing, if necessary
- To sought for financial support from the local panchayat / pradhan if the damages are so severe.
- To create assets of its own.

Continuous monitoring and follow up is very much necessary. The local government can easily take up this part. So much so, the local government staff needs to be right from the initiation of scheme up to the completion and be familiar with the terms and conditions of execution of the project as well as responsibilities of maintenance committees towards future maintenance. A special effort is required to apprise the local panchayat to act accordingly as well as to provide support as and when needed.

References

Despande, R.S., B.K. Dey. 1999. In response to nature's challenges: an assessment of the soil conservation projects of NBTDP. North Bengal Terai Development Project.

Kundu, N and G. Soppe. 2002. Water resources assessment: Terai region of West Bengal. New Delhi: Jawahar Publishers.

Singh, Gurmel, C. Venkaramanan, G. Sastry and B.P. Joshi. 1990. Manual of soil and water conservation practices. New Delhi: Oxford/IBH Publishing.

Annex 1: Evaluation of selected wet watershed sites in North Bengal

Scheme	**Type of work**	**Cropping intensity (%)**		**Gross crop value per ha (INR)**	**Soil moisture available (days)**		**Land value per ha (INR)**	
		Before	**After**		**Before**	**After**	**Before**	**After**
Chhotosimulguri	Protection bund, graded bund, field bund	96	171	11641	2.5	15	37300	86000
Dharmapur	Protection bund, graded bund, barrier bund	96	367	14434	2.5	10	14000	84000
Khagribari	Gully control	140	183	23051	2	15	56000	112000
Nimati Domohani	Protection bund, gully control	33	130	16821	1	5.5	3850	35000
Titiyarkuti	Barrier bund, graded bund and field bund	67	199	29694	1	5	52500	147000
Utta Simlabari	Graded bund	107	160	9765	3	15	21000	42000
Average		**90**	**201**	**17573**	**2**	**10.9**	**30750**	**84300**

Source: Despande and Dey (1999)

Annex 2
Main wet water harvesting and soil conservation measures

In this annex the different wet water harvesting and soil conservation measures are described including the thumb rules that developed over the years. Almost without exception a series of these measures is implemented in an integrated package.

Wet watershed measure	**Purpose**
Graded bund	Spread sheet flow to reduce erosive effects of high velocity flows that will otherwise lead to gully formation. Also retain water behind bunds and increase soil moisture reliability.
Field bunds	Retain rain water in farm plots to improve soil moisture, reduce rill erosion and mitigate sheet flow peaks – will ultimately help rebuilt soil fertility
Earthen gully plug	Increase groundwater tables and avoid further gully formation, even reverting it (in case of cross bunds); spreading sheet flows over large areas
Concrete gully plug	Increase groundwater tables and avoid further gully formation
Protection bunds	Protect land and property against floods as well as retain sheet flow behind bunds so as to increase groundwater levels and mitigate river flood peaks
Farm ponds	Create water resource for irrigation or fishery and increase flood water storage capacity
Drainage channels and culverts	Avoid water logging and controlled removal of excess water
Diversion channels	Provide supplementary irrigation
Reclamation of sand laden area	Prepare land for cultivation by removing wild vegetation such as cassia grass
Supporting agronomic measures	Reduce the splash effect of rain, help improving soil structure, help in retarding and reducing overland flow

Graded bund (G.B.)

Graded bunds are used in areas where controlled removal and retention of large quantities of sheet flow is of prime importance. They serve to spread water or retard sheet flow. In the high rainfall Terai area of Jalpaiguri, Coochbehar and Siliguri graded bunds are commonly used.

The degree of slope and the length of slope are the two main features of topography of land that affect the velocity of run off. If the length of land slope is increased two times, the erosive velocity, as represented by the kinetic energy of the flowing water, is increased about 1.4 times. From this observation, bunding has been accepted as the most effective mechanical measure in conserving soil and water. It is nothing but a series of mechanical barriers across the land slope to break the slope length also to reduce the slope degree where necessary. The districts of North Bengal typically have a natural slope of 2-3%. Combined with the heavy rainfall in the monsoon period (3000 mm to 3500 mm), this creates huge sheet flows and surface flows. At high velocity these flows cause the formation of gullies-, which destroy land, and lower groundwater tables in rain fed paddy areas, seriously affecting crop yields. Bunding with some grade along with spreading water or spreading it to disposal channels is the solution for these tracts.

