1.2 Rural Road Improvement

In this section, improvement works on rural road basically focuses on the improvement of currently existing roads, referring to Publication 1 (JLRP) listed below. A detail improvement planning for a particular case in Namtar area is explained in Section 2.1. For a planning of newly construction of road as well as details of each designs, references are found in the following publications:

1) Road Construction in the Nepal Himalaya: The experience from The Lamosangu - Jiri Road Project, ICIMOD Occasional Paper No.8, March 1987;

2) Nepal SPWP Manual No.1 A Participatory Approach to Environmental Protection Measures for Hill Irrigation Schemes in Nepal, Poverty Alleviation Through Employment Generation in Irrigation Works Programmes for the People of the Hills of Nepal, HMG-N/ UNDP/ ILO/ World Bank, July 1992.

3) Vegetation Structures for Stabilising Highway Slopes - A Manual for Nepal - , Department of Roads, HMG-N, March 1991

1.2.1 General Design of Rural Road

General Design Conditions

The road has the principal objective of interlinking as many village centres as possible, thus best serving the majority of the population of the region. In prior to design road dimensions, conditions, such as road service life (years), traffic volume (nos. of vehicles, direction), traffic increment (yearly increase in %) should be estimated. An overloading of the trucks of approximately 50% as well as the narrow road width was taken into consideration for the dimensioning of the road base.

General Standard

In general, rural road base may not have been paved with any materials such as gravel, stone soling. However it is highly recommended to be gravel metalled with a single or double layers at a total thickness of 15 to 20 cm. In addition, a layer of stone soling in a thickness of 5-15 cm enables to avoid the penetration of the generally silty sub-grade material (during wet weather conditions) into the road base, thus weakening the bearing capacity and therefore, its service life. Normally, if the purpose or the function of a road is fixed, the engineering standards to be applied are picked out of the Road Standard of Department of Road (DOR). The following is a sample list for engineering standards for a Feeder road Class II:

Standard for a Feeder road Class II

-	Design speed	:	30 km/hr		
-	Formation width	:	5.70 - 6.10 m		
-	Bridge width	:	3.50 m		
-	Gradient	:	longitudinal max.	--	12%
			longitudinal avg.	--	7%
			longitudinal min.	--	1%
			cross fall	--	4% (always towards ms)
-	Minimum radius	:	normal curves	--	10 m (15 m is used in Standard)
			hairpin bends	--	8.50 m
-	Slope inclinations	:	normal (ms)	--	1:1 (pure soil)
			maximum (ms)	--	4:1 (rock)
			embankments (vs)	--	2:3
			maximum (vs)	--	4:5 (plus planting)

Note: Standard is adjusted to a case for Rural road without black top; ms = mountain side; vs = valley side

1.2.2 Choice of Alignment

Basic Considerations

Due to the very difficult natural preconditions in the hills of Nepal the choice of alignment should be made very carefully to find the best alternative in terms of the road's function, safety for traffic, its service life, influence on the environment, and its economy (construction and maintenance cost).

Mistakes in the choice of alignment can have enormous impact on the construction and maintenance cost because, once the construction has started, alignment changes are normally no longer possible and the engineer is forced to save the situation by the application of complicated and expensive construction measures which are always followed by higher maintenance cost. Therefore, only well trained and widely experienced specialists like geologists, geotechnicians, road engineers, and structure engineers should be assigned to this challenging task. They should be given enough time to conduct the necessary exhaustive survey and investigation of the road region (Figure 1.2.1).

It is important to prepare a maps of a scale of 1:5,000 with contour line intervals of 5 m along a large enough corridor of the proposed general alignment according to the feasibility study. These maps allow the finding out of all possible alignment alternatives in the office in a minimum of time. For the evaluation of these alternatives they have to be verified in the field. A more advanced method to reduce field work is preparation of a special map, the "Potential Risks Map", which discloses the areas of potential land movement risks (rock slides, landslides and slumps) and is a very helpful instrument for the road engineer to reduce his possible alignment alternatives to the technically feasible ones only.

In general, the most economic solution is the alignment with the shortest possible distance between two points. For the hills of Nepal this is very often not the case. A longer detour of alignment to avoid a difficult or unstable patch of terrain can be immediately economical during construction or compensated in the future with less maintenance. Therefore, areas with a deep blanket of loose soil, water saturated zones, areas with traces of old slides and new slides, and terrain where the rock strata falls with the slope should be avoided if at all possible.

At this point it may be mentioned that in some places a narrow jeepable or truckable road with a technically unsound alignment may exist which can be widened. In such cases it is more beneficial to completely disregard previous investments and select a better alignment.

Fitting of Alignment into the Terrain

As soon as the best alternative of alignment is found the centre line has to be fixed in the terrain very carefully. The main problem will be the dubious stability of the slopes. These slopes should be touched as little as possible to avoid slides. In other words, the alignment should be adapted according to the constraints of the terrain by having curve radii according to the contour lines (or close to them) and by narrowing the road width to a reasonable degree along very steep terrain. Obviously, such an alignment does not need huge and costly structures. Desirable speed, one-lane roads with passing places at an appropriate interval and a design speed of not more than 30 km/hr will be sufficient in hilly areas in general. Such a standard is also justified by the fact that trucks are normally heavily over-loaded and can move upwards not faster than 50 km/hr and should drive downwards also not faster than 30 km/hr because of safety reasons .

In general, the road profile should not entirely be cut into the slope because it interferes with the slope stability by cutting away the slope toe and will produce slides. Therefore, a road profile which is only cut half into the slope is the most appropriate solution in terms of environmental considerations as well as long term investment (slightly increased construction cost, but drastically reduced maintenance cost). Another advantage of this solution lies in the tremendously reduced amount of surplus material in relation to the ful-cut road profile or even in a full mass balance (Figure 1.2.2).

Fixing of Centre Line in Slope

Steep ascent can be designed and constructed by cutting the entire road profile into the slope; a method which is applied nearly everywhere in the hills of Nepal and which seems to be safe enough because, if slides occur, they do not affect the road structure as such but only the mountain side (ms) slopes which can be easily cleared over the road edge down the slope.

Henceforth, the centre line shall be fixed in general according to Figure 1.2.2. Very often, where the slope is too steep to allow a safe natural slope inclination, retaining walls on the valley side (vs) and toewalls on the mountain side are needed.

In exceptional cases, where the slope stability is guaranteed (sound rock), the road profile can be cut fully into the slope.

In cases where the slope stability is doubtful the centre line has to be shifted to the valley side so that the slope may not be cut and the entire road rests on a valley side retaining wall.

In general, there will always be a certain surplus of excavation material along the construction site. If safe deposit places are not available and the material is of appropriate quality, it can be used for embankments by shifting the centre line to the valley side where the slope conditions allow it.

Material and Equipment

Locally available materials are listed below for the rural road construction, and construction equipment may be used only if the prescribed work quality could not be achieved by hand or the work became uneconomical.

- Explosives for rock excavation, if required, under instruction of road engineer(s)
- Galvanised, mild steel wire for gabions,
- Cement for cement masonry and concrete works, and
- Concrete pipes for pipe culverts

Construction equipment is needed for

- Rock excavation (chisels, rock drills and compressors),
- Small size aggregate production (stone crusher),
- Concreting works (concrete equipment),
- Compaction (light vibro rollers and heavy rollers), and
- Transport of more than 600 m distance (tractors, trucks).

1.2.3 Drainage System Designs

Water Management Works

The extremely high concentration of precipitation makes it very difficult to control water run-off. The basic principle is to collect not only the water from the slope above the road, but also the whole road surface water in the mountain side side drain and lead it to the nearest natural rivulet or brook. Therefore, the cross gradient of the road is normally kept to the mountain side, varying from 4% for straight sections and mountain side curves and 0% for curves turning the opposite way. In extreme cases, such curves can even have a cross fall of -2% depending on the long gradient and curve radius, but the water flow into the side ditch must be guaranteed. The standard sections of side ditches are shown in Figure 1.2.2. It is recommended to use a cement masonry type where other structures, such as gabion prop walls, drainage culvert will be constructed near by, to give sufficient force to support and accommodate with these structures. Even side ditch of dry masonry types should be constructed all along the road, so as to enhance the drainage of excess water within adjacent soil (Figure 1.2.3).

Standard Types of Side Drains

Closely following the contour lines of the terrain has a positive impact on the size of structures, especially for crossing of valleys and gullies. In most cases, a simple culvert (Figure 1.2.4) or causeway is the appropriate solution. In exceptional cases, slab culverts of a span of 4 m, or small bridges of spans between 4 and 12 m, should be constructed. In the case of water discharge, only culverts should be built, whereas in cases with additional debris flow, causeways should be chosen to avoid a blockage of the drainage system (Photo 1.2.1, 1.2.2).

Where side drain water is discharged into a rivulet or brook the previous run-off volume is considerably increased and side as well as depth erosion of the gully is the consequence, if it is steep enough. Therefore, such gullies have to be protected by checkdams as far down as they are erosion endangered in order to break the water speed. In addition, the valley sides should be protected against slides by a plant cover. Very often, the fully bottom is of poor soil quality that it has to be sealed and the water flow channelled to avoid the water breaking out against the gully sides, which results mostly in the destruction of the checkdams by scouring. Channels were built with stone slabs and the joints sealed with cement mortar. Checkdams are built with gabion boxes. They should not be higher than 4 m in order to avoid a too high water energy build-up. The crown of the checkdam as well as its steps have to be protected by stone slabs where the water flows to avoid the destruction of the gabion wire and therefore, the tearing off of the checkdam by the water and debris flow. Usually, such valleys have not only to be protected in their outlet but also in their inlet to the road crossing point.

Gabion structures will be also used to channelise rivers for the construction of bridge abutments. In such cases, it is very important to protect the gabion structure (e.g. the gabion wire) from fast flowing water which always contains sand or small stones and destroys the structure very fast. This can be achieved by putting big size boulders in front of the structure so that the water speed along it is reduced to almost zero.

To obtain maximum slope stability it must be drained in such a way as to guarantee that most of the rain water can flow off superficially. This has to be observed especially for mountain side slopes which have been made steep by cutting. It can be done by diverting the water coming from above the cut slope through catch drains running parallel to the upper end of the slope towards the nearest gully and in case of seepage in the slope, by the additional construction of vertically running French drain systems of "I" or "Y" shape which will lead the water directly and fast into the road side drain (Figure 1.2.3). A combination of French drain systems with bioengineering measures (planting of trees with good water absorption capacity like alders) will increase the slope stability .

1.2.4 Slope Protection Works and Environmental Protections

The best method to prevent erosion would be not to touch the mostly unstable slopes of the hills of Nepal at all. They should be left uninhabited with their original plant cover (forests). Obviously, this is not possible as this belt of land is the habitat of some million people who have to manage their living on it. Therefore, the unstable slopes have to be used by different activities in favour of this population.

The construction of roads is a massive interference with the environment and should therefore be undertaken with the utmost care. In other words, if one has to tread without leaving load imprints, it is better to tread lightly. In the road construction activities, erosion as well as construction and maintenance cost should be minimised. Following this line, slope failures have to be immediately repaired to prevent further extension and avoid the possibility that they become uncontrollable. Where the water run-off is not tightly checked, the system has to be improved to prevent 'creeps' and slides.

The causes of slope erosion can be attributed to various reasons. A concentrated deluge of surface water run-off can create erosion. Steep slopes (natural or cut) tend to fail. Water-saturated zones where the sub-surface water exerts uplift, are erosion prone areas and consequently creep or, when the water acts as a lubricant, slide. A thick blanket of loose soil, boulders, or debris over rock strata falling with the slope invite erosion. Without such a blanket, the rock slope is quite unstable.

To improve the stability of a slope, or to regain it after a failure, three different measures can be applied:

i) To improve the slope by getting it as dry as possible (drainage system), or
ii) To support the slope by structures, or
iii) To stabilise it by bioengineering methods.

In most cases these three methods should be combined to achieve the optimum. Before any work starts, the reason for the failure has to be found in order to choose the proper repair measure. Therefore, the first work step should always be the proper drainage of the slope.

Erosion control structures include those which have to retain soil masses like toewalls and retaining walls and structures which should prevent slope surface erosion, like stone layers, systems of stone arches, and terraces (Figure 1.2.5).

Bioengineering Erosion control measures are mostly directed against slope surface erosion and consist mainly of sowing plants suitable to the climatic conditions of the site. Most important is the plant's capacity for deep rooting, thus tightening together the soil surface, and water absorption power (drainage effect). Another surface Erosion control measure is the combination of planting and mini terrace construction out of wood. Finally, mini toewalls made out of wood will be also constructed.

It has to be emphasised that areas with new plant cover have to be fenced off or watched by watchmen to avoid foraging by free grazing animals, causing an eventual failure of the protection measure.

Erosion prevention measures have to be applied from the beginning of road construction and continuously throughout the whole life span of the road. This implies the existence of nurseries along the road to provide the needed raw-material for such measures.

In case structures or bioengineering methods can be applied with the same chances of success, the latter should be chosen as they are much cheaper. Bioengineering/ vegetative measures are also commonly used in slope protection measures for irrigation canal, and thus, a further explanations and designs will be found in Section 1.3. The general people's participatory approach described in Section 1.1 will be also applied to rural road improvement.

1.3 Rural Irrigation Improvements

In Nepal, a large number of irrigation schemes are categorised into "Farmers Managed irrigation Schemes (FMIS)". FMISs are small in scale and have primarily been planned, constructed and managed by farmers, under utilisation of empirical knowledge, local resources and materials. However, in many cases, poorly designed due to lack of knowledge, constructed and maintained inadequately irrigation projects, without systematic people's participation has led to a wastage of irrigation water. Moreover, regardless of environmental protection has led to vulnerability to natural hazard, i.e., destruction of irrigation systems and increased land degradation through landslides, gully erosion, waterlogging, siltation etc. Ultimately irrigation development has been followed by poor land-use practices and a reduced agricultural production per capita of population.

This section will first analyse on the vulnerability of irrigation system, especially for FMIS in hill area, through the investigation in the study area and other similar areas. Then, some effective protection measures are introduced in order to reduce damages and expenditure spent for recovery from the water induced disaster; accordingly to improve and sustain the FMIS, the most essential gear for rural dwellers to self step-up.

1.3.1 Common Problems found in FMIS Schemes in Hill Area

In general, an FMIS scheme consists of several types of structures, such as intake, canals, diversion, crossings, offtakes, etc. While among these structures, the following components are mostly vulnerable to water induced disasters: intake structure as well as protection works, head reach canal sections, and crossing structures.

Intake structures are usually constructed in rivers and streams, and thus often attacked and destroyed by floods and debris flows; either scoured, washed away and/ or covered by debris. Since a head reach section commonly lies over a long distance, it can be exposed to hazardous areas, such as adjacent to rivers/ streams, unstable bank slopes, etc. Therefore, it may be either covered by floods and debris, or landslides. On the other hand, a crossing structure is installed over a small streams and a gully, so that destruction tends to occur at its abutment through further erosion of streams and development of gully, especially when the protection work is indurable. Table 1.3.1 summarises the types and the causes of damages for each vulnerable structures. Therefore, this section focuses on the remedies for these structures.

1.3.2 Improvement of Intake Structures

Intake structures on torrents have been constructed in various places in the country in order to intake river water in mountainous or piedmont area for local water demand. In most cases these intakes were constructed, operated and maintained by local people with their wisdom. However, an intake structure with gate(s) or stoplog has been planned and designed in many cases which is not always suitable for torrent morphology and requires frequent troublesome operation and maintenance (O&M) works in a remote structure site.

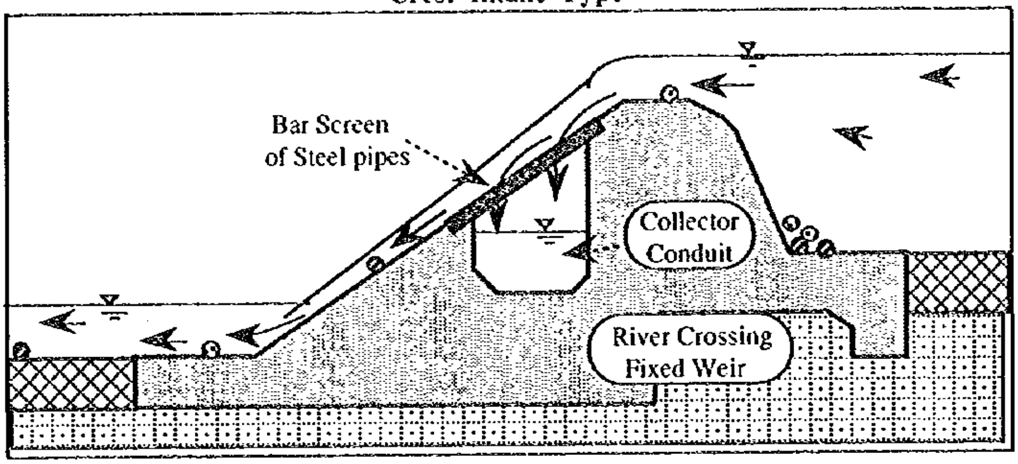
Several types of intake structures, which are quite durable against floods and debris flow as well as operated and maintained with smaller efforts, are introduced hereunder.

1.3.2.1 Improved Bar-screen Torrent Intakes

In order to avoid troublesome gate operation and intake maintenance, a non-gated intake structure is suitable for torrent water intake, especially in a remote hilly area. The Crest Intake Type of the bar-screen torrent intakes, which are introduced hereunder, have a water intake mouth covered with bar-screen, instead of intake gates or sluice gates. In addition, the structure is simple and could be constructed relatively easily by local people.

