# Recharge Ponds
# Handbook
## For WASH Programme

Ministry of Federal Affairs and Local Development
**Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)**

# Recharge Ponds Handbook

## For WASH Programme

Ministry of Federal Affairs and Local Development
**Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)**

Kathmandu, 2013

**About DoLIDAR, RWSSP-WN and NWCF**

**DoLIDAR:** The Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) under the Ministry of Federal Affairs and Local Development (MoFALD) undertakes infrastructure development programmes in accordance with decentralization policies for attaining the goals set forth by the Government of Nepal's National Strategy for Rural Infrastructure Development. MoFALD/DoLIDAR is responsible for water supply schemes serving less than 1,000 beneficiaries through its decentralized structure. The schemes are implemented and managed by communities. MoFALD through the District Development Committees (DDCs) and Village Development Committees (VDCs) is responsible for district and VDC level WASH coordination.

**RWSSP-WN:** Rural Water Supply and Sanitation Project in Western Nepal (RWSSP-WN) is a sector support programme under Ministry of Federal Affairs and Local Development (MoFALD) for rural water, sanitation and hygiene (WASH) in Nepal. The project period is 5 years from August 2008 to July 2013 (including one year no-cost extension). The second phase of RWSSP-WN is planned to start immediately after the first phase. RWSSP-WN is funded by the Governments of Nepal and Finland. In addition, the District Development Committees, Village Development Committees and the users contribute to their respective WASH programme. RWSSP-WN operates in nine districts: Myagdi, Parbat, Baglung, Syangja, Tanahun, Nawalparasi, Kapilbastu, Rupandehi and Pyuthan.

**NWCF:** Established in 1989 and re-organized in 1997, Nepal water Conservation Foundation (NWCF) is a non-governmental, non-political and not for profit organization conducting interdisciplinary research on interrelated issues that affect the use of management of water with specific focus on the Himalayan-Ganga region. The foundation was reincorporated (registered) with the district Administration office Kathmandu in 2000 meeting the governmental requirements.

Since its establishment, the foundation has dedicated its focus to generate and disseminate knowledge on water management through research, publications, training and engagement in public dialogues. It has also sought to address emerging challenges and ever changing educational needs of water management. NWCF works with local community as well as with organizations at local, national, regional and international levels. At the local level, NWCF helps strengthen institutional capacity of community and civil society groups for informed participation in decision making process.

**The Government of Nepal**
**Ministry of Federal Affairs and Local Development**
**Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)**

# Preface

It is my great pleasure to introduce the "*Recharge Ponds Handbook for WASH Programme*," that aims to implement groundwater recharge ponds and to manage depleting water resources in the districts covered by the Rural Water Supply and Sanitation Project in Western Nepal (RWSSP-WN). This handbook will be used as a guiding document in all the 75 districts of Nepal, instead of being confined in the areas covered by *RWSSP-WN* program at present. Essentially, I believe the dedicated professionals, who are working hard in securing and supplying fresh water for people, such as the respective district engineers, sub-engineers, technicians, social mobilizers and facilitators representing at the district, VDC and community levels, will find this handbook substantially helpful. I am thankful to the resources and contributors who facilitated and delivered this valuable guide for the welfare of the people particularly living in the rural areas of the country.

By 2017, through three focused priority areas, the Government of Nepal remains committed to the sustainable use of water resources and to improve supply of drinking water. These include (1) "reaching to the unreached," (2) "improving functionality and sustainability," and (3) "improving the water quality." However, challenges such as depleting water resources impede our progress; and the fear that adverse impacts of climate change will make the situation worse. In this context, the "*Recharge Ponds Handbook for WASH Programme*" sheds the hope and light we desperately needed. I trust this handbook provides impeccable features on planning, constructing and managing dug out ponds that facilitate groundwater recharge. In addition, the handbook is a practical guideline for recharge pond implementation, and supports the *WASH* stakeholders in managing depleting water sources in the Middle Hills, Mahabharat, Siwaliks, Bhabar and Terai region.

Moreover, the "*Recharge Ponds Handbook for WASH Programme*" includes the 'general context' and 'introduction' on 'recharge pond concept,' which cover topics such as the physiographic regions, hydrological context, different pond types and their specific advantages, tips on practical implementation, and steps for planning and construction. Finally, this handbook is in line with Government of Nepal's existing policies, guidelines, and development priorities; and, it can be used as a supporting document to the water resource management and sustaining water supply in the context of climate change in Nepal.

Bhupendra Bahadur Basnet
Director General
Department of Local Infrastructure Development
and Agricultural Roads (DoLIDAR)

# Acknowledgements

This document was prepared by an expert team composed of Sushma Acharya, Binod Sharma, Nirendra Basnet, Dipak Gyawali, and Anil Pokhrel. We would like to thank them all. We acknowledge the conceptual guidance provided by Madhukar Upadhya. Thanks are also due to Mayanath Bhattarai and Govinda Sharma for providing logistical support to the expert team as the tasks of preparing the document progressed. We duly acknowledge the support provided by Surendra Pradhan in making the sketches. Overall guidance for the work was provided by Jari Laukka of RWSSP-WN. His support is highly appreciated. Pilot works of making ponds in Myagdi, Nawalparasi and Kapilvastu would not have been possible without the support of Bishnu Prasad Sharma (LDO Myagdi), Guneshwar Mahato and others including Chandra Bista, Gambhirman Gurung, Suman Shrestha, Shashi Bhusan Thakur, Ramji Adhikari and other members of DDCs of the pilot districts and RWSSP-WN. All of them deserve thanks.

# About this Handbook

This is a practical guideline for planning, construction and management of dug out ponds, with focus on recharging groundwater aquifer in water scarce areas. The purpose of this Handbook is to help the WASH (Water, Sanitation and Hygiene) stakeholders in understanding concepts to manage depleting water sources in the mountains, mid-hills and Terai regions in the context of Climate Change. This Handbook draws heavily on Madhukar Upadhya's book- *Pokhari ra Pahiro, Madhya pahadi Chhetrako Paani- Sanskriti, Khadya Pranaali ra Bhu- Kshayako Artha Raajniti*. Though this Handbook, an outcome of many years of experience in constructing ponds in Nepal, is aimed at helping WASH planners, it is a useful reference to everyone interested in catching rain where it falls (rather than just where it later concentrates), to enhance local water availability and to bring a positive change in the quality of life for people dependent on stored groundwater, which, in the mountains serves to feed Springs, providing water for everyday needs. It has become urgent in view of the fact that climate change induced impacts are already beginning to be felt with incidents of increased frequency and intensity of floods and droughts, new approaches (such as that of water harvesting ponds technology) have to be explored and adopted to enhance the resilience capacity of rural Nepal.

**This Handbook has following chapters:**
**The Introduction** section provides the general context and elaborates on the polices and strategies of the government with respect to promoting ponds for increasing water yields in the watersheds by augmenting groundwater. It also sets out the objectives for readers to get a clear idea of the purpose of this Handbook.

**The Setting** - The most important aspect of pond construction is to store as much rainwater as possible where it falls during the monsoon and save it for non-rainy season either in the pond itself or through recharge in the groundwater below it. The best way to do this is to store water in the aquifer by activating the natural hydrological cycle in such a way that less water is lost in immediate runoff and evaporation. The amount and the distribution of rain and the nature of aquifer differ from one physiographic region to another. This section provides brief account of the physiographic features and the significance of recharge ponds in each of the key physiographic zones. The section also provides information on the climate and hydrological context and explains the importance of spring hydrology in the mountains, which will be impacted directly by the emerging climate change with direct consequences on water and sanitation application in the rural areas.

**The Recharge Ponds** section helps define recharge ponds and the rationale for constructing them in the context of depleting water sources and providing water for income generating activities and WASH purposes. It also gives practical information on the types of ponds, their advantages and disadvantages as well as guidelines to the users in determining where, when, and how to build ponds.

**The Practical Guidelines** section has been developed to orient the users about important things to be considered before actual construction of the pond. It provides practical guidelines for selecting the site, shape, size, and number of the pond/s, obtaining official permits if necessary, and some aspects of design details. The section also talks about the time of construction, construction tools and material required, and makes the users aware of the need to protect the pond and its surroundings, mainly by the use of bioengineering.

**The Pond Construction** section starts with the description of design layout and guides the users through the steps to be followed for actual construction of the ponds. Examples of the quantity and cost estimates as parts of investment planning have also been included in this section.

The guidelines are presented using a matrix that summarizes information given in detailed sheets for each type of pond layout for specific area and are supported by sketches for clarity. Steps for each action have been provided in bullet points to minimize confusion, therefore it is hoped that many water users of water supply projects will find it user-friendly.

# Abbreviations

| | |
|---|---|
| DDC: | District Development Committee |
| DFO: | District Forest Office |
| DoLIDAR: | Department of Local Infrastructure Development and Agricultural Roads |
| DSCWM: | Department of Soil Conservation and Watershed Management |
| GON: | Government of Nepal |
| HDPE: | High-density polyethylene |
| LID: | Local Infrastructure Development |
| MBT: | Main Boundary Thrust |
| MCT: | Main Central Thrust |
| MFT: | Main Frontal Thrust |
| MoFALD: | Ministry of Federal Affairs and Local Development |
| NGO: | Non-governmental Organization |
| NWCF: | Nepal Water Conservation Foundation |
| RWSSP-WN: | Rural Water Supply and Sanitation Project in Western Nepal |
| VDC: | Village Development Committee |
| WASH: | Water, Sanitation and Hygiene |

# List of figures

# List of tables

# Contents

# 1 Managing Water Depletion Using Recharge Pond

## 1.1 The Context

An inherent problem of water is that it is difficult to get good quality water in a required quantity at the required place when one needs it. Therefore, making water available from its source to where people are through use of technology requires substantial cost. But first and foremost, water must be available at the source. The problem is that even though the principal source of water is precipitation that occurs for a limited period, only a small part of it is stored as groundwater, which in the mountain watersheds is released gradually through springs and seepages to form streams and rivers. Geology, vegetation, and climate influence the hydrologic connections within watersheds. Nepal, as with much of South Asia, lies in what is called a semi-arid zone, arid for about eight of the non-monsoon months. In this monsoon climate surface runoff occurs during the monsoon in response to rainfall events, while groundwater contributes to springs and stream flow during the non-rainy season. Up in the higher elevations, snowmelt water feeds rivers that originate in the high elevation during summer months, but before and after summer months these rivers are also augmented by tributaries that originate in the mountains below snow line that are fed by groundwater. In the Mid-hills and Terai zones where the bulk of Nepal's population lives, there is no snowfall of any kind. Some mountain tops have snowfall in rare, freak events of a few days, too little to make any serious impact on all stream flows except for major rivers.

Availability of water in the springs and streams thus depends entirely on the amount of water stored in the groundwater, which is augmented during the monsoon by continuous rain of four months and supplemented to some extent by the less intense winter rains. At times when the groundwater within these hills is not fully replenished, for various reasons explained later in this handbook, water availability becomes scarce. To counter such a risk, rainwater harvesting forms the major component of water management, which helps augment groundwater storage.

## 1.2 Pond Policy and Strategy

Planning, monitoring, and evaluation of water supply and sanitation programmes; along with other development programmes like rural roads, irrigation systems, river control, rural energy and others; is a major objectives of the Department of Local Development and Agricultural Roads (DoLIDAR) as stated in its policy statement. One of the major issues in the water supply function is severe shortages of water in the dry period in many districts of Nepal. This problem is likely to be accentuated by the effects of the ensuing climate change. While seeking to address this issue, the pond technology has emerged as a highly practical means of increasing water availability in the rural sector through recharge of the ground water. Recognizing this potential of the pond technology, the Ministry of Federal Affairs and Local Development (MoFALD) and DoLIDAR have already adopted a policy to make at least one pond in every village of Nepal.

Ponds are centuries old tradition in managing water and watersheds. The Department of Soil Conservation and Watershed Management (DSCWM) recognizes the construction and maintenance of multipurpose ponds as a means for increasing water holding capacity of the watersheds and for increasing water yields through water harvesting. It is also one of the nine techniques described in the DSCWM publication "Soil Conservation and Watershed Management Activities" as appropriate and recommended technique for Nepal.

The GON's Three Year Interim Plan in irrigation sector has adopted a strategy for irrigation development which emphasizes implementation of non-conventional irrigation technologies such as drip, sprinkler, and runoff harvesting ponds to cater to the needs of small and marginal farmers in areas where development of conventional surface and groundwater irrigation are not feasible. A "Non-conventional Irrigation Technology Project" has been conceived as a specific programme under this strategy. It is also implicit in the current Irrigation Policy 2060 of the Government of Nepal, which sates "*For expanding year round irrigation, water reservoirs, rainwater harvests and ground water resources shall be developed, conserved, promoted and utilized as supplementary sources to the seasonal rainfall".*

Similarly, in the Agriculture sector the Interim Plan adopts a strategy to help farmers reduce their costs of production through the Government's investment in micro irrigation and rain water harvesting technology in the hills for ensuring regular water supply. The ongoing work on Agriculture Development Strategy also promotes rain water harvesting. The pond technology is also highly compatible with the objectives of the National Adaptation Programme of Action to Climate Change (NAPA) which stresses the need to combat the adverse effects of climate change through appropriate technology. NAPA (2010) specifically emphasizes empowering vulnerable communities through sustainable management of water resources, promotion of rainwater harvesting structures and technologies as well as by conserving water supply sources and strengthening of existing schemes.

This shows that the Government agencies are well aware of the “pond” technology and are willing to support it as it is very much within their agenda directly (as mentioned specifically in the DSCWM and Irrigation Sector strategies) or indirectly as a means of rain water harvesting. This, in combination with enthusiastic support and involvement of local and International NGO community, this technology stands a fair chance of being widely adopted as a viable means of recharging groundwater sources as well as possibly the only identified option for adapting to the anticipated adverse effects of climate change in water source protection.

## 1.3 Objectives

The main objective of this handbook is to help facilitate planning, construction, management and use of ponds for recharging groundwater in different geographical regions of Nepal. The handbook specifically aims to help water managers in Middle Hills, Mahabharat, Siwaliks, Bhabar and Terai regions to build recharge ponds for augmenting aquifers and realize the additional benefits from water stored in ponds.