Location of the bunds

In general for the graded bunds a grade of 0.2% to 0.4% is ai6(,).344-.515(a)-.9535(t)..t

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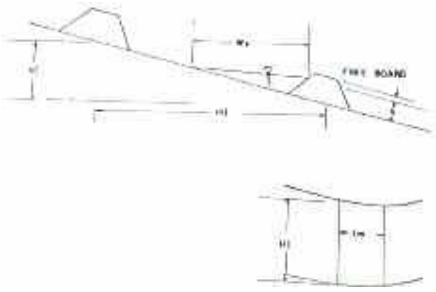
Distance and difference in height
Graded bunds are usually constructed in a series. The distance between two graded bunds (called Horizontal Interval or H.I.) and the difference in the height between two successive bunds (called Vertical Interval or V.I.) depends basically on the slope of the land. See diagram 2. The formulas for these are given below.

- V.I.=(S/3)+2
- H.I.= V.I/S X 100

V.I.= Vertical Interval in Feet.
S = Percentage slope of the land.
H.I.= Horizontal Interval in Feet.



Dimensions
The side slopes of graded bunds are usually between 1:1 and 2:1. As farmers do not readily dispose of their land, the steeper 1:1 side slopes are most common. Typical dimension of a graded bund are:

a)	Height of Bund	:	2'-00"
b)	Top Width	:	1'-00"
c)	Bottom Width	:	5'-00" (or 9'-00")
d)	Side Slope	:	1.1 or (or 2.1)

Disposal channel
The graded bunds will redirect the sheet flow. It is important that at the excess water is collected and transported to the drainage channels. This may require the excavation of drainage channels and the placement of new culverts (see section on drainage channels and culverts).

Construction period
Bunds – whether it be graded bunds, main field bunds or protection bunds – are preferably constructed in December-January, as this gives the bunds time to settle under the impact of cattle and human movement before the onset of the monsoon. Bunds that are constructed just before the monsoon may fill up with water and are more likely to breach.

Field Bund (Level Field Bund):- (F.B./L.F.B.)

The basic concept for field bunding is to detain and conserve as much as possible of rainwater within two bunds. Apart from improving soil moisture this also checks the formation of rills out of free flowing water. With water contained within farm boundaries moreover erosive sheet flows will be contained.

In field bunding main bunds and laterals are made. The laterals are placed at straight angle with the main bunds. Usually they are constructed on farm boundaries. In sand-laden areas this may require systematic discussion to establish the precise locations of these boundaries. Laterals extend from one main bund to another.

Dimensions of main bund
A side slope of 1:1 is most common for the main bunds in field bunding. The width of the bund is determined by the available land and the willingness of the landowner to sacrifice land for the bund.

The main bunds commonly have the same sizes as the graded bunds, i.e.

Height of Bund	:	2'-00"
Top Width	:	1'-00"
Bottom Width	:	5'-00"
Side Slope	:	1:1

Distance and difference in height
In field bunding the main bunds are constructed in a series. The distance between two graded bunds (called Horizontal Interval or H.I.) and the difference in the height between two successive bunds (called Vertical Interval or V.I.) depends basically on the slope of the land. See diagram 2. The formulas for these are given below.

- V.I.=(S/4)+2
- H.I.= V.I/S X 100

V.I.= Vertical Interval in Feet.
S = Percentage slope of the land.
H.I.= Horizontal Interval in Feet.

In main field bunds the vertical interval and the horizontal interval are slightly smaller than in graded bunds.

Dimension of laterals
The dimension of the laterals are often the same as the cross section of the main bunds, but are usually smaller – much depends on the land that is spared for them by farmers.

Gully Control: - (G.C.)