This type is often called "Tirolean Type", since it was originally developed in Tirol, Austria. This is the most popular type for torrent intake and the general features of the standard type are given below:

Crest Intake Type



This crest intake type is often designed or constructed in the following typical wrong ways:

1) The bar-screen is often wrongly designed to install relatively horizontally or on a level with the river bed. Accordingly, all gravel and stone flowing from upstream directly attack the horizontally installed screen and damage the screen, especially in floods. The damaged screen often receives the gravel and stone in the collector conduit and designed water can not be intaken in the worst case. The floating materials such as trees, leaves and so on also block off the screen even in a normal flow condition. (i.e. Intake in Pobati village in Dolakha District)

2) The bar-screen is often wrongly constructed in many cases. The popular cases are that the top of the screen is not horizontally attached to the weir body or the weir crest is not horizontally constructed. In these cases, the over-flow water on the crest is not evenly distributed and the design discharge is not intaken.

In this crest intake type, the intake discharge is determined by length of the bar, bar space, installation angle of bar-screen and width of bar-screen. The longer the bar length is in this type, the more water falls into the collecting channel. The unit intake discharge per meter is 0.1 to 0.3 m^3/sec in general where the installation bar angle is less than 30 degree, the bar length is about 1.0 m and the spaces between bars is 20 to 30 mm. And the diameter of bar is 100 mm.

The following two points must be taken into account for the selection of this method :

a. In-order to keep design intake discharge, maintenance works such as cleaning of bars or taking out sealing materials on bar spaces always be made whenever floods attack the structures.

b. Duration of water intake time can not be always expected, especially during flood times.

Major structure components of this type are a fixed river-crossing weir, bar-screen, collector conduit. As for the construction materials, the weir can be made of concrete or stone masonry. The bar-screen can be made of a gas pipe, H-steel or iron bar, e.t.c. which are available in local markets.

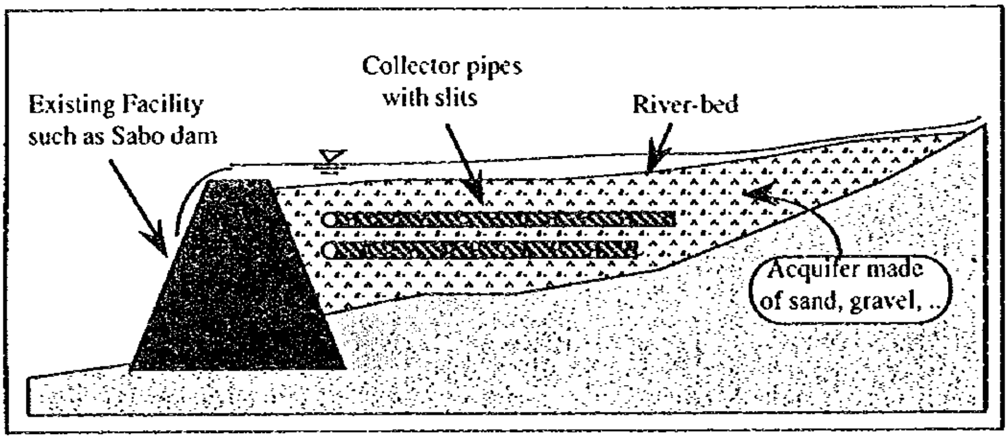
As mentioned in the above, the unit intake discharge in this type is 0.1 - 0.3 m^3/sec/m and it is not suitable for this type to intake all river water. Accordingly, this type is suitable to be applied in a medium-scale river/torrent (so-called "KHOLA" level in Nepal) which normal flow is more than 1.0 m^3/sec and it is not always suitable for a small stream or rill.

1.3.2.2 Collector Pipe Intakes

Collector pipes are buried under river-bed on a torrent, and water intake is made through slits of the pipes. The intake discharge by collector pipes depends upon pipe diameter, pipe length, pipe gradient, transmissivity of aquifer, impounding depth above ground surface and so on. Generally unit collecting discharge per meter is around 1.0 to 1.5 lit/sec where the diameter of the pipe is about 1.0 to 1.5 m. The larger a design intake discharge becomes, the longer pipes are required. Accordingly, this type is restricted to a topographically suitable location on a torrent for burying required pipe length.

Many slits of buried pipes are generally sealed and the intake discharge decreases as time passes, and the discharge decreases depend on kinds of river deposits and fluctuations of water surfaces. In addition, buried pipes are often exposed on river-bed by scouring and damaged by floods. This collector pipe type intake is not applicable to a torrent where river discharge or river-bed fluctuates widely.

Collector Pipe Intakes



In and around the Study area, there are several existing as well as proposed ground sills or check dams where artificial aquifer and stable impounding water are available. These ground sills and check dams, which have been filled up with river debris, will be favourable locations for this Collector Pipe Intakes.

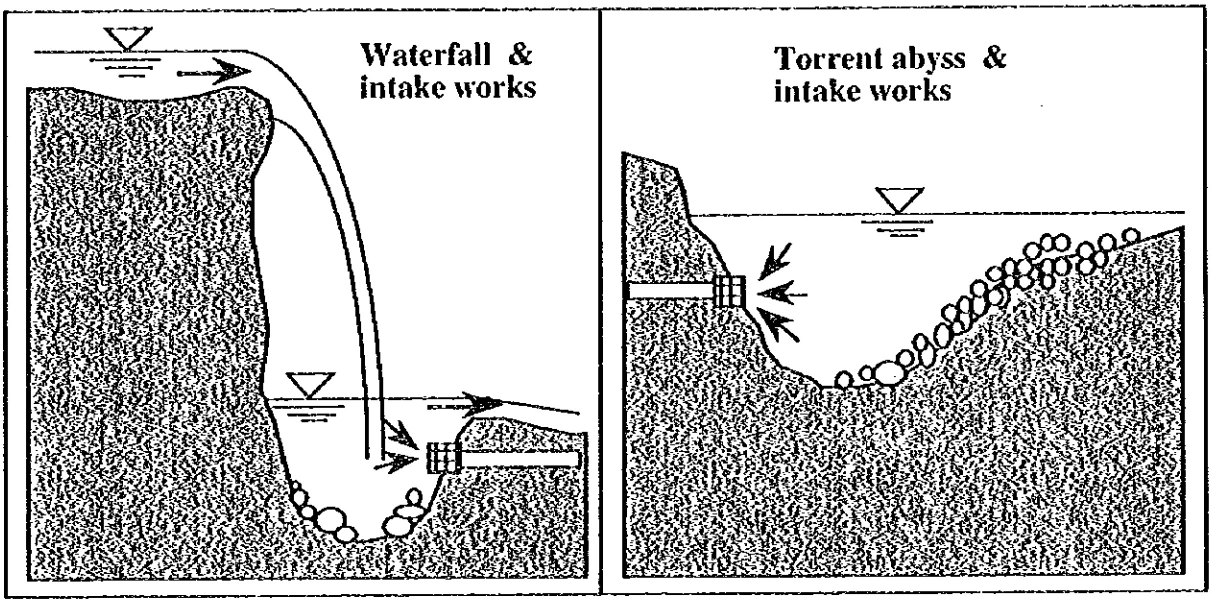
Regarding the head reach capacity as well as prevention of the collapse of canal system, it is important to install a regulation facility such as spillway or wastway at the inlet of open channel, to release excess water back to stream.

1.3.2.3 Direct Intakes

Direct and stable water intake can be expected through installation of an intake mouth below natural water level on the basin of a waterfall or an abyss on a torrent which can keep rather constant water levels. The intake structure of this group is the most simple in general.

Basin of a waterfall or abyss is a natural water cushion/pool formed by torrent flow and is never buried under normal flow conditions. During floods, however, intake discharge sometimes exceeds design discharge in this group and it is required to install a control device for excess water intaken in this case. In addition, it is necessary to consider a sand trap or a sand/gravel control structure, since more sand and gravel tend to be intaken to head reach.

Direct Intake Method



Utilisation of flexible high density polythene (HDP) pipes is proposed for this direct intakes, where debris flows had eroded down to hard rock foundation at both intakes and head reach sections. Installation of a pile of flexible HDP pipes with narrow diameter of 1 to 2 inches is to be feasible technically and economically. Small pipes are most likely to assure a full flow condition so that it can convey water from intakes to the target location where the gap distances are relatively short, 5 to 30 m. In addition, hydraulic syphonic action can be expected on hilly topographic conditions. One of the suitable location is given in Fig. 1.3.1.

1.3.3 Improvement on Head Reach Section

Generally in the FMIS, intake structures as well as head reach channels are the most common sections vulnerable to floods and debris flows; either washed out or covered by debris. The head reach portion covers a reach between an intake site and beneficiary area, and it often passes on river bed, hilly steep slope or a land sliding spot.

For the rehabilitation of head reach sections, the adoption of high density polythene (HDP) pipes seems to be one of the most effective procedures, as is seen in the Garrigaon scheme of Phedigaon/Phatbazar by the IFAD. The advantages of pipeline are that it can be protected from debris by either fixing to or burying under ground, and that it can accommodate with topographic changes, especially slight upward slopes, as long as the hydraulic gradient is maintained with full flow in pipe. The disadvantage may be a relatively high material and installation costs, in comparison with earth canal.

In addition to the HDP pipeline, there are several measures against floods, debris flows or land sliding which are galvanised iron sheeting and vegetative measures such as soding. Recommended measures for head reach section are explained below:

1.3.3.1 Pipelined Head Reach

Head reach channels in the FMIS are the most common sections vulnerable to floods, debris flows and land sliding caused by floods or heavy rainfall. In many cases, the head reach section is of open channel and often receives fatal damages ; either washed out or covered by debris. Hard works for FMIS farmers are required for maintenance of the head reach section hazarded by natural disasters, especially after heavy rainfall.

Pipelined head reach by HDP pipe in the FMIS will be one of the most effective measures where the pipeline passes through river bed, steep slope, a land sliding spot or remote area from villages. The HDP pipe is flexible enough to withstand minor land sliding and light enough for farmers to retrieve the pipes from downslope in times of major land sliding such that caused by both seepage and toe erosion.

Among the study area, the left bank scheme of Palung Khola is left to be the largest; the beneficial area of 70 ha used to be irrigated by a tributary, Bhottekhoria Khola. Similar to the Garrigaon scheme explained in the above, HDP pipes can be buried along the riverbed for a distance of 1.2 km, between the intake and the beneficial area. The farmers have already identified a site for an intake at the outlet of a stable stream of this tributary, just before the mouth of riverbed expansion.

Pipelined head reach, however, has a certain disadvantage for the maintenance works which is that troublesome works may require when the pipe is clogged up with debris or floating materials entering from the intake. In order to avoid pipe clogging, it is essential to provide screen and desilting basins (or sand traps) at the intake and additional points along pipeline with a regular interval. In addition, the following attentions are required in the planning and design.

a. Careful attention should be paid to the joints to ensure maximum flexibility and prevent breakages.

b. The pipeline should include designed break structures which control spill water when the pipe(s) move downslope with the landslide. Spill water should pour over solid rock (or boulders) or down natural drainage lines and not over the landslide zone.

c. The pipeline should be designed so that farmers can retrieve the pipe(s) and reassemble the pipeline themselves and without outside assistance.

d. The pipeline should be fixed with ground by anchors where the pipeline is exposed on the ground.

For reference in planning or designing, a siphonic head reach is illustrated in Fig. 1.3.1, a simple pipelined head reach system in Fig. 1.3.2 and a pipelined head reach in land slide section in Fig. 1.3.3.

1.3.3.2 Head Reach by Galvanised Iron Sheeting

Galvanised iron sheet, similar to HDP pipe, is a common construction materials available in the country. The galvanised sheet, however, can be used for open channel reach in the FMIS and suitable for conveying larger amount of water than the above-mentioned HDP pipeline system.

The construction of concrete hume pipes, masonry boxed canals, and other expensive, heavily and rigid structures on the following types of land are not always appropriate measures for the FMIS and may lead to environmental degradation when the system collapses.

- Land forming steep slope (more than 45 degree),
- Land which is highly unstable with active landslides and active gully erosion

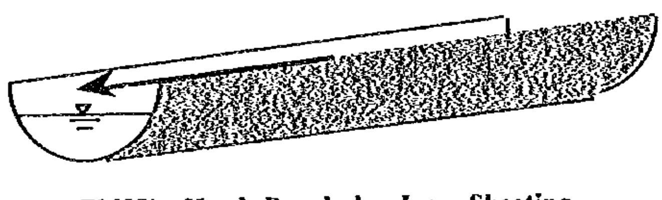
These types of structures will break up on falling and cannot be repaired by the farmers once they have been carried away by subsequent sliding. Popular participation of the farmers on the regular maintenance of temporary canal channels is more appropriate and more sustainable than fixed, supposedly permanent structures .

The head reach channel by galvanised iron sheeting in the FMIS will be one of the effective measures, especially on a land sliding place. The galvanised iron sheet is light enough for farmers to maintain or replace the sheet from downslope in times of major land sliding. The corrugated iron sheets can be utilised for head reach on such locations in the FMIS as a temporary canal channel. In the planning and design, the following attentions are required.

a. Galvanised iron sheeting should be well-jointed to prevent seepage and easily repaired by the farmers during times of serious land sliding.

b. The sheeted channel should be fixed by anchor supports, especially where the channel passes over depressed spots.

c. Hollowed-out oil drums may be utilised instead of corrugated iron sheets as an alternative measure where the drums are available.



FMIS's Head Reach by Iron Sheeting

1.3.3.3 Vegetative Measures to Head Reach for Erosion and Landslide Control

Head reach in the FMIS often passes through steep hillslope, gully, rill or landslides where cut & fill works are made during the construction time. On such places the head reach is often washed out or covered with debris by erosion or land sliding, especially in heavy rainfall.

Vegetative measures is one of the essential measures in the FMIS on an unvegetated and unstable hillslope, erosive area and land sliding places, which can be conducted by beneficial farmers themselves, using available local natural materials.

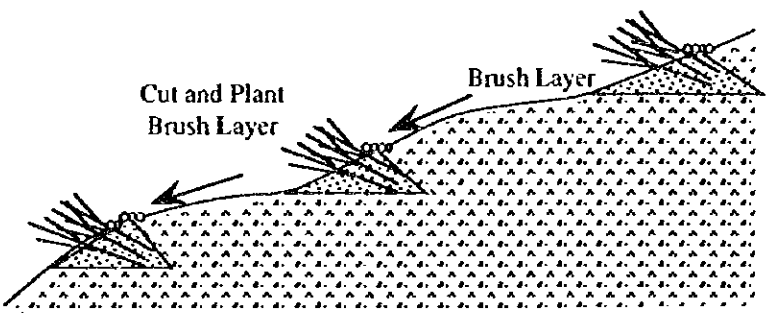
All bare surfaces are required to be re-vegetated as quickly as possible to reduce the risk of rain splash erosion, overland flow and riling. Measures for re-vegetation and types and species of plant are selected in accordance with the local availability and the farmers experience.

The following vegetative measures are recommended for re-establishing vegetation on bare and unstable slopes of land which are covered with still active unconsolidated or weathered material.

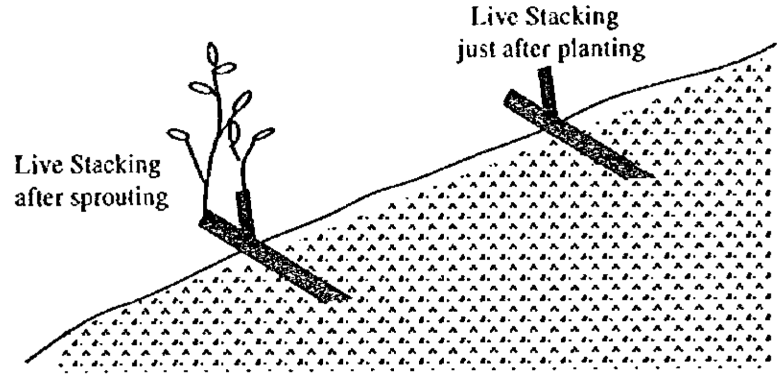
a. Brush Layering,
b. Live Stacking,
c. Bush Wattles (slope fanciness),
d. Pioneer Plantation, and
e. Vegetative Riprap

The above measures how to re-vegetate and stabilise mass-wasting area are explained below:

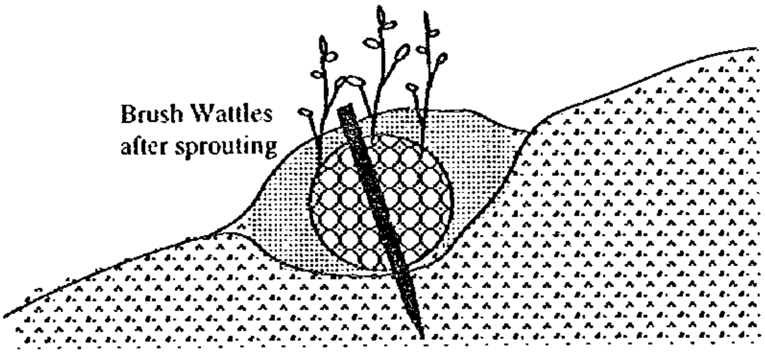
Brush Layer
This brush layer is allied for effective stabilisation of steep slopes. After rooting of planted brush, slopes are reinforced. This is said to be very important deep stabilisation method for wet slopes or steep and rocky slopes.



