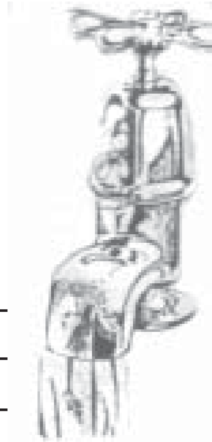
WATER NEPAL



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WATER DEVELOPMENT BULLETIN

Wooden Channel of old irrigation system
Surkhet, Nepal

Newly built Aqueduct
Surkhet, Nepal

IN THIS ISSUE

WATER
NEPAL

Editor
AJAYA DIXIT

Water Nepal is published once in three months in English.
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A DROP NOT WASTED IS A DROP SAVED WATER IS LIFE, CONSERVE WATER

EDITORIAL

Post Decade Drinking Water Improvement in Nepal

The International Water Supply Decade has ended. In the ten-year period, from 1980 to 1990, about five million Nepalese people were supplied with drinking water through pipes and tube-wells. For the generations that had languished in obscurity, High Density Polythene Pipes (HDP), brought water, the most felt need closer to homes. And in the process, HDP pipe became, and in all probability may continue as the polemical weapon to push through political manifesto.

While most of the society was kept isolated from development till the 1950s, the powerful aristocracy that ruled Nepal never lagged behind in benefiting from western technology. Kathmandu's drinking water system, *Bir Dhara* was built about one hundred years ago to serve palaces in the capital. The aged and leaking pipes below the streets of Kathmandu, today still forms part of the city's supply network. Supply improvement outside the capital was unattended and even today remains so.

The problems have been created partly by geographical constraints, remoteness, scattered settlements, mountains and accessibility difficulties. While lack of education has forced people to use contaminated sources, absence of alternatives has continued the drudgery of bringing water from distant sources. Even though, the country's earlier five year plans incorporated drinking water improvement activities, it was only in the late 1970's did the government act. This belated initiatives however, came about more to fulfil outside pressure; to be part to the international decade, than for meaningful internal changes. The plan itself was the first major long-term programme implementation exercise in the sector and had to be based on hypothetical assumptions.

And it was indeed ambitious; supply extension to 69 per cent of the population by the decade's end. Mostly towns and larger district settlements then had access to piped water supply. Whether the State had the mechanism, will, and if the service delivery system needed fine tuning to achieve the target were peripheral issues in the plan. This gap in extending the service shows the apathy nurtured in the intervening period by a state that had imported the supply technology almost a century earlier.

Ten years, hundreds of millions of rupees, several survey and construction efforts, later more rural Nepalese appear to be deprived of piped water as they were when the decade started. Thanks to the unbriddled population growth and poor system maintenance. Jinxed by resource scarcity, donor's trial, little programming experiences and above all a fluid political commitment, the set target was not achieved. The experiences beyond doubt proved that one can not implant solutions in an unrepresentative sociopolitical context. The use of century old pipeline in Kathmandu's water supply speaks either highly of the input quality in the early days or absurdity of its acceptance.

The focus on project construction for supply improvement in the late seventies, nevertheless, have had some positive fall outs. Several expatriates, foreign volunteers and consultants spent time in remote villages in trying circumstances, to assist in achieving the target. They went bank several years richer in experiences. In the process, hundreds of Nepalese households, got access to nearer water sources.

The decade has been also marked by simultaneous growth of expertise at different tiers technicians, middle level and managerial. Propelled by the compulsions of competition and fuelled by the desire of not being left out in the technological race, consulting firms mushroomed in the capital. For the new entrants to the professional world water supply feasibility assignments offered opportunities to make mistakes and to learn.

The efforts have resulted in studies and evaluation reports, which today fill racks in the ministries. Though different in the presented format, all reports concur in the findings; users do not regard the system at theirs, health impact has not been positive, time saved in collecting water has not been productively utilised, systems are poorly, maintained, *et al.* Instead of reforming the policy as demanded by the feed backs, water programme was sustained to perpetuate the myth; indispensability of the Panchayat System. The decentralisation approach, enunciated in the previous political system, to implement the water programme among others, appeared to have been pursued to stymie dissensions.

The objectives of water supply improvement, reducing diseases and lessening drudgery on women, thus have not been met. Health education, literacy improvements and agriculture development were not taken up as the follow-ups of tapstand construction as they should logically have. And how would the quality of water be assured? Its management in urban areas is yet to be meaningfully pursued, while in rural areas the quality concerns are limited to selecting uncontaminated sources.

Most of the outstanding constraints affecting drinking water supply extension and improvements in the country are known. The new and emerging political environment in the country is yet to show commitment to ease the hard life style of the people. For the common family, it is a pitcher of water fectched by mother, wife or little daughter. This, the democratically elected government of Nepal must understand, which must take a vow to serve replacing the concept of governance to deliver services. Otherwise, in the Himalayan watersheds, the streams and rivers as always would flow as reminder of unfulfilled promises.

WHERE WATER LEAVES THE IRRIGATION SYSTEM

M.G. Bos

(Consumptive use for irrigation accounts for major use of fresh water in the world. Irrigation water application changes the water balance both in the irrigated area and the river basin. This article explains how water in an irrigation system moves through different stages. It then explains the process of waterlogging and salinity growth in agricultural land. Irrigation return flow gets to downstream reaches of the project area immediately or after a time lag. Although flow is augmented, the quality might be lowered as residue of fertilizers and pesticides dissolved in water also find way to the river, leading to ecological and socio-economic problems in lower river basins. With practical example, the author concludes that improving efficiency of water uses at project level have long term benefits Editor).

INTRODUCTION

Irrigation today is practised in some 200 million hectares in the world. About half of this area is in arid or semi-arid regions. There, the irrigation water supplied usually exceeds 10,000 m^3/ha a year, significantly more than the annual precipitation. As a consequence, irrigation in such regions has a great impact on the environment.

As the major user of water, irrigation affects the water balance of the irrigated area and its related river basin. This is illustrated in Figure 1, which is based on the report of the Inter-agency Task Force on Irrigation Efficiency.[1] In the following explanation of this figure, the numbers cited in the text refer to the numbers in the figure.

To apply a given quantity of irrigation water to a crop, water has to be diverted from a supply source (1). The quantity diverted has to be greater than the quantity required by the crop because the diverted water will leave the irrigated area not only

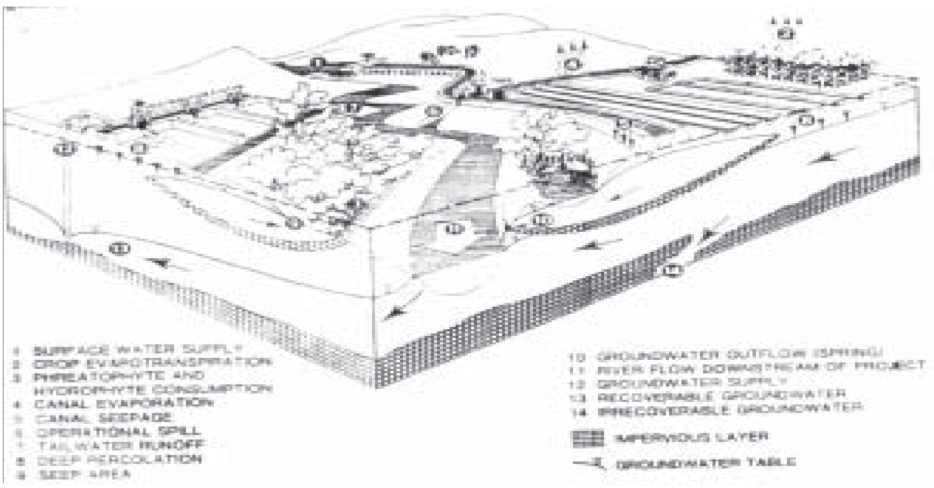

Figure 1: A River Basin and an irrigated area

1 SURFACE WATER SUPPLY
2 CROP EVAPOTRANSPIRATION
3 PHREA TOPHYTE AND HYDROPHYTE CONSUMPTION
4 CANAL EVAPORATION
5 CANAL SEEPAGE
6 OPERATIONAL SPILL
7 TAIL WATER RUNOFF
8 DEEP PERCOLATION
9 SEEP AREA
10 GROUNDWATER OUTFLOW (SPRING)
11 RIVER FLOW DOWNSTREAM OF PROJECT
12 GROOUNDWATER SUPPLY
13 RECOVERABLE GROUNDWATER
14 IRRECOVERABLE GROUNDWATER

as evapo-transpiration by the irrigated crop (2), but also as consumption by non-irrigated vegetation (3), as evaporation (4), and seepage (5) from the conveyance and distribution systems, and as operational spills (6), tail-water runoff (7), and deep percolation (8).