# 2 The Setting

## 2.1 Physiographic Regions

Water regime across Nepal varies in amount and distribution from place to place due to topographical and climatic variations. Understanding natural phenomenon of water regime across different physiographic zones requires a general understanding about the orographic variations.

Nepal is often classified into three broadly understood geographical regions of Mountains, Hills and Terai. Actual physiography, however, is a little more complex than this. The commonly understood Mountain region consists of the high mountains and Himalayas with permanent snow and ice; the Hills include Mid-hills, Mahabharat and Siwalik regions; and the Terai refers to the plains in the South. Thus, in the context of promoting recharge ponds, the following physiographic divisions of the country are appropriate: 1) The Himalayas, 2) The High Mountain, 3) The Mid-hills and Mahabharat Region, 4) The Siwaliks, 5) The Bhabar Zone, and 6) The Terai. A brief description of each of the broad physiographic regions is given below (Also refer to Figure 1 for the Physiographic Regions as described here).

### 2.1.1 The Himalayan Region

The Himalayan Region includes the three distinct high mountain regions of 1) The Trans-Himalayan Hills and Plateaus; 2) The Inner Himalayan Mountains; and 3) The Main Himalayan Range. The Himalayan Region occupies about 15 percent of the total land area of the country. Lying mostly above 4000 Meters in elevation on an average, this region is sparsely populated. About seven percent of the total population of the country inhabits this region.

The area lying to the north of the main Himalayan range is in rain shadow and receives less than 200 mm of rainfall. The westerly winds produce considerable amount of snowfall during the winter in high altitude valleys like Humla, Mugu, Thak Khola (Mustang), and Manang. Snow stays on the ground for quite a long time. Wind blows with high speed in the mountains and valleys of this region and streams freeze during winter. The main Himalayan range is broken in several places and the major rivers like Arun, Bhote Koshi, Marsyangdi, and Kali Gandaki flow southwards through deep gorges along these breaks. This region contains high peaks covered with snow and ice, glaciers, and glacial lakes which serve as a source of water for the great rivers. Even though water demand is low due to low population density managing water is a big problem in the region.

### 2.1.2 The High Mountain Region

High relief and steep slopes characterize the High Mountain region. It is not uncommon to find a relief of 2000 meters in a single valley which can result in tropical type of climate in the valley bottom to cool temperate on the mountain tops. The High Mountain region comprises about 19% of the total land area of the country. Due to an extremely rough terrain the region has historically remained remote and inaccessible. Only recently were a few districts like Jumla and Mustang connected with the rest of the country by means of motor vehicles. Agricultural lands exist in pockets and are farmed at subsistence levels. Forests are in comparatively better conditions than in other regions, mainly because the demand for forest products is limited due to low population density. The problem of water availability and management are similar to the ones in the Mid-hills region as described below.

### 2.1.3 The Mid-hills and Mahabharat Range

The Mid-hills and Mahabharat range occupies the largest geographical area with about 40 % of the population living here. Diverse in culture, ethnicity, and language; the area is also diverse in climate and vegetation, precipitation, and everything that depend on them. One of the striking characteristics of this region is that the people have depended on income from sources outside the region because the income from the farm production has not been sufficient to meet their needs. The interdependence between farms, forests, and livestock is quite evident in middle hills than in other areas of Nepal. These linkages are maintained by availability of water, which provides a basis and the incentive for people to manage these resources. However, in places where water availability has reduced the incentive to manage these resources also have weakened.

The southern slopes of the mountains in the area are highly eroded but are heavily settled. The elevation ranges from below 1000 m to more than 3500 m with varying degrees of mountain slopes from below 10 degrees to more than 60 degrees. The average slopes can be taken as about 20-30 degrees. On these varying slopes one can find villages and farms from the valley to the ridge areas, which make it completely unique in terms of defining water problems. For those living at higher altitudes the only sources of water are the springs and streams located below the villages, because there is no place to capture water during the monsoon and to store it for later use. The villages in the valleys and at the foothills have sufficient water sources from springs and streams coming from watersheds above. In addition they also have access to the water from the rivers flowing in the valleys. For the villages in the middle parts that are generally settled on colluvial deposits there are springs above and below the settlements. People dependent on the springs above can come down to the springs below the villages when the springs above dry out. The water supply system uses the gravity flow and therefore is connected to the springs above the villages.

The Mahabharat Range, which occupies the southern part of the Mid-hills region, is characterized by steeply sloping and rugged mountain slopes and deep valleys. Soils are shallow and infertile. There is very little land available for sustainable agriculture. As a result, the population density is low. The mountain slopes generally have dense forest cover with patches of shrubs. The area often receives high intensity rain and is characterized by high soil erosion with periodic catastrophic erosion caused by cloud bursts that initiate hundreds of shallow landslides in the densely vegetated slopes.

### 2.1.4 The Siwaliks

Extending from west to east, the Siwalik Hills, locally known as the Chure, in the southernmost frontier is the youngest and the last mountain range in the Himalayan range. The Siwaliks has a width of about 8-10 kilometers. It rises abruptly from the Bhabar and has a slope of more than 50 degrees with deep gullies and vertical landslide scarps. The southern slopes are steeper than the northern slopes. The Siwaliks have thousands of small catchments from which numerous small streams originate. Though it is a separate chain of mountain, the Siwaliks is separated from the Mahabharat by the inner Terai or Doon in some places. In other places, it merges with the Mahabharat and it is difficult to distinguish the two.

The Siwaliks is characterized by high erosion, low water availability, and sparse settlements. Spring sources are available in isolated pockets whereas erosion during the monsoon is widespread with generation of massive amount of sediment that gets deposited in the Bhabar – the piedmont of Siwaliks. Slope stability is a big problem in Siwaliks.

### 2.1.5 Bhabar Zone

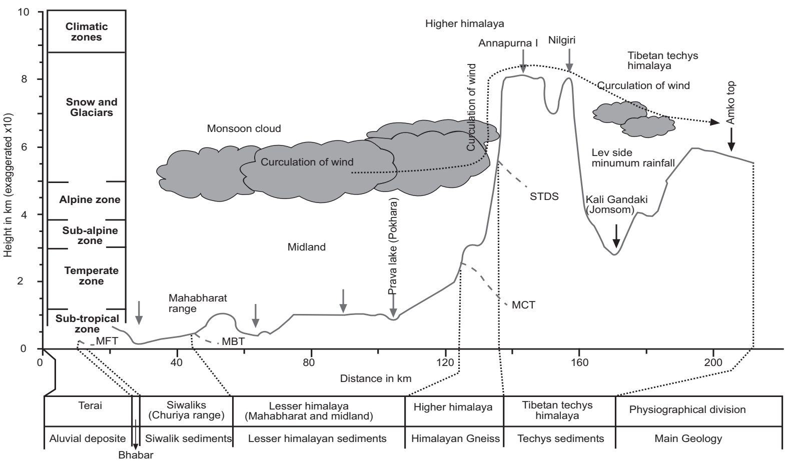
The corridor lying at the base of south of the Siwaliks is the Bhabar zone which is the northern most flank of the Ganga plain and extends from the piedmont of Siwaliks southward to a maximum width of 8-10 kilometers. The region is extremely poor in water availability. Rainwater is retained for a short period and is available only when it rains. Rainwater either seeps underground immediately or runs as overland flow resulting in a flash flood. The rivers from the Siwaliks meander and sometimes flow in braided forms.

The Bhabar zone is mainly composed of boulders, pebbles, cobbles and coarse sand derived from the rocks of Siwalik and Mahabharat Mountains. These boulders, pebbles, and cobbles are mostly made up of sandstones and the rocks from the immediate northern vicinity.

Bhabhar zone is a major recharge zone for the Terai. The rivers including Koshi, Gandaki, Karnali and all other minor rivers flowing from the Himalayas dump a huge amount of water into the groundwater aquifer continually while passing through the Bhabar. Even ephemeral rivers originating from Mahabharat and Siwaliks add water to the groundwater of the Gangetic plain while crossing the Bhabar, but their contribution compared with the snow fed rivers is only nominal. Water tables in Bhabar are deep and fluctuate sharply between the wet and dry seasons. Therefore, agriculture and other economic activities that require continued supply of water is difficult in Bhabar.

Watershed boundaries within Bhabar are dynamic and change frequently. Stream density is low with undefined boundaries between two streams. Small irrigation channels built by villagers turn into large streams in no time causing massive damages to settlements and farms. Unlike in the middle hills, villages in Bhabar cannot get water supply from the high grounds in the Siwaliks because Siwaliks does not have springs like in the middle hills or Mahabharat. Drawing water from groundwater is also not easy because of deep groundwater level.

FIGURE 1: **Physiographic Regions**



### 2.1.6 Terai

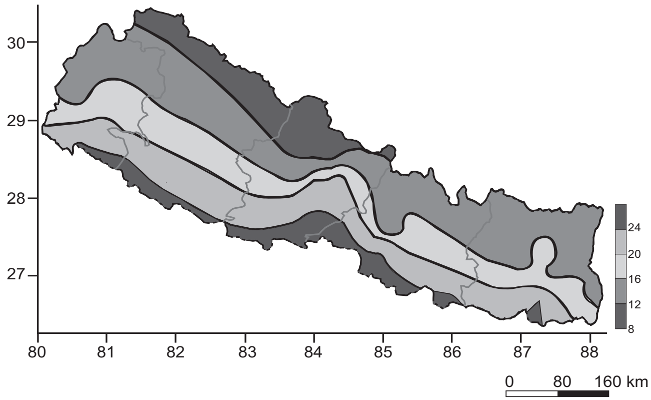
South of the Bhabar zone lies the Terai which extends southwards up to the Indian border. The soils of this zone are quite deep and have high water holding capacity. Terai is frequently flooded during the monsoon season. Water table fluctuates considerably between the wet and dry seasons. Amount and intensity of rainfall varies from east to west in Terai. While the soils remain saturated almost always during the monsoon, the Western Terai begins to experience water deficiency as early as November in contrast to the Eastern Terai where the soils begin to dry out only in January.

It should also be remembered that Nepal Himalaya range is crossed by three major geological faults, the Main Central Thrust (MCT) just along the foot of Higher Himalayas, the Main Boundary Thrust (MBT) just south of the Mahabharat Range, and the Main Frontal Thrust (MFT) that straddles the base of Siwaliks. The country is also divided geo-tectonically in “blocks” by several north-south transverse faults, making the entire region geologically very dynamic.

## 2.2 Climate

Climate in Nepal varies from subtropical in the Terai to arctic in the High Himalayas within a short span of about 125 kilometers across the breadth of the country. The wet season lasts from June till September and is caused due to the south-west monsoon. October through May is mostly dry, occasionally interrupted by a few showers in the winter and spring season. Thus the main rainy season is confined to the monsoon season followed by a cool to cold, dry, post-monsoon season and a hot, dry pre-monsoon season. Depending upon the location of springs

FIGURE 2: **Average annual temperature distribution in Nepal ($^{O}$C)**




*Note: The axes in the figure indicate Latitude and Longitude* in the mountains some springs begin to dry out as early as October and others continue to flow for longer period.

## 2.2.1 Temperature

Minimum temperatures occur in December and the maximum in May in all parts of the country. While this is a general phenomenon, the temperature itself is strongly affected by the topography. Especially in the Mid-hills and Mountains, temperature is directly correlated with altitude. A lapse rate of about 0.6 degrees Celsius fall in temperature with every 100 m rise in elevation is a generally accepted norm.

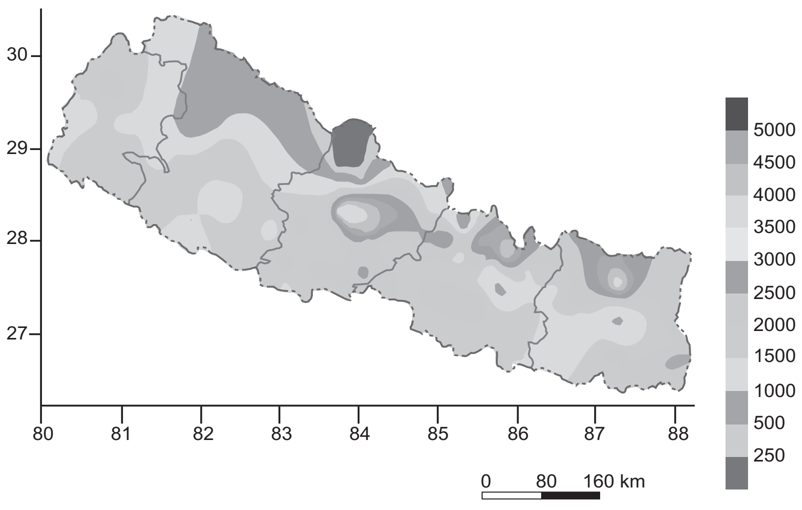
Figure 2 shows the distribution of annual average temperatures for Nepal which clearly reveals the inverse relationship between elevation and temperature.

## 2.2.2 Rainfall

The rainfall and its distribution in Nepal is characterized by the following features:

1. Main rainy season occurs during the four months of monsoon from June to September. About 80 percent of the annual rainfall occurs during this season and the rainfall regime covers, the whole country except the northern Himalayan region.
2. Westerly weather systems bring occasional rains during the winter and early spring. But occurring occasionally, they affect isolated hilly areas, often the western part of the country.
3. During the pre-monsoon season from March to May, local orographic or convective rains may occur

FIGURE 3: **Average annual rainfall distribution (mm/Year)**




*Note: The axes in the figure indicate Latitude and Longitude* mostly over the hills and inner Terai areas. But they affect isolated areas, mostly in the form of brief thundershowers.

The rainfalls of latter two types are rather unreliable and account for only about 20 percent of the annual total precipitation. They are occasional and affect isolated areas only. However, for local water management in the dry season and maintaining soil moisture (i.e. Green Water), they are very important. They occur after months of practically no precipitation from October onwards, and the winter rains during December and January come in lesser intensity at a colder period resulting in more recharge to runoff and less evapotranspiration. Ponds help in capturing more of this rain just before the onset of the driest hot period of April and May.