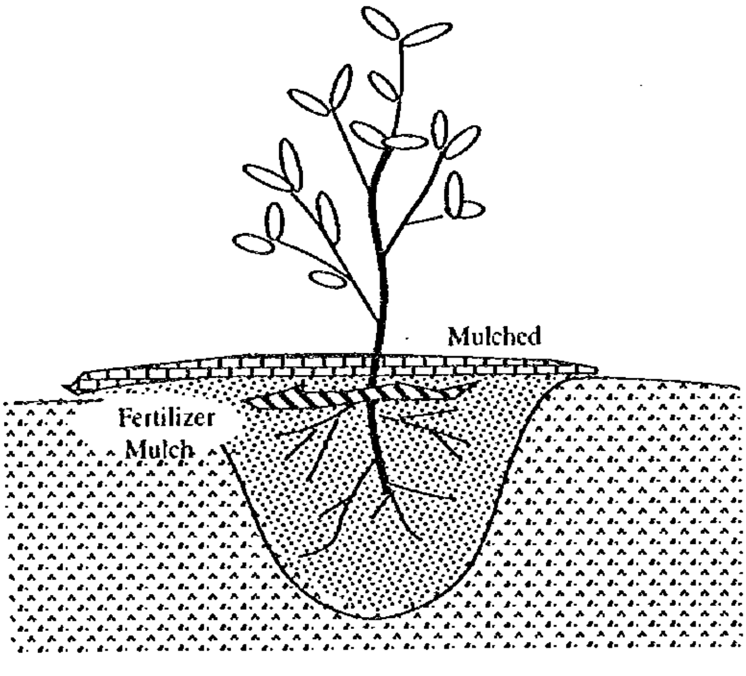
Live Stacking
This live stacking is a quick and effective measure of secure a vegetative cover. Slope stabilisation is made only after rooting of the plant.



Brush Wattles
This brush wattles are applied for slope stabilisation and drainage of backcuts and slides at surface, and they holds back sediments and useful for bank protection.

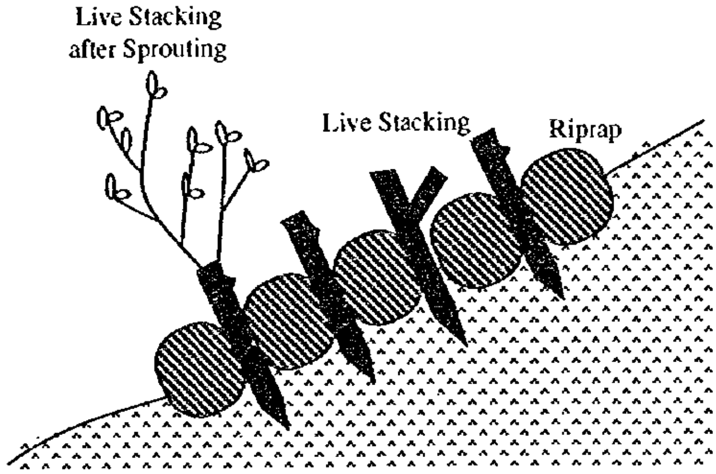


Pioneer Plantation
This pioneer plantation is applied for stabilisation of slopes and can also provide fuel wood, fodder and fruits. The mulching to cover slope surface helps the plants to grow faster by regulating moisture.



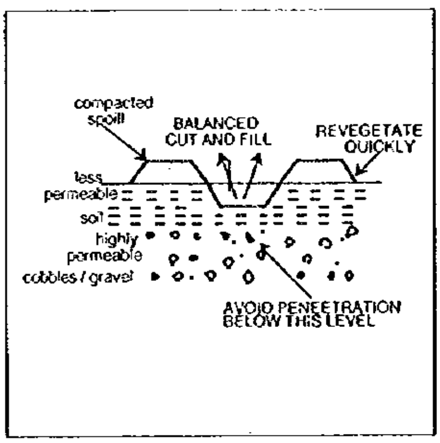
Vegetated Riprap

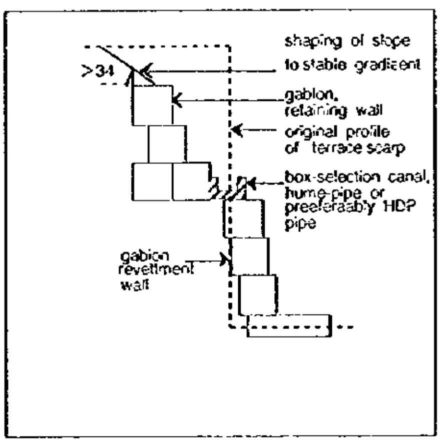
This vegetated riprap is applied for punctual and linear stabilisation of slopes and toe protection. Due to vegetation dry masonry structure becomes more flexible, and the plants reinforce the fill behind the masonry structure. The drainage water can leak out through spaces between riprap stones.



In addition to the above-mentioned vegetative measures, revetment for further steep slopes is also one of the effective measures for land stabilisation. The older higher terraces and the lower younger terraces are generally stable but highly permeable and erodible if surface residual soil cover is penetrated. The younger lower terraces and flood plains are susceptible to seasonal flooding.

On the flat or gently sloping terrace tops use balanced cut and fill to ensure that the canal channel remains in the less permeable upper soil layers as given in the following figure.





1.3.4 Improvement of Crossing Structure over Gully and Small Streams

Various crossing structures damaged by floods or debris flows have been inspected in the course of the field investigation. Existing crossing structures are broadly divided into three types, i.e. Aqueduct type, Culvert type and Siphon type. Improvement idea of respective types are explained below :

Aqueduct type

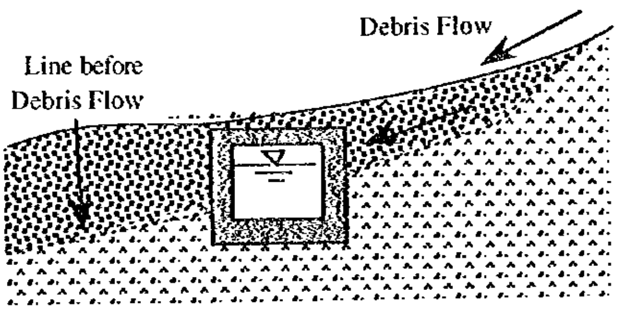
Aqueducts are not always damaged heavily by flood or debris flows. The flows passed under the superstructure of the aqueduct. Damaged parts are abutments or pier footing in general cases if any damages are observed. Accordingly, aqueduct is recommended structure for river or gully crossing.

Flexible high density polythene (HDP) pipes are available in local markets in the country in these days as explained in the previous section. Accordingly, this HDP pipe can be utilised for superstructure of aqueduct instead of concrete or steel plate flume. By using HDP pipe, the weight of superstructure becomes light and thus can save numbers of piers to support the superstructure. This idea is illustrated in Fig. 1.3.1.

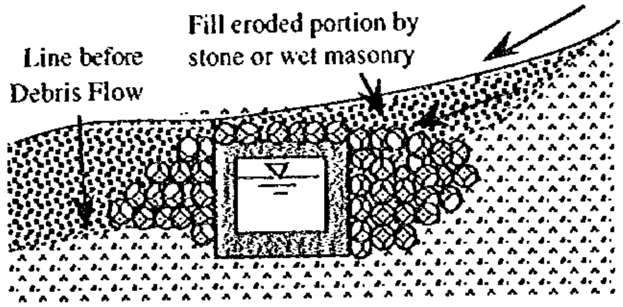
Culvert type

Culverts are, in general, damaged heavily by flood or debris flows. The flows attack the main body of culverts and wash out in many cases. Damaged parts are not only the main body but also abutments in general cases. Accordingly, culvert is not always recommended structure for river or gully crossing.

Present Culvert Construction



Improvement of Culvert



Siphon type

Siphons are not always damaged heavily by flood or debris flows. The barrel is buried relatively deep underground, and the flows pass over the barrel. Damaged parts are inlet and outlet parts of the siphon if any damages are observed. Accordingly, siphon is recommended structure for river or gully crossing, though the construction cost is high.

1.4 Appropriate Technologies for Rural Community Development

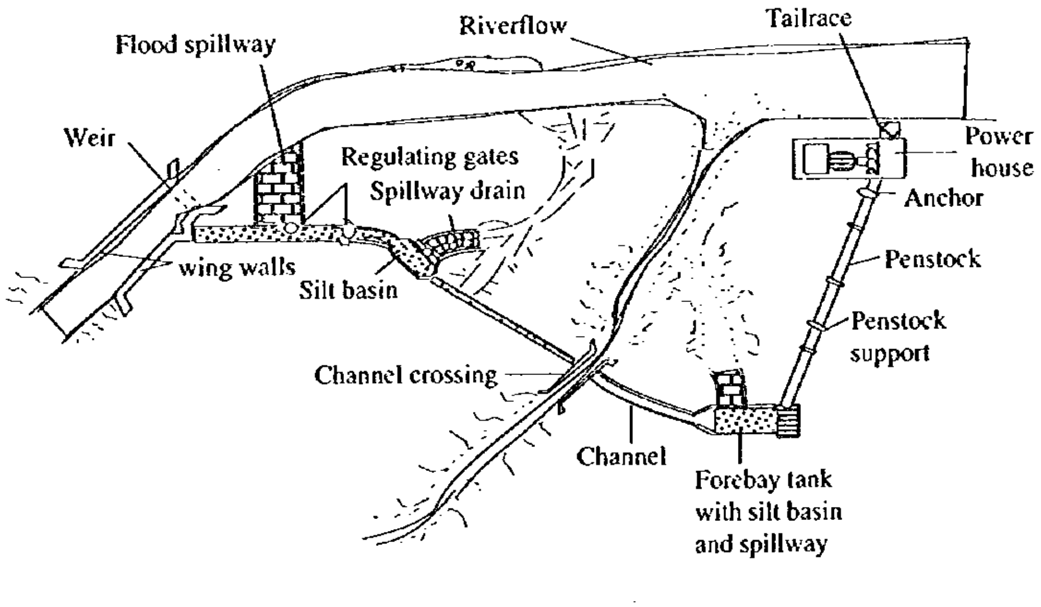
1.4.1 Micro-Hydropower Plant

There is an increasing need and demand for electricity power supplies to the CDPP study area, mainly to provide lighting at night. A micro-hydropower plant is one of economic alternative for the regional electrification to extending national grids, especially for the remote area where the national power grid line will not be extended in the near future and water resource is abundant. An independent micro-hydropower system saves on the cost of grid transmission lines to be extended and can be designed and built by smaller organisation using locally made components or machinery. A list of turbines which can be supplied by Nepalese manufacturers is given in Table 1.4.1.

(1) General Micro-hydropower System

The micro-hydropower plant generally does not supply electricity to the national grid at all and provides electricity to just one rural industry or one rural community. It ranges in size from 200 w (watts), just enough to provide domestic lighting to a group of houses, to 300 kW, which can be used for small factories and to supply an independent local mini-grid. The micro-hydropower system comprises a weir with an intake, regulating gates, spillway, a desilting basin, connection channel, a forebay tank, penstock with supports and anchors, powerhouse, tailrace and other structures such as river crossing which are given below;

Components of Micro-Hydropower System



Weir and Intake

A system must extract water from river or torrent in a reliable and controllable way. The water flowing in the channel must be regulated during high river flow and low flow conditions. Torrent intakes explained in the previous section will be suitable intake types. A sabo dam is also utilised as an intake for the system.

Spillway

The spillway is a channel flow regulator in order to spill out excess intake water. In general, it is combined with control gates to provided a means of channel emptying.

Desilting Basin and Forebay Tank

A desilting basin is provided at the beginning portion of a connection channel, in order to regulate small particles of solid matter such as sand flowing into the channel through an intake mouth. A forebay tank is provided at the end of the connection channel to trap suspension load such as silt, for protection of a turbine of a plant. A penstock is connected to the forebay tank and inlet of the penstock must be installed at the tank to be submerged.

Connection Channel

The connection channel conveys water from the intake to the forebay tank. There are various types of the channel section such as lined open channel, pipe and flume. Where the channel passes hillside and cross small streams or rivulets, special care must be taken to protect the channel against floods and river crossing structures such as an aqueduct and a siphon will be required for the protection.

Penstock

The penstock is the pipe which conveys water under pressure to the turbine. Major components of the penstock assembly are penstock gate, vent pipe, expansion joint, slide block, anchor block, pipe joint, valve and pipe. The materials of the pipe are mild steel, ductile iron, high-density polyvinyl chloride (HDPE), medium-density polyvinyl chloride (MDPE) and so on.

Power Plant

The plant consists of turbine, governor, generator, transformers and transmission lines. The turbine converts energy in the form of falling water into rotating shaft power. The governor is used to control the speed of turbines. There are several types of the turbine which can be supplied by Nepalese manufacturers. They are crossflow, turgo, propeller, pelton and francis type. (See Table 1.4.1).

The energy produced by falling water is its weight multiplied by the vertical distance over which it exerts its weight. The net power received by consumers in planning of micro-hydropower can be estimated as follows :

$$P_{net} = e_o \cdot Q \cdot g \quad h_{gross}$$
$$= 0.50 \cdot 9.8 \cdot Q \cdot h_{gross}$$

where, P_{net} : Power received by consumers (kW)
e_o : Overall efficiency of the system
Q : Flow discharge (m3/sec)
g : Acceleration due to gravity (=9.8)
h_{gross} : Head (m)

(2) Existing Micro-hydropower Schemes in Nepal

Jharkot Micro-hydro Scheme

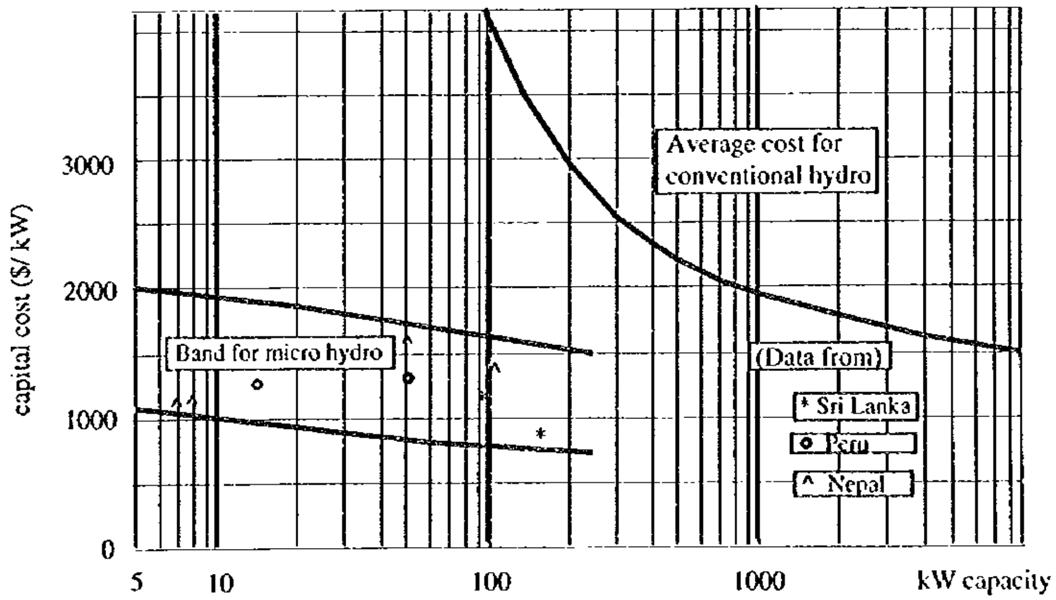
The scheme was constructed at the cost of NRs. 900,000 from the strong initiative of the villagers in 1989 who considered that the available water for hydropower scheme was more than sufficient for the water needs of the existing irrigation scheme. The hydropower plant uses 80 m of head and 80 lit/sec to generate 36 kW of power. The power has been transmitted by 400 Volts lines to two load centres about 750 m away. The forebay tank is located along the main canal of the existing irrigation scheme. From the forebay tank there is 152-m long steel penstock pipe to the power house.

The operation and maintenance of the canal, forebay tank, penstock pipe and power house is made by the Jharkot/ Khinga Electrification Committee. Once annually the canal is desilted and reshaped by the beneficiaries. For the regular operation and maintenance, two persons are hired. The funds required for the monthly salary and minor maintenance is covered by the electricity service charge collected from the beneficiaries. The service charge is NRs. 10 per 40 watt bulb per month and is collected NRs. 4,500 monthly.

(3) Cost of Micro-hydropower Schemes

The cost of a micro-hydropower scheme is divided into two major categories, capital costs and running costs. The total capital cost is 1,000 - 2,000 $ per kW based on the data in 1985 as given below:

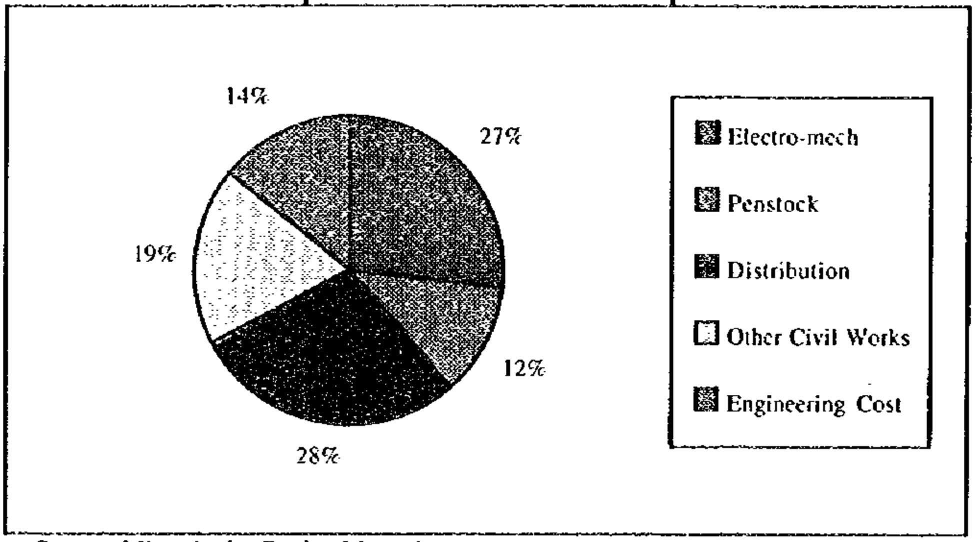
Capital Cost Breakdown in Nepal



Source: Micro-hydro Design Manual

Typical cost breakdown in Nepal is given below;

Capital Cost Breakdown in Nepal



Source: Micro-hydro Design Manual

The running cost consists of fixed annual costs and variable running costs in general. The fixed annual costs are labour wages and cost for management committee, special overhaul, maintenance and so on. The variable running costs are costs for spare parts, replacement of equipment and so on.