The amount of seepage (5) from the conveyance and distribution systems depends on the type and condition of these systems; lined canals and pipelines will have less seepage than unlined canals. Most of the water lost through seepage returns to the river, either directly through drains in the seep area (9) or indirectly via groundwater outflow (10) Upon reaching the river, this water is once again available for instream use (fisheries, recreation, shipping)and for downstream diversion (11). The quality of such return-flow water, however, has usually deteriorated, which may cause problems to downstream water-users.

The entire process of diversion, conveyance, field application, and return flow may take from a few hours, with tail-water runoff, to several years when water returns via the groundwater system. These return, flows, especially those from a groundwater system, may supplement the dry-season low flows downstream of the irrigated area. Hence, any great improvement in irrigation efficiency may decrease the downstream dry-season flows.

Operational spills (6) result from a reduction in the demand for water after it has been withdrawn from the supply source. They also result if the flow diverted from the river is significantly more than the water required by the farmers. These spills seldom become polluted, they can provide good-quality water for instream or downstream uses. The main disadvantage of spills is that they require the irrigation system to be over-dimensioned; but this, in turn, makes it easier for the system management to meet the water demands of the farmers.

Phreatophyte and hydrophyte consumption (3) is evapo-tran-spiration by non-irrigated vegetation growing adjacent to irrigation canals and drains, or in areas with shallow watertables. The existence of such vegetation often provides or enhances wildlife habitats. Environmental considerations are often a reason not to improve the efficiency of irrigation water use.

A small percentage of the water applied to the crops should move downward below the root zone. This deep percolation (8) is needed to remove salts that would otherwise accumulate in the root zone. The water required for this purpose is called the leaching requirement. The percentage of water needed for leaching depends on soils, climate, water quality, and the uniformity with which water is applied.

Depending on the geology of the area, deep percolation water and the salts it contains may slowly recharge the groundwater basin, and may enter the river through natural or man-made drainage systems. Poor irrigation management or the non-uniform application of water inherent in many irrigation systems often causes deep percolation in excessive quantities.

Applying irrigation water on graded fields often results in tail-water runoff (7) at the lower ends of the fields. The quantity depends on the field application method, the field design, soil conditions, and operational practices. Some tail-water runoff may be unavoidable when fields are graded to achieve adequate uniformity and efficiency of water application. Tail-water can destroy the lower parts of a field, or it can be consumed by phreatophytes, or reach stream channels as return flow. It may be collected on-farm and pumped back into the distribution system for re-use, or it may be intercepted by other users as a supplemental or primary water source.

Irrigation water that percolates deeply and recharges in aquifer adds to the water supply available to the users of groundwater (12). Some farms and small irrigation systems depend entirely on supplies of 'recoverable' groundwater (13). Aquifers are some times used to store excess surface water or to meet the water requirements in dry seasons or dry years. 'Irrecovrtable' groundwater (14) is groundwater that cannot be pumped economically or that needs to flow out of the area to prevent the groundwater from becoming saline.

Return flows to rivers resulting from operational spills (6) tail water runoff (7), drainage flows (9), or groundwater discharge (10) may provide all or part of a downstream user's water supply. In arid and semi-arid regions, such return flows often increase the flow in small streams to an extent that they can support fish and wildlife which would otherwise have been impossible.

The effects of irrigation can thus be regarded from two points of view: from that of the river basin and that of the irrigated area.

EFFECTS ON THE RIVER BASIN

In arid and semi-arid regions, where water is scarcer than land, all (or almost all) of the water in a river is likely to be diverted during the irrigation season. Often, the need for more irrigaton water will be met by the construction of a storage dam. This will decrease the wet-season flow in the river.

If the river has no storage dam, its water will usually be diverted into the irrigation system via a sand trap – the entrapped sand subsequently being flushed back into the river. This means that the sediment load of the river will remain about the same but the transport capacity of the remaining river flow will have decreased. This will cause sedimentation, which will gradually raise the river bed and make the downstream embankments and dikes vulnerable to overtopping. As well, the gravity flow into the river from tributaries and drains may decline because of a decreasing hydraulic gradient.

The reverse process occurs if most of the river water and its sediments are caught in a storage reservoir. Downstream of the reservoir, the sediment-free river water will start to pick-up new sediment until its transport capacity has been reached. The river bed will thus be eroded and will become deeper, which may undermine the foundations of bridges and other structures along the river.

Downstream of the storage reservoir, the river flow is often reduced to a statistically non-dependable flow, or to zero flow, if the reservoir can hold all the river water. In Figure 2, the quantity of water diverted from the river for irrigation is expressed as 100 per cent. the width of the arrows in the figure illustrates the relative magnitude of water quantities in an 'average' irrigation systems in arid or semi-arid regions.

The movement of water through the irrigation system, from the river diversion to the crop, can be regarded as three separate operations:

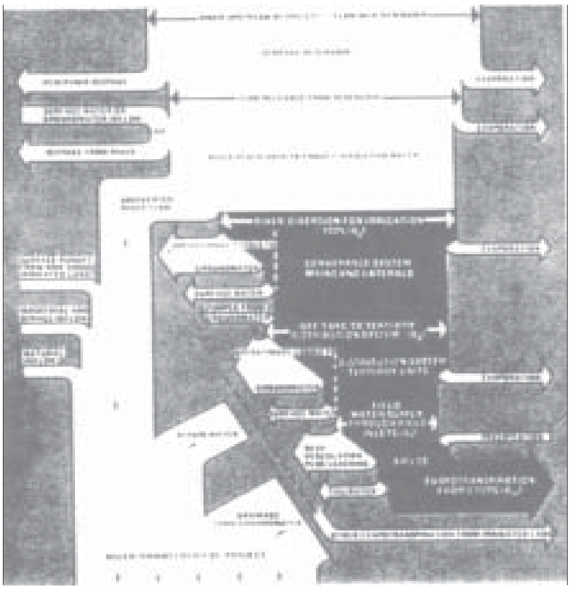

Figure 2: The relative magnitude of quantities of water flowing through an 'average' irrigation system[2]

- Conveyance, which is the movement of water from its source through the main and secondary (or sub-lateral) canals (or conduits) to the tertiary off-takes;
- Distribution, which is the movement of water through the tertiary (or distributory) and quarternary (or farm) canals (or conduits) to the field inlet;
- Field application, which is the movement of water from the field inlet through the field system and the application mehod to the crop.

During each operation, water is lost from the system so that it cannot be evapo-transpirated by the crop.

Figure 2 shows the minor losses due to evaporation and the quite considerable operational losses to groundwater and surface water. These operational lossesreturn o the river – with or without a time lag. As a result, the river discharge downstream of the project is higher than one would expect when looking at the river immediately downstream of the storage reservcoir.

The downstream river discharge can subsequently be diverted by a downstream user. He, however, will have to cope

Photo 1: Groundwater can supplement low river flows in a dry season

with water of lesser quality than the upstream user because the drainage water from an irrigation project can be quite saline; as well, it usually transports chemicals in the from of pesticides or fertilizer. This is a world wide problem. It is illustrated by Table 1, which shows the irrigation water losses and the related transport of salts from the Grand Valley to the Colorado River.

Both the decreasing discharge and the increasing salt load of the river in downstream direction can lead to ecological and socio-economic problems in the lower part of the river basin. These problems can only be alleviated by improving the efficiency of water use at irrigation project level.[3,4]

EFFECTS ON THE IRRIGATION PROJECT

The principle of a water and salt balance in an irrigation project is illustrated in Figure 3.

Table 1
Water losses and salt transport from the Grand Valley U.S.A.,[5]

Source of water	Volume of water m3 x 106	Salt load x 1,000 kg
Seepage from:		
Main canal (conveyance)	70.2	270.000
Lateral canals (conveyance)	58.7	226.000
Farm ditches (distribution)	13.8	53.000
Deep percolation (fields)	37.00	142.000
Surface runoff	125.8	4.500
Total		**695.500**

*Irrigated area = 24,000 ha

In irrigation projects with a stable watertable, the sum of all inflows must equal the sum of all outflows. Frequently, however, water that originates from canal seepage and deep percolation recharges the groundwater at a rate that exceeds the natural discharge. As a result, water is stored within the project area and the watertable rises. The rate at which this rise occurs depends

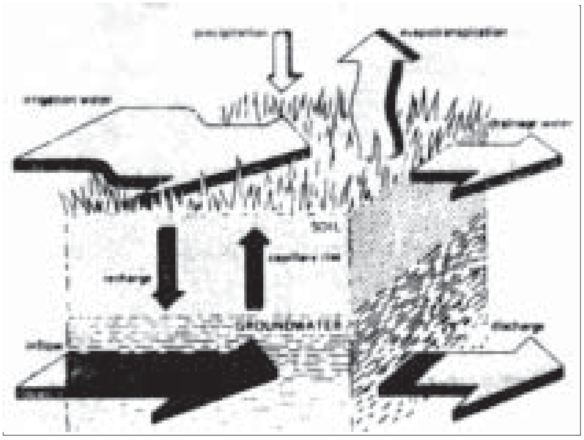

Fig 3: Principle of a Water, and Salf Balance in an irrigated area[6]

greatly on the volume of water applied to the field. Since te field application efficiency in most irrigated areas is well below 100 per cent,[7] the excess water will percolate to the groundwater and thus leach the root zone to a salt level that id acceptable for crop growth. Often, however, the farmer will apply additional water to his fields because he thinks they need more leaching. As a result, the watertable below the irrigated and leached fields rises rapidly. The ensuring waterlogging and salinity problems are often more severe than the original problems that triggered off the initial excessive leaching.