Annual rainfall varies from about 250 mm in the rain-shadow areas of north-west Dolpa and Mustang to about 5000 mm in the windward slopes of Kaski district (Figure 3). Western parts receive less rainfall in the monsoon compared to central and eastern parts. During the winter, however, rainfall is more reliable in the west than in the east. More rainfall occurs on the south-eastern slopes which act as windward side to monsoon winds during the summer. The hilly areas of western and north-western slopes as well as those behind the high mountains receive little rainfall. Isohyets of 1500 to 2500 mm cover most of the eastern and central hilly regions while those in the western region are between 1000 to 1500 mm. This difference in annual rainfall distribution may be due to topography, continentally and partly due to late onset and early retreat of summer monsoon in the west.

The above analysis of rainfall characteristics indicates that across all the physiographic regions there is too much rain during the Monsoon period followed by severe shortage of water during the dry season for not only agricultural activities and animal husbandry but also for daily necessities of the households. Capturing excess water that falls during the Monsoon and in the winter is thus a practical means of storing water underground for use during the dry season.

## 2.3 Hydrological Context

Though Nepal receives an average of 1500 mm of annual precipitation, its distribution is skewed. About 80 percent of the annual precipitation is dumped within 3 – 4 months between June and September. This rain recharges the water sources including the groundwater reserve, which supports ecological, environmental and economic demands for water. Between September and May, Nepal receives the remaining 20 percent of the annual precipitation. As a result, this period is mostly dry.

Water in the hills and mountains is often concentrated in the streams in deep gullies too far below hill settlements to be of much use due to the prohibitively high energy cost of pumping. As a consequence, Nepal's Mid-hill hamlets have traditionally relied on spring sources for drinking water, for domestic animals and for small-scale farming. Nearly half of the country's 26.6 million who live in hills and mountains depend on spring sources for their water needs. The springs are fed mainly by the monsoon rains, and the winter rains too contribute to prolonging their life well into the pre-monsoon dry season. It is ultimately the rainwater that is stored in the groundwater within the mountains that leaks out in the form of spring and sustains hill life and livelihood.

The Mid-hills of Nepal support high population density and suffer from the "altitude challenge". It consists of a daily battle against gravity, which is most pronounced in the availability of water for domestic use as well as for animal husbandry and farming.

It needs to be stressed that all streams that are used for collecting water also ultimately depend on springs (and the hill 'water towers' that store the monsoon waters) for their flow. Water management here unlike in the high-Himalayan watershed must be thought in terms of monsoon and winter rains and harvesting and storing this precipitation to provide water security during the dry season.

## 2.4 Water Sources in Terai

Water sources in Terai include surface as well as groundwater sources. All rivers flowing from the mountains and the intermittent streams from the Siwaliks flow as surface water sources. In addition, there are ponds, lakes and wetlands. A huge amount of water in all rivers leaks to the groundwater reserve as soon as they cross the porous areas of Bhabar region. Water sources in Terai are part of the far larger interlinked Ganga basin system. The groundwater is, in fact, an extension of the groundwater of the Gangetic plain.

The interaction between groundwater and surface water is strong in Terai. As a result, in some places, the small streams disappear in the Bhabar and reappear as it reaches Terai plain. This indicates that much of the stream flow in the lower section near the Nepal-India border is probably contributed by groundwater. Identification of a distinct basin is difficult.

During the monsoon season, most of the Terai is inundated for weeks with several feet of standing water. Low lying areas remain wet for a considerably long period after the monsoon season while in the higher land water table starts to go down soon after the monsoon ends. This fluctuation of the water table in the wet and dry seasons determines the availability of water in this region.

Groundwater is used for drinking in most parts of Terai. Water is drawn either by digging wells or by using hand pumps. In towns and cities, groundwater is pumped up to overhead tanks using electric pumps.

The basic purpose of ponds in the Terai

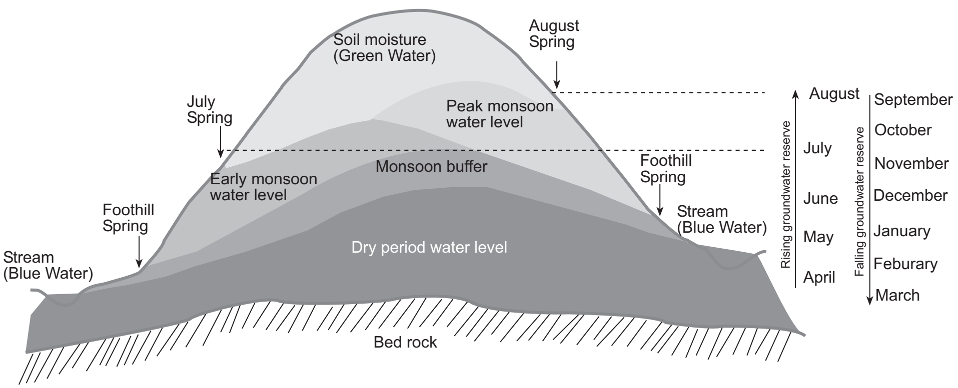
is to make water available to household uses as well as for animals. But it is often used for income generating activities like fishery and for irrigating kitchen gardens. Even if it is not as significant as it is in the mountains where no specific area exists for groundwater recharge, the recharge ponds in Terai do help replenish groundwater. If strategically located, ponds may also serve as a mechanism for controlling flood, which occurs frequently in the region

## 2.5 Spring Hydrology

The interdependence of rainfall and topography in the hills results in the sprouting up of springs at various elevations as the monsoon progresses. The eco-hydrology of these Mid-hill springs is poorly understood. Springs (*Mool* in Nepali) have not been properly mapped in Nepal, nor have their typology, hydrology and socio-economic dependence been systematically studied, even though the majority of Mid-hill Nepalis depend upon them for domestic water supply as well as livestock rearing and some homestead farming.

In terms of typology, based on their location in the 'water tower', springs can be classified as August springs (*Saune Mool*), which are located at the higher elevation on the mountains. They are short lived and dry out as soon as monsoon ends. Located below August springs are the July springs (*Asare Mool*) which begin to flow in the middle of the monsoon season and continue to flow until middle of the dry season. At the bottom of the mountains are the permanent springs (*Sthai Mool*) which flow year round with varied level of discharge between the dry and wet seasons. These types of springs have not been properly mapped, their varying discharge levels have not been scientifically ascertained for villages that are dependent upon them, nor have the current uses as well as future needs

FIGURE 4: **Typical "Water Tower" in the Mountains**



been charted. Without these physical and social sciences in place, a sustainable exploitation of these valuable resources, their proper conservation and possible enhancement through anthropogenic-induced recharge is not possible.

The soil moisture in the farms and the amount of water available around the villages depend on two things: the location of the village and how much water has been saved in the soil and the groundwater aquifer during the monsoon. Figure 4 depicts a typical hill 'water tower'. The monsoon rains percolate into the soil contributing to groundwater replenishment and the bursting forth ('*Mool Phutne*' in Nepali) of springs at different stages of the monsoon. The August springs indicate complete recharge of groundwater reserves. These springs and the groundwater table begin to decline until replenished by winter rains or, if these fail, only in the next monsoon. The drinking water supply systems in the Mid-hills tap different sources, store it in a reservoir tank and distribute via community tap stands. Gravity flow systems have been built to supply drinking water.

Water stress in the mountains is actually measured by farmers in terms of when or how early particular springs dry out. Immediately after the monsoon season ends in September, the hills begin to face water shortage. Soil moisture in all farms and grassland begins to deplete. Springs located in the upper areas start to gradually dry out. Springs, at the lower areas, keep flowing, but not for long. As the winter progresses, the discharge reduces in the springs even at lower foothill areas. Many of them dry out during April/May. Water taps connected to the springs at the upper slopes also dry out.

## 2.6 Climate Change

Rising global temperature is projected to lead to a change in the existing climatic pattern with multiple impacts on natural resources including water. The delicate balance between various processes of hydrological cycle will be threatened due to the change in rainfall pattern, its intensity, evapotranspiration, and so on. When that happens, there may be a critical decrease in stored water whether in terms of soil moisture, groundwater table or in ice and snow in the higher mountain regions. This will result in a general decline in water availability in hill catchments leading to increased water stress both in the hills and plains. The differences between wet and dry seasons are also likely to increase: the dry seasons are expected to be much drier for prolonged periods and wet season much wetter with intense rainfall events. Changes in frequency and magnitude of high intensity rainfall events are likely to increase flash floods and water induced disasters as well as accentuate the differences between high and low water flow regimes. Ponds technology is one of the more feasible technical options for rural communities to cope with and adapt to climate related changes.

# 3 The Recharge Ponds

## 3.1 Why recharge ponds?

Rainfall distribution in Nepal is highly skewed with too much of it coming within four months of the monsoon and very low rainfall during the rest of the year. This "Too Much and Too Little" of rainfall causes problems in terms of availability of water during the dry period. Winter rainfall is helpful in augmenting ground water, if there is adequate amount of rain. In recent years, winter rain has been inadequate in many parts of Nepal causing extended drought. Thus, as all aspects of our livelihood for the eight months of the non-monsoon months depend on the water stored in the groundwater aquifer during the monsoon, there is need for a system to capture as much water as possible during the monsoon for later utilization.

Gravity water supply systems in the hills and mountains use springs and streams as source of water. The springs and streams are fed by aquifer, which are replenished naturally through rain soaking through soil and rock to the aquifer below. Some of the streams also feed water to the springs through infiltration. The groundwater reserves begin to deplete as soon as the monsoon rain stops, the springs begin to dry out gradually beginning from the upper elevation areas to the lower ones. Water supply systems connected to the spring sources suffer as soon as the flow rate in the springs decline or dry out completely. Water supply systems generally fail to operate at the optimal design level when the sources deplete. Many water supply systems have turned into relics after they have ceased to provide water. There are many reasons for the source to decline including change in the landuse, weather variability, change in the rainfall distribution and intensity, climate change, population growth, and increasing urbanization and so on. The bottom line is that the water supply systems fail affecting the livelihood and health and sanitation of the people who depended on the system.

Enhancing natural rates of groundwater recharge by using ponds is an easy and low cost method of augmenting groundwater sources. Ponds are an appropriate and practical means of establishing such a system for collection and storing water or in other words for replenishing the "water tower" in the Hills and Mountains. Recharge ponds can be used to store rainwater, runoff, and waste water or even water from spring sources before they flow down the slope. Recharge ponds involve diverting surface water into ponds that allow water to soak through the unsaturated zone to the underlying unconfined aquifer. Once captured in the ponds, water continues to seep down and recharge the ground water long after the rainfall ceases. Pond water can also be used for watering animals, washing clothes, doing dishes, and kitchen gardens irrigation. Ponds are also useful for a number of other purposes like maintaining soil moisture for the growth of shallow rooted vegetation as well as to put out fire. In higher elevations where there are very few or no springs, storing water in the ponds is the only option for making water available in the dry period.

The "water tower" concept explains the fluctuation of groundwater table in the hills but the situation in Terai is different. While springs constitute the source of water supply in the hills, in Terai it is the groundwater that provides water which needs to be pumped up either manually or using machines. The water table fluctuates considerably and many places experience drought during the dry season. Thus, the strategy of storing as much water as possible during the monsoon for later utilization is a valid strategy for the Terai region as well.

As mentioned earlier, climate change is going to cause increased droughts and floods. Drought will be more intense where rainfall decreases, and floods would increase where amount and intensity of rainfall increases. Balancing this skewed distribution of rainfall is essential to adapt to both floods and droughts.

Experience of using ponds has shown that it helps to reduce landslides and erosion in the hills and flooding, to a certain extent, in the Terai by regulating runoff. Therefore, ponds will be helpful in adapting to the changes in water regime triggered by climate change.

Major advantages and disadvantages of ponds for a community and possible mitigation measures to reduce the disadvantages are shown in Table 1, below.

## 3.2 Types of Ponds

There are several types of ponds that can be built depending upon the area where they are built and purpose for which they are built. If the purpose is to store water for a long time, for instance for irrigation or for fishery, the sides and

TABLE 1: **Advantages/Disadvantages of Ponds**

| Potential Advantages | Disadvantages | Mitigation Measures |
|---|---|---|
| • Recharge ground water.<br>• Enhance water availability.<br>• Controls instant over flow of runoff and reduces floods and erosion.<br>• Watering animals (ponds have been useful in watering animals and buffalo wallowing.)<br>• Watering kitchen garden.<br>• Fish production (in Bhabar and Terai).<br>• Fire protection (access to water to put out fire).<br>• Helps in maintaining soil moisture.<br>• Supports in maintaining ecosystems.<br>• Can be used for recreational activities. | • May cause risk to small children if the pond is deep.<br>• Mosquito breeding is likely in warm and polluted areas.<br>• Big ponds in the steep areas have potential to break causing erosion in the downstream area.<br>• Landuse restricted to pond only. | **Risk for children**: To avoid this risk fences can be built around the pond.<br>**Mosquitoes**: Regular cleaning if scum develops.<br>**Erosion in hills** can be controlled by making the pond small. |

bottoms of the ponds must be partially impervious. At one end of the spectrum are the ponds built with heavy masonry and concrete linings and at the other end are those simple dugout types without any lining. There can be many intermediate types between these two extremes. For recharge purpose, ponds must be able to hold water for some time as well as to percolate it down into the ground water system. Depending on location and geological condition, at least some sides of the ponds may need to be lined, but the bottoms must remain unlined. The basic types of ponds identified for the purpose of recharge are described in brief in the following sections:

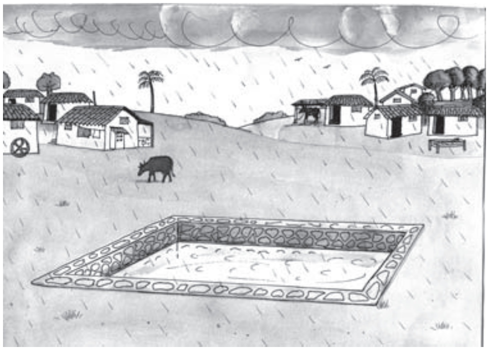
### 3.2.1 Excavated Ponds

An excavated pond is often built on level terrain by digging soil and sometimes rocks if it is near the surface (Figure 5). An excavated pond is generally built on residual soil or ridge of the hill or a grazing land where flat area is available. An excavated pond requires low maintenance and can be built to hold more water by increasing depth or its size, if enough area is available.