1.4.2 Biogas Plant

Since the Seventh Five Year Plan (1985-90), the Government started taking keen interest in the promotion of this technology by including national target for biogas plants construction. By the end of February 1993, a total of 10,340 biogas plants has been constructed in more than the 50 districts of Nepal including the hill area.

Biogas is one of the alternative energy source for domestic purposes, especially in the rural area of Nepal. The gas is burned directly for cooking and lighting and can be used to replace imported kerosene or natural fire wood for cooking, lighting, which would contribute for national foreign exchange saving or natural forest conservation. In addition, a slurry as by-product of a biogas plant is used as fertiliser for farming.

The biogas plants have been constructed in various countries in the world. The popular countries for the plant installation are China (7-8 million units), India (100,000 units) and South Korea (29,000 units). The potential biogas production in Nepal is reported to be about 670 million m^3 (Present Structure of Bio-gas Sector in Nepal, 1993). The potential production by district is given in Table 1.4.2.1 and is summarised below;

Potential Gas Production

Location	Potential Production ($1,000\ m^3$)	Unit Plant Production (m^3/Unit)
Mountain Region	4,000	385
Hill Region	243,000	535
Terai Region	419,000	510
Total in Nepal	666,000	520

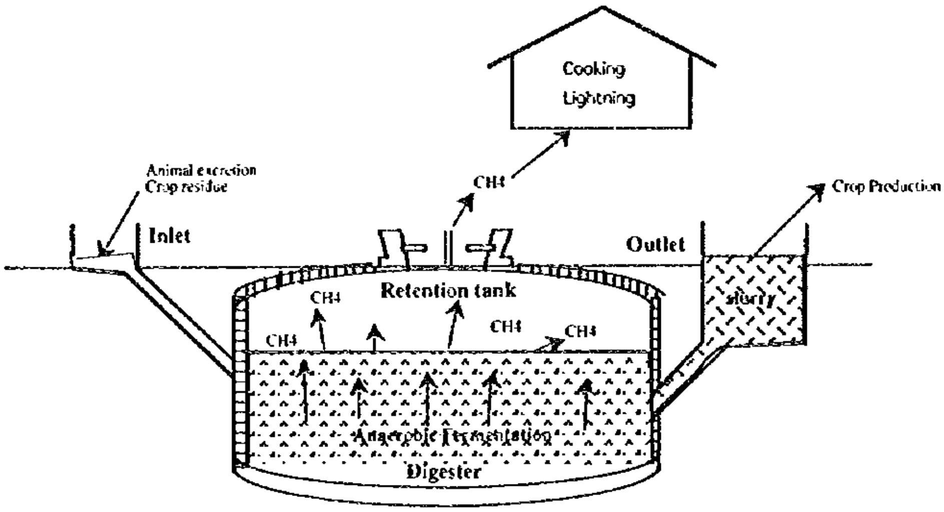
Between 1.3 and 1.9 m^3 of biogas, which generally contain 55 % of methane and 45 % of carbon dioxide, is reported to 1.0 litre of gasoline (Renewable Energy Technologies by ITDG). Accordingly, 666 million m^3 of potential biogas production can be evaluated to about 420 million litre of gasoline.

Generally one family uses 2 - 4 m^3 of fire wood for cooking in a year. The potential number of the plants is 1.28 million units (See Table 1.4.2.1). Accordingly, 2.5 million m^3 of fire wood at least could be saved in a rough estimate if all the potential units would be constructed.

The biogas production process involves the biological fermentation of organic materials such as cattle dung, agricultural wastes in an anaerobic (oxygen deficient) environment to produce methane(CH_4), carbon dioxide (CO_2) and traces of hydrogen sulphide (H_2S) by bacteria. The fermentation reduces the input organic materials to a slurry as by-product which can be used as fertiliser for farming. The biogas production by bacteria is much influenced by temperature. There are two optimum temperature ranges for methane producing bacteria which are 30-40° C and 50-60° C and the rate of methane generation approximately doubles for every 10° C rise. The daily gas production volume is generally 0.1 - 0.4 of the digester volume (e.g. 0.6 - 2.4 m^3 of biogas for typical 6-m^3 digester).

A biogas plant consists of three major components which are a inlet part, a digester and a outlet. The main part is the digester which has generally 6 types (4, 6, 8, 10, 15 & 20 m^3) in Nepal under the Biogas Support Programme (BSP). These 6 types with dimension table are given in Figure 1.4.2.1 and a schematic biogas plant (6-m^3 type) is given below :

Schematic Biogas Plant (6-m^3 type)



The required quantity of dung and water is mixed in the inlet tank and this mix in the form of slurry is digested inside the digester. The gas produced in the digester is collected in the dome, called as the gas holder. The digested slurry flows to the outlet from the digester. The slurry then flows through the overflow opening to the compost pit where it is collected and composted. The gas is supplied to the point of application through the pipeline.

Before deciding the size of plant, it is necessary to collect dung for several days to determine what is the average daily dung production. The amount of dung daily available helps in determining the capacity of the plant. At least six kg of dung is required for 1/m^3 of plant capacity. The size of plant has to be selected on basis of the available dung volume not on the family size.

Daily Input (Dung & Water) Requirement

No	Size of Plant (m^3)	Daily Fresh Dung (Kg)	Daily Water (Litters)	Required Cattle (Approx. Nos.)
1.	4	24	24	2-3
2.	6	36	36	3-4
3.	8	48	48	4-6
4.	10	60	60	6-9
5.	15	90	90	9-14
6.	20	120	120	14 and more

* Based on a hydraulic retention time of 70 days.

The following points should be kept in mind when deciding on a site for biogas plant construction.

<u>Site Selection</u>

1) For proper functioning of the plant, the right temperature has to be maintained in the digester. Therefore, a sunny site has to be selected.

2) To make plant operation easy and to avoid wastage of raw material specially the dung, the plant must be as close as possible to cattle shed and water source. If the nearest water source is at a distance of more than 20 minutes walk, the burden of supplying water becomes too much to be installed in such places.

3) If longer gas-pipe is used the cost will be increased as the pipe is expensive. Furthermore, longer pipe increases the risk of gas leakage due to more joints in it. The main valve has to be opened and closed before and after use. Therefore, the plant should be as close as possible to the point of use.

4) The edge of the foundation of the plant should be at least two metres away from the house or any other building to avoid risk of damages.

5) The plant should be at least 10 metres away from the well or any other under ground water sources to protect water from pollution.

The major construction materials are cement, sand, gravel, bricks, stone and pipes and its appliances. The list and required volume of construction materials are given in Table 1.4.2.2. On the basis of the above construction materials and quoted manufacturer cost, plant construction cost has been estimated which details are given in Table 1.4.2.3. For the construction there is a governmental subsidy which is NRs. 7,000/ unit for Terai Region or NRs. 10,000/unit for Hill Region at present. The estimated costs are summarised below :

Preliminary Cost Estimate of Plant

Plant Size (m3)	Cost (NRs)
4-m^3 Type	15,000
6-m^3 Type	17,000
8-m^3 Type	21,000
10-m^3 Type	23,500
15-m^3 Type	30,000
20-m^3 Type	36,500

It has been reported that a reasonable level of subsidy is thought to be 25 percent which enhances the private profitability, and it has been conservatively estimated that by

installation of 56,000 plants with a total capacity of 689,727 m3 would approximately save an annual consumption of 198,022 metric tonnes of firewood, over 1,700 kilo-litres of kerosene, plus an increase in plant nitrogen of 4,200 metric tonnes, together valued at NRs. 196 million (Silwal, B.B., 1991).
On the other hand, the rate of increase in the number of biogas plants is still low, since the installation seems to be more attractive to comparatively rich people than to the rest of many potential users who sees more advantages from easy access to forest and cheap firewood. The problems which are pointed out in common by users and researchers are the followings:

i) high capital cost involvement

ii) low livestock holding among the users

iii) gas leakage due to crack in domes; leakage of gas valves

iv) pipe clogging by dung (inlet), slurry (distribution pipe)

v) significant reduction of gas production in cold climate or in the winter season.

vi) lack of adequate after-sales service for the existing plants.

However, a subsidy amount of NRs. 7,000 for users in Terai region would reduce the cost of biogas production to NRs. 3.6 and 4.4 per cubic metre of gas for a 20 m^3 plant (big user) and a 4 m^3 plant (small user), respectively. Biogas will then be more or less competitive as cooking fuel compared to firewood costing NRs. 1.0 per kg. An additional subsidy of NRs. 3,000 for users in hill regions is an allowance for the high transportation cost of construction materials to make it more attractive. Recently a number of local masons have been trained by biogas companies as well as other construction sites, so that they are expected to contribute for the improvements of construction quality of domes and digesters to reduce leakage. Problems regarding low temperature would be some how accommodated by insulation of digesters through covering around them with materials such as compost, straw, transparent PVC sheets, etc. (Biogas Newsletter No. 21, Oct. 1985), and other heating appliances, if any.

Finally, the quality of service is expected to be improved by joining of six new biogas companies, other than GGC, who have been registered with the Department of Cottage Industry, HMG/N, by the end of March 1993. Their name and address are given below:

i) Ace Kishan Gobar Gas Udyog, Trishuli, Nuwakot.

ii) Baral Gobar Gas Sewa Kendra, Pokhara, Kaski.

iii) Himalayan Gobar Gas Tatha Gramin Sewa (P) Ltd., Bharatpur, Chitawan.

iv) Nepal Gobar Gas Bistar Tatha Bikash Company, Dumre, Tanahu.

v) Nepal Gobar Gas Company, Head Office, Kathmandu.

vi) Rastriya Gobar Gas Nirman Tatha Sewa (P) Ltd., Bharatpur Chitawan.

In its 17 years of service to the promotion of technology, trained and skilled manpower has been created in biogas plant construction. In view of the past trend, it appears difficult to meet the government target of establishing 30,000 biogas plants during the Eighth Five Year Plan without active involvement of the private companies. Therefore, the private companies need support to increase their technical competence along with the mechanism to ensure that they provide quality services to the users.

1.4.3 Ropeline/ Ropeway

General

Ropelines or ropeways had been introduced in a rural area of Sikha Valley in western hill regions of Karnali District, West Nepal, in mid 1970's by ATCHA, a Japanese NGO, and have been used and developed as a means of transportation in those hill areas. There are mainly two types of ropelines or ropeways: Gravitational (one-way) type and motorised (two-way) type. The former "one-way" module was initially installed aiming to "carry down" fuelwood, fodder, and some agricultural products which are harvested and collected from upper parts of hill, towards the residential area and/ or port to outer villages in lower parts of hill. It has been helpful for village porters, especially women and children who are engaged in the transportation of those goods. On the other hand, the latter type has enabled a two-way transportation of commodities or daily materials on demand, in both direction of downwards and upwards. For instance, in the Bagmati Watershed Project (BWP, HMG-N/ EU) they have invented a "Conservation Ropeway" for collecting and transportation of milk and agricultural products produced by farmers in the project area; carry them "upwards" to the upper station near the road-head, to further transport by truck and sell them in outer markets. As a trade, goods from outer village, such as animal feed, kerosene, fertiliser, and other essentials, as well as empty milk containers are carried "downwards" on its return to the villagers. Both types have been used in remote rural areas, where access motorable roads may be at a distance from the villages, so that the villagers have to carry goods over small mountain trails or paths for hours all the way to and from road-heads.

Components

Components of ropelines/ ropeways are the followings:

Terminal stations: They are provided at upper and lower parts of a single hill (single slope span) or over two different hills (bridge span), and some additional support towers may be built at appropriate intervals (no support tower for gravitational type). Stations are commonly made of wet or/ and dry stone masonry for light duty lines, and concrete and/ or steel bars for heavy duty lines. An anchor is built to support and keep required tension to a cable line.

Cable lines: A cable is the most important gear, by which career is transported along. A cable is made of strand of wires with a standard cross section of 22 mm^2 (diameter ϕ = 5.3 mm) or more. For instance a tensile force of around 1,000 to 1,500 kg is applied to the cable for light duty lines (carrying 30 kg of goods at a time), supported by anchors at two end stations. For heavy duty motorised lines, an endless cable with an approximate ϕ = 15 mm (165 mm^2) is used in BWP.

Career: This is designed to transport goods, hanging under the main cable. It consists of a pulley, hooks, a cage/ basket, and other supporting materials. For a light duty line, it simply consists of a pulley and a hook, and farmers brings in their own cages/ baskets and hang them under the hooks. For heavy duty line, cage is commonly installed as a part of a career.

Hook (gravity type): A "Hook" consists of a pulley and a hook. It rolls down along the cable lines (detail shown in Figure 1.4.3.1). Maximum load per hook is designed to be 30 kg.

Support towers: They are built between the terminal stations to give further support to the cables. They are commonly made of the same materials as for terminal station towers.

Driving machine and power source: They are required for a two-way motorised lines. In the case of the BWP an electric motor and a set of 20 KVA generator is installed at the upper station.

Other components: Shock absorber made of branches or other materials may be provided for light duty gravity lines, to reduce the speed of and the impact on the career at near the base points.

A schematic diagram of ropeline is shown in Figure 1.4.3.1 (dimensions are those for light duty lines), and technical information as well as approximated costs for both light duty gravity type of the ATCHA and a motorised two-way heavy duty type of the BWP are given in tables below.

Technical Information for Ropelines (by ATCHA)

Design hanging load	: 30 kg (excluding hook)
Horizontal distance	: 1,000 - 2,000 m
Level difference	: max. about 400 m
Support tower	: 2 nos. (upper and lower stations)
Main Cable (S=22 mm^2)	: D = 5.3 mm, max. Tensile force : 1,000 kg
	Breaking load = 3.3 t
(S=30 mm^2)	: D = 6.5 mm, max. Tensile force : 1,500 kg
	Breaking load = 5.2 t
Hook	: Pulley: D = 60 - 100 mm; Hook: 50 mm
	Total weight: about 1.0 kg, NRs. 50/ nos.
Construction Cost	: Cable (S=22 mm^2), L = 1,500 m, at site.
Cable	: NRs.100,000, imported from Kobe, Japan
Tower	: NRs. 70,000 - 100,000, including materials, labour cost
Total	: NRs. 170,000 - 200,000 + hooks, as of 1995.

(Source: Mr. T. Chino, former JICA expert for Alternative Energy)

Technical Information for Conservation Ropeway (by BWP)

Total payload	: 450 kg (including career)
Line speed	: 0 -3m/s
Horizontal distance	: 3,010 m
Level difference	: 506 m
Support tower	: 6 nos. with 18 m max. height
Driving machine	: Electric Gearmotor at Upper station
Power source	: 20 KVA Generator at Upper station
Communication system	: Telephone (battery operated)
Skyline cable	: D = 14.5 mm, L = 3,300 m.
Circumferencial cable	: D = 9.5 mm, L = 6,500 m.
Telephone cable	: D = 5 mm, L = 3,300 m.

Total Construction Cost: Approx. US$ 300,000, completed in June, 1995.

(Source: The Activities of the Bagmati Watershed Project, in Particular, Its Conservation Ropeway, BWP, HMG-N/ EU, June 1995)

Operation and Maintenance (O&M)

In case of ATCHA, prior to installation of a ropeline or ropeway, several meetings were held between villagers and project team for the determination of introduction of facilities, then agreed on its alignment, construction, operation and maintenance. A users1 group and / or Committee have been formed under villagers initiative, to help establish the ropeline/ ropeway. The groups have been involved since the initial survey and will be responsible for the operation and maintenance of the ropeway. Technical assistance and training, O & M equipment as well as financial assistance have been provided through each individual project, respectively. Users1 fee is collected from each group by the users Committee, and it has been pooled and spent for salaries of local operators and technicians, and other associated cost for O&M.

In the case for Sikha Valley, their initial objectives are the followings:

i) To achieve adequate use of forest resources and forest conservation through avoiding depletion from particular spots of forest. The system enables villagers to collect forest resources not only from vicinity of the settlements but also from remote area, so as to enhance growth and natural development of trees by rotating collection spots, and

ii) To reduce burdens of women and children who have been engaged in transportation of the above products, so as to increase opportunities for education, housework, etc., A users group consists of five households, and owns a hook. The group use their line once a week: they carry their hook to upper station, collect firewood, fodder, leaves, agricultural product, etc., and send them down by ropelines.

In the case for BWP, the initial objectives of the project are to transport fresh milk, collected from surrounding villages of about 500 households, to Kathmandu, in order to reduce villagers khuwa (concentrated form of milk) production, which consumes and deplete forest resources, as well as from which expected return to the villagers is relatively low. 6 staffs (1 operator, 1 technician, 4 loading staffs) are involved in O&M of conservation ropeway, since the beginning of operation in June 1995. Villagers pay a transportation charge of NRs. 0.75/ kg per single-way (as of May 1996) for sending their products or other goods. Group members have already been trained and will continue to receive necessary follow-up trainings as well.