To illustrate the severity of this problem, Figure 4 shows the progressive rise of the watertable in two areas; West Nubaraya in Egypt and Bhatinda Mansa in India.

To avoid a salinity problem due to capillary rise from the groundwater, watertables should be kept at a certain minimum depth. The required depth depends on the soil type. Figure 5 shows a curve expressing evapo-transpiration versus groundwater depth. Such curves can be used to decide whether the field application efficiency needs to be improved or whether a drainage system should be installed.

As was shown in Figure 2, water losses in the conveyance and distribution systems of an 'average' irrigation project can be considerable. They occur mainly through seepage and incorrect management practices.[1010] Ibid Bos, M.G. and Nugteren, J. 1974.

The importance of these factors is illustrated in Figure

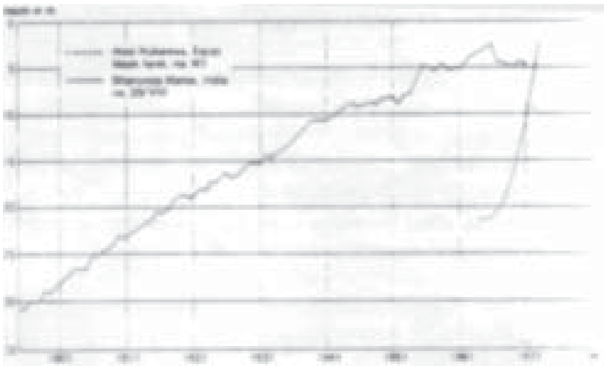

Fig 4: Progressive water table rise since the introduction of irrigation[8],[9]

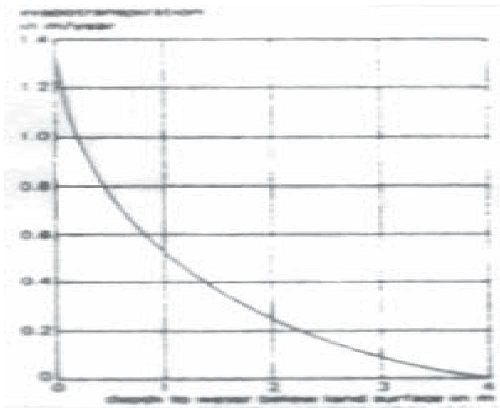

Fig 5: Estimated annual evapo-transpiration from the water tablr, San Luis Valley, Colorado, U.S.A.

6, which compares the conveyance efficiencies (e_c) of two similarly-managed systems in Australia: the Goulbourn and the Campaspe systems.

When the Goulbourn system first operated, its conveyance efficiency was about $e_c = 0.50$, while that of the leaking Campaspe system was as low as $e_c = 0.39$. In the Goulbourn system, after proper structures had been installed to measure and regulate flows, and a related improvement in its operational practices, its e_c – value rose to about 0.80. Later, the leaking Campaspe system was lined and fitted with structures similar to those in the Goulbourn system, and its operational practices, too, were improved. As a result, its e_c - value rose to about 0.90, some 10 per cent higher than that of the unlined Goulbourn system. The long-term benefits that can accrue from proper flow measurement structures and their efficient operation are obvious.

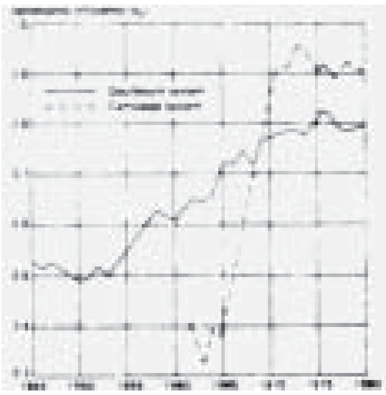

Fig. 6: Conveyance efficiencies as a function of time in two irrigation systems in Australia.[11]

Photo 2: Over irrigation will reduce yields

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MODEL-BASED DESIGN APPROACH – A CASE FOR DESIGN OF WATER SUPPLY SYSTEMS IN NEPAL

Poorna B. Adiga

(Even with the efforts made during the water decade, piped water, according to the Government Statistics is available to only about one third of the country's population. In rural Nepal, the percentage of people without access to improved water supply is still higher. The gap has to be filled at the earliest and can be done through innovative ways that built on experiences gathered so far. This article introduces Model-Based Approach for water Supply System Design. Based on his experience at Asian Institute of Technology, the author puts up a case for the approach as one of the tools for efficient design and water supply improvement programmes in the country. Editor)

MODEL BASED DESIGN : CONCEPT

Conventional design of a pipe line by the analytical approach can be considered as a two step procedure. Knowledges and experiences of flow velocity pipe diameter and head loss are used to initially estimate preliminary dimensions of the pipe. Hydraulic analysis is then carried out to check whether or not the calculated flow velocity, head loss and other factors are within the limit specified for the component. The dimensions are modified, and the procedure repeated until the parameters fall within the limits.

Model-based design on the other hand, introduces an objective function and includes a set constraint in the design process. The outcome is the mathematical representation of the physical characteristics of the water system along with the defined objectives and the constraints. Optimisation calculus is then used to meet the objective. The iteration method inherent in the conventional design is thus changed.

In a water supply design, the typical objective function is the selection of the pipe costing least to convey the desired flow. Head loss, velocity limit, residual head represent the constraints within the system. Both; the constraints and the objective functions can be mathematically formulated and used in the design calculus to obtain dimensions of the pipe that meets the objective within the limits of the constraints.[1]

APPLICATION PROSPECTS

In most practical applications, the objective function and therefore, the criterion for good or better engineering design is the cost. By maximising or minimising the objective function, in the design calculus within the boundaries of the constraints, better solution that cost least can be arrived at. Use of Model based design therefore, often results in significant cost saving as compared to the conventional design. As the objectives, design criteria and constraints become the defined part of the model function approximations are easily avoided. The saving on time and resources, as a result, are significant.

Another advantage is the sensitivity analysis. With this approach it is feasible to evaluate the impact of different system concepts and changes in the design criteria on the optimum solution. Simple alteration of the parameters would show the departure from an optimum solution. This can be achieved without having to exert tedium on the designer that a conventional designer would normally have to undergo. Several design choices can be put forward for decisions and the most appropriate one selected.

The approach as district advantages in complex water systems with loops and pumps. In such cases, a set of alternative solutions can be produced and the most feasible one selected from the available choices. Since model based design serves specific purpose within the design process, the approach is applicable also for sizing individual parts of the system. By pre-defining relevant parameters, the method can advantageously be used for designing even simple dead end systems. The opportunities of defining the parameter and checking the outcome available through this approach almost eliminates the designer's personal errors.

Model based design approach can be used for a variety of applications in water supply areas; from design of new system to analysis of an existing system for the purposes of upgrading and/ or rehabilitation. One such application has analysed the cost implications of house connection and public standpost supply in a rural water supply system. The study compared the cost of upgrading the level of service from standpost supply to house connection over a period of time in a selected village module.[2]

DESIGN PARAMETERS

In order to examine the implications of a number of options were considered. Combination were made from different population density, per capita consumption rates, design periods, upgrading phases and the level of service in each phase. The design parameters are considered and for each two phases of upgrading were set. First with a lower service level (majority getting access through stand post supply) and secondly with higher service level, where full house connections were provided.

The cost of the component/structures and the service pipes were calculated separately considering the economies of scale. For the economic analysis, present worth criteria was adopted. The software package used in the analysis was MPSX/370. The programme package used linear programming double stage optimisation technique, which exclusively considers the distribution mains.[3] The design parameters are shown in Figure 1.

MODEL OPERATION

As explained above, the guiding factor in operation of the model is the level of services in the two phases. In double stage optimisation, for any given length, the minimum diameter pipe from a given set of available pipes is determined by the model such that the constraints of phase I, when the service level is lower is satisfied. Then by checking it against the constraints of phase II, a minimum cost option was determined from among the alternatives.

Selections were made from options such as parallel pipes being added in phase II or larger diameter pipe being selected right in the first phase. The option of including pipe with consecutive diameters in series between two nodes was also checked. Operation was continued until the differences between successive values of the objective function; the cost was, within the pre-defined value. The model did not consider the situation where a pipe.