The excavated ponds built in pervious soils such as that of Siwaliks must have vertical sides of stone masonry in cement mortar to prevent seepage through the sides and allow infiltration through the bottoms of the ponds. The

FIGURE 5 A: **Excavated Pond (Unlined)**

FIGURE 5 B: **Excavated Pond (Lined)**



ponds in the Bhabar region, on the other hand, must have unlined sloping sides so that infiltration can take place from the sides and bottoms of the ponds.
In Bhabar region, ponds can be located close to streams originating from the Siwaliks, so that the stream flow can be diverted to ponds fed by flow from these rivers. Caution should be exercised in some areas of Bhabar where diverting water from streams can result in floods in new areas.

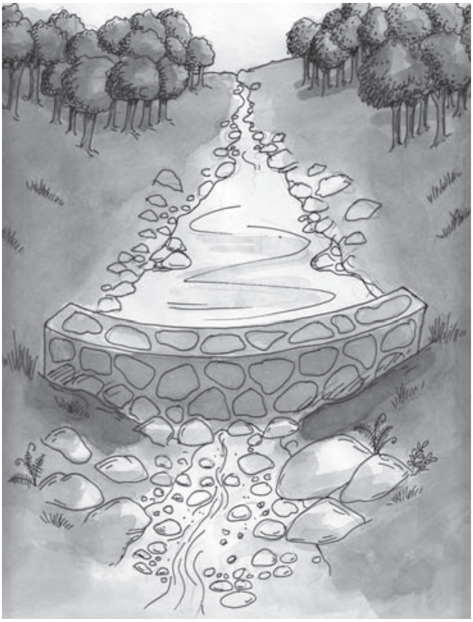
### 3.2.2 Embankment Ponds

Embankment pond is built by erecting a stone masonry or earthen dam to impound flowing water in a stream or on gently sloping gully (Figure 6).
Embankment pond is suitable in small streams at the foothill areas, because of gentle slope of the stream beds. Except for building foundation of the stone masonry dam there is no excavation involved. Earthen dam can be built by pulling soil from the lower areas and sides where impounding is done.

TABLE 2: **Advantages and Disadvantages of Excavated Ponds**

| Advantages | Disadvantages |
|---|---|
| ● Facilitate re-charge into surrounding ground which in turn improves soil moisture, improves agricultural productivity and mitigates against drought.<br>● Can assist augmenting spring discharge through recharge of shallow aquifer.<br>● Can reduce salinity of soil in high evaporation area. | ● They can silt up easily.<br>● Maintaining dams requires effort.<br>● High evaporation rates. |

FIGURE 6: **Embankment Pond**



In embankment ponds there will be plenty of water coming in the pond. However, impounding flowing water can be problematic for fish and other aquatic animals which travel up and down stream. Floods can also be problem for the dam. Therefore, expensive cement mortar should be avoided because earthen or dry masonry dams can be re-built if it is damaged by floods in the monsoon. Generally, this type of pond should be considered for specific purpose of slowing down the stream flow and recharging the groundwater.

### 3.2.3 Contour Trenches

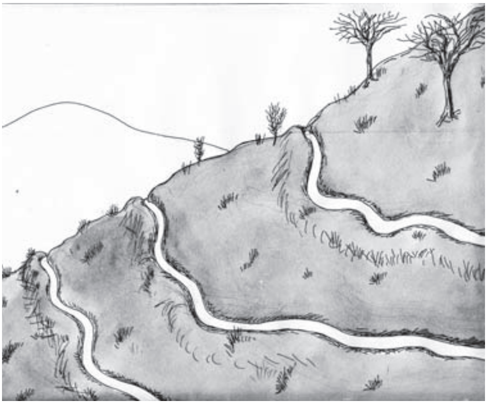
Contour trenches are ditches dug along a hillside to check the runoff on the slope (Figure 7). Trenches are dug in such a way that they follow a contour and run perpendicular to the flow of water. The spoil material taken out of the ditch is used to form a bund on the downhill edge of the ditch. The bund needs to be planted with native grasses to stabilize the soil and for the roots and foliage in order to trap any sediment that would overflow from the trench in heavy rainfall events.

TABLE 3: **Advantages and Disadvantages of Embankment Ponds**

| Advantages | Disadvantages |
|---|---|
| ● Reduces flow in the gully and helps recharge groundwater faster for longer period.<br>● Plenty of water available in the impoundment for irrigation.<br>● Easy to build as it does require construction or excavation on one side only. | ● They can silt up easily.<br>● High flood in the gully can create damaging floods in the down stream.<br>● Maintaining dams requires effort.<br>● High evapora-tion rates. |

Contour trenches are used to catch runoff water, which then infiltrates into the soil. Small scale contour trenches can also be used within farms. The water that infiltrates can be used as soil moisture for crop. This technique will help farmers to grow crops such as vegetables and at the same time help recharge the aquifer.

FIGURE 7: **Contour Trenches**



Long trenches can be risky for heavy rain and therefore the trenches can be made short in length and not connected if the area has a history of receiving cloudburst rainfall events.

TABLE 4: **Advantages and Disadvantages of Contour Trenches**

| Advantages | Disadvantages |
|---|---|
| • Improves soil moisture and helps aquifer recharge.<br>• Improves grazing potential and helps mitigate against drought.<br>• Reduces soil erosion Can assist recharge of shallow aquifer Can improve soil fertility by adding organic matter. | • Trenches silt up faster and will need periodic maintenance.<br>• Difficult to maintain bunds along the trench which when breaks due to animals or by high runoff, can cause erosion along the slope.<br>• Reduction in grazing area when trenches are full of water. |

### 3.2.4 Eyelash Trenches

Eyelash trenches are small trenches that are built as eyelashes across the slope (Figure 8). It is suitable for slopes where coutour trenches are not feasible due to steepness slopes. Slopes greater than 30 degrees are not suitable for counter trenches and hence should be land out as eyelash trenches. The depth of the eyelash trenches need to be about 30 to 60 cm, while the width can be maintained at 50 cm. Bigger than 50 cm may cause erosion as they hold more water and can fail during heavy rainfall events.

FIGURE 8**: Eyelash Trenches**

TABLE 5: **Advantages and Disadvantages of Contour Trenches**

| Advantages | Disadvantages |
|---|---|
| • Silt up in eyelash trench is slower than contour trench.<br>• Helps break erosive force of runoff along the slope.<br>• Holds water in small pockets to improve soil moisture and helps aquifer recharge<br>• Improves grazing potential and helps improve residence against extended drought.<br>• Reduces soil erosion<br>• Can assist recharge of shallow aquifer. | • Cumbersome to make them in several numbers along proper alignment.<br>• Reduction in grazing area when trenches are full of water. |

# 3.3 Shape, Size and Depth of Ponds

## Shape

Excavated recharge ponds can be built to almost any shape desired suiting local site conditions. It can be rectangular or circular or elliptical in shape. If the plan is to line the pond with stonewall, it is better to build a circular pond because of its cost effectiveness. A circular pond has higher volume for the same perimeter as that of rectangular or square ponds (also see the box 1).

## Size

The size of recharge pond depends on the area available to build it on and the location of the pond. In the hills, for instance, a recharge pond can be as small as a small pit of say one cubic meter (1m x 1m x 1m) to as large as 2 to 3 thousand cubic meters (say 50m x 30m x 2m). In the valleys and plains ponds can be built to hold hundreds of thousands of cubic meters of water. The size is also determined by the amount of inflow that can be expected in a given period, and the fund available.

In Mid-hills and Siwaliks, large number of small recharge ponds is preferred compared to few and big ones, whereas large ponds are suitable in valleys and in plains of Bhabar and Terai.

**Box 1. Volume comparison between circular and square shaped ponds**

Assume a square shape with side 4m. Its perimeter will be 16m. Now, if we want to create a circle whose perimeter or the circumference is of the same length, it’s radius will be 2.55m, and with 2m depth, the volume will be 40.76m$^3$, about 27% more volume than for the square shape whose volume is 32m$^3$ (See calculation below).

| | | | |
|---|---|---|---|
| Square | Length | X | 4.00 |
| | Perimeter | P=4*X | 16.00 |
| | Area | A1=X^2 | 16.00 |
| | Depth | D | 2.00 |
| | Volume | V1= A1*D | 32.00 |
| Circle | Circumference | P=2*pi*R | 16.00 |
| | Radius | R=P/(2*Pi) | 2.55 |
| | Area | A2=Pi*R^2 | 20.38 |
| | Depth | D | 2.00 |
| | Volume | V2=A2*D | 40.76 |
| | Difference in volume | V=V2-V1 | 8.76 |
| | % Difference | V*100/V1 | 27.39 |

### Depth

The most important dimension in a pond is its depth. For practical purposes, the design depth of water in the recharge pond should be up to 1.5 to 2 m. In Mid-hills and Siwaliks, the design depth of water recharge pond should be 1.5 m and it can be increased to up to 2 m in Bhabar and Terai region.

The following "rule of thumb" may be applied while fixing the size of pond.

- *Small pond:* small pond can be built in privately owned land, dug by one family. It is mostly used for collecting runoff from homestead area and for reducing runoff damage further down. Water thus collected will help recharge the soil moisture. [See ponds type 1 and 4], they are about 1x1 to at the most 2x3 meters and about 1 to 1.5 meter deep.

- *Medium sized pond:* it is preferable to build medium sized ponds near a tap stand or at the saddle over pass in the mountains. It is a common type that fits into the requirement of many and fits well with available area in the mountains. The size under this category could be 10 to 25 meter wide and 25 to 30 meter long. [See pond types 2, 3, and 5]

- *Large pond:* suitable for foot hills and grazing areas in the hills. Large ponds in the ridge are suitable as far as they do not reduce grazing area. Average size under this category could be could be 25x25 meters or more. [See pond type 2, and 3], however, it is always desirable to build small but several ponds on the ridge rather than one or two big ones.

- *Terai ponds:* ponds in Terai can be quite large and are usually built for fish farming. Big ponds allow multipurpose uses like Fish Farming in combination with water used for irrigating a fairly large area and recharging the groundwater as well [See pond type 6].

Technically recharge ponds can be made deeper (more than 3 meter deep from the surface). In fact deep ponds help hold more water in a small area allowing continued infiltration to augment groundwater storage. But due to safety reason, especially where small children are likely to play around, it is appropriate to make pond not deeper than 2 meter with water level not more than 1.5 meters when it is full. Shallow ponds require large area to hold required amount of water, but they have larger area as well for infiltration allowing more water to seep in a short period. Shallow ponds also allow grass to appear on larger area around the pond, which helps reduce surface erosion.

## 3.4 Getting Started

Organized planning and construction of ponds requires a team work and coordination among various stakeholders. The team could include communities, field coordinators, engineers, technicians, construction masons, contractors, social development officers. Water Users and Sanitation Committee is an ideal local institution that can take the lead in constructing recharge ponds.

### 3.4.1 Preparatory Work

**Identifying water scarce areas**

Areas that are water scarce or areas that have shown indication of decreasing spring discharge or falling water tables must be identified. A good way to identify such areas is to compare the water discharge in water supply systems, with design discharge rate. Generally, in water scarce areas water taps have reduced flow, and the users need to wait for longer time to fill the pots.

**Mapping of existing ponds**

Number of the preexisting as well as newly constructed and proposed ponds, history behind their existence, or loss and local concerns for the particular pond should be recorded systematically. Such information would help in flagging the number of the existing ponds and calculate the location and number of them to construct further in need based criteria.

**Prioritization of VDCs for pond construction**

Listing VDC's with specific criteria for pond construction according to records made in mapping and other relevant social and environmental aspects, will help in selecting the location and the sites based on VDC's with need based priorities in particular. Prioritization can be based on few or all of the following ideas:

- Examination of local needs.
- Information about landscape and water issues at the location.
- Household benefited/affected by the water issues.
- Core interest of the community and the local authorities regarding the construction work on selected sites.
- Selection of communities.

**Identifying linkages**

Find out how proposed recharge project can be linked with development activities of other government and non-government agencies so that appropriate support can be sought and required coordination can be established for potential cooperation, funding, technical support, construction, and management. If there are various agencies supporting the construction of ponds, it should be made clear for necessary coordination. Permission from forest office is usually needed to construct ponds in the forest area, which is usually the case in high ridges where ponds are essentially important for recharging the groundwater.

**Purpose of ponds**

Type and size of ponds to be built are determined by the requirement of their uses. If the pond is constructed only for augmenting the groundwater, the ponds need to be located at higher elevations and away from the villages, but if the pond is also to be used for other purposes such as irrigating kitchen garden, or watering animals, then it must be close to the villages. Similarly, if it is being built in ridge area, it is necessary to build several ponds, rather than one or two big ones.

If the pond is used for wallowing buffaloes, it should be made in such a way that animals can enter and exit the pond without damaging it. Stones must be paved on the slope used as entrance for animals. Pond in such a case must be wide enough and not so deep.

### 3.4.2 The Users and their Involvement

It has been widely accepted that users must be involved in pond construction to make them sustainable. For this, the users must be encouraged to participate in every stage of project development. Information about local needs; varying interests of people; availability of resources; and the level of local knowledge, skills, and technology will help make ponds more durable. It will help in making decision, and garner physical and sometimes material support for pond construction. Therefore, the people must be consulted and their priorities and needs assessed at the planning stage. Every member of the community must be involved in the decision making process as well as in actual construction of the ponds. All community people have an equal right to influence and participate in the process.