Impact Analysis

In case of ATCHA, any technology is bound to create both types of impact. The issue confronting the users of new technology is not so much the rejection of the technology but the reduction of its negative impacts. Researchers have pointed out the following aspects (Impacts of The Ropelines on the People and the Resources in Sikha Valley, IHC-KMJT, Sept. 1995):

Impacts on the villagers (users):

- Saving of time seems to be as one of the best contributions of the ropelines, particularly to the women, through assisting their daily chores such as fetching fodder and fuelwood from distant forests and it reduced their physical strain.
- Evident increase in the number of school children in the area, especially schoolgirls, has found in the last 20 years. It is quite uneasy to judge whether this increase is an impact of ropelines or a national trend, however, it has influenced the community, to some extent, by proving that the technology is time saving.
- Positive impact on villagers health through reducing heavy loads of transporting forest biomass over a long distance both in time and amount to be carried

Impacts on forest and pasture resources:

- This technology could not be introduced on the basis of the requirement of a management plan and programmes ensuing therefrom.
- The sole objective of the ropelines installation was to enable farmers to get necessary biomass from the distant forests due to the depletion of the forests in the vicinity of the settlements.
- The ropeline was contributing to the protection of the forests and was very optimistic about the future of the ropelines in the Sikha Valley. In some cases, however, it causes a depletion of specific species of natural plants/ trees.
- The present ropeline system in both categories has a fixed head, and fixed base located at a strategic point near or in the village, normally anchored in an accessible place. To avoid deforestation of a particular spot, e.g. vicinity of stations, the system is likely either to be discarded or shifted to another location if technically (length and strength of the cable) feasible.

- The preservation of the forests would not be possible with the help of hardware like the ropelines alone.
- The villagers as well as research groups warned that it is necessary to facilitate a careful consideration of the "software" part, namely the management, in order to achieve a sustainable development. Preparation of the guidelines for forest conservation should be included in a further planning.

Apart from constituting forest management groups which concentrated much on controlling and regulating the villagers could not come up with technical plans to manage the forestry resources in a sustainable way. The system was not initially taken as part of the measures to avoid negative practices applied for forest exploitation in the frequently used forests near the settlements. It can be assumed that the impacts of the ropelines would have been much different today had there been a forest management plan with the ropelines playing a crucial role. However, the impacts of the ropelines in this study are being assessed taking into account the absence of management programmes for the forests now accessible with ropelines.

Limitation of Gravity - Ropelines

- The system is effective and useful only if natural resources are above settlements. If natural resources lie in areas below the village, the ropelines are ineffective.
- In case of multi-pitch span, e.g. with two or more base points, it requires several times of loading/ unloading and hauling, until reaching the final base point. The single-pitch spans have proven to be more convenient to the farmers in general, since its location in particular seems to be decisive.
- Light loads such as fodder leaves sometimes get stuck and do not reach the base.
- A hook is technically prone to get lost en-route or break on impact at the base when reaching base points, due to lack of proper brake system within its mechanism. This physical impact sometimes causes a breaking of load bundles and the straying of the hook/ carrier. A simple locking pin mechanism could perhaps help it. A technical barrier or hook-brake at the loading point could help prevent accidents

Limitation of Motorised - Ropeline/ Ropeways

- Operating a two-way ropeline would raise the question of viable energy source.
- Since the initial investment may be quite high for motorised system, it is important to assess and estimate future demands, any existing regional development plan by the Central and/ or local Government, in prior to installation.
- It is recommended to remodel supporting towers to be ⅄mid-stations⅄, so that villagers living in the middle of a hill will also be able to access to and

benefited from the facilities. Integration could be done through training of staffs, and effective use of telecommunication systems between main and mid-stations.

- “Twin” is another type of a two-way ropeline using a career with a bicycle-like handle unit for self-mobilisation, has also been invented by engineers of ATCHA. This type is initially designed as an alternative measures to a suspension bridge across a river. Because of its man-power operation, it is suitable to install over a rather flat plane with small elevation gaps. The system may be further integrated by installation of a small motor unit into the career.

Potential for Utilisation

The system may be effective in areas where the construction of motorable road is not quite feasible in the near future as well as at present. It is also noted that the following factors should be fully considered when an introduction of the system is planned:

1. Effective length of a span for gravity system and the number of mid-stations for motorised system should be assessed to realise the number of potential users and for a further increase in the users’ convenience

2. Cost of installation (gravity types versus two way with motorised) over future demand for transportation (demanded load for sending “upwards” and “downwards”).

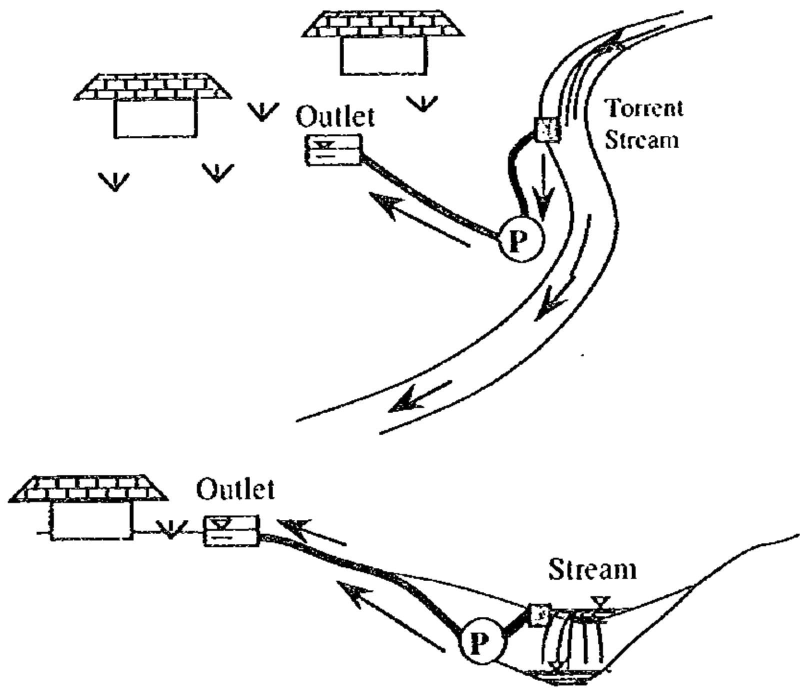
3. The preservation of the forests would not be possible with the help of hardware like the ropelines alone, but also necessary to facilitate with a careful consideration of the "software", namely the management: Guidelines for forest conservation should be prepared under villagers initiative with some technical support from outer agencies.

1.4.4 Natural Power Pump

Natural power pump is one of the alternative way to lift water without an engine or a electric motor. The pump is operated by a power produced by water hammer which is one of hydraulic action of water flow. For the operation of the pump, it is not necessary to provide any energy source such as electricity, diesel, kerosene and so on. Accordingly, it is thought to be suitable for applying the pump in the remote or the rural area of Nepal. The standard price of the pump is around NRs. 0.3 - 0.4 million in Japan.

The pump capacity is, however, small and the range is around 5 - 70 litre/min. Accordingly, the pump is suitable for domestic water supply for washing, cooking and so on. Domestic water is often brought from a water source nearby by man power, especially children and women. This type of pumps have been installed as a trial, in Sikha Valley in Karnali District by NGO (ATCHA), and been used successfully by the villagers.

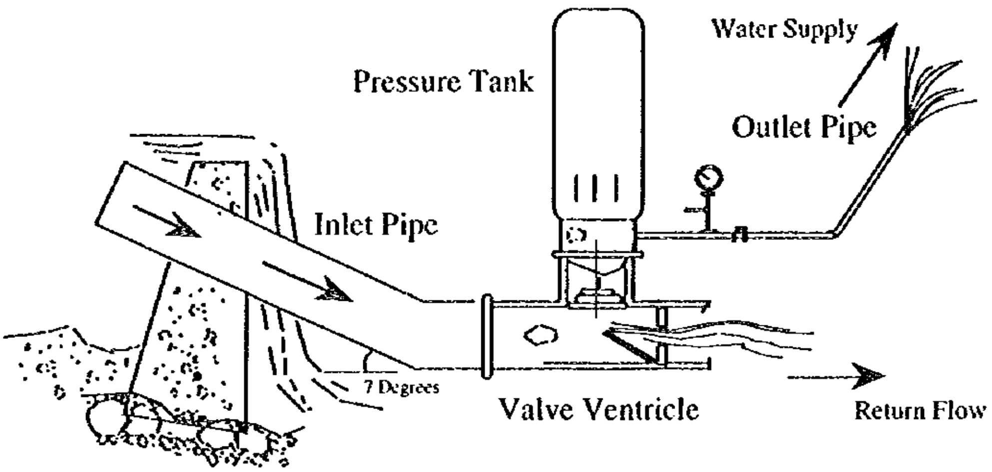
Sample Application of Natural Power Pump



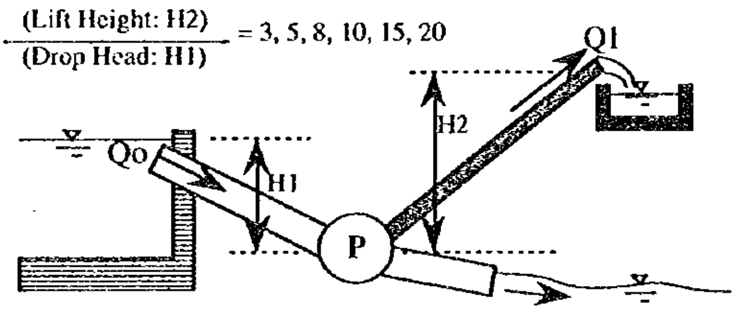
A natural power pump consists of an inlet pipe, a valve ventricle, a pressure tank and an outlet pipe. The inlet pipe conveys water from an intake mouth to a valve ventricle. The valve ventricle produces water hammer and the produced hydraulic power is led to a pressure tank with a regular interval. The pressure tank regulates the intermitted pressure and produces a constant pressure to lift water.

The general feature of a natural power pump is given below :

General Feature of Natural Power Pump



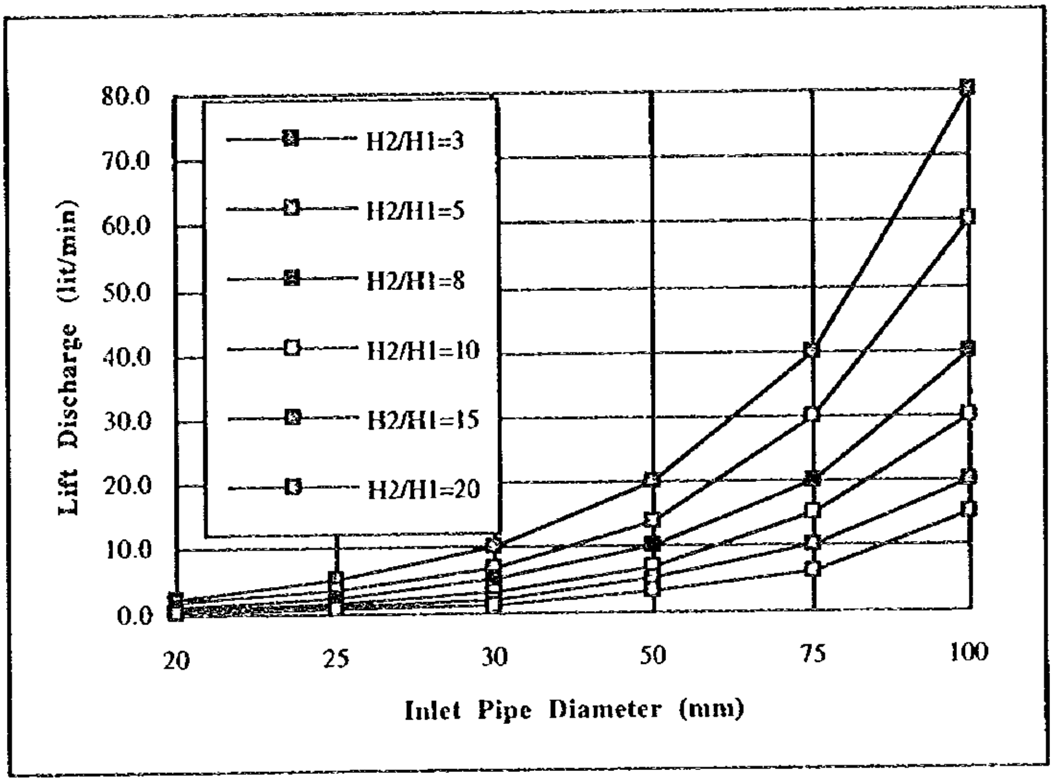
The lifting capacity of the pump is 3 - 80 lit/min. approximately where the inlet pipe diameter is the range of 20 - 100 mm. The lift discharge is decided by the ratio of H2/H1 shown below. The lift discharge: Ql in respective ratio of H2/H1 is also given below :



General Capacity of Natural Power Pump

Diameter of Inlet Pipe	mm	20	25	30	50	75	100
Diameter of Outlet Pipe	mm	13	13-16	16-20	20-25	25-35	35-40
Inlet Discharge	lit/min.	4-20	8-20	20-50	40-100	80-200	160-400
				Lift Discharge (lit/min.)			
(Lift Height)/(Drop Head)	H2/H1=3	2.5	5.0	10	20	40	80
"	H2/H1=5	1.7	3.5	7	14	30	60
"	H2/H1=8	1.2	2.5	5	10	20	40
"	H2/H1=10	0.8	1.5	3	7	15	30
"	H2/H1=15	0.5	1.0	2	5	10	20
"	H2/H1=20	0.2	0.5	1	3	6	15

General Capacity of Natural Power Pump



It has been empirically suggested that an angle of the inlet pipe should be carefully adjusted to about 7 degrees to the horizontal axis, and a suitable range of the inlet pipe length is to be 6 to 8 times of the drop height (H1), so that an efficient water lift is achieved. As seen in the preceding tables, figures and graphs, this system can be installed in a combination with a checkdam on a stream from which a stable amount of water can be yielded. An intake site may be a v-shaped valley where rock surface is exposed, and it has been steeply eroded by a stream, and inhabitants stay a fairly above the stream. The pump set should be properly protected from debris flow. The amount of water supply may be suitable for domestic use, but may not be sufficient for a gravity irrigation system especially where unlined canal is used.

1.5. Co-ordinations of Available Training Facilities with the Development of Rural Community Infrastructure

1.5.1 Problems and Key issues of the Rural Community Infrastructure Development

From field observations of current rural infrastructure systems in the Study Area as well as other mountainous regions, there have been found enormous enthusiasm and efforts of villagers for the development of their systems. Photos 1.5.1 through 1.5.9 depict the current development activities of rural community infrastructures on regional and smaller scale bases, found in the course of this study. However, it is also pointed out that it could be improved gradually and/ or drastically if some additional though simple technical knowledge were available among the villagers, in planning and construction of these development activities. For instance, the following types of technical and institutional problems are often observed in "Farmers Managed Irrigation Schemes (FMIS)", and rural roads:

i) Improper levelling of an irrigation canal bed, i.e., fluctuation of bed, will not allow a complete gravitational flow down to tail portion.
ii) Lack of proper excess water release system, i.e., regulating facilities at canal head and spillway structures along irrigation canals, may lead to water induced disaster, such as flooding over farmland, landslide, disconnection of canal, etc.
iii) Relatively small numbers of offtake structures along canals, motivates farmers to cut canal banks which deteriorates the systems and induces disasters.
iv) Lack of drainage systems, such as side-ditch and drain culvert, along a rural road, tends to deteriorate and weakens the road surface and shoulders. This enhances the destruction of checkdam foundation and the formation of gullies.

Another cause of inefficient system development is the difficulties of dispatching district office engineers and/ or technicians to these small scaled project sites, since the number of staffs is relatively small. Although they visit project sites at the beginning (the time of survey and appraisal), some of the construction works have been done without instruction of engineers. If the construction has been carried out at least under instruction of overseers or technicians, the result would be rather successful.

Regarding these situations and accomplishment of the sustainable rural community development, transfer of technologies through several generations and several disciplines will be one of the most important strategy. Therefore, the desired rural community development will be enhanced through co-ordinating the above mentioned strategy and an effective employment of young technical and vocational human resources, such as graduates from Jiri Technical School (JTS). Since the JTS graduates have been trained in the said two types of disciplines (explained in the following section), they would play an important roll as an assistant to a community organiser or they can be trained to be organisers. They also substitute the roll of overseers in hilly regional development programmes and they can even be trained to be engineers through further trainings. This also stimulates and encourages the JTS as well as other technical schools to teach and train young students in a disaster prevention programmme, not only in civil engineering but also in agricultural programmes, such as afforestration program, SALT technologies, sericulture, etc.

In addition to the JTS, the Local Development Training Academy (LDTA) also provide adults and groups with a variety of useful rural community development training and education in both institutional and technical fields.

Thus, the following is a model scenario for a sustainable step-up development of rural community infrastructure on village and regional (National) bases:

- Step 1) Effective employment of JTS graduates as VDC, or village technical staffs.
- Step 2) Send eligible students from rural society to technical schools, such as JTS.
- Step 3) Arrangement of available short educational programmes in JTS and LDTA for training of community organisers, technical staffs and other motivated candidates, including women.
- Step 4) Establishment of similar educational institute in the Central Development Region, specialised in Disaster Prevention and rural community development programmes as a long term plan.

1.5.2 Jiri Technical School

Jiri Technical School (JTS) was established in 1982 as a joint Project of HMG/N and Swiss Development Co-operation. At present the technical school is running under the Council for Technical Education and Vocational Training (CTEVT), and a technical support to the school has still been continued from SDC. The major purpose of this facility is to provide young people with technical training, which are applicable for a sustainable development in hilly regions. Furthermore, one of the strong features of this school is the "vocational training" and "On the Job training (OJT)" in its curriculum. The students will be trained not only in technical background but also in community development discipline, such as "rapid rural appraisal (RRA)".