RESULTS

In an optimised network design, the cost of the distribution mains required for providing complete house connection in the beginning of the design period itself is not much different (<3%) than the cost of the distribution main required for total public stand post supply upgraded to house connection at a later date.

This conclusion is relevant in the Nepalese context, especially while designing water systems for a large village or upcoming town. In such situation, an optimised design (minimum cost) can be prepared such that the distribution mains have the capacity and residual pressure head requirements to accommodate house connections, even-though such connections might be affordable by the community only at a later period.

The initial capital investment required for such a system will not be significantly higher than the sum of the initial and additional capital investments required for future capacity expansion, when the time value of money is considered. This conclusion is worth considering as such a system provides opportunities for allowing house connections whenever the consumer desires.

When the costs of operation and maintenance incorporating the concept of cost sharing by consumers for service connection, and revenue collection from regular payments of water bills were compared, the overall economy of the system was found to depend on the capability of the consumers to pay. In a community, where the members can bear the costs, a higher level of service providing for immediate house connection becomes economical compared to phased upgrading of service to higher level.

In a poorer community, on the other hand, when the investment funds are limited, phased transition to a higher level of service becomes economical. In any case, the distribution mains should be designed for an immediate provision of house connection while standpost should be provided for those who can not afford immediate house connection. Since pipe costs are influenced largely by the length of the pipeline and to a lesser extent by increase in the diametre, the community would be better served if the distribution mains at any point in the network is not farther from any household than a standpost would normally be.

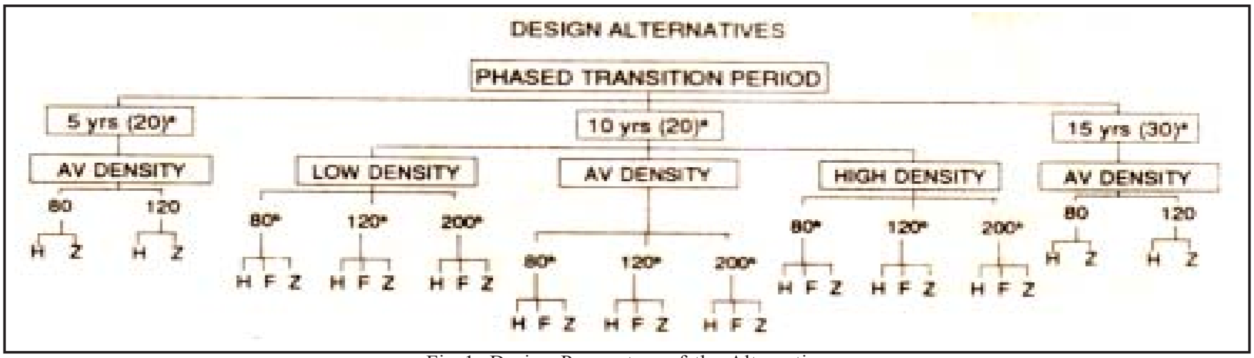

Fig 1: Design Parameters of the Alternatives

CONCLUSIONS

The advent of microcomputers and availability of state-of-the art software packages for solving different pipe problems have significantly extended applicability of model based design approach. It can be used even within the existing framework as additional information or details would be needed for this method.

The approach allows for easy changes in the objective function and consideration of constraints so that he amended designs are immediately available during implementation. Model based design improves effectiveness of investment as in the time one spends in design of a conventional system, more water systems can be designed by this process. This means in the same time more design population can be achieved. Standardised designs can be thus developed.

The approach would strengthen professionalism in the design level. Improvements in the designs would inevitably transcend into the implementation level, resulting quality construction. Sustainability of all new water supply systems would be enhanced.

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ESTIMATION OF PRE-MONSOON SNOW MELT RUN-OFF FROM HIMALAYAN CATCHMENTS

Khadga B. Thapa

(Snow process is an important component of the hydrological cycle. Snowmelt run-off during the dry months significantly supplements the flow of first order Nepalese Rivers. Estimation of water contribution by each component of the hydrological cycle; particularly from the melt is crucial for rational planning and designs of water resources systems. In the Himalayan region detailed analysis of run-off contributed by snowmelt is yet to be made. Paucity of data on snow processes are the major stumbling blocks in this endeavour. This article discusses a general snowmelt run-off forecasting model and demonstrates potential operational value of the satellite imageries for forecasting spring run-off in the Himalayan rivers. – Editor)

INTRODUCTION

Snow accumulation and melt are the important processes of the hydrological cycle. Their combination supplements streamflow and in many catchments dominate the timing and magnitude of surface run-off.

Run-off from snow results from melting of the accumulated snow pack. Snowmelt run-off estimates are needed for the regional planning and design of water resources. Forecasting seasonal water yields, reservoir regulation and flood flow studies need accurate assessment of contribution from the snowmelts.

Snowmelts run-off results due to the transfer of heat to and from a snow pack. The transfer may take the from of conduction, convection and radiation. Various approaches estimate the run-off, which range from simple regression methods to more sophisticated techniques based on degree-day or various dominant indices affecting the melt process have been developed.

For estimating the run-off, information on area covered by snow, snow depth, water equivalent of snow and the details of energy transfer to and from the snow pack are essential. It is possible to predict snow melt run-off in points in space using techniques that are based on the physics of the snow melt processes. On a basin wide scale however, the procedure becomes complex as other factors, which have to be accounted for, also enter into the picture.

The accumulation of snow pack starts during the early winter and with the advent of spring the pack start to melt. For estimating spring snow melt run-off from a basin, the area covered by snow may be used conveniently, and interpreted more easily than other parameters. Development of remote sensing technique has made this approach possible as snow coverage area may be ascertained with the help of the landsite imagery. Spring snowmelt run-off can be estimated using the above information.

CASE OF NEPAL HIMALAYAS

Snow accumulation and melt processes play dominant role in the run-off response from the catchments of the river in the Himalayan region. Rivers originating from these regions are classified as the first grade river and have substantial dry season flow. The catchments of some of the rivers also extend into the Tibetan region.

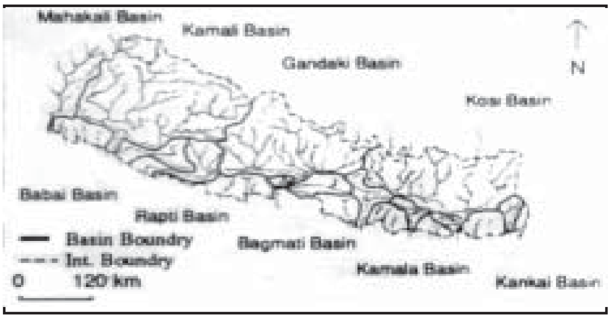

Fig. 1: River Basins of Nepal

Relatively very little is known about the snow hydrology processes in the Himalayan region of the country. Studies carried out so far have analysed to the process in a rather broad manner.[1,2,3] Hydrological uncertainties in interpretation and forecasting have led to poor project planning. It is perhaps one of the stumbling blocks in the efforts of sound planning, development and management of water resources.

The problems arise mainly because of the diverse topography. Variations in the climate conditions are extreme, with tropical climate in the southern regions to arctic environment in the north. Even-though the general two rainfall seasons prevail in the country. The aerial distribution of precipitation varies greatly due to or graphic effects. For example, in central Nepal and around the rain-shadow regions, the annual rainfall is 250 mm where as on the other side the rainfall as high as 4500 mm in a year has been recorded. The lee and luff effects are quite evident.

Timing of the precipitation onset is the another factor. The onset is earlier in the eastern Himalayas than that in the western region. Also the eastern areas receive more rainfall than the western region. The amount of precipitation is higher in the western part of the country than in the east. Pre-monsoon rains are frequented by the squalls and thunder storms. Another characteristic features of the Himalayan region is the high wind-speed, which varies with altitude. Generally, at an altitude of 6000 m amsl the wind speed is about 50 to 60 Km/h while that at the summits reach 120 Km/h.[4]

The combination of all these factor, make any effort of predicting snow melt run-off using sophisticated methods quite difficult as reliable micro level information of how the variations occur so not exist. The problems are further compounded by the trans-himalayan nature of majority of the rivers. A more general approach to estimate the order of the run-off magnitude is attempted here.

SNOW COVER RUN-OFF RELATIONSHIP

In the Himalayas, the snow pack accumulation begins in September and continues till March when the thawing starts.[5] The snow line is at its lowest altitude in the month of March after which it starts to recede with the advancement of the spring season and continues till May. The process of melt continues during these months and supplement the dry season flow.