Earthen gully plug – diverting water and raising groundwater tables

Plastered masonry gully plug – raising groundwater levels

Gullies are formed due to accelerated erosion of topsoil by run off. There are two forms of gully formation in the region:

- Gullies form within the cultivated areas and gradually enlarge and bifurcate, engulfing and spoiling cultivated lands.
- Medium to large size long gullies formed many years back and presently serving as drainage canals particularly during rainy seasons.

The approach toward the erosive first type of gully is to stabilize them through diversion of water and/or retention of water through the construction of gully plugs. This will stop and reverse the

scouring process, with the gully usually filling up again. Gully plugs will also ensure that the gullies no longer over drain and that land earlier lost because of the formation of the gully is recovered.

In case of the second gully (drainage path) the approach is to allow the gully to continue as drainage channel. But in some places one may also divert a portion of the flow for irrigation.

While planning and designing a gully control scheme proper estimation at anticipated volume and rate of flow through the gully are most important. Primary field inspection and survey are therefore prerequisite for proper and effective gully control scheme. There are two types of gully plugs:

- Earthen gully plugs
- 'Pucca' gully plugs, usually plastered masonry weirs

Earthen gully plugs are preferred where there is scope to divert and spread the excess water. While constructing them first the gully is closed and the gully plug – often connected to graded bunds – is built on top of it. The side of the gully plug facing the water is usually built at angle 1:1, whereas the downward slope is 2:1. The water facing side may be reinforced by a stand of bamboo – whereas the plantation of grass sods to stabilize the earthen gully plug is standard.

Pucca gully plugs are usually built inside a gully, where there is no possibility for spreading and diverting excess water. The site for the gully plugs is usually chosen on observation – the gully should be relatively narrow and the banks should be strong – for instance where there are trees. . (In the generally sandy terrain of the North Bengal Terai there are no rock outcrops to use as the location of the gully plug.) As a rule of the thumb the weir crest is built in such way that the midpoint between the crest of the weir and the apron equals the adjacent land level plus 6" to 1 foot. This allows the paddy fields to be inundated where required.

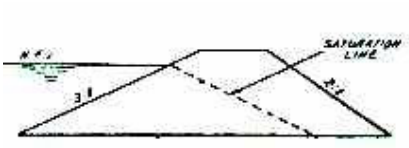
Protection Bunds: -

Protection bunds usually serve two purposes. The first and main purpose is to keep the flood water out. They are put parallel to the river courses and beels (oxbow lakes) to protect land and domestic property from flash flood and sand deposition. Subsequently those lands can be reclaimed for cultivation. The second purpose is to retain water behind the protection bunds and retard the inflow into small rivers and beels and oxbow lakes. When this second function is most important the bunds may be smaller and will be called 'periphery bunds'. In developing protection bunds one has to realize that the drainage pattern in the Terai is quantitatively different in the wet season than it is in the dry season. During the monsoon water levels in the rivers are high and water starts to flow in several oxbow lakes and river arms that were stagnant or empty during the dry months. Under wet watershed management the smaller protections bunds are made – not the large protection bunds constructed along the main rivers

In developing a protection bund basic data for at least last ten years of the site has to be collected with respect to the maximum flood level, soil type, depth of soil, present land.

Dimension of the protection bund
The height of the bund is determined by an assessment of maximum flood level. As a rule of the thumb an additional freeboard of 15% is allowed on top of the maximum flood level.

The side slope of the bund is related to the material of which the bund is made. The side of the bund that faces the river is usually 1:1, whereas the back slope of the protection bund is usually at a gentler angle of 2:1. In case the material is very loamy a back slope of 1.5:1 may be considered.



The total width of the protection bund has to be wider than the hydraulic gradient or the saturation area. The hydraulic gradient determines the part of the bund that is saturated with water during high water levels. If the back slope of the bund is also saturated with water during a flood the bund is likely to break. See diagram 3. As thumb rule the hydraulic gradient in sandy bunds such as common in the North Bengal Terai need to be 2.5 times the maximum flood level.