In the course of this study, the Study Team has been impressed with the importance of RRA as a strong gear to the "people's participation" type of programmes. Through an RRA, villagers gradually but clearly realise what the problems are among their community, and will be motivated to seek solutions by themselves. When the Study Team interviewed senior students at the JTS, most of the students in all three trades felt a big confident after having OJT. In OJT, they stay in a rural village for 6 months, having communication with villagers through RRA approach. As a result of RRA's, the villagers as well as the students will participate in a small "hand-made" project, which may be a fruitful solution to a problem in the community. At the same time, it is the biggest opportunity for students to practice their skills, they have been trained for, in the real world.

Primarily, trainees had been selected from 6 hilly districts, and currently they are selected from nation-wide after 1995. Since the establishment, approximately a total of 500 trainees have been trained in three trades: Agriculture Trade; Construction Trade and Health Trade, in the following fields:

Agriculture Trade:	Agronomical farming, livestock management
Construction Trade:	General civil engineering, including irrigation
Health Trade:	Primary health care and family planning

Minimum qualification in order to be eligible in the programmes are as follows:

- Candidates should have passed grade ten.
- Candidate should have the age between 16 and 35 yrs.

The duration of the long term training is 2 1/2 years, including 6 months of OJT. After completion of the programme, students receive Technical School Leaving Certificate (TSLC), which is equivalent to high school graduate.

Agricultural Trade has also been conducting short term training, and the duration of a course ranges from one week to one month. The tuition fee for each condition is set as the followings:

Tuition fees

Duration of courses	< 4 weeks	> 4 weeks
Sponsored candidates	Rs. 1000/-	Rs. 2000/-
Self financed candidates	Rs. 300/-	Rs. 300/-

The followings programmes are covered in Agriculture Trade in both short and long term programmes:

- Organic Vegetable Farming
- Plant Propagation
- Broiler Production
- Animal Nutrition
- Community Facilities Course
- Vegetable Preservation
- Fruit Preservation
- Animal Health
- Bee Keeping

There is only long term training in Construction and Health Trades. The following fields are covered in Construction Trade :

- Construction
- Surveying
- Quantity and Cost Estimation
- Carpentry
- Technical Drawing
- Construction Supervision

Likewise, Health Trade covers the following programmes:

- Maternal and Child Health
- Immunization
- First aid
- Health Education
- Family Planning
- Hospital Working and nursing procedure
- Antenatal, Natal and Postnatal services
- Control of diarrhoeal Diseases and ARI

According to Mr. K. Td. Neupane, the Principal of JTS, and Mr. S. Wagley, the Project Advisor of SDC to JTS, the demand is extremely high for students in Health Trade, of which 100 % of the graduates get jobs in nation-wide. In contrast, over 50 % of students in Agriculture and Construction Trade, are having difficulty with getting jobs. Some of the engineering students get jobs in VDCs as overseers and technicians; some agricultural students get jobs in some Agriculture offices of local government or in farming at home village; but the rest of the students either return to their villages or stay in cities for job search. It seems to be a rather waste of good qualified human resources.

As mentioned in the previous section, regarding the transfer of technologies through several generations and several disciplines will be one of the most important strategy for a sustainable rural community development. Therefore, the desired goal will be attained by combining the said strategy and effective employment of these young technical and vocational human resources. On the other hand, some short term courses especially in agriculture trade also seems to be quite useful for the farmers of proposed project sites, since the course has given priority to field practices. Further, if the number of participant are enough (10-15) the coursecontent can be modified as per need. In construction trade also, short term training could be provided as per their schedule and need of the candidates.

1.5.3 Local Development Training Academy

History of this Academy is traced back to 1952, when a Rural Institute was setup under Tribhuvan Rural Development Programme, the first integrated development approach towards the modernisation of Nepal. Between 1960 - 1986, eleven training centres on the regional basis emerged under the fold of a Development Board with the main objective of strengthening the local government institutions and supporting rural, urban and woman development programmes through training as well as research activities. After the political change in 1990, these training centres were directed to meet the training needs of new local bodies and some other development projects in the changed context.

Under the present government, Local Development Training Academy (LDTA) has been created to meet the following prime objectives:

- Impart or enhance knowledge and skills and developing attitudes and values of the concerned individuals towards a desired direction;
- Facilitate the institutional growth and development tasks of the local bodies entrusted to them through qualitative trainings, research and other relevant activities as the leading institute in the area of local development.

In particular, the Academy has three main objectives:

a) to initiate, organise and conduct training programmes for the individuals related to local development activities.
b) to carry out research appertained to the training and development activities.
c) to undertake consultancy services in the areas of training and research and provide information services.

The local bodies (local authorities) in Nepal embody District Development Committees (DDCs), Municipalities and Village Development Committees (VDCs). In the changed context, they have been the focal points of rural and urban development task to be carried out under the local bodies necessarily require a wide variety of knowledge and skill including personal mastery in pursuit of these organisations goals. Keeping this in view, the LDTA has set its objectives & has been striving for implementing various programmes in its areas on the priority basis.

<u>Organisation</u>
LDTA is an organisation that has attempted to blend various types of experiences while managing training and other activities related to local bodies. It works as the secretariat of the council, and the Council is responsible for formulating policy, approving periodical and annual budget.

The members for the Council of Academy at the apex are the followings:

The link ministry: the Ministry of Local Development (MOLD).
Head: Local Development Minister
26 high level members includes:
Upper House: 5; DDC Chairmen: 5;
Municipal Mayors: 5; VDC Chairmen: 3;
National Planning Commission: 1;

Secretaries of different concerned Ministries: 5.
(Executive Director of the Academy: the member-secretary of the Council)

The head office of the Academy is located at Jawalakhel, Lalitpur. Under the Academy there are altogether eight training centres throughout the country, as listed below. Each training centre is headed by a principal:

Local Development Training Academy (LDTA):
The head office of the rural, women and urban development training centres
Jawalakhel, Lalitpur Municipality, Central Develop. Region

Rural Development Training Centres (RDTC): 5
RDTC Jhapa: Kalbalguri, Jhapa District, Eastern Develop. Region
RDTC Janakpur: Mujeliya, Dhanusa District, Central Develop. Region
RDTC Nepalgunj: Mahendra Nagar, Banke District, Midwestern Develop. Region
RDTC Doti, Dipayal: Puna, Doti District, Far Western Develop. Region.
RDTC Kharinitar: Kharinitar, Tanahu District, Western Develop. Region.

Women Development Training Centre (WDTC): 2
WDTC Jawalakhel: Jawalakhel, Lalitpur, Central Develop. Region
WDTC Surkhet: Birendra Nagar, Surkhet District, Mid-western Develop. Region

Urban Development Training Centre (UDTC): 1
UDTC Pokhara: Pokhara Municipality, Western Development Region

Activities

The Academy is responsible for developing administrative and managerial capabilities of local bodies by initiating, and delivering various types of training programmes based on their needs. Besides, it is devoted to carry out research works on various issues and providing consultancy services. Major activities are as follows:

Training Components:
Major training activities related to the rural development are the followings:
- Organisation development, Institution building,
- Women development, Health and sanitation, Population education
- Skill development, Income generating activities, Training methodology
- NGO management, Issues on sustainable rural development.
- Environmental planning and management, Social welfare,
- Office administration and record keeping, Staff administration,
- Area planning, Resource mobilisation, Financial management

Apart from the training for clientele groups, the Academy organises training for its own staff development.

Research Components:
To improve training programmes and find out practical solution, the Academy and the Training Centres carry out studies on variety of rural, urban, women and community development issues; such as planning approaches and development practices of local bodies, impact of project implementation, baseline survey, profile preparation, backward community development, indigenous group, poverty alleviation, local-self government, training need assessment, follow-up of training and so on.

Consultancy and Information Services

With a view to meet the increasing needs of training & research activities and spreading widely the idea and information on development thoughts, approaches and programmes, the Academy provides consultancy as well as information services. It provides consultancy services on training and research areas to the organisations involved in the development activities. It also caters the advisory needs of MOLD, and the local bodies on policy matter related to rural & urban development, the institutional development of local-self government, service development and management aspects.

Moreover, the Academy intends to develop library and documentation centre so as to strenghthen educational facilities and disseminate information on rural and urban issues through the publications of research works, news bulletins, journals, training manuals, modules, and reports.

Types of Training

In view of both practicality and cost effectiveness, the training centres conduct institutional as well as field training. Training centres basically run training programmes as per the approved annual programmes of their own and sponsored programmes. Research projects are also similarly carried out.

Target group

The clients of the Academy include persons related to local development. Categorically, they can be classified in to eight groups; local representatives, social workers, project beneficiaries, personnel working for local bodies, officials of development line agencies. NGO members, women staffworking for women development programmes and members of rural women groups formed to carry out women development plans/ programmes. It is noted that the local representatives consist of heads of VDCs, Municipalities and DDCs. Social workers refer to those who are informal leaders and contributing directly and indirectly to the development activities. Project beneficiaries indicate the members of user's groups as well as other beneficiaries involved in women development activities.

Training method

Varieties of training methods and techniques are applied as per the need, level and perception of clients. Focus is put on participants centred (interactive and participatory) training approaches based on adult learning principles.

Professional capability

The Academy and the training centres are run by a team of professionals having good background of different disciplines. Besides, there is a roster of resource persons the service of whom is utilised in the training and research programmes as per requirement. LTDA's fields of expertise are training and research on various aspects of rural, urban, women and community development including institution building.

2. PRELIMINARY DESIGN FOR COMMUNITY INFRASTRUCTURES FOR CDPP PRIORITY PLANS

Chapter 2 gives preliminary designs for four priority plans of community infrastructure development projects in the Study Areas of this feasibility study. In Namtar/ Tilar Area, 3 projects are selected and proposed among several over-all development plans (Section no.); Rural road improvement (2.1), Rehabilitation of Namtar Irrigation Project (2.2), Micro-hydropower scheme development (2.3). In Chisapani Area, 1 project has been proposed: Rural water supply network development project. (2.4). It is noted that the rural road project in Namtar/ Tilar Area and rural water supply network project in Chisapani Area are formulated under the strong request of the villagers, and project will be carried out on "people's participation" basis. The irrigation rehabilitation project in Namtar/ Tilar Area has also been formulated based on the request of the villagers and preparation works for construction has been conducted under District Irrigation Office of Makwanpur. On the other hand, Micro-hydro Scheme has been proposed as a multi-purpose utilisation of disaster prevention structures for basic human needs project.

2.1 Rural Road Improvement in Namtar/ Tilar Area

2.1.1 Objectives

Major improvement works and further development of all season motorable road are proposed in Namtar/ Tilar Area for the following objectives:

i) To assist a further economical development of the community and the surrounding areas through agricultural development in co-operation with the road improvement, i.e., to generate income through safe and efficient transportation of agricultural products to outer markets in cities.

ii) To enhance the reduction of vulnerability among the community and the area against water induced hazards through participation of villagers to the road construction works.

iii) To achieve a sustainable economical development as well as operation and maintenance of infrastructure through above activities for the future.

Moreover, the activity may enhance the electrification of the village, possibly from Chuniya.

2.1.2 Background of the Community

There are about 130 households in Namtar / Tilar Area, Ward-No.2 in Namtar VDC. The educational level of the villagers in the community is relatively high among the District of Makwanpur, since there is Kalika Secondary School, at which students up to 10 th grade (equivalent to high school) are taught. Thus, villagers seem to be influenced and are ambitious for self development of the community as described in Sector Report on sociological analysis of the community development.

The villagers have been cultivating several kinds of crops, not only cereals, but also ginger, onion garlic, vegetables, etc., and fruits, of which the demands have been rising within the country. After destruction of the irrigation facilities in the community of Namtar/ Tilar in the early 90's, they have gradually shifted to cash crops cultivation which grows with relatively small amount of water, and also developed horticulture for both forest conservation and income generation purposes. They have an ambition to sell their products in outer market at as higher price as possible, through telecommunication with market in Hetauda, using solar telephone.

The villagers, however, do not have sufficient knowledge and fund for construction of permanent/ semi permanent facilities but have a willingness to participate in the project actively through forming a users Committee for the infrastructure development as well as agricultural co-operation groups and through gaining and being trained of appropriate technologies. In this way, the community will be capable of sustaining and developing the infrastructures by themselves, after the implementation of the project.

2.1.3 Hazardous Assessment and Counter Measures for Priority Sites

General layout of the investigated rural road is given in Fig.2.1.1. In order to improve and maintain this 6 km-long rural road, vegetative measures and/or bioengineering will be applied along the remarkable landslide areas. These are the cause of frequent transportation blockage due to slope failure or earth/rock fall, despite the fact that it is so called the life-line route for the Namtar village. The application of vegetative measures or bioengineering will be meaningful in terms of low cost construction as well as people's participation in community development and its maintenance activities. It can be also pointed out that one of the main causes of slope failures is lack of side-ditch, which can be installed by people's participation under a proper instruction of local engineers. Since a slope failure occurs so frequently in this study area, it is important to store some materials and equipment such as gabion wire, stones, boulders, cement, etc. This stock will further help and enhance the villagers for a periodical maintenance and repair of road by themselves.

The locations of currently identified five hazardous sites as shown in Figure 2.1.1, and Table 2.1.1 summarises the site-wise problems, geological/ topographical conditions and proposed countermeasures against each hazardous locations. Photos 2.1.1 through 2.1.5 can be explained as in the following. The schematic diagrams, Figures 2.1.2 to 2.1.5, illustrate the ideas. The vegetative measures are schematically shown in Section 1.3 hereof.

Site-(1)

Collapsed slopes across the road are located at the top of a devastated ravine. As against the cliff it is necessary to dispose a few lines of horizontal belts of gabions on the slopes to stabilise the slopes as well as to check further collapses. The structures shall be carefully arranged to drain the rain water. For the purpose of effective drainage, some of drop-chute channels are recommended to set out adequately in proportion to the site topography in detail.

Gabion prop wall to be set out beside the road shall be with several metres in height and backfilled with soil firmly so as to bear up the earth mass upward. For the foundation of the prop wall, it is also necessary to make sure of expectable bearing strength of the earth.

The surface of slopes is finally expected to be covered with locally dominant vegetation after the mechanical way of construction mentioned above. Some of species of grasses such as Eupatorium, Artemisea, and Miscanthus can be available. The way of vegetation introduction will be usually done by 'line sodding' on the surface of embankment.

Rooted-cuttings of grass species can be gathered in adjacent areas. However, successful consequence in vegetative way of construction always calls for proper selection of seasonal implementation. Toward the beginning of the rainy season the rooted-cuttings should be prepared, rapidly transported and be brought into practice on the site. The application of straw-mat or jute-net at the same site will lend great support to the growth of grasses which may enable quicker introduction of tree species.

Site-(2)

One site is situated at the saddle portion of hill slopes, and the road-shoulder on the left side to Namtar has been destroyed due to slope failure, It is practical to install a gabion wall on the shoulder so as to maintain a necessary width of the road.

The other site is situated near the above mentioned site, and the hill slopes on the right site collapse. It is needed to arrange a row of gabion prop wall with side-ditch along the road. As the length of rocky slopes is short, it is expectable that the vegetation will be naturally introduced after the installation of the gabion prop wall as long as minimal amount of soil is available. (Back-fill soil behind the prop wall and a little amount of soil-dressing on the lower portion of slopes may facilitate the rapid growth of vegetation).

As for the drainage of rain water, it is insufficient to merely arrange a limited length of side-ditch along the road. Some of pipe culverts to drain the water to valley side across the road should be provided around this site. Not only the culvert but various kinds of drainage system such as drop-chute and French drain are to be provided in accordance with site topography, because the drainage system of rain water is one of fatal components to be destined the success or failure in the process of road management and maintenance.

Schematic diagram shown in Figure 2.1.5 can be referred to as an implementation example for installation of drainage facilities.

Site-(3)

The existing road is situated on the mass of rather large-scale landslide in the past. At present, it is feared that the mass still tends to move toward Dobi Khola which flows down at the foot of downward slopes of the road. The slope length, however, is too long to treat as a countermeasure against landslide, hence the foundation of wall to prop the valley side of the road cannot be helped to put on weathered rock which appears in the middle of downward slopes, desirably near the road. The wall can be build up with gabions by way of piling them up properly. In order to secure the gabion structure it is needed to place a thin layer of levelling cement mortar on the base and to use a little volume of wet masonry as against the wing portion attaining to original ground.

Meanwhile the hill slopes on mountain side of the road have a short range with a little of natural vegetation though there develops the gully/rill erosion. Prop wall made of gabions is also needed to secure the safety of the road. In advance, removing of unstable surface soil and grading or trimming of irregular slopes which includes the rounding of cliffs on the top are essential so as to check further gully/rill erosion as well as accomplish smooth and rapid drainage of rain water.

Vegetation introduction to the mountain side slopes of the road can be carried out by planting rooted cuttings of grasses along contour line. Depending upon site situations planting of shrub species may also be possible by means of providing properly home pits with proper intervals. For the gabion structures on the valley side of the road it is naturally desirable to accomplish the vegetated gabion in terms of bioengineering.

Site-(4)

The situations of this site are almost the same as those of the Site-(3). Namely, the existing road is also situated on the mass of old landslide. Geological/ geomorphological settings of this landslide, however, seen to be much inferior to those of Site-(3). This comes from the result of visual inspection: the slopes undulate to a higher degree, apparent remnants of repeated landslides are found and what is remarkable is the symptom of high level of water existence in the earth.

Thus, the countermeasures should be more carefully established, particularly for the drainage of rain water. Not only the drop chute or the side ditch to catch the rain water but one or two drain pipes should be provided across the road and be guided up to a safe spot to discharge.
Gabion structures are naturally to be vegetated-gabions and naked slopes are desirably covered with local grasses and shrubs. As for the tree planting in such typical case of landslide or slump sliding will be little of effect, in general. Existence of grass and shrub cover will be enough to control the washout of soil particles.