It would be possible to establish a functional relationship between the area covered by snow and the seasonal flow thus derived from its melting. The established gauging stations with upstream drainage area under snow have been chosen for flow analysis. Since the thawing season lasts from March till May, flow records for this period have been used. The cumulative run-off is shown in table 1.[1]

The problem now is to establish extent of the area covered by snow in the inaccessible and remote Himalayan catchments. Landsat imagery provides an easy and efficient method of delineating the areas with particular focus on sections covered by snow. The imageries of 1:50,000 scale taken by the National Remote Sensing Centre, Nepal in the years of 1975, 1977, 1984 and 1985, have been used. Imageries in the band of 5(0.6 to 0.7 microns) has been selected, as it provides the best contrast between the snow cover and the snow free terrain. For visual interpretations and delineating purposes, it was the most useful one.

Table 1
Three Months Cumulative Run-off

Catchment	Stations with Elevation (m)	Total Volume in melt seasons $m^3 \times 10^4$
Seti	Banga (328)	551
Kamali	Asara Ghat (629)	1301
Bheri	Jamu (246)	536
Kali Gandaki	Seti Beni (546)	499
Marsyangdi	Gopling Ghat (320)	479
BurhiGandaki	Aru Ghat (485)	439
Trisuli	Betrabeti (600)	484
Bhotekosi	Barabise (840)	166
Sunkosi	Khurkot (455)	764
Likhu Khola	Sangutar (453)	92
Dudhkosi	Rabuwa Bazar (460)	423
Arun	Turke Ghat (414)	1710
Arun	Turke Ghat (414)	1388
Arun	Turke Ghat (414)	1184
Tamur	Mul Ghat (276)	926
Tamur	Mul Ghat (276)	682

In order to ensure that snow covered areas are correctly estimated, imageries taken in the month of March have been selected. The whole thawing season has been thus represented while estimating the area, which was carefully planimetered. In some cases, interpretation was made difficult by cloud cover and shadows. Also, limitations were imposed by unavailability of year wise satellite data for the same catchement. The snow-covered areas thus interpreted and measured within Nepal and in China are given in Table 2.

A regression analysis of the snow covered area and the cumulative run-off for the three thawing months show a linear trend. The functional relationship is derived as

$$Q = (0.09\ A \times 329.8) \times 10^6 \quad \dots (1)$$

Where Q = March to May cumulative run-off in m^3
A = Snow covered area in Km^2

With the correlation coefficient (r^2) of 0.936.

The relationship is graphically shown in Figure 2.

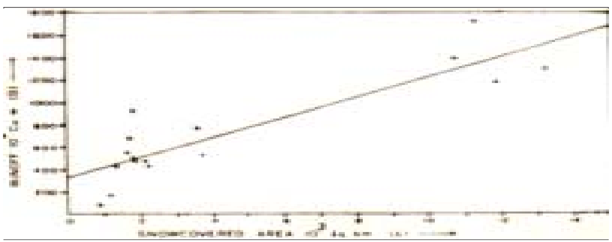

Fig. 2: Area Run-off Relations

Table 2
Snow Cover Estimation and the Runoff

Catchment	Date of the landsat imagery	Snawcovered Area in Sq. Km. within			Catchment Area in Sq. Km. within			Percent of Snow covered Area within the confines of		
		Nepal	China	Total	Nepal	China	Total	Nepal	China	Total
Seti	22/3/77	1738.00		1738.00	7460.00	-	7460.00	23.30	-	23.30
Kamali	22/3/77	11803.00	1642.51	13445.51	16810.00	2450.00	19260.00	70.21	67.04	69.81
Bheri	22/3/77	3738.24	-	3738.24	12290.00	-	12290.00	30.42	-	30.42
Kali Gandaki	22/3/77	1850.00	-	1850.00	6630.00	-	6630.00	27.90	-	27.90
Marsyangdi	22/3/77	2370.50	-	2370.50	4192.70	-	4192.70	56.54	-	56.54
Burhi Gandaki	22/3/77	1096.81	983.26	2080.07	2828.00	1442.00	4270.00	38.74	68.19	48.71
Trisuli	22/3/77	460.70	1417.09	1877.79	1382.00	2728.00	4110.00	33.33	51.95	45.69
Bhote Kosi	22/3/77	84.37	1323.16	1407.53	313.00	2097.00	2410.00	26.96	63.10	58.40
Sun Kosi	22/3/77	936.64	2697.16	3636.80	6529.00	3471	10000.00	14.39	77.70	36.37
Lkhu Khola	22/3/77	84.37	-	84.37	823.00	-	823.00	10.25	-	10.25
Dudh Kosi	22/3/77	1383.00	-	1383.00	4100.00	-	4100.00	33.73	-	33.73
Arun	22/3/77	806.00	10446.47	11252.47	5056.00	23032.89	28088.89	15.94	45.35	40.06
Arun	19/4/84	257.00	10446.47	10703.47	5056.00	23032.89	28088.89	5.08	45.35	38.11
Arun	15/2/85	1335.00	10446.47	11801.47	5056.00	23032.89	28088.89	26.8	45.35	42.01
Tarnur	22/3/77	1714.00	-	1714.00	5640.00	-	5640.00	30.39	-	30.39
Tarnur	/3/75	1775.00	-	1775.00	5640.00	-	5640.00	31.47	-	31.47

The result evidently reveals that higher spring run-off can be expected with larger snow covered area. Similar results have also been obtained in other Himalayan catchment, where the aerial coverage and run-off are positively related.[6,7,8] The technique can serve the purpose of a general snow melt run-off forecasting model for the spring season and should be considered encouraging.

CONCLUSION

Satellite imageries can be satisfactorily used for snowmelt run-off prediction from the Himalayan catchments where the limitation of data is acute. Considering the inaccessible terrain of the region, repetitive snow cover data can be obtained from satellites, delineated and used for predicting the spring melt run-off.

A better assessment of the snowmelt run-off can be obtained by working with individual catchments. This would allow more accurate representation of the diverse catchments conditions of individual rivers. More specific results would be thus obtained which would allow development of better run-off models. In absence of appropriate data, individual catchments have been lumped in this analysis.

This analysis has not considered few other factors, which need careful investigation and the order of their influence assessed, on the run-off magnitude. Often the run-off may get supplemented by glacier dam out-burst events,[9] which has not been considered in this analysis.

The estimation of snowmelt run-off from the Himalayas need more understanding of the accumulation and melt processes of the snow pack. Only more information of the snow processes permits better estimation of the contribution of snowmelt on the regional water resources. More information would also improve the reliability of the prediction techniques. This calls for updating and strength ening of the hydro-meteorological monitoring systems in the upper catchments. As large portion of the catchments drain areas in Tibet, attempts must be made for developing a mechanism to allow for continue exchange of data.

NOTE

[1] Steamflow data are collected and published by the Department of Hydrology and Meteorology.

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HEGEL AND THE AMAZON BASIN

Samuel C. Florman

The essentially tragic face,' wrote the philosopher Hegel, 'is not so much the war of good with evil as the war of good with good.' I thought of this remark recently in connection with the production of electric power in Brazil.

Lacking significant reserves of oil or coal, and plagued with chronic technical difficulties at its single nuclear plant, the Brazilian government has resolved to use hydroelectric dams to meet the nation's future energy needs. At first, this struck me as a splendid decision. According to the environmentalist literature I have seen, hydroelectric power is usually ecological benign – much preferable to hydrocarbon fuels, which brings acid rain and worsen the greenhouse effect, and surely better than nuclear power, which gives us safety problems, radioactive waste, and large doses of political angst.

And where could it make more sense to exploit river resources than n Brazil, which contains a fifth of the world's fresh water? The Amazon runs 4,000 miles to the Atlantic Ocean, and at least 15 of its tributaries are more than 1,000 miles long. The state power monopoly has identified 136 prospective sites for new dam-more than half of them in the Amazon Basin – and at least 90 are already on the planning agenda.

Energy without environmental cost – it seems too good to be true. Unfortunately, it is. Complications arise because Brazil's thousands of miles of rivers run mostly through low-lying country. Building a dam invariably means flooding large areas of jungle. The Balbine Dam, for instance, built on the Uatuma River, submerged 900 square miles of jungle to produce only 250 megawatts, barely half enough for the needs of nearby Manaus. The recently completed Samuel Dam, on the Jamari River near Porto Velho, is somewhat more efficient, creating a lake of 200 square miles and producing 217 megawatt. But like the Balbina, it cannot even meet local demand, much less contribute electricity to the far-off southern cities of Sao Paulo and Rio de Janeiro.

When considering the Amazon Basin, an area as large as the United States east of the Mississippi, many Brazilians see little reason to be concerned about flooding a few thousand square miles of

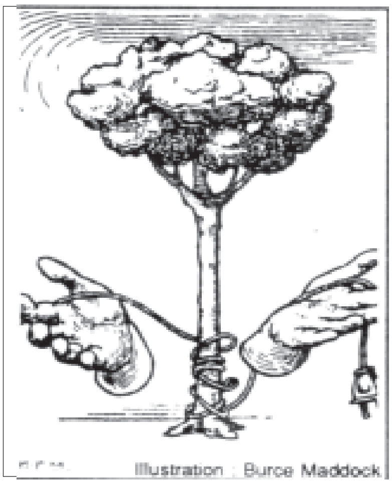

Illustration : Burce Maddock

jungle. 'There is plenty of space,' an engineer told a *New York Times* reporter during a boat ride last year on the Balbine Reservoir. 'If one day we need the land, we can take away this dam.'