### 3.4.3 Equity Concerns

A recharge pond is intended to improve the water availability and help water users in drier areas. But other benefits of the ponds such as washing, irrigation are equally valuable and thus it is important to consider the possible disputes it may create over the distribution of benefits. In other words, the question of equity on the basis of gender and other social context must be considered. Perhaps some group may try to take undue favor in use of pond such as irrigation or fishery, and may not involve itself in construction and maintenance in a fairer manner. These should be kept in mind during the design stage. Particular attention should be paid to the rights and equal participation of people who are vulnerable and socially excluded.

### 3.4.4 Land Tenure

Land tenure issues can have a variety of influences on pond construction projects. On one hand the people may be reluctant to invest in pond construction on land which they do not own. Where land ownership and rights of use are complex it may be difficult to persuade the water users to construct ponds that may be used later by others who the land belongs to. On the other hand there are examples where the opposite is the case - farmers like to construct trenches because they own the land and can use the benefits rightfully.

The most difficult situation is that of common land, particularly where no well-defined management tradition exists. Villagers are understandably reluctant to treat areas which are communally grazed.

### 3.4.5 Village Land-use Management

The question of land management by village communities is extremely important. Degraded land in and around villages can only be improved if land use management issues are addressed by communities themselves. One of the techniques which can assist in rehabilitation of degraded land is catching rainwater - but it is only one tool among several others and cannot be effective in isolation. Unless, for example, grazing controls are implemented, there is little point spending money on pond structures. This is particularly important if ponds are constructed in grazing land, which is used by large number of people.

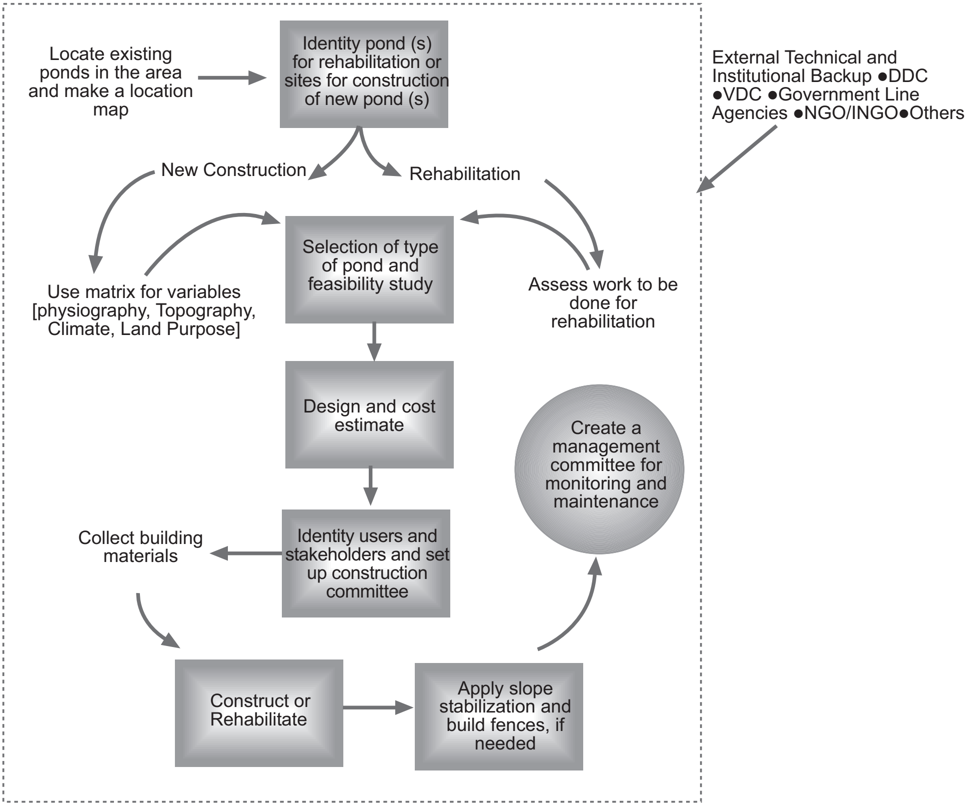
### 3.4.6 Building Consensus

It is essential that consensus will be built on all issues regarding pond construction. Therefore, it is important to hold a meeting in the beginning with community members. Meeting of the local users should be called before making important decisions. If needed, follow up meetings will be necessary to share concerns of all in making the final decision about the types of ponds, size of ponds, and location of ponds. Such meetings will help understand local concerns for more inclusive and informed decision, while it will also help promote the local resources and knowledge and make users more responsible for upkeep of the pond.

The meeting should focus on:

- Information sharing
- Understanding with local concerns
- Planning and construction details
- Task assignment with designated team leader
- Monitoring and maintenance
- Dispute resolution method

FIGURE 9: **Process Flow Chart of Pond Construction**



# 4 Practical Guidelines

## 4.1 Site Selection

Selecting the site for building pond(s) is an important decision. The site should be selected with clear understanding of why the ponds are being built, what type of ponds will be built, how many ponds will be built. Therefore, the time spent on selecting the site will pay dividends in the easier management and construction of ponds(s). While selecting site for a recharge pond, local people should be consulted so that their concerns are addressed and cooperation obtained.

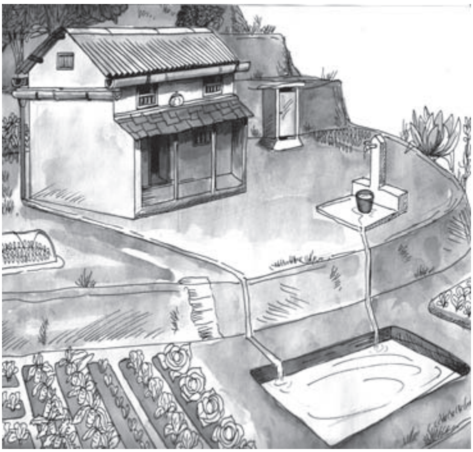
## 4.2 Location of Ponds

Ponds should be located by considering three factors: runoff collection, drainage channels and safe disposal of excess water.

### 4.2.1 Runoff Collection

Recharge ponds should be placed in strategic areas such as a pass or base of slopes where run-off from around concentrates. They are most commonly built in areas comparatively flat but well-drained. The low point of a natural depression is often a good location. A pond can be located in a drainage way or to one side of a drainage way if the runoff can be diverted into the pond. The pond must be sited on suitable place so that it can hold adequate amount of rainwater or runoff water and remain stable when heavy rain causes overflow.

FIGURE 10: **Runoff Collection**
**(The roof of the house is guttered to catch rain water and stored in the ponds)**



The pond can also be located near a house or a school building to collect water from the roof and open area around the building each time it rains. While making ponds near houses, the depth should not be more than 1 meter for safety reason and should be at least 20-30 meters away from the building.

Pond can be built near a tap stand where the waste water from the tap can be collected in the pond before it flows down. These ponds could be of small size. Also the excess water from intake or RVT can be diverted to the pond.

### 4.2.2 Drainage Channels

It is always necessary to ensure that runoff from around the pond is directed to the pond by shallow drainage channel. Usually there are trails in the catchment which divert runoff from one place to another. Such trails can be connected to the pond to ensure continued flow of runoff to pond. Figure 11 is a sketch of a drainage network to divert water to ponds.

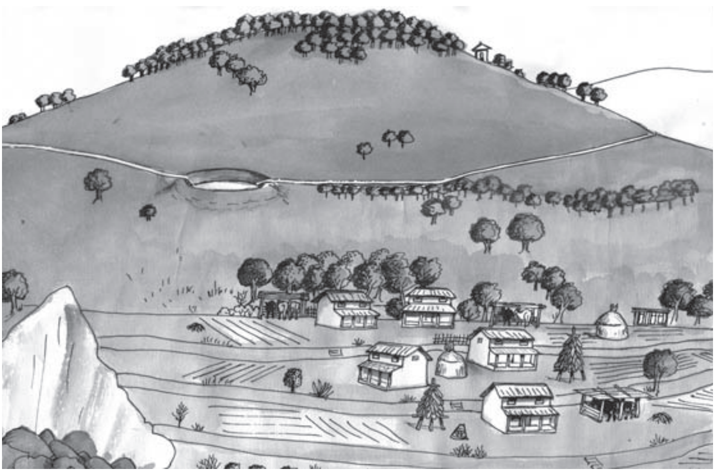
### 4.2.3 Disposal of Excess Water

After the pond is filled, excess runoff escapes through regular drainage ways. Also, consider availability of safe drainage site in the vicinity so that overflow from the pond can be discharged safely and economically.

### 4.2.4 Locations to be Avoided

- A pond should not be located near compost pit, cowshed, septic tanks, or along the main trail.
- It should not be built in an area that always stays wet.
- Don’t locate a pond close to big trees that may collapse into the pond.
- Don’t locate it on a disputed land.
- Avoid building pond in a rocky land because it is difficult to dig.

FIGURE 11: **Diverting Natural Drainage to Recharge Ponds**



# 4.3 Important Design Principles

Ponds have multiple uses and their design and construction depends on the purpose for which they are built. The purpose of making recharge ponds is to catch rainwater or runoff to augment groundwater, and hence a person who designs a pond needs to adhere to some principles as laid out below.

- A pond must be designed to promote augmentation of groundwater.
- To ensure recharge over a wide area it is advisable to build many small ponds rather than a few larger ones. It is about how wide area is covered by a pond than how much water is held within the pond.
- A pond needs to suit local needs and requirements and be built according to the decision of local water users.
- A pond should not be deeper than 2 meters with water depth of about 1.5 meters to reduce risks to small children.
- A pond should be built with local materials as far as practicable.

# 4.4 Design Details

### 4.4.1 Free Board

A free board of 0.5 m must be provided above designed water level of pond to safely accommodate sudden excess inflow to the pond.

### 4.4.2 Side Slope

Side slope of earthen pond should be kept as 1:2 (Vertical: Horizontal). In case of lined pond side slope can be reduced to 1:1.5, which can be lined by stone pitching (thickness of 10cm - 15cm).The sides can also be made vertical, in which case, the side should be lined with stone wall whose thickness should be at least 60cm.

### 4.4.3 Bottom of Pond

Bottom of pond should be left unlined to allow infiltration for recharging of aquifer. However, it can be partially lined with dry stone pitching to reduce the rate of infiltration so that comparatively more water is available for other purposes.

### 4.4.4 Inlet

Generally, runoff enters the pond from several points around the pond, but if the runoff from a particular point such as a house or front yard of a house is to be collected in the pond, consider using stone lined inlet or simple HDPE pipe for collecting run-off in the pond.

### 4.4.5 Overflow

Stone lined spillway can be provided for overflow. If needed consider using simple HDPE pipe for draining out the excess water above designed water level (Pond level).

### 4.4.6 Spoil Bank

The excavated earth shall be deposited around the pond to form spoil bank. The inside toe of spoil bank should be kept 1 m away from the edge of the pond so as to create a berm. Top width of spoil bank should be kept 2 m and inside and outside slopes as 1:1.5.

### 4.4.7 Fence

Normally, fencing is not necessary for a recharge pond, but if it is located within or close to a village, where small children are likely to get close, the pond should be fenced with hedge plants. The shoulder and edges of the pond must be put under suitable shrubs and grass cover. In any case, avoid a wall or barbed wire fence.

### 4.4.8 Ramp

If the pond is to be used for wallowing of buffaloes, a ramp needs to be built for the animals to enter and exit the pond. The stones used for ramp must not have length smaller than 15 cm or larger than 30 cm. The ramp must be built in such a way that it extends to the pond floor so that the repeated tamping by the hooves of the animals does not reduce the infiltration capacity of the bottom of the pond.

## 4.5 Number of Ponds

Recharge function by one or two ponds is ineffective in augmenting groundwater. The key is to make tens of ponds in strategic locations in a wider area. If the land is flat and has no limitation, the ponds can be large. But, in Mid-hills and Siwaliks where the area available is constrained by topography and slope, large number of small recharge ponds is preferred instead of a few big ones.

## 4.6 Official Permits

Usually ponds are built on public lands which are either under the authority of the VDCs or the District Forest Office. Many of such public land are also likely to be part of community forests or leasehold forests. In such cases permission from the concerned groups and authorities must be obtained before building ponds.

## 4.7 Time for Construction

There is no specific time for making ponds. They can be built at any time of the year, but it is appropriate to make them before the onset of monsoon so that they can store rainwater during the whole monsoon. The advantage of making the before the rainy season is that it allows adequate amount of time for grass to grow on the freshly deposited soil on the spoil deposit, which will help stabilize the outer area of the pond. A pond constructed before the monsoon will have entire monsoon period to experience the rain and runoff impact. One can monitor if there are any weak points from where the pond can break, or water leak, in which case repair and maintenance can be done in time.

## 4.8 Construction Materials

If the pond is going to be lined, stones for lining the pond would be collected. The stones would be normal size that can be used in making the lining. If there are odd size stones, they need to be chiseled to give desired shape. If erosion control measures are also planned, it is necessary to identify source of plant materials. Tree seedlings are available from the nursery of forest offices. The grass seedlings can be collected from either a nursery of from farmers' field. List of suitable grass species is given in the annex 1.

## 4.9 Tools Required

Digging tools such as spades and picks are enough for making pond. The spoil needs to be safely deposited on the shoulder, for which simple burlap sacks can be used.

## 4.10 Choosing a Lining

A recharge pond needs to allow stored water to seep into the soil. Therefore the pond bed is generally left unlined to allow regulated infiltration for a long period. However, in the initial years the bed of the pond is generally quite porous and water seeps in very fast. The pond dries fast. When it dries fast, the recharge function also stops.

As the pond gets old, the silt gets deposit at the bottom, which then reduces the infiltration rate. Water in the pond will be available for a longer period providing recharge functions for a longer period. The bed can be lined with stones leaving sizable gaps in between the stones. Stone lining on the bottom also facilitates cleaning pond regularly without further deepening it.

### Lining on walls

If a pond needs lining to save its side slopes from collapsing stone masonry is useful.  If seepage from the side slopes has to be reduced, then cement lining is required on those slopes. It can be used in combination with stone lining with outer part lined with cement

### Lining on the floor

If in case the infiltration at the bed is unlikely to decline even after few years, which generally happens in places where soil is made up of coarse material, the pond bed requires partial lining.