Site-(5)

Subsidence and destruction of road subgrade have been caused by clumsy drainage of rain water. The side-ditch seen on the left of the road gathers a good amount of water from the upper catchment, and the water overflows at a clogged drain pipe and infiltrates into the earth, resulting in the formation of such a cavity under the road surface. Occasional careless embankment seen on the right side of the road obviously hampers the drainage. This embankment should be removed to accomplish the drainage of surface water. The existing clogged pipe culvert, needless to say, should be first improved so that it may have good capacity and durability. Another pipe culvert is necessary at the bent corner of the road seen in this photograph so as to drain much of side-ditch water flowing down from the upward. The outlet of pipe culvert is also needed to be carefully treated so that discharged water would not destroy the valley side slopes. Vegetated drop-chute or drop-check-chute will be most preferable for the purpose of low cost construction. The circumstances around this site give a good example showing the importance of the drainage of road.

Based on the above explanation, designs and quantities of major construction works for the improvement on this 6 km - rural road are proposed and summarised in Table 2.1.2. The five hazardous locations will be facilitated with gabion structures, such as checkdams and prop walls, on either sides of the road (ms for mountain side; vs for valley side) for slope stabilisation. A side-ditch is provided along the mountain side of the road at the foot of slopes. Some other drainage facilities are provided to the sites where insufficient drainage is one of the main causes of slope failures. It is noted that installation of dry rubble masonry side-ditch is also proposed to as much as possible to cover 6 km along the road, and other drainage facilities to be provided every 200 meters over the area. Vegetative measures also play an important roll at each site, and it is expected to be achieved as a peoples initiative activity under instructions of soil, forest and/ or agricultural engineers. Finally, gabion nets / wires, small amount of cement as well as RCC pipes should be provided to the community as spare parts for a further sustainable maintenance activities by the villagers.

It is also notable that the construction of a causeway proposed at the crossing point of Manhari Khola, as a mechanical measures of disaster prevention, finally connects the branched access road from Chuniya to Namtar/ Tilar Area

2.1.4 Implementation Program for Rural Road Improvement Project in Namtar Area

It is proposed to accomplish the project in a form of people's participation program as discussed in the previous paragraphs, since the construction cost for the project may be at relatively low cost, and the villagers would be trained and gain their ability for the application of appropriate and sustainable technologies to a further development planning as well as construction by themselves. Moreover, the project is strongly recommended to be funded by a small grant aid fund, such as the Grass Root Grant Fund under the involvement of an (I) NGO for a technical and administrative support to the villagers. Through several times of discussion held between villagers and the Study Team, the villagers have been emphasising and agreed that they are planning to form a users Committee on this project, and willing to participate in collection of construction materials as well as to work as common labourers to be trained.

Based on the quantity estimated for the above major work items listed in Table 2.1.2, the total construction cost for the project is estimated at about NRs. 3.0million (US$ 54.5 thousands), and the total project cost is at NRs. 4.7 million (US$ 85.0 thousands). The details are given in Chapter 3 Cost Estimate.

2.2 Rehabilitation of Namtar Irrigation Project in Namtar/ Tilar Area

2.2.1 Objective

Rehabilitation of the Namtar Irrigation scheme, which is one of the largest scheme used to feed 50 ha, and was one of the most severely damaged system, has been proposed to accomplish the following objectives:

i) To retrieve the past agricultural activities and to develop the agricultural productivity in the community

ii) To reduce the vulnerability of the community through raising the living standard by the agricultural development as well as other infrastructure development.

The rehabilitation works will be conducted by combining of two irrigation schemes on both side of Manhari Khola; the Namtar Scheme (right bank; 50 ha) and the Dungeon Scheme (left side; 40 ha). It has been proposed that the water introduced to Dungeon scheme, from the Manhari left bank intake, will be conveyed over Manhari Khola using a huge crossing structure.

2.2.2 Background of the Community

Several FMIS schemes are now under recovery since the 1993 disaster, nonetheless still confronting with several problems. There exists a total farmland area of about 65 ha in Namtar Ward No. 2., of which only 15 ha has been irrigated under supplies from Manhari Khola (Namtar Lower Scheme) and Gorduwa Khola (Gorduwa scheme), since a severe destruction of the largest scheme, the Namtar Upper Scheme (referred to as "Namtar Scheme" herein after). The Namtar scheme, which used to feed 50 ha, was constructed by the ILO during 1982 - 1984. However, during the 1993 disaster, the riverbed had risen by over 20 m with debris, which destroyed its intake as well as the head reach section, along the right bank of Manhari Khola. Moreover, some parts of upper reach had been completely buried by a sequence of landslides, which is difficult to be re-excavated and recovered.

On the other hand, the Dungeon scheme, which irrigates about 40 ha in Ward No. 4, is one of a few well functioning system, which has been maintained by farmers for about 30 years. Its source is located in Dhed Khola, near the confluence of Manhari Khola, and a canal runs along the left bank of the Manhari. Therefore, the villagers in the study area (Ward No. 2) have come up with a rehabilitation plan; that is to invent a new intake for Dungeon Scheme on the left bank side of Manhari Khola, and convey the yielded water through the Dungeon scheme, then transport to Namtar by a crossing structure over Manhari Khola, such as suspension type aqueduct. People have already identified a site for this new intake. Regarding the request from the villagers to Makwanpur DDC, District Irrigation Office (DIO) has formulated a rehabilitation project for a total area of 90 ha, by combining the said two schemes, after conducting a feasibility study in June 1996. Then this project has been approved by the National Government in July 1996 and the detailed survey as well as the design is now undertaken by the DIO, although the budget for the year 96/ 97 is rather small. According to the National criteria, the budget ceiling for a rehabilitation project of irrigation in hilly area is NRs. 30,000 per ha, that is NRs. 2,700,000 in total. (cf. NRs. 60,000 per ha for a new project).

In the command area, a number of crossing structures and earthen canals are left either damaged or destroyed, thus disconnected the system. Culverts, aqueducts as well as gabion protections and retaining walls had also been either destroyed or covered by debris.

2.2.3 Proposed Components of the Rehabilitation Scheme

Proposed components of the irrigation rehabilitation schemes are as the followings:

<u>Dungeon Scheme</u>:

Intake structure (Intake)	: Diverting 400 lit./sec., Newly constructed (side intake type)
Headreach canal	: Intake - T/O: Earth canal 0.80 km: Existing Enlarged T/O - R/B-1: Earth canal 0.25 km new
Turnout structure (T/O)	: 220 lit./sec. Diverted to Aqueduct; Newly constructed
Regulating basin (R/B-1):	Located at the Entrance to the Suspended Aqueduct Newly constructed
Main canal	: T/O - Road-head: Earth canal; 1.2km: Existing canal Partially Reshaped
Crossing structures	: 2 nos. Reinforcement of existing wooden structures

<u>Namtar Scheme</u>:

Suspended Aqueduct	: Clear span: 70 m; Pipe (HDP) suspended by cable and scaffold; 2 Abutment (RCC) Newly constructed
Regulation basin (R/B-2):	Located at the Exit from the Suspended Aqueduct Newly constructed
Headreach canal	: R/B-2 - Farmland: Earth canal 0.60 km Reshaped
Main canal	: Farmland - Water tank near school Earth canal 1.60 km Reshaped
Crossing structures	: 9 nos. 2 nos. Rehabilitated and 7 nos. reconstructed
Retaining wall	: 3 nos. Total length of 35 m 2 nos. Rehabilitated and 1 nos. newly constructed
Recovery from Landslide:	4 locations: Total length of 100 m; Excavated Total length of 70 m; pipes should be laid and buried

The location of the above structures are shown in Figure 2.2.1, and schematic diagrams for the suspended aqueduct and an example drawing for landslide recovery works are shown in Figures 2.2.2 and 2.2.3, respectively.

2.2.4 Technical Findings by the Study Team

The findings by the Study Team regarding this rehabilitation project are as follows:

a) New proposed site for intake will be able to yield enough capacity and suitable for construction.

b) According to the geological survey and soundings, it is less feasible both technically and economically to reconstruct the original head reach section along the landslide part of the Manhari right bank.

c) Improvement of the Gorduwa scheme alone can cover less than 1/3 of the command area of the Namtar scheme, due to its lower elevation relative to the Namtar scheme.

d) Therefore, it seems to be the best alternative to make use of the Dungeon scheme and an invention of a crossing structure to convey water to Namtar/Tilar.

e) In the case of d), some enlargement works, i.e., increasing and reshaping of canal section, of the Dungeon scheme will be required to accommodate an additional discharge

f) Along the Dungeon and the Namtar schemes, appropriate sites are available for the construction of abutments for the suspended aqueduct.

g) The DIO has been conducting detailed survey, design and cost estimate for a project preparation since June, 1996, hoping that the construction to be started in December, 1996.

h) Construction cost for the suspended aqueduct, which span is about 70 to 80 m, is estimated to be ranging from NRs. 2 to 3 million, based on the cost for another existing suspension bridge in Namtar.

i) Since there are not only a number of crossing structures to be reconstructed in the scheme, but also protection works and new intake structure, the total construction cost is estimated to be over NRs. 4.5 to 5 millions, which exceeds the budget ceiling of NRs. 2.7 millions.

j) The project has been approved by HMG/ N, and a budget of NRs. 2.0 millions has been allocated for the fiscal year 96/ 97 for the beginning of construction work. Every year, some budget will be allocated until it is completed, however, it may take 4 to 5 years to complete, and the villagers should cover 7 % of project cost until completion.

k) It is highly recommended to conduct the above clause g) within the fiscal year 96/ 97, if possible, so that the scheme will be usable from the late 97.

l) If a check dam crossing Manhari Khola is realised, an alternative to the suspended aqueduct is a siphon, which will be combined into the crest of the check dam.

By rehabilitation of this scheme, stable farming activities are assured, including cultivation of paddy as well as winter cash crops, such as ginger and garlic. It is also possible to supplement irrigate the lower part of farmland by excess water from a micro-hydropower scheme through villagers effort, after its construction (described in 2.3).

2.2.5 Recovery of Other Surrounding Schemes - for a Further Regional Development -

Other schemes in Namtar/Tilar, on the other hand, can be improved by relatively minor repairs (shown in Table .2.2.1). Since the Gorduwa Upper scheme yields a good amount of water at its intake, its performance can be dramatically improved by the following works: Proper levelling works on canal bed slope with reshaping of canal section; adoption of HDP pipes at some steep critical sections. The Lower schemes of both Manhari and Gorduwa, whose command areas are small, can be improved by providing culverts at road crossing sections.

In Ward 4, both the Khade and Syarse schemes have good potentials for stable and high yields of water, with respect to their flow condition. One of the structural weakness of the intake facility may be its location, crossing the wide flood plain expanded by the debris flow.

Regarding the capacity as well as prevention of the collapse of canal system, it is important to install a regulation basin/ tank at the inlet of open channel, to release excess water back to stream. If a good amount of water is collected at the intake, then the released water may be utilised for a watermill, possibly for a micro hydropower plant. The land slide section in the Syarse scheme can be also recovered by using HDP pipes, fixing at a firm foundation found on both edges of the section.

On the other hand, the village of Bhadaure has been planting and growing a good amount of orchard, such as citrus, pears, etc., which not only can be sold in the outer market, but also be helpful for soil conservation. However, most of the orchard is currently under rain-fed, and in drought years, the plants suffer from worms and larva, which eat up roots and stems of young plants. In order to encourage further development and production, a small scale irrigation should be introduced. The water source is located about 3 km from the orchard plantation. Since the water consumption of these trees are low, it is still feasible to install pipe line to convey irrigation water to the area. The water can be stored in farm ponds above trees, and sprinkled around the root zone of the plants, so that it also prevents from pests.

2.3 Micro-Hydropower Scheme Development in Namtar/ Tilar Area

2.3.1 Objective

A high check dam is proposed to be constructed at No.2 + 930 m on Manhari Khola as explained in Annex-2 and 4. The dam is wet rubble masonry type with 16-m in height and the crest elevation of the spillway of the proposed check dam is at EL. 865.00 m. Since the dam construction enables to intake river water stably, a construction of a micro-hydropower scheme has been proposed for the following objectives:

i) To supply electricity as an alternative energy to fuel woods for cooking, heating and lighting.

ii) To raise the living standard of the villagers through electrification

In this way, the vulnerability of the villagers against disaster will be reduced through not only by the accomplishment of primary purpose of disaster prevention, but also through conservation of the forest resource through utilisation of abundant water resources

2.3.2 Background of the community

Nevertheless the electricity has reached to Chuniya, the branch off point to Namtar/ Tilar from the Tribhuvan Highway, the electrification of these villages has not been conducted. One of the reason may be a high cost for facilitating distribution lines from the national grid. A micro-hydropower scheme is one of the effective alternative for the regional electrification, especially for this area where water resource is abundant. Through a stable yield of the water at an intake, water will be introduced to a micro-hydro scheme after desiltation treatment. Water will be regulated before entering into penstock, so that an excess water, if any, could be utilised for irrigation through an effort of the villagers.

2.3.3 Design Conditions

<u>Future Power Demand</u>

Namtar and Tilar area are located at the downstream area of the proposed check dam. The community of Namtar/Tilar has 140 households and 820 in population. The area is located long away from the national electricity grid lines and has no electricity at present. The community people have been longing for electricity supply, especially for their houses and school and health post.

The power demand on the basis of 140 households and community buildings in the area is estimated at <u>15,000 W</u> as follows;

Estimated Power Demand

Location	Purpose	Unit Demand*	Power Demand
140 household	Bulb	40 W x 2 bulbs	11,200 W
10 household	T.V.	150 W	1,500 W
School (12 rooms)	Bulb	120 W	1,440 W
Health Post (2 rooms)	Bulb	120 W	240 W
Health Post	Refrigerator	100 W	100 W
Other Future Demands			520 W
Total Demand			15,000 W

Remarks; Unit demand is estimated, referring similar schemes in Nepal.*

Available Water for Micro-Hydropower

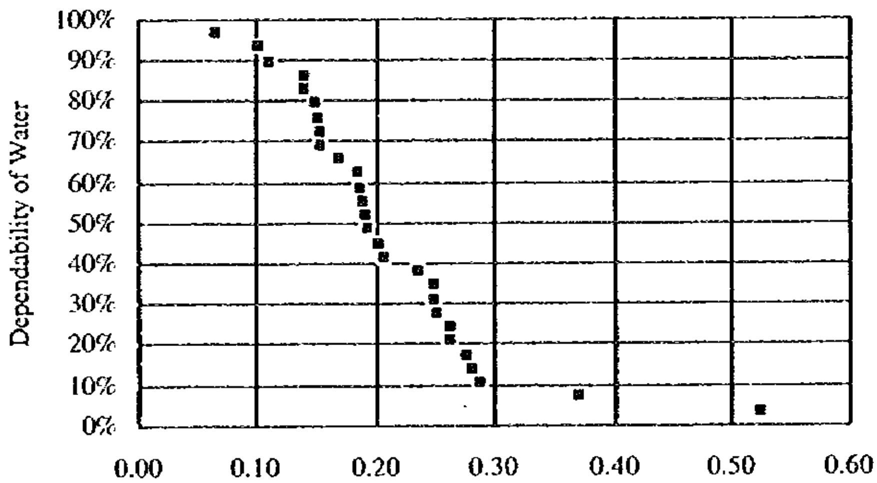
The water source for hydropower generation is runoff of River Manhari at the proposed check damsite. The river runoff has been observed at Manhari and its catchment area is 472 km^2. Its minimum monthly discharge records during 1963-1990 are given in Table 2.3.1 and the yearly minimum discharge at Manhari is 0.8 m^3/sec in April and May. Runoff discharge at the proposed damsite, however, has not been carried out. The yearly minimum runoff discharges at the damsite are in a range between 0.06-0.52 m^3/sec and the water source's dependability is summarised below (Table 2.3.2 explains in detail);

Generally water dependability for micro-hydropower is 85 % in the planning. Accordingly available runoff water at the proposed check is estimated at about 0.15 m^3/sec at maximum for the power generation. Before the start of the detailed design for hydropower, it is recommended to observe runoff discharge at the proposed damsite, especially during March-June.

Estimated Water Source's Dependability

Order	1	2	3	4	5
Discharge (m3/sec)	0.06	0.10	0.11	0.14	0.14
Dependability	97 %	93 %	90 %	86 %	83 %

Dependability of Water at Damsite (1963-90)



Available Head for Micro-Hydropower

The crest elevation of the spillway of the proposed check dam is EL. 865.00 m. The power house is proposed to be at the point 100-m away from east end of Namtar village houses as shown in Fig. 2.3.1 since the point is located between the damsite and centre of village houses and is covered by upland crop field with relatively flat topography. The ground elevation of the proposed power house is about EL. 820.00 m. Accordingly available head including water conveyance is 45 m (=865 m - 820 m) in total.

Water Conveyance Facility

For the water conveyance it is necessary to provide conveyance pipes, a desilting basin with a spillway and river crossing structures. HDP (High Density Polyethylene) pipe is proposed to be used for water conveyance, since the pipe is often used for micro-hydropower in Nepal from view-points of economy, durability and flexibility in use and its maximum diameter in common use is 10 inch (250 mm) in the country. Total length of the proposed pipe is about 780 m between the check dam and the forebay tank. The desilting basin is proposed to be provided between the check dam and the existing intake site for watermill.