Environmentalists in Brazil and around the world do not share this cavalier attitude. They see the gradual destruction of the Amazon Rain Forest as a disaster in the making. It could cause the extinction of thousands of plant and animal species and harm the global climate. (Since trees absorb carbon dioxide and emit oxygen, they are a countervailing force to the greenhouse effect). There is already great concern about the burning of forest for agriculture and cattle raising, and about the spread of industrial development through the region. Flooding large are as to create power – which in turn is likely to attract even more development – only makes a bad situation worse.

In an effort to retard this process, organisations such as the Worldwatch Institute have called upon international creditors to cut off funds for new projects. Recently the World Bank responded by demanding environmental safeguards as a condition for processing a vital $500 million energy loan.

Brazilians recent being pressured in this way, particularly by citizens of developed nations that did not let environmental niceties get in the way of exploiting their natural resources. Earlier this year, the Brazilian government, joined by the seven other nations of the Amazon Pact, denounced outside interference in the region's environmental affairs.

So the use of hydroelectric dams to meet Brazil's energy needs – which at first reading seemed an ideal solution to a serious problem – confronts us with new difficulties, not only in environmental policy but also in our relations with the Third World. Adding to the urgency of the problem is the fact that over the next 20 years Brazil's population is expected to

> Philosophy
> can shed light on questions
> that science alone
> can't answer

grow from 140 million more than 200 million. A dreadful dilemma indeed, the tragic war of good with good.

In our no-nonsense age of science and technology one rarely seeks practical solutions from philosophers. Still, science which has solved many of the problems that long puzzled classical philosophers – has its limits. Systems analysis alone cannot tell us what to do about electric power in Brazil. Unless wisdom and sensitivity are brought to bear, the situation might escalate into an ominous political confrontation.

Of course, Hegel cannot help us or the Brazilians decide how many dams should be built in the Amazon Basin. But his vision of life as a process of coping with and reconciling 'the strife of opposites' – in this case, economic development and environment concerns – encourages us to look for workable compromises. Where the jungle is flooded for the sake of electric power, perhaps its destruction for other purposes should be limited by an equivalent amount. Surely, efforts to conserve the use of energy should be intensified. And Brazilians may even decide that the reckless industrialisation of other nations need not serve as a model for their own development. Recent studies show that harvesting fruits, cocoa, and latex from the rain forests may be economically and socially more viable than large-scale clearing for other purposes.

Making such decisions intelligently requires diplomacy as much as science and technology, and , yes, it requires philosophy as well. Like electric power in Brazil, our technological predicaments can be so confounding that they force us to stop in our tracks and reflect on who we are and what we really want. A little old-fashioned philosophising may be just what we need.

Source : Technology Review Oct. 1989 Vol. 92 No.7.

BCI AWARD TO ROADFORD RESERVOIR

Flooding hundreds of hectares of un-spoilt Dartmoor valley to form a seem an unlikely scheme to receive an environmental award. Yet the strategic importance of the newly formed Roadford reservoir in Devon, coupled with scrupulous measures taken during construction to minimize the impact on the environment, has led British Construction Industry Award judges to give the scheme one of their first ever commendations for environmental excellence a high commendation in the civil engineering category, writesRichard Watson in New Civil Engineering October 1990. Judges say the scheme showed 'card and quality' in every aspect of the work.

The reservoir is created by the 430 m long 40 m high rock fill dam in the river Tamar. The dam was designed by Babtie Shaw and Morton and built by Sir Alfred McAlpine for client South West Water.

It is characterised by a number of unusual features. The bellmouth spillway and intake structures were slip-formed in a continuous 10 day period, the embankment was sealed with an asphaltic membrane and construction traffic in the narrow lanes between Roadford and Launceston was minimised by using local fill material taken from borrow pits dug into the valley.

Additionally, surplus water flowing into the reservoir will be used to generate electricity for the national grid.

Few engineers doubted the need for Roadford reservoir. Devon and Cornwall are burdened with heavy tourist traffic and water demand has outstripped supply year after year. The new reservoir should go a long way to improve the reliability of supply. Flows in the river will be regulated by reservoir storage and water can be pumped around the area via trunk mains.

Kulekhani Reservoir,Nepal : How scrupulous !

Before impounding began, surveys of plant and animal populations were made, rare plants transplanted, mammals caught and moved to safety. Additionally, fish traps and holding facilities were built to ease seasonal migrations and 150,000 trees and shrubs have been planted around the reservoir. The final result is a scheme said to 'enhance' and not detract from the natural environment.

South West Water and the National Rivers Authority are continuing the good site practice. Reservoir water quality is carefully checked and early fears of acid seepage from the local pyrite-rich embankment fill now appear to have been unfounded.

Conserve Electricity
Save Money

SMALL SCALE IRRIGATION DEVELOPMENT IN HILLS

Mahesh M. Shrestha

*(*Small-scales irrigation systems built and managed by the farmers are spread across the hills and mountains of Nepal Even though the systems operate with low efficiency, they are effective in meeting local food requirements to some extent. Selective rehabilitation of traditional irrigation system is a cost-effective approach for improving its efficiency. This article introduces the Small Farmer's Irrigation Development Programme in the country and presents the case study of four small-scale hill irrigation systems. Where farmers have better control over the system management, and when external supports are timely, the performance of small irrigation schemes are satisfactory. *–Editor)*

PROBLEMS IN HILLS

The hills and mountains occupy about 68 per cent of the land area of Nepal, and support 65 per cent of the country's population. Ranging in elevation from 500 m amsl to 4000 m amsl, the hill region is characterised by several agro-ecological units. Within a small area, distinct variations in temperature, rainfall, wind, light duration and intensity, soil type and slope are found. Thousands of streams dissect the hills, and many times, during the rainy seasons isolate communities in the hills.

Hill agriculture is limited to small river valleys and terraced slopes. Broadly, cultivation is done in two major land types. These are the 'khet', with bound where paddy is grown, and the unbounded upland 'bari' areas where rainfed crops are grown. About 600,000 ha of land in the hills is estimated to be under cultivation.[1] The average land holding of 0.5 ha in the hills is smaller than that in the Tarai, which is 1.7 ha.

With the increasing population pressure, even steep and unstable slopes in the hills are being cultivated. Farming methods however, are traditional and the chief source of nutrient is compost made of animal manure, crop residue and forest littres. Agriculture is mostly of subsistence nature. Irrigation is available only along the river valleys.

SMALL SCALE IRRIGATION SCHEMES

In the hills almost all of the 'Khet' areas have already been irrigated by schemes built by the communities. Information extrapolated from the detailed inventory of one river basin and land resources maps, indicate that the schemes would probably be over seventeen thousands in number.[2] About 182,000 ha, which represents 82 per cent of the total irrigated land in the hills are irrigated by these schemes.[3] The command area range in size from less than 1 ha to a federation of systems, which cover more than 15,000 ha. Using indigenously built structure, the schemes divert water from rivers, streams and springs into unlined and poorly aligned canals.

Hill irrigation systems are extremely variable in terms of design, unit cost and the benefit potentials. Available water in most cases determines the cropping intensity. Benefits vary, depending on the nature of soil and terrain. Steeply sloped hill terraces are less productive than the valleys and tars. The head works range from a simple intake with a temporary diversion made of brushwood and stones to a more permanent one depending on width, slope and the river hydraulics. The head reach canal can be long. And, if aligned through slide prone and/or pervious areas require high technical input. Frequent washing off of the diversion structures, high conveyance losses and erosion effects make these system highly dependent on regular maintenance.

Traditional Canal and Wooden Aquaduct: Chitwan, Nepal

Most of the existing schemes today rely on external assistance even for operation and maintenance. Rehabilitation of the schemes, have been found to depend mostly on external financing, mainly because the cost cannot be made by the users. The cost of maintenance in recent times has increased by the general increase in cost of the construction materials such as cement, steel and pipes. In the hilly regions, the problems have been further compounded by accessibility and transportation difficulty.

In many cases, lacks of local resources have also exacerbated the problems. Depletion of forests in the hills for example has forced people to get the otherwise locally available timber from distant localities. Also support for improvements in many cases, have been organised without involving the users. Lack of resources and increasing dependency on external assistance have discouraged farmers to organise regular maintenance functional irrigation systems have gradually deteriorated and ceased to be operational as a result.

Expansion/rehabilitation of traditional system through selective structural improvements; aqueduct, intake etc., can significantly enhance its efficiency. The investment cost per hectare including that for operation and maintenance are usually lower than that for larger public schemes. Economic returns of the rehabilitated systems are also higher. The comparison of the two category projects is shown in Table 1.