## 4.11 Plant Material for Slope Stabilization

Spoil material deposited on the outer slopes of the pond is generally loose and needs to be protected against erosion. The most appropriate method of stabilizing such slopes is to use bioengineering methods such as brush layering, fascines and live staking. Of course, there are other techniques that can be used, but for a quick and effective result, it is recommended to use brush layering and fascines (See annexes 2 and 3).

It is always good to have shade over the pond especially for small ponds where evaporation loss can be very high. The shade can be provided by planting shrubs around the pond. Pond will allow grass to appear on the shoulder of the pond. The grass must be maintained because it helps reduce erosion and enhance aesthetic view of the pond. Grass can also be planted on the outer slopes to protect the pond from erosion. If planting is planned, it needs to be done in the beginning of the monsoon season preferably in early July, when the soil is wet and allows plants to get established before the monsoon ends. The suitable plants species are given in the annex 1.

## 4.12 Maintenance

The pond should be inspected periodically. It should be examined after heavy rains to determine whether it is functioning properly or needs minor repairs. Any damages should be repaired immediately to avoid the need for more costly repairs later. The damage may be small, but if neglected it may increase until repair becomes impractical and the entire structure must be replaced.

A pond, no matter how well planned and built, must be adequately maintained if its intended purposes are to be realized throughout its expected life. Proper maintenance extends ponds' useful life. Maintenance of pond involves two major activities: (1) maintaining the lining and side slopes, and (2) cleaning the floor of deposited sediment.

**Maintaining the Lining and Side Slopes**
Stone lining provided around the pond is likely to be damaged by human activity or by animals walking over it. Sometimes the walls also collapse due to activities of rodents and crabs in the dry season. If they are damaged, they should be maintained immediately. If unlined lopes have collapsed due to erosion from inside, they should be fixed by redoing the slopes.,

**Cleaning the Floor of Deposited Sediment**
Deposition of sediment in the pond reduces pond's capacity to hold water and hence is a major problem in maintaining the pond. Ponds keep accumulating sediment during the monsoon. Runoff itself brings sediment from surface erosion in the catchment or from the scouring of the channel during heavy rainfall events. The sediment thus transported by runoff eventually is deposited in the pond. Heavy sediment fills the pond in a short period. Generally the ponds need to be cleaned and sediment removed every two to three years. Sediment should be removed from the pond when the depth of deposition is more than 30 cm.

The flowing can be done to minimize sedimentation:

Sediments can be reduced by careful design of runoff channel or trails that divert water to the pond. Diversion and intake structures should be made so as to minimize input of silt to the ponds. Keep a good cover of grasses in the run-off area.

In larger ponds such as Terai ponds, constructing ridges on the floor of the pond and controlling water level can allow fine silt to deposit in troughs, allowing most infiltration to take place on the sides of the ridges. If removing the sediment is difficult in large areas, mechanical ploughing of the floor of the pond can also increase permeability.

## 4.13 Conservation Works in the Upper Catchment

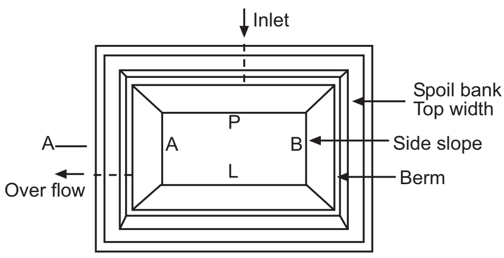
If the ponds are made away from the villages, it is recommended to protect the catchment area of recharge pond against erosion by applying soil conservation techniques, such as landslide stabilization, gully stabilization, plantation etc. In addition to this, networking with the Forestry Groups and other actors in the catchment area for better Conservation Works should be done.

# 5 Pond Construction

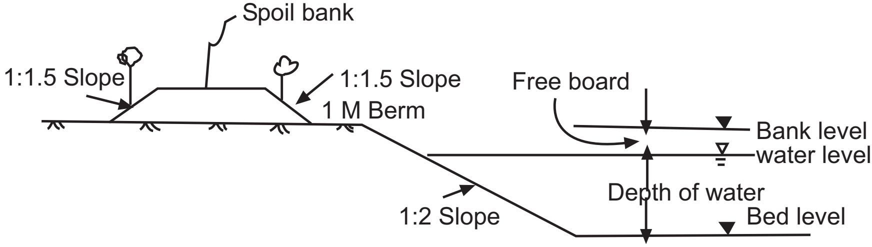
## 5.1 Design Layout

From purely engineering consideration, the recharge ponds are of two different types; the first is an unlined dug out pond with sloping sides and the other is with vertical sides lined with stone masonry. The plans and cross sections of these two generic types of ponds are given below (Figures, 12 and 13). These can be taken as reference design layouts in guiding the design in the field which can assume different shapes and sizes depending upon the location and purpose.

FIGURE 12: **Generic Type 1. Unlined Pond**

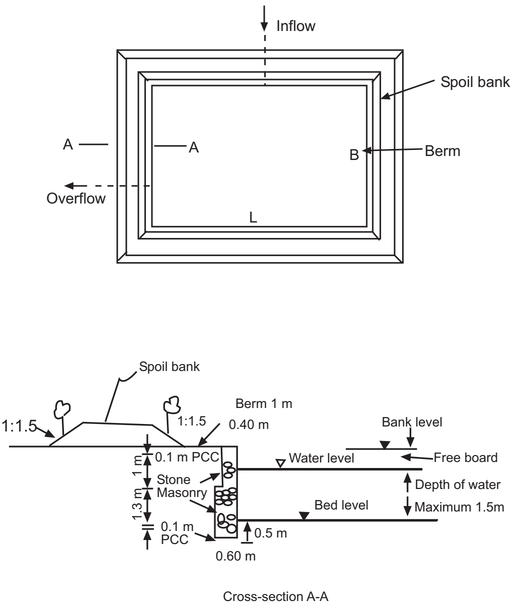



Plan




Cross-section A-A

FIGURE 13: **Generic Type 2. Stone Lined Pond**




# 5.2 Steps for Pond Construction

Once the size, shape and type of pond is finalized, and site for construction is located pond construction can begin. The following are the key steps for pond construction.

### 5.2.1For Unlined Pond (no stone walls from inside)

1 Make sure that work is divided among the workers, who will do the digging and who will take the spoil out of the pit.
2 Outline the shape on the surface where you want to make ponds using a rope and pegs.
3 Dig out the pit using local tools such as spade and picks.
4 Make sure that the side slopes from inside are maintained while making the pit.
5 Deposit the spoil on the shoulder around the pond and beginning with the lower side.
6 If the slope is steep, start depositing spoil from the lower end and pack every layer properly as you proceed.
7 If internal shelve is also planned make sure to create internal shelves for planting.
8 Use a plank to pack the spoil properly.
9 Plant grass and shrubs as a surface cover on the fresh spoil deposit.

### 5.2.2 For Stone Lined Ponds

1 Required quantity of stones of proper size and shape are collected for lining and stored nearby pond site.
2 Work is divided among the workers for digging and taking the spoil out of the pit.
3 Outline the shape on the surface where you want to make ponds using a rope and pegs.
4 Dig out the pit using local tools such as spade and picks.
5 For a lined pond the side slopes from inside are generally vertical.
6 Make sure that the side slopes are made vertical while making the pit.
7 Deposit the spoil on the shoulder around the pond and beginning with the lower side.
8 If the slope is steep, start depositing

spoil from the lower end and pack every layer properly as you proceed.

9 Once the pit is dug to the required depth, dig foundation for the stone line from inside about 20 cm deep from the bed level around the pit.

10 Build the stone wall as per the design as lining around the pond giving it the required slope around the pond.

11 Plant grass and shrubs as a surface cover on the fresh spoil deposit outside the pond.

# 5.3 Investment Planning Estimate

Table 6, below is a recommended format for calculating the work volume and cost estimates for constructing simple dug out pond and stone masonry work in mud mortar.

TABLE 6: Format for Quantity and Cost Estimation for Pond Construction

**…………………… VDC/Municipality, Nepal**

***Detail Estimating and Costing Sheet***

Project Name:
Fiscal Year :
**Site:**
Date:

| S.N. | Description of work | No. | Length (m) | Breadth (m) | Height (m) | Quantity | Unit | Rate (Rs/$m^3$) | Amount (Rs.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Earth work in excavation | 1 | 10.00 | 5.00 | 2.30 | 115.00 | m3 | | **X** | |
| 2 | Stone masonry work in mud mortar | | | | | | | | | |
| | Long walls- 1st step | 2 | 11.20 | 0.60 | 1.30 | 8.74 | m3 | | | **L= 10+0.6+0.6=11.2** |
| | 2nd step | 2 | 10.80 | 0.60 | 1.30 | 8.42 | m3 | | | **L=10+0.4+0.4=10.8** |
| | Short walls- 1st step | 2 | 5.00 | 0.40 | 1.00 | 2.00 | m3 | | | |
| | 2nd step | 2 | 5.00 | 0.40 | 1.00 | 2.00 | m3 | | | |
| | | | | | | 21.16 | | | **Y** | |
| **Total amount** | | | | | | | | | **X+Y** | |

**<u>Note:</u>** In the column of Amount, the figure is computed by multiplying rate and quantity. The rate should be as per VDC/DDC/ Municipality norms or as per authentic norms.

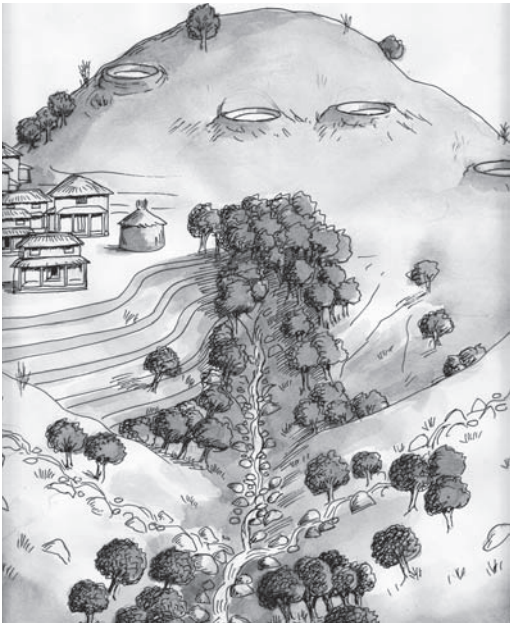
# 5.4 Guidelines for Selecting Ponds Types

As explained earlier, the types, shapes and sizes of recharge ponds vary depending upon the location. The matrix below (Table 7) provides a simple guideline for selecting appropriate type of pond for a particular situation. The first column refers to the rainfall characteristics of the area categorized into either high or low rainfall areas. The second column refers to the slope of the site where the pond is to be located. Three landform types depending on the slope are envisaged: 1) the top of a hill or a ridge 2) the middle slope where the slope is moderately steep to steep; and 3) the relatively flat valley floor or lower slope in case of the hills and the plains in the Terai. The third column queries about the size and number of ponds to be built, and the fourth column refers to the pond design type described in detail in individual sheets in the next section (Pages 37 to 44).The fifth column provides additional remarks.

TABLE 7: **Guidelines for Selecting Appropriate Recharge Pond Types**

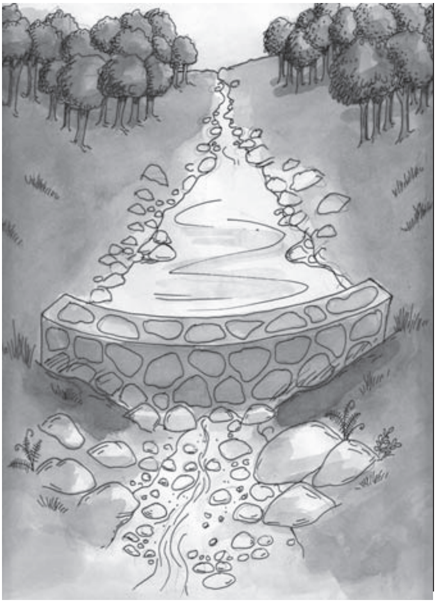
| Rainfall | Slope | Size and number of pond | Design type | Page numbers | Remarks |
|---|---|---|---|---|---|
| High rainfall | Ridge Top | Small but many | 1, 7 | 37, 43 | |
| | Middle | Few | 3, 4, 5, 7 | 39, 40, 41, 43 | Ensure safe disposal through spillway |
| | Valley/Plains | Large and few | 2, 4, 6 | 38, 40, 42 | Ensure safe disposal through spillway |
| Low rainfall | Ridge Top | Shallow, small, many | 1, 8 | 37, 44 | |
| | Middle | Shallow, many | 3, 4, 5 | 39, 40, 41 | Collect water from surrounding area through drainage |
| | Valley/Plains | Large and few | 2, 6 | 38, 42 | Collect water from surrounding area through drainage |

# 5.5 Design Descriptions of the Recharge Pond Types

<table>
<tr><td>Type No. 1</td><td>Area: Ridge area pond</td><td>Size : 10 m x 10 m</td></tr>
<tr><td colspan="3">Suitable for Mid-hill, Mahabharat and Siwalik regions.</td></tr>
<tr><td rowspan="9"></td><td>Layout</td><td>Staggering with spacing at more than 20 m between each other</td></tr>
<tr><td>Location</td><td>On the slopes or in the small valleys of the ridge area</td></tr>
<tr><td>Runoff collection</td><td>From around the pond</td></tr>
<tr><td>Spoil deposit</td><td>Usually on side valley or around the pond</td></tr>
<tr><td>Maintenance</td><td>Every 3-4 years</td></tr>
<tr><td>Lining on the sides</td><td>Not required</td></tr>
<tr><td>Lining on the floor</td><td>Not required</td></tr>
<tr><td>Materials:</td><td>Not required</td></tr>
<tr><td>Tools:</td><td>Agriculture tools for digging</td></tr>
</table>

**Construction Steps:**

- Select the site in the ridge area, which are usually open and gently sloping.
- Clear the pond area of all undesired vegetation.
- Mark the location of ponds which are placed in a staggered manner.
- The ponds are usually round or oval in shape. The size can be about 10m diameter, but depends upon area available.
- Mark the outside limits of the proposed excavation with stakes. On the stakes indicate the depth of cut.
- Dig the pond to a depth of about 1.5 meters.
- Deposit the spoil around the pond or on the lower side.
- Compact the soil in layers while making spoil bank.
- Make small drainage channels from around the pond to direct runoff to the pond.
- Leave space in spoil bank as spillway for overflow during heavy rain.
- While making spillway, ensure that the runoff does not cause erosion on the lower slopes.