Construction period
Bunds – whether it be graded bunds, main field bunds or protection bunds – are preferably constructed in December-January, as this gives the bunds time to settle under the impact of cattle and human movement before the onset of the monsoon. Bunds that are constructed just before the monsoon may fill up with water and are more likely to breach. In construction a larger protection bund the work has to proceed in layers allowing each layer time to be compacted. In determining the height of the bund it is useful to keep an extra margin as the bund may shrink slightly after construction.

The planting of grass sods on protection bunds is standard, as it helps strengthening the bund.

Farm Ponds (F.P.)/ Water Harvesting Structures (W.H.S.)

Ponds created by putting a cross bund in borrow pit

In high rainfall areas like Terai region run off water goes as waste causing soil erosion and even resulting in moderate floods. Farm Ponds / Water Harvesting Structures are constructed to store the run off. Apart from serving as flood storage, the ponds can also be used as a source for supplementary irrigation. Besides, they may be used for short-term fishery. The general sandy condition of the wet water harvesting areas often makes perennial fishery difficult.

The construction of ponds is done with an eye to the situation of land/ topography. The example in the picture illustrates this – here was an opportunity to convert borrow pits into ponds by putting in a bund across the borrow pit, effectively compartmentalizing the water body.

There are several types of farm ponds:

- Embankment Farm Pond – a bund is provided in which excess water is collected
- Dug out Farm Pond – the pond is excavated and excess water collects in it
- Embankment-cum-Dug out Farm Pond – a combination of bunding and excavation

Drainage channel and culverts: -

In wet watershed management rainfall and sheet flow is retained and excess water removed to the existing drainage system, be it a drainage channels, a beel or a river.

In some cases this may require the excavation of additional drainage channels linking up with the existing ones or the construction of additional culverts in the road bunds.

In constructing a new drainage channel care is taken in selecting a gentle slope to avoid scour and gully formation. Given the size of most watersheds a typical drainage channel has a bottom width of 3 1 meter, a depth of 1 meter and a side slope of 1:1, resulting in a top width of 3 meter. Vegetation is provided on the slopes to stabilize the channels.

In a number of areas water logging is a problem. This is usually because drainage paths were distorted in the aftermath of floods. In some sand-laden areas drainage channels have to be constructed to drain out the excess water from the field. Sometimes such drainage channels can be used for irrigation too by diverting water to field channel.

Diversion of Water Course (D.W.C.): -

In some wet watershed areas perennial water sources coming from small streams/ forests are diverted to cultivated fields through masonry or earthen structures for irrigation purpose. As a result cropping intensity can be increased to a great extent.

Reclamation of Sand Laden Area (R.S.L.A.): -

Sand laden area covered with casia grass prior to treatment

The reclamation of sand laden areas is the composite terms for the initial measures in recovering a flood-affected area. In many cases considerable time has lapsed before the area is reclaimed. A range of measures will be applied – the uprooting of weeds and rids, field bunding, land leveling, gully plugging, several of which were described earlier.

The most common plant in the sand laden areas is the cassia grass. While removing casia grass, grass roots are spaded and coarser particles are scraped and dumped on land. Cut grasses are collected and removed and the dried grasses are used as fuel for cooking and also used as roof making.

Supplementary agronomic measures: -

Several agronomical measures are adopted, supplementing the mechanical measures in the treated lands, the process of soil erosion (detachability and transportability) will continue resulting fluctuating crop fields.

These measures include: -

- Contour Farming. - planting on contours
- Mulching – using various techniques that will increase the water retention capacity of the soil, for instance mixing straw and breaking clods. Mulching is particularly helpful in vegetable cultivation, where assured soil moisture is a necessity.
- Use of dense growing crops/ cover crops – for instance cowpea, pulses, paddy, wheat. These will reduce splash erosion.
- Mixed cropping. – increasing the capacity to retain water
- Inter – cropping or strip cropping, alternating either blocks or strips with different crops.
- Use of organic manure or green manuring with legumes, such as cowpea, dhaincha, pulses. This improves water-holding capacity.

The above agronomical measures helps to intercept rain drops and reduce the splash effect; help in improving infiltration rate by improving soil structure; help in retarding and reducing overland flow. All these practices can easily be taken up by the farmers, but require a special extension effort.