Table 1
Comparison of Irrigation Investment Alternatives[4]

Types of Investment	Range of Investment cost (US $/ha)	Range of 0 and M cost/yr. (US$/ha)	Range of Estimate (IRR %)
Public Schemes/New const. (Hills)	3350-5000	28-65	7-18
Public schemes Expansion/Rehabilitaction	1500-4000	15-40	12-25
Farmer schemes Expansion/Rehabilitation	200-3000	10-35	12-60

The cost of the project can be minimised by involving the users in all the project activities. Special skills and procedures are however, required for implementation. Users involvement is essential for minimising dependency on external supports and in the long run instrumental for sustainable agriculture production. And in most cases, farmers are willing to participate in the process through labour input. Since the system's gestation period is shorter, the designed production stage is reached earlier than larger projects. The outstanding advantage is that even after rehabilitation they remain under farmer's management and do not represent a burden on the government's resources.

PROGRAMME APPROACHES OF SMALL SCALE IRRIGATION SCHEME

Two alternative approaches of project formulation, designs and implementation for development of hill irrigation systems ate practiced in Nepal.[5] These are

a) Capital intensive approach and
b) Low cost approach

For larger command area, and whenever site conditions call for expensive and complicated headwork and main canal construction, the first approach is followed. The lower cost approach is suitable for rehabilitation of an existing Farmer's Managed System or when the site conditions are relatively simple. In the later case, a new project may be the most appropriate one, if maximum participation of the beneficiaries' can be achieved.

The low cost approach was started by the Farm Irrigation Water Utilisation Division (FIWUD) within the Department of Agriculture in 1973. Its objective was to bridge the gap between the engineering and agricultural extension including water management services in both the public and farmers' managed irrigation systems. For the first time in the country, the programme incorporated the concept, and involved farmers in identification, design and construction of irrigation systems.

About 300 schemes built by FIWUD in the hills and Tarai irrigate about 26800 ha land by the end of 1986. The schemes were built at a cost of US $ 190 - $238/ha at 1984/85 prices. The FIWUD and the programme of Local Development Ministry were amalgamated to form Small Irrigation and Water Utilisation Division (SIWUD), within the DOI in 1988. The Small Farmer Development Programme of the Agricultural Development Bank also Follows the low cost approach.[6]

The users contributed 25 per cent of improvement costs. To qualify for assistance, for either rehabilitation or new construction, five per cent of the estimated costs had to be deposited in a bank account by the users before the work started. The proportion of contribution by each beneficiaries was decided by a committee of 5 to 7 members, which was generally based on the land owned by the family. Rest of the contribution could be either in the form of cash; as a loan from bank, or labour. A declaration by the users to participate in construction and undertake operation and maintenance responsibilities was mandatory.

CASE OF SINKALAMA IRRIGATION PROGRAMME

The SINKALAMA irrigation programme[7] was started in 1985 in Sindhupalchowk, Kavrepalanchowk, Makawanpur and Lalitpur Districts of the Central Development Region. The objective is to assist farmers in upgrading or constructing new irrigation schemes in the districts. About 55 schemes covering approximately 2500 ha will be constructed or upgraded during the seven year project period.

Up to now 28 schemes serving 1418 ha of land have been completed and 15 more schemes covering 795 ha are under construction. Size of the systems range between 8 to 125 ha. with an average size of 51 ha. Length of the canals vary from 400 m to about 5 km. The average construction cost per ha of new schemes is Rs 12,278. The costs includes only that of the construction materials, labour and transportation. Design and supervision support are provided by the Department of Irrigation.

Evaluation of four Sinkalama irrigation schemes whose physical descriptions are shows in table 2, in June 1990 show positive results. Two of the rehabilitation projects; Archale Khola and Haletar Farm Irrigation Schemes have the IRR of about 35 per cent from year 10 onwards. In the case of the Khurmi Khola Irrigation System, the IRR is 92 per cent, while that for the Shahare Khola Irrigation scheme is 276 per cent.

Table 2
Details of Irrigation Schemes

Name of Scheme	Haletar Farm	Khumi Khola	Sahare Khola	Archale Khola
Village	Thula Darlung	Gindi	Shikharpur	Siauley
District	Lalitpur	Lalitpur palchok	Sindhu palchok	Sindhu
Project Type	Rehab	New	New	Rehab.
Year of Construction	1988	1989	1988	1987
Canal Length(m)	800	1500	2100	400
Net command area (ha)	15	22.5	50	35
Project Cost NRs.	134162	257385	671643	314625

Food grain production has been increased by 1.4 tonne/ha per year at the Haletar farm Irrigation Scheme and by 3.3 tonne/ha at the Khurmi Khola. At the Shahare Khola Irrigation Scheme the increase has been 8.6 tonne/ha of grain plus 1.86 tonne/ha of potatoes whereas that a Archale Khola has been 1.9 tonne/ha.

Studies in the upper Indrawati River Basin in Sindhupalchok District also show an average increase in yield of about 50 per cent from 1.5 to 2.2 tonne/ha.[8] A sample of 106 farmers with over 44 ha of rice land that had intermittent access to irrigation in the past reported that on an average, their yield went from 1.2 to 2.3 tonne/ha, showing an increase of almost 90 per cent.

The pre and post rehabilitation scenarios of productions at the four schemes are summarised in table 3.

'KEY ISSUE' FOR THE SUCCESS OF THE PARTICIPATORY APROACH

For success of participatory approach of development of hill irrigation,[9] following issues are important and should be considered.

A. Demand Driven Project

The demand for construction/improvement of the scheme should come from the beneficiaries. All the beneficiaries should express their willingness in the project. Weather or not the request has been made by the beneficiaries should be confirmed.

B. Need Assessment of Candidate Project

In many cases, the real problems do not get identified. Even when it is done, the solutions are more according to the designers perception than the genuine need. If a system requires improvement of only the aqueduct, only that component must be improved. It should never be extended to the whole system.

C. Involvement of Beneficiaries

The management capacity of the beneficiaries will be reinforced if they are encouraged and allowed to share responsibility for the planning, design and complementation. Farmer are the best sources of information for crop preferences, soil conditions variations in the area, stream flows and stability of land forms. Where cadastral maps are available, they can assist in compiling accurate area estimates of both existing and potentially irrigable area to be included in the project. The beneficiaries can quickly point out bottle-necks and priorities for improvements during a 'walk though' of the system.

Policies however, need to be specific in defining the role of the beneficiaries and the assisting agencies who should also be involved in the larger projects. They must be thoroughly consulted, and their suggestions entertained. Beneficiaries should be given only those works, which they can successfully accomplish.

D. Formation of Users Committee

Existing and functional organisation, should not be forced to adopt a rigid standard format. They should be allowed to retain their own organisational form and management procedures. This organisation should be also used as the construction committee with the consent of the beneficiaries. When a new organisation has to be formed, consent of all the beneficiaries should be taken to form the committee from among the beneficiaries.

E. Cash Contribution

In some cases, all the beneficiaries are not able to deposit the five per cent cash. Instead they offer to contribute their share in the form of labour, or request the committee members or other people to pay on their behalf. The progress of work when all contribute, I generally faster than when only one or few do so.

In case, when only a few pay cash, the amount from those who do not contribute is recovered through extra voluntary work. Where there is no organisation, those promising extra labour are found to be reluctant to do so after the project is approved. This puts those who have paid in an awkward position and even hampers the work progress.

The arrangement offers options to the beneficiaries in paying with either cash or labour contribution. It is FIWUD's experience that the persons who have paid extra cash work harder to organise and mobilise the voluntary works so that they can recover their deposits earlier.

F. Transparency of Account

Decisions of contract award, material purchases, labour bill payments etc. should be recorded in a minute book. Resolution of disputes and other decisions of the committee should be also recorded. It should be kept open to anyone wishing to check the information.

G. Joint Account System

Fund should be handled jointly by one or several of the designated members of the construction committee and the agency's accountant. Authorisation for releasing the fund should be against the approved written order of the designated members and the site supervisor.

CONCLUDING COMMENTS

Nepalese hill farmers have a strong traditional base in organising and managing group activities for operation and maintenance of irrigation systems. Additional external inputs in organisational aspects therefore, may not be needed. They however, require assistance in physical improvement work, timely delivery of agricultural input services and training in using the inputs more effectively.

Precaution needs to be taken to ensure that only the essential improvements are undertaken in any assistance programme.