<table>
<tr><td>Type No. 2</td><td>Area: Foot hill (water impounding)</td><td>Size : Variable</td></tr>
<tr><td colspan="3">Suitable for streams at the Foot Hills.</td></tr>
<tr><td rowspan="9"></td><td>Layout</td><td>Not required because of limited number of ponds made by erecting small dams</td></tr>
<tr><td>Location</td><td>No specific location. Any place suitable on a stream to catch water, but away from main trail</td></tr>
<tr><td>Runoff collection</td><td>Divert from gullies to pond if stream is small</td></tr>
<tr><td>Spoil deposit</td><td>Around the pond with good bioengineering</td></tr>
<tr><td>Maintenance</td><td>Every year</td></tr>
<tr><td>Lining on the sides</td><td>Not required if the dam is wide enough with gentle slopes on both sides. Lining from inside may be required if the slope is less than 1:1.5</td></tr>
<tr><td>Lining on the floor</td><td>Not required</td></tr>
<tr><td>Materials:</td><td>Stones, clayey soil</td></tr>
<tr><td>Tools:</td><td>Agriculture tools for digging</td></tr>
</table>

**Construction Steps:**
- Select the site in the stream valley where water impounding is feasible and can be used for irrigation. It is usually suitable for low gradient streams in the hills or in Bhabar region.
- Mark the line where the dam will be created.
- The dam needs to be long enough to block stream water for impounding.
- Dig the foundation of the pond.
- Build the dam, which could be earthen dam with stone lining from inside.
- Construct masonry structure from inside of the dam.
- Provide overflow pipe to safe drainage point or irrigation channel.
- Plant grass and trees toward the end of the dam on both sides on the dam if required.

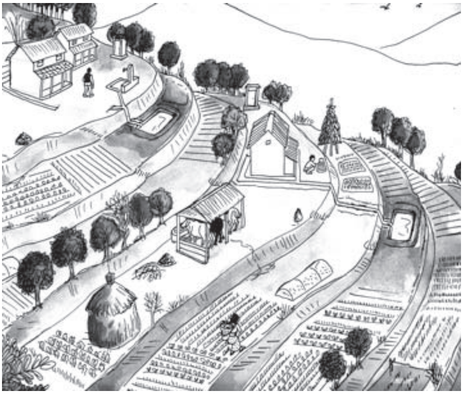
| Type No. 3 | Area: Community pond in the village | Size : 20 m x 25 m |
|---|---|---|

**Suitable for villages in Mid-hills and Siwaliks.**

| Layout | Only one |
|---|---|
| Location | Away from houses and without any risk to them, but must be accessible for all |
| Runoff collection | Divert from homesteads |
| Spoil deposit | Around the pond |
| Maintenance | Every year |
| Lining on the sides | Partial lining is necessary if water is to be retained for other purposes, such as buffalo wallowing. |
| Lining on the floor | Not required |
| Materials: | Stones, clayey soil |
| Tools: | Agriculture tools for digging |

**Construction Steps:**

- Select a site close to the village and in a place accessible to all community members.
- Mark the outside limits of the proposed excavation with stakes. On the stakes indicate the depth of cut.
- Mark the size as planned but should not be bigger than 20-25 m in diameter or on the sides.
- Mark the inside limits of the proposed spoil bank for disposal of excavated material to form Bank around the pond.
- Excavate the pond area (about 1.5 meters deep).
- Construct masonry structure in case side slopes of pond are lined.
- Leave space in spoil bank for constructing inlet and overflow structures.
- Deposit the spoil around the pond or on the lower side. Compact the soil in layers while making spoil bank.
- Make small drainage channels from around the houses and direct the runoff to the pond.
- Collect the runoff from the front yard of the houses also to the pond.
- Ensure that the overflow is directed to a safe drainage point.
- Plant grass and trees on the spoil bank by using appropriate method as given in annex 2-4.

| Type No. 4 | Area: Private pond | Size : 2 m x 3 m (max) |
| --- | --- | --- |
| **Suitable in all physiographic regions.** | | |
|  | Layout | Only one per household |
| | Location | On terraces in front of the house but at least 20 m away from the house |
| | Runoff collection | Divert from roof top and homestead |
| | Spoil deposit | On the terrace |
| | Maintenance | Every year |
| | Lining on the sides | Preferable, but not compulsory |
| | Lining on the floor | Not required |
| | Materials | Stones, clayey soil |
| | Tools | Agriculture tools for digging |

**Construction Steps:**

- Select the site on the second terrace in front of the house for pond construction.
- Mark the line that will be the boundary of the pond.
- Excavate the pond area to a depth of about 1.5 meters.
- Deposit the spoil around the pond or on the lower side. Compact the soil in layers while making spoil bank.
- Construct masonry structure in case side slopes of pond are lined.
- Make small drainage channels from around the house and direct the runoff to the pond.
- Collect the runoff from the front yard also to the pond.
- Plant perennial vegetables (*Tamatar, Ishkus*) or spices (*DalleKhursani,* Cardamom) on the banks.

| Type No.5 | Area: Pond for tap water collection | Size : 1.5 m x 10 m (max) |
|---|---|---|

**Suitable for all physiographic regions.**

| | |
|---|---|
| Location | In front of the tap stand and bit below it |
| Runoff collection | Waste water from the tap and runoff from around the slope |
| Spoil deposit | On the lower side slope |
| Maintenance | Every year |
| Lining on the sides | Required |
| Lining on the floor | Not required |
| Materials: | Stones for lining |
| Tools: | Agriculture tools for digging, mason tools |

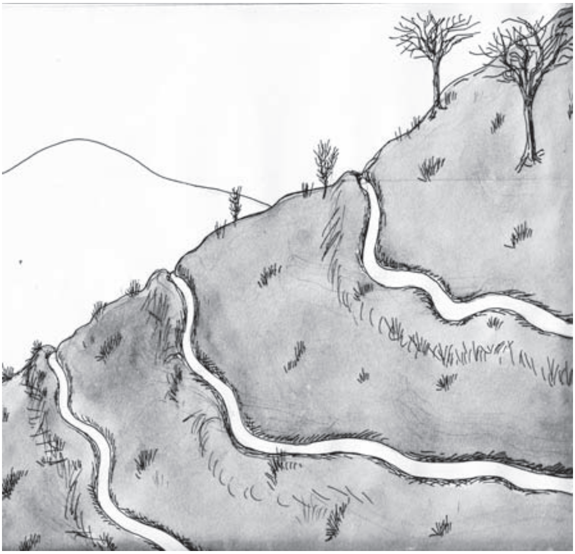
**Construction Steps:**

- Select the site in front of the tap stand about 3 meters away from it so that the pond does not disturb the tap users.
- Mark the line that will be the boundary of the pond. The length can be as much as the space allows, but the width is generally 1.5 to 2.5 meters.
- Excavate the pond area to a depth of about 1 meter.
- Deposit the spoil on the lower side of the pond. Compact the soil in layers while making spoil bank.
- Construct masonry structure to line the pond with stones.
- Make small drainage channels from around the tap stand and direct the runoff to the pond.
- Plant woody plants on the lower slope, if the slope length is longer than 2 meters.

<table>
<tr><td>Type No.6</td><td>Area: Terai ponds</td><td colspan="2">Size : 50 m x 100 m (often variable)</td></tr>
<tr><td colspan="4">Suitable for Mountain Valleys, Bhabar and Terai regions.</td></tr>
<tr><td colspan="2" rowspan="8"></td><td>Location</td><td>Accessible to users and close enough to regular supervision</td></tr>
<tr><td>Runoff collection</td><td>Runoff from around</td></tr>
<tr><td>Spoil deposit</td><td>On the sides</td></tr>
<tr><td>Maintenance</td><td>Every 2 years</td></tr>
<tr><td>Lining on the sides</td><td>Not required</td></tr>
<tr><td>Lining on the floor</td><td>Not required</td></tr>
<tr><td>Materials:</td><td>Clayey soil for bunds</td></tr>
<tr><td>Tools:</td><td>Agriculture tools</td></tr>
</table>

**Construction Steps:**

- Select the site in the village where public land large enough is available where water harvesting is possible. It could be a grass land or forest area.
- Mark the line that will be the boundary of the pond. The length can be as much as the space allows.
- Large ponds are generally square of rectangular in shape.
- Excavate the pond area to a depth of about 3-4 meter depending upon the purpose for which it is being built. For fish farming the depth of the ponds need to be fixed after consultation with agriculture technicians of the area.
- Deposit the spoil on the side of the pond. Compact the soil in layers while making spoil bank.
- Allow spillways in suitable points for overflow.

| Type No. 7 | Area: Contour Trenches | | Size : 1.5 m x 10 m (max) |
|---|---|---|---|
| **Suitable for Mid-hill, Mahabharat, and Siwalik regions.** | | | |
|  | Layout | On a contour at a spacing of about 2 meter | |
| | Location | Away from home on grassland and forest areas | |
| | Runoff collection | Runoff from the slope | |
| | Spoil deposit | On the lower side slope | |
| | Maintenance | Every year | |
| | Lining on the sides | Not required | |
| | Lining on the floor | Not required | |
| | Materials: | Stones, clayey soil | |
| | Tools: | Agriculture tools for digging | |

**Construction Steps:**

- Mark the alignment of trench using a stick of about 2 m length along the contour.
- Clear the trench area of all undesired vegetation.
- Restrict the length to about 5 meter maximum.
- If longer trench are to be built, break them into 5 meter each with a clear boundary of about 2 meters undisturbed slope in between the trench to avoid large amount of water on shallow trenches.
- Excavate the trench to about 75 cm depth and 1 m width and make spoil bank as per drawing.
- Deposit the spoil on the lower side slope.
- Compact the soil while making spoil bank.
- Ensure safe points for overland flow.

<table>
<tr><td>Type No. 8</td><td colspan="2">Area: Eyelash Trenches</td><td>Size : 2 m x 2 m (max)</td></tr>
<tr><td colspan="4">Suitable for Mid-hill, Mahabharat, and Siwalik regions.</td></tr>
<tr><td colspan="2" rowspan="10"></td><td>Layout</td><td>Placed on a staggered manner on a contour at a spacing of about 2 meter from each other</td></tr>
<tr><td>Location</td><td>On gently sloping grassland and forest areas</td></tr>
<tr><td>Runoff collection</td><td>Runoff from the slope above</td></tr>
<tr><td>Spoil deposit</td><td>On the lower side slope as back of the trench</td></tr>
<tr><td>Maintenance</td><td>Every year</td></tr>
<tr><td>Lining on the sides</td><td>Not required</td></tr>
<tr><td>Lining on the floor</td><td>Not required</td></tr>
<tr><td>Materials:</td><td>None</td></tr>
<tr><td>Tools:</td><td>Hand tools for digging.</td></tr>
</table>

**Construction Steps:**

- Mark the positions of each trench at a spacing of about 2 meter from each other and on contour.
- Clear the trench area of all undesired vegetation.
- The length should not be more than 2 meters.
- Mark the trench on the ground in such a way that they form an arc with convex part facing the lower side of the slope.
- Dig the trenches to about 50 cm depth and 1 m width.
- Deposit the spoil on the lower side slope.
- Smoothen the spoil for grass cover.

# 1 Annex

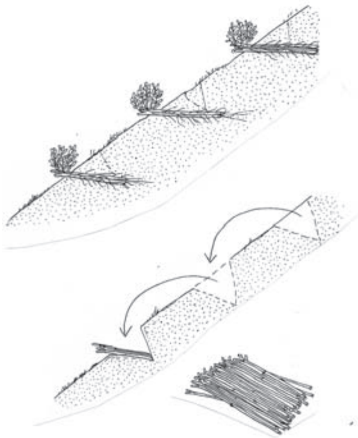
## Suitable and Commonly Available Plants for Slope Stabilization in Nepal

Shrubs and grasses must be planted around the edges of the ponds, especially on the sides that are filled with spoils from excavation to help stabilize the soils and protect the sides of the ponds. Some medium sized trees may sometimes be planted a little further away from the pond so that they enhance the aesthetics of the general area and cast shadows over the ponds and reduce evapotranspiration, but generally trees are not recommended for pond protection.

| S.N. | Elevations (m) | Trees | |
|---|---|---|---|
| | | Nepali Name | Botanical name |
| 1 | T- 1900 | Chuletro (seto) | Braesaiopsisnainla |
| 2 | 800- 2000 | KalkiPhul | Callistemorcirinus |
| 3 | 950- 1900 | Sissoo | Dalbergiasissoo |
| 4 | T- 1400 | Phaledo | Erythina spp. |
| 5 | T- 1700 | Lankuri | Fraxinus floribunda |
| 6 | 1200- 2700 | Dabdabe | Garugapinnata |
| 7 | T- 1300 | Kangiyo | Grevillearobusta |
| 8 | T- 1800 | AsharePhul | Lagerstroemia parviflora |
| 9 | T- 1800 | Sitalchini, Sohijan | Noringaoleifera |
| 10 | T- 1000 | Kimbu | Morus alba |
| 11 | T- 2400 | Amala | Phyllanthusemblica |
| 12 | 1000- 1700 | Painyu | Prunuscerasoides |
| 13 | 100- 2500 | Bainsh | Salix spp. |
| **S.N.** | **Elevation (m)** | **Bushes/Shrubs** | |
| 1 | T- 1500 | Assuro | Adhatodavasica |
| 2 | 1500-3000 | Ban Chutro | Berberisaristata |
| 3 | 900- 2500 | Chutro | BerberisAsiatica |
| 4 | T- 1600 | Bagamkali | Bougainvillea Spaetabilis |
| 5 | T- 1600 | Nilkanda | Durantarepens |
| 6 | 900- 1800 | Siuli. Siudi | Euphorbia royleana |
| 7 | T- 1000 | Bihaya. Besharm | Ipomeafistulosa |
| 8 | T- 1600 | Sajiwan | Jatrophacurcas |
| 9 | T- 2100 | Bilouni | Maesachisia |
| **S.N.** | **Elevation (m)** | **Legumes/ Herbs** | |
| 1 | T- 1500 | Stylo | Stylosanthesguianensis |
| 2 | Palpa | Ban Silam | Eisholtziablanda |
| 3 | Palpa | Arile Kanda | Caesaliniadecapetata |
| 4 | 800- 1500 | Khasre | - |
| **S.N.** | **Elevation (m)** | **Suitable Grasses** | |
| 1 | T- 1800 | Dubo | Cynodondactylon |
| 2 | 500- 2000 | Salimokhar | Chrysopogongryllus |
| 3 | T-1800 | Babiyokhar | Eulailopsisbinnata |
| 4 | 500- 2000 | Kikuyu | Pennisetumclandestinum |
| 5 | T- 2000 | Amlisso, Amrisso, Kucho | Thysanolaena maxima |
| 6 | 500- 1800 | Bansoghans | Eragrostistenella |
| 7 | T- 2000 | Narkat | Phrageites maxima |

# 2 Annex

## Stabilization of Loose and Deep Slope



***Brush layering:***
Stabilizing shallow loose soil slopes on the valley side slope of a pond. Benches are excavated in the loose slope, branches of vegetatively propagated plants such as willow are laid, on a slight angle, on the benches; branches are covered with soil, with just the tips sticking out.