Forebay Tank, Penstock & Power House

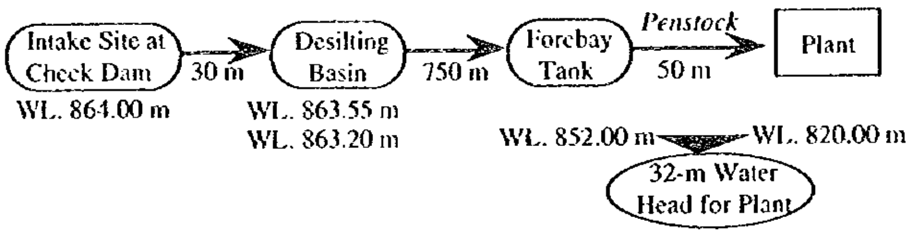
The forebay tank is proposed to be located at the point shown in Fig. 2.3.3 which is closed to the proposed power housed and is around EL. 848 m. Penstock is of steel pipe with a length of 75 m. The proposed power house requires 50 m^2 (5 m x 10 m) and is of wet stone masonry. The tail water is proposed to be released to a natural stream nearby. The recommended turbine is Crossflow type which can be supplied by manufacturers in Nepal. The penstock is of steel iron pipe with a diameter of <u>10 inch (250 mm)</u>.

<u>Hydraulic and Power Generating Calculation</u>

Hydraulic conditions for the calculation and the calculation results are given in Table 2.3..1 and summarised as follows :

HDP pipe, f 10 inch (250 mm)
Flow velocity: 2.3 m/sec
Discharge: 0.113 m3/sec < 0.15 m^3/sec
(= Dependable water source) OK!
Hydraulic Gradient, 0.015 or 1/67 by Hazen-Williams formula

The water levels along the pipe are calculated on the basis of the above hydraulic gradient as given below ;



The power received by villagers (P_{net}) is calculated as follows;

$$P_{net} = e_o \cdot 9.8 \cdot Q \ h_{gross} = 0.50 \cdot 9.8 \cdot Q \cdot h_{gross}$$

$$= 0.50 \cdot 9.8 \cdot 0.113 \text{ m3/sec} \cdot 32 \text{ m}$$

$$= 17.70 \text{ kW} > \text{Power Demand: } 15{,}000 \text{ w} \qquad \text{OK!}$$

The calculated P_{net} is 17.7 kW which is bigger than the power demand of 15 kW.

Under the above-mentioned conditions, the work quantities of major construction items and the construction costs have been estimated on the preliminary design basis which are given in Table 2.3.4. The estimated total project cost is NRs. 7.836 million or US$ 140.6 thousands (referred to Chapter.3 Cost Estimate for detail).

2.4. Rural Water Supply Network Development in Chisapani Area

The village of Chisapani Ward-2 in Agra VDC, was one of the most severely damaged area by the 1993 disaster, which washed away a large number of houses as well as cultivated land in this village. On account of intermittent loss of farmland, many villagers feel it is not safe to keep living in the village. However, most of the migrant from this as well as other villages have been facing that although residential area with a tiny piece of land had been donated by foreign and local agencies in the suburb of Hetauda, they cannot grow sufficient crops nor find jobs to buy food and sustain their family. More worse, it is quite pessimistic for those migrants to buy farmland in the suburb of Hetauda and Terai region and that they have a strong tendency to return to their former farmland in damaged villages for farming, their only choice. In the course of field study over the community and hazard assessment, it has been identified that some of the land in this village is quite safe and stable, and that the key issues of the community for a further development, in terms of infrastructure, are protection and stabilisation of unstable land and water resource management. Since 1980's, the village has been developed their own sustainable way of cash crop farming, cauliflower in particular, taking advantage of its cool weather and the seasonal timing allows them to sell their products at a high market price in large cities.

2.4.1 Objective

A rural water supply network development project under people's participation program, has been proposed to fulfill and assist the following demands and potential activities:

i) Supply water for domestic use (drinking and house use) through a systematic method;

ii) Supply water for sprinkler irrigation supplemental during non-monsoon season; and encourage farmers to grow two cultivation of vegetable crops, such as cauliflower, and

iii) Assist villagers to sustainable develop and reduce vulnerability through forming water users' groups and activating economy on both household and regional basis.

Some of the community water sources in the stream had been destroyed, and the villagers have either recovered or invented sources by themselves. Three main water sources have been identified; upper part of Chhap Khola West tributary (Chhap W), and Chhap Khola East tributary (Chhap E), and Majuwa on the hillside at mid elevation of the village. At present, villagers in the area have a high feeling for water scarcity, mainly due to lack of storage facilities. However, it has been assessed and estimated that these sources have a potential to supply about 60 litres /min. as a total, which is equivalent to over 1,000 litres of water per capita per day (Table 2.4.1). Therefore, a construction of storage tanks and delivery system in the area would be highly feasible and contribute to water supply for domestic use (standard requirement of 45 litres/day/capita) as well as for agricultural production activities (additional cultivation of winter cash crops). A proper water resource management is expected to be accomplished by the community through the proposed network system, coupling with people participation program. Figure 2.4.1 shows the layout for the water supply network system development in Chisapani Area.

2.4.2 Background of the Community

General layout of the existing water supply system is given in Fig. 2.4.1.

In the course of the study, several discussion among the villagers have been held besides baseline survey as well as the communication meeting with the study team. Study team and villagers have confirmed that villagers are willing to form water users' groups and solve the water scarcity problem and enhance a fair water distribution through discussion among themselves. For instance, the Source S-1B and S-1E had originally been invented privately after the 1993 disaster by a small number of farmers, who reside over a ridge of Kailashdanda. They deserve to receive a higher amount of water compared to other farmers after their inventory effort, but they are willing to give right of the source S-1 E to be connected into the storage tank S-1 exclusively for the community use. Although irrigation has not been commonly done in practice due to feeling of water scarcity caused by lack of storage facilities, this advanced farmers have been demonstrating a good practice and performance to the community; they have been storing the surplus water in a drum-can, and irrigating over cash crops by locally made plastic sprinkler connected to drum-can through HDP siphon pipes. Such a simple pressurised type of irrigation system enables farmers to grow two crops of cauliflower or other cash crops as well as their staple food potatoes, during the dry winter season. Therefore, the village has a good potential to sustainable develop through a proper management and systematic use of the available water resources under awareness and participation of both the community and individual bases and this scheme will highly contribute to an additional agricultural production. Moreover, excess water can even be transferred to the adjacent villages.

The Study Team has also assessed that it is not feasible to install a gravity type hill irrigation system, mainly for the following reasons: The total amount of regional water supply is not sufficient to run a gravity system of which the conveyance efficiency is low; water requirement of vegetables, in general, is low, and crops prefer well drained soil; and construction of canal system may induce a further landslide over the region, by increasing the unit weight of the soil around the canals, running around edges of terraces.

2.4.3 Major Components of the System

The proposed network system forms a "star-like" delivery system, so that the total length of pipeline will be reduced in a whole system, and maintenance should be done by each small user's group. As described in the previous section, the network system consists of the following components: Intake structures; HDP pipelines; Storage tanks; Distribution tanks; Delivery tanks; Household storage tanks w/ sprinkler irrigation unit; and related structures such as break pressure tank and valve chambers.

Intake:
A precast intake protection unit is installed at each water source site in both stream and spring/ seepage. It is also protected by dry rubble wall from debris flow.

Pipelines:
There are 4 types of pipelines, the first 3 of which fall into category "community line". Transmission main connects primary level tanks (storage/ major distribution tanks), while distribution lines send water from primary level tanks to secondary level tanks. Community delivery lines supply water from distribution to delivery tanks, and private delivery lines lead water to household storage tanks.

Tanks:
There are 4 types of water tanks. Storage tanks are categorised as primary tank, and

designed to store water, supply water to distribution tanks within a system, and transmit surplus water to lower primary tanks in other systems, through transmission main. A distribution tank plays a roll of either primary or secondary tanks. Secondary level distribution tanks primarily supply to household storage tanks as well as delivery tanks to fulfill their basic demands. Water is delivered through delivery lines or distribution lines, and tanks are regulated by float valves to avoid storing surplus water (types II-c, II-b). On the other hand, primary level distribution tanks are additionally designed to transmit surplus water to lower storage/ distribution tanks (type II-a). A delivery tank is located in the centre of a group of houses to supply to those houses through delivery lines, and also plays a roll of a "tapstand". A household storage tank is the minimal unit, which primarily stores water for individual house use and then surplus water can be used for sprinkler irrigation. Both household tanks and delivery tanks are regulated by float valves, to prevent from introducing excess water and thus from overflow.

Related structures:
Break pressure tanks are provided along community pipelines (transmission mains, distribution lines and community delivery lines) where a static pressure within a pipeline exceeds 60 m. It releases an excess pressure to avoid breaking of a pipeline. While air valves and/ or vent valves for flushing soil, etc., are provided every 200 m (at least 1 unit) along community pipelines, and they are protected by precast valve chambers.

It is noted that a HDP strainer unit is installed at every outlet on intake structure and tanks of all levels, in order to filtrate small particles and suspended substances. Figure 2.4.2 shows the sketch drawing of major components in the network system.

2.4.4 Design of Network System

The design of network system is based on the Design Criteria for the Design Guidelines for Community Based Gravity Flow Rural Water Supply Schemes published by HMG-N/ UNICEF (cited in Ch. 1.1 Rural water supply system, referred to as "Criteria"). A flow chart for design of network system is shown in Figure 2.4.3, and the schematic drawing for tank network system is also given in Figure 2.4.4.

Basic Water Requirement Analysis on Household Basis:
Design of all tanks are based on the water requirement on household basis, which consists of domestic use and irrigation use.

Domestic use requirement:
Referring to the Criteria, it is recommended to design at 45 and 60 lit./ capita/ day in the rural area and bazaar, respectively. Hence, the water requirement for domestic use is set to be 45 lit./ capita/ day and thus, set to be 270 lit./ household/ day for an average household of 6 family members.

Irrigation use requirement:
Major advantages of irrigation during non-monsoon season are the followings:

i) Enhancement of crop growth and quality
ii) Frost protection
iii) Increase in agricultural production and hence income
iv) Conservation of topsoil from wind erosion

Table 2.4.2 shows the relation between available water amount and potential irrigation performance. Generally in vegetable crops irrigation, an application depth of 28 mm at an irrigation interval of 7 days (i.e., 4 mm/ day) has been recommended and practised during non-monsoon seasons.

In other words, that a farmland is divided into 7 plot and each plot is irrigated once a week. While accordingly, an application depth of 15 mm at an interval of 5 days (i.e., 3 mm/ day, so called "deficit irrigation") is also employed where water supply is short. A water supply of 200 lit./ day enables to irrigate over 1 ropani of land during non-monsoon season, at application depth of 4 mm/ day.
Accordingly, about 3 ropani of land, which is an average size for cash crop cultivation per capita in the village, can be irrigated by about 550 lit./ day at the said application depth.

Over-all water requirement on household basis:
As a total, supply of about 800 lit./ day is estimated to be the target amount of supply per average household of 6 family members. Therefore, from the economical view point, a tank capacity of 200 lit. has been chosen, since this is the common minimum size for a ready-made plastic (linear low density polyethylene) tanks, and a storage amount of 75 % of daily requirement 270 lit. seems to be reasonable for domestic use. Initially a full tank of 200 lit. will be utilised for domestic use. And additionally, a potential amount of 600 lit. of water will be supplied to tanks for irrigation use, feeding to crops through sprinkler unit, as long as the water level in tank is below its maximum water level (a float valve will regulates inflow and it closes to avoid overflow). In a practical sense, a maximum daily amount of 100 lit./ average household may be consumed for domestic use at present. Therefore any surplus amount stored in tanks will be used for irrigation.

Tank Capacity:
Based on the water requirement analysis on a household basis, and the size of household storage tank (200 lit.), the sizes for higher level tanks are designed to at least insure the initial amount of supply, 200 lit., to each household, and are determined as follows (Description of tanks are summarised in Table 2.4.3):

- Delivery tank: 200 lit. x household nos. to cover

- Secondary Distribution tank (Sub-type II-b; II-c; II-b,c):
  - (II-c): 200 lit. x household nos.
  - (II-b): Sum of delivery tank capacities
  - (II-b,c): Sum of II-c and II-b

- Primary Distribution tank (Sub-types II-a,b; II-a,c; II-b,c):
  - (II-a,b): Sum of delivery tank capacities + 50 %
  - (II-a,c): 200 lit. x household nos. + 50 %
  - (II-a,b,c): Sum of II-c and II-b + about 1,000 lit.

- Storage Tank: Sum of basic requirement + 25 %

- School: Regarding the fact that school building was used as a shelter during the time of the 1993 disaster and that the villagers experienced water shortage, school tank has been design to be 1,500 lit. to cover school demand (10 lit. x 50 students) as well as reserved capacity of 1,000 lit., i.e. an additional supply of 10 lit. for 100 persons.

Structural Design of Tanks:
Based on the required tank capacity, the primary and secondary level tanks should be

constructed on site. After a trial calculation of wet masonry type vs. reinforced concrete type, the latter type (RCC : CM = 1:3) tanks are proposed for the primary and secondary level tanks, from the following economical as well as technical view points:

i) Smaller concrete volume in tank resulted in a relatively cheap in total cost
ii) Tanks requires smaller base area and can be built on a limited safe portion of land
iii) Shortage of good mason for a high plastering quality in masonry works;
iv) Higher in sturdiness.

On the other hand, since delivery tanks as well as household storage tanks are small in size and should be less expense, ready-made plastic tanks (linear low density polyethylene) are proposed. Each tanks are provided with required pipe fittings and community tanks are provided with wet stone masonry/ precast valve chambers for protection of inlet/ outlet valves and pipes. Design of tanks are summarised in Table 2.4.4. Since the plastic tank size of 600 lit. seems not be available in the market, 750 lit. (actual capacity size 800 lit.) tank is chosen for tanks whose capacity requirement is either 600 or 800 lit. The preliminary designs for storage tanks, related structures are shown in Drawings 2.4.1 through 2.4.4.

<u>Hydraulic design of Pipeline:</u>
Basically, the network is divided into two types: Open system and semi-closed system. Open system is employed for transmission main, where static pressure is adjusted and regulated by break pressure tank. On the other hand, semi-closed system is used for distribution and delivery lines, where flow and pressure is regulated by float valve installed at the inlet of delivery and household storage tanks.
According to the Criteria on water demand during peak hours between 7:00 AM and 12:00 PM, at least 35 % of total daily demand for domestic use should be supplied:

270 lit. x 35 % = 94.5 lit./ household,

Hence, a full tank amount of 200 lit./ household, which is 25 % of overall daily water requirement per household, is targeted to be supplied within the peak hours. To meet this requirement, flow rate Q (l/s) for supplying a single household storage tank is simply calculated as follows (5 hours = 18,000 seconds):

$$Q = 200 \text{ (lit.)} / 18{,}000 \text{ (sec.)} = 0.011 \text{ (l/s)} \qquad \text{(Eq.-1)}$$

Therefore, supply flow rate into each tank will be estimated by tank capacity divided by 18,000 (sec). The flow velocity in a pipeline is designed not to exceed 1.0 (m/s) in general, and it is set in the range of 0.3 to 1.0 (m/s) for transmission main and distribution line, 0.2 to 0.5 (m/s) for community delivery lines, and 0.1 (m/s) for private delivery lines, respectively based on the Criteria.

<u>Hydraulic gradient and Head loss:</u>
The following equations are employed for hydraulic calculation:

$$Q = A*V \qquad \text{(Eq.-2)}$$

$$R = A / S = (\pi D^2 / 4) / (pD) = D/4 \qquad \text{(Eq.-3)}$$

$$V = 4Q / (\pi D^2) \qquad \text{(Eq.-4)}$$

where, Q = flow rate (m^3/s); A = flow area (m^2); V = velocity (m/s);
R = hydraulic radius (m); S = wetted perimeter (m)

D = pipe inside diameter (m)

Applying Hazen-Williams equations gives

$$V = 0.84935\ C R^{0.63}\ I^{0.54} \qquad \text{(Eq.-5)}$$

$$I = (V / (0.84935\ C\ R^{0.62}))^{1.852}$$

$$= (V / (0.84935\ C\ (D/4)^{0.62}))^{1.852} \qquad \text{(Eq.-6)}$$

since, I = Hf / L, head loss Hf is given by

$$Hf = L*I \qquad \text{(Eq.-7)}$$

where, I = hydraulic gradient (dimensionless);
Hf = Head loss (m); L = pipeline length (m);
C = coefficient for velocity (dimensionless),
C = 140 for HDP pipe I.D.< 150mm

Here, the head losses due to pipe fittings and small valves are neglected. Table 2.4.5 shows the summary of hydraulic calculation and pipeline length for water supply network system in Chisapani Area.

2.4.5 Quantity of Network System

The quantity of major components for the proposed network system in Chisapani Area is summarised in Table 2.4.6. It is noted that sprinkler unit consists of a single piece of sprinkler unit and 30 metres of extension HDP pipeline, so that villagers can feed surplus water to their own individual farmland. It is also important to store some extra pipes and materials for operation and maintenance as well as for future extension purposes.

2.4.6 Implementation Program for Rural Water Supply Network Development in Chisapani Area

It is proposed to accomplish the project in a form of people's participation program as discussed in the previous paragraphs, since the construction cost for the project may be at relatively low cost, and the villagers would be trained and gain their ability for the application of appropriate and sustainable technologies to a further development planning as well as construction by themselves. Moreover, the project is strongly recommended to be funded by a small grant aid fund, such as the Grass Root Grant Fund funded by the Embassy of Japan to Nepal, under the involvement of an (I) NGO for a technical and administrative support to the villagers. Through several times of discussion held between villagers and the Study Team, the villagers have been emphasising and agreed that they are planning to form a users Committee on this project, and willing to participate in collection of construction materials as well as to work as common labourers to be trained. Implementation schedule of this project is shown in Figure 2.4.9.

Based on the quantity estimated for the above major work items listed in Table 2.4.6, the total construction cost for the project is estimated at NRs. 2.0 million (US$ 35.3 thousands), and the total project cost is at NRs. 3.1 million (US$ 55.1 thousands). The details are given in Chapter 3 Cost Estimate hereof.