Table 3
Comparision of Four Schemes before and after Interetions

Name of Scheme	Type of crop	Area under crop (ha)		Croping intensity (%)		Production (t/ha)			Net agricultural returns (Rs.)		IRR at ten years
		Before	Afer	Before	After	Before	After	Increase	Before	After	%
Haletar Farm	Paddy	15	15			2.5	3.0	0.50			
	Wheat	-	7.5			-	1.4	0.70			
	Maize	10	10			2.1	2.4	0.20			
	Total area	25	32.5	167	217				146735	202260	34
Kurmi Khola	Paddy	15	22.5			2	3.5	2.17			
	Wheat	-	20			-	1.7	1.51			
	Millet	5	-			1.5	-	0.33			
	Vegetable	-	1			-	6.2	0.28			
	Total area	20	43.5	89	193				69358	318759	92
Sahare Khola	Mainpaddy	-	50			-	5	5			
	Earlypaddy	-	10			-	5	1			
	Wheat	-	25			-	4.14	2.07			
	Maize	50	40			1,65	4.14	1.66			
	Millet	50	-			1.38	-	-1.38			
	Mustard	-	10			-	1.43	0.29			
	Potato	-	5			-	18.6	1.86			
	Total area	100	140	200	280				81350	1969612	276
Archale Khola	Paddy	35	35			1.5	2.0	0.50			
	Wheat	17.5	20			1.38	2.76	0.89			
	Maize	17.5	15			1.38	2.76	0.49			
	Total area	70	70	200	200				-20058	112760	350

Additional physical inputs than required always have negative impacts in sustainability and cost of the schemes. Actual need assessment therefore, remains the key issue for successful, interventions.

Irrigation system development process is dynamic in nature. The approach should be not to provide an ideal system at a time. System improvement or modification should go to together with the willingness and capabilities of the beneficiaries to efficiently utilize the facilities. The technology should be simple, efficient and within the capability of the beneficiaries. Their capability is enhanced by trainings.

Farmers however, do not have experience of joint management of medium and large public irrigation schemes. External input in organizational, improvements and technological aspects are needed for such projects. Co-ordination among various agencies for providing right quantity and timely inputs are required more in bigger systems.

Whenever, assistance is provided it must be limited to the schemes performing below their capacity. In no way should the programmes become a source for the financing 'deferred maintenance'. The responsibilities of the farmers for operation and maintenance should never be undermined.

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MICROCOMPUTERS AND IRRIGATION

Micro-computers using proven software, could be used for the improved design of small scale irrigation schemes in developing countries. The production value of irrigated schemes can be 3-5 times that of rainfed schemes.

Projects of between 50 and 1000 ha often proven more effective, promote self-reliance and are socially more beneficial than larger export oriented schemes. Yet, to achieve full potential they require a high standard of design and construction. In many developing countries there are few irrigation professionals and small schemes are often unable to justify the initial expense of a fully-trained design team.

The Overseas Development Unit (ODU) of HR of Wallingford plans to counter this problem through used of its newly-developed MIDAS (Minor Irrigation Design Aid Software) program. It has been designed for use by professionals who are not necessarily engineers. Its menu-driven program requires the designer to make conscious decisions at each step, although many default values are provided. The sophisticated graphical display allows the designer to see the overall layout to the scheme and to look in detail at each component. Information on contours, canals, slopes, etc., may be overland.

As it stands, the package designs surface irrigation schemes under furrow or border strip, with tertiary canal serving groups of between 20 and 30 farmers.

John Skutsch and George Hare (of the ODU), who wrote the program, say it incorporates ODU's wide international experience and prompts the designer to consider the many factors which are prerequisites of good design. These include broad considerations, such as the health risk from stagnant water and variations in cropping pattern, as well as location specific details, such as suitable irrigation methods and soil type. MIDAS enables the scheme to be designed for simple operation and maintenance, taking full account of the needs of the farmer. Associated packages generate ground contours and produce layouts and design long sections. Working drawing are easy to modify and standard details may be stored and modified as required.

MIDAS has been developed following research in the performance of three small holder projects in Zimbabwe with funds from the Overseas Development Administration. It is shortly to be handed over for evaluation and use by Zimbabwean designers. It may then be developed for projects in East Africa.

The MIDAS package may also be used as a training tool.

Irrigation design is a complex art requiring an understanding of the local environment, a sensitive approach to the needs of the farmers, knowledge of national agricultural priorities and an awareness of international trends in supply and demand. MIDAS prompts the designer to keep these complexities in mind and reduces the drudgery of routine design work. For further information contact: John Skutch of HR UK.

GHALE WOMEN OF LAPSIBOT AND STAND-POST

Jagat Basnet

(Water supply improvement in the rural areas has been one of the priority activities in Nepal. As water is the most critical felt need of the people, supply improvement was chosen as the entry point for the participatory approach for a community's 'development' . In many cases, the inputs instead of improving the situations have become the simple issue of targets and achievements. This experience emphasises the need for taking cognisance of local perceptions in any development effort. – Editor.)

The women were amused. Water flowing over a stone spout in the *Pandhero* or through the series of half cut bamboo duct that brought water to their household from the springs in the upper hills was the natural way which they understood. The new water system built recently in their community however, supplied water through a vertically rising pipe. Something devilish was feared by the women, water could never climb up.

The only person they knew who could explain to them the enigma was the ward chairman. "Why is this water climbing up?" was their common query to the chairman.

This was something the ward chairman never perceived he would have to deal in his political career, and as expected was unable to explain. It was not his business to explain how water flowed anyway. The women continued using the tap and the chairman became happy to know that new water system was after all useful to the village.

Things however, did not end there, Few days later, the ward chairman, to his dismay, found that the vertical portion of the high density polythene pipe, which was fixed to the wooden stand-post, had been cut at a number of points. He had heard of vandals, and thirsty shepherds cutting exposed pipes. But this was inexplicable. Enquiry revealed that the inquisitive group again had been the women folk.

"Why did you people cut the pipe line?" The chairman demanded of the women.

"We wanted to see why water climbed up. No matter where we cut, the water kept coming. Tell us why this happens or we are not going to use this tap."

Lapsibot is a small village in Phulkhark Village Development Committee of Dhading District of Nepal's Central Development Region. It is located at a distance of three day's walk from the district centre, on the northern slope of the Mahabharat hills. The water project served 42 household, community of Ghale gurung. The drinking water project was one of the first major development interventions in the village.

The project was part of the programme package aimed at assisting rural communities to take initiatives in mobilising resources for improving their living conditions. Funded by the GTZ, the programme attempted on confidence building measures among the local populace. The package required the beneficiaries, to first identify the priority need in their ward. Once it was done, and the project formulated, a fixed amount was provided, mostly in the form of materials. In this particular case, the amount was used for procuring pipe. Technical support for the design and implementation wherever needed was provided by the agency.

This experience though has its lighter moments, in real sense shows that water supply projects[1] have yet to lessen drudgery on women and bring them in the mainstream development process. Many small scale drinking water projects, built at community levels have been abandoned or not properly looked after because the beneficiaries have never been taken into confidence, neither at the programming nor during implementation stage.

The accepted approach has been to dump coils of pipe, hastily complete the scheme with substandard quality and register it is as one more achieved target. Whether the scheme has remained functional or not as intended is another matter altogether. As Nepal moves ahead to provide drinking water to the population in the post water decade era, new approaches and initiatives are essential. Instead of treating rural water supply improvements as a mere combination of pipes and cement, other factors affecting the development need to be considered. It must be followed by reactivation of local in situations for sustainable interventions. Many state inspired inputs in Nepal have not been successful and the approach has greatly increased dependency on external support.[2] This must be avoided at any cost in the future.

NOTES

1 Several studies on rural water supply sector in Nepal have already expressed the need for considering the other factors. This sentiment is also expressed by Ray. S. Leki in his letter to Water Nepal Vol. 2 No. 1. April 1990.

2 See, Water in Nepal by Gyawali Deepak, East West Centre for an excellent treatment on expanding

Nation State Theory and how functional local institutions have been made ineffective by external interventions.

Water Nepal requests authors to send books and other materials on water published from Nepal.
We shall endendeavour to review books and provide you a wider relationship.

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P.O. Box 2221, Kathmandu

IN 1927 AD, the United Province of Allahabad made arrangements to pay Rs 50,000 and exchange of 4000 acres of land in Baharaich District, India to the State of Nepal in connection with the Sarda-Kitcha Project. Nepal could take 460 cusec, and provided cultivated land was increased and water sufficient, 1000 cusec flow from 15th October to 15the May from the head work.

Based on copy of the letter by the chief secretary, the united Province to the British Envoy at the court of Nepal.

SCIENCE, TECHNOLOGY AND WATER DEVELOPMENT IN VEDIC TIMES

Kiran Shankar

(Ancient civilisations is South Asian region had perfected unique systems of utilising water for meeting various human needs. This article recounts the development of science and technology in vedic times, and the earlier interpretations of hydrology. Past history must inspire us to utilise the flowing water for ensuring an equitable well being of the people of the region, the author suggests. - Editor)

Life on earth cannot be visualised without water. Plants, animals and human being need water for survival. One of the Sanskrit classics Manu-smriti equates water with life.

"A' po Na' ra' h"