***Construction Steps:***

- After the spoil is deposited and compacted it should be treated with bioengineering method for stabilization especially on the lower side slope of the pond where spoil depth is more than 30 cm.
- To begin the vegetative treatment of brush layering, start the process from bottom of the slope.
- Collect enough branches of vegetatively propagated plant material.
- Prepare the branch of about 100 cm length each from freshly cut pieces.
- Once the branches are ready, make a bench of about 70 cm width on a slight slanted way across the slope on a contour.
- Place the branches on the bench with tips facing outside the slope at an angle as shown in the figure and criss-cross with each other.
- Make sure that 20 % of the top of the branch is sticking out of the slope.
- Mark another bench about a meter above the first one on the slope and make the bench. Spoil removed from the second bench should be used to cover the branches of the first bench.
- Repeat the process of making bench and putting branches up to the top of the slope.
- Water the slope until the rainfall occurs.

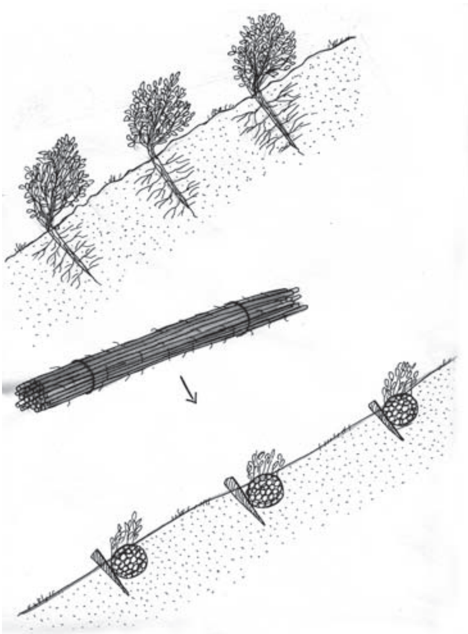
# 3

# Annex

## Stabilization of Shallow Slope

***Fascine:***

Stabilizing shallow loose soil slopes on the valley side slope of a pond. Benches are excavated in the loose slope, branches of vegetatively propagated plants such as willow are laid, on a slight angle, on the benches; branches are covered with soil, with just the tips sticking out.

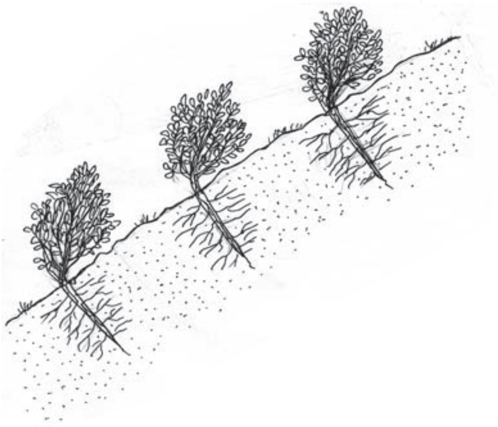


***Construction Steps:***

- Collect vegetative propagated branches of over a meter length from a freshly cut branches in enough quantity.
- Tie about 20-30 branches together with rope as shown in the drawing to form bundle of about 15 cm diameter.
- Mark a channel across the slope starting from the bottom in the freshly deposited spoil.
- Dig the channel to about the same depth as the diameter of the bundle.
- Place the bundle in the channel in such a way that the bundle is barely visible on the surface.
- Drive wooden pegs at every 2 meter to fix the bundle.
- Repeat the process in the next channel about 1 meter above from the first one.
- Water the slope to keep moist until the rainfall occurs.

# 4 Annex

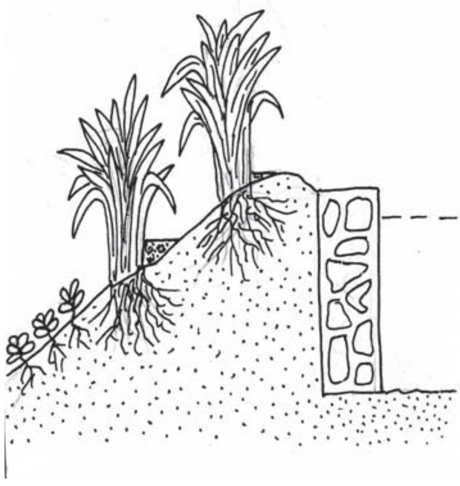
## Greening Bare Slopes



***Live Stakes:***
Greening and stabilizing shallow loose soil slopes on the valley side of a pond where runoff is less likely to erode the slope. This technique is simple and requires no further earthwork as in brush layering or fascine.

***Construction Steps:***

- Begin the treatment just before the monsoon.
- Take live branches of about 1 meter length of one year old vegetatively propagated plant.
- They should be prepared from a freshly cut branch.
- The branches should be driven into the slope on a contour. The cuttings should be driven at every 60 cm from each other.
- The space between the lines can be maintained at about 1.5 – 2 meters.
- If the treatment is done in March, which is favorable for most vegetatively propagated plants, the cuttings need to be watered regularly until rainfall occurs.



# Glossary

| | |
|---|---|
| August Spring: (SauneMool) | Late breaking spring in the upper parts of a watershed. It be comes active only towards the later part of the monsoon season. |
| Bhabar Region: | An 8 to 10 Kilometer wide strip at the foothills of the Chure range and adjacent to the Terai plains. It mainly consists of the coarse sandy soils and boulders and gravels at depth. |
| Braided: | One of a number of channel types and has a channel that consists of a network of small channels separated by small and often temporary islands called braid bars. |
| Brush Layering: | A bioengineering method used to stabilize shallow loose soil slopes on the valley side slope of a pond. Benches are excavated in the loose slope, branches of vegetatively propagated plants such as willow are laid on a slight angle, on the benches; branches are covered with soil, with just the tips sticking out. |
| Bursting of Springs (MoolPhutne): | The time when a spring becomes active and starts to discharge water. |
| Chure Region: | Please see "Siwalik Region" |
| Contour Trench: | A trench made along a contour (a line with equal elevations) across a slope to collect runoff from above. |
| Dallekhursani: | Nepali name for small round chilli. |
| Doon: | Flat valleys within the Siwalik physiographic region, also called 'inner Terai' |
| Drainage Channel: | Natural or artificial removal of surface and sub-surface water from an area |
| Drip Irrigation: | An irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters |
| Dug out pond: | Please see "excavated pond" |

| | |
|---|---|
| Earthen Dam: | A massive artificial water barrier built to impound water. |
| Embankment Pond: | A pond made by impounding water by building a small dam across a flowing stream. |
| Equity: | The value of an ownership interest in property, including shareholders' equity in a business. |
| Evapotranspiration: | Sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. |
| Excavated Pond: | A ponds built by excavating earth from the ground and with or without linings on the sides and the bottom. |
| Eyelash Trench: | Small trenches built in the shape of eyelashes across a slope to collect runoff from above. |
| Fascine: | Rough bundle of brushwood or other material used for strengthening an earthen structure. |
| Gorge: | A deep ravine between cliff s often carved from the landscape by a river. |
| Gullies: | Landform created by running water, eroding sharply into soil, typically on a hillside. Gullies resemble large ditches or small valleys, but are meters to tens of meters in depth and width. |
| Iskhus: | Nepali name for chayote. |
| July Spring (AsareMool): | Early breaking spring, usually on the lower parts of a watershed. It becomes active soon after the monsoon starts. |
| Land tenure: | The legal regime in which land is owned by an individual, who is said to "hold" the land. |
| Mahabharat Region: | A mountain range consisting of narrow valleys, steep slopes and sharp peaks that lies just north of the Chure or Siwalik hills and to the South of the mid-hills. |
| Masonry: | A stone or brick work to build structures from individual units laid in and bound together by mortar. |
| Meander: | Formed when the moving water in a stream erodes the outer banks and widens its valley and the inner part of the river has less energy and deposits what it is carrying. |
| Mid-hill Region: | The hilly region of Nepal that lies between the high mountain region in the North and the Mahabharat range in the South. |
| Mool: | A Nepali term for spring. |
| Permanent Springs (SthaiMool): | A spring that remains active throughout the year. |
| Piedmont plains: | Piedmont Plains are those plains which are found on the foot of mountains or hills. Piedmont Plains are formed by the deposition of materials. |
| Pond: | A body of standing water, either natural or man-made, that is usually smaller than a lake. |

| | |
|---|---|
| Post-monsoon season: | A brief period of scattered rains during mid-August to September, just after the main monsoon season. |
| Pre-monsoon Season: | A short season (April-May) characterized by scattered rains and thundershowers that occurs just before the main monsoon season. |
| Rain Water Harvesting: | Accumulation and deposition of rainwater for reuse before it reaches the aquifer. |
| Recharge Pond: | A pond built for the purpose of recharging the groundwater by collecting rain water. |
| Runoff Harvesting Pond: | A pond used for collecting water from different sources like springs, streams, tap water, and rain for future use. |
| Scouring: | Washing away of materials from the bed and sides of a stream or river by the rapidly flowing water. |
| Shallow Ponds: | Ponds that are usually less than one meter deep used primarily for watering livestock and wallowing for buffaloes and can be used as recharge ponds. |
| Siwalik Region: | A system of fragile hills just North of the Terai plains and merges with the Mahabharat range in the North. It also contains the inner Terai valleys (locally called Doons) like the Chitwan and Dang valleys. |
| Slope Failure: | Geographical phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows. |
| Spillway: | A structure used to provide the controlled release of flows from a dam or levee into a downstream area. |
| Spoil Bank: | Pile of refuse, created by excavation of earth materials from a site. |
| Springs: | A natural source of water. |
| Sprinkler Irrigation: | A system of irrigation that uses water under pressure to operate sprinklers to water plants; mainly used for vegetables, high value crops, and gardens. |
| Surface Erosion: | Degradation and removal of the soil by water, wind or gravity. |
| Tamatar: | Nepali name for tomato. |
| Terai Region: | The flat plains bordering India in the South and the Chure hills in the North. The region contains deep and fertile soils and is often referred to as the bread basket of Nepal. |
| Trans-Himalayan Hills and Plateaus: | The hills and plateaus to the North of the main Himalayan range. |
| Water Tower: | The height or rise of groundwater table when it gets fully recharged. |
| Watershed: | The region draining into a river, river system, or other body of water. |

# Bibliography


A model Guideline for District Water Supply for Sanitation and Hygiene (WASH), Rural Water Supply and Sanitation Project- Western Nepal (RWSSP-WN), Pokhara, 2009.

Handbook for Bio-Engineering Methods in Gully and Landslide Stabilization works, Lamosangu- Jiri Road, Charnawati Rehabilitation Programme, Phase III; HMG/N/SDC, 1990.

Land Systems Report, Land Resource Mapping Project (LRMP); Kenting Earth Science Ltd., 1986.

Log-frame of the Department of Soil Conservation and Watershed Management Programme; Department of Soil Conservation and Watershed Management, Kathmandu, 2007.

*Pahadi Chhetrama Paani Intajaam,* A. Dixit, Upadhya M., Tamrakar A., Nepal Paani Sadupayog Foundation, Kathmandu, 2062 BS.

*Pokhari ra Pahiro, Madhya Pahadi Chhetrako Paani- Sanskriti, Khadya Pranaali ra Bhu-Kshayako Artha-Raajniti,* M.Upadhya, Nepal Water Conservation Foundation, Kathmandu, 2009.

Ponds and Landslides: Water culture, food systems and the political economy of soil conservation in mid-hill Nepal; M. Upadhya, Nepal Water Conservation Foundation, Kathmandu, 2009.

Soil Conservation and Watershed Management Activities (definition, objective, scope and working strategy); Department of Soil Conservation and Watershed Management, Kathmandu, 2001.

Soil Conservation and Watershed Management Measures and Low cost Techniques, Soil Conservation and Watershed Management Component (NARMSAP); Department of Soil Conservation and Watershed Management, Kathmandu, 2004.

Three Year Interim Plan (2007/08 - 2009/10); National Planning Commission, Government of Nepal, Kathmandu, 2007.


**Hyperlinks**


http://www.moir.gov.np/pdf_files/irrigation_policy_2060.pdf

http://www.dolidar.gov.np/about-dolidar/function/

http://www.rwsspwn.org.np/materials/guidelines-manuals-and-norms

http://www.dolidar.gov.np/programme-projects/western-nepal-rural-water-supply-and-sanitation-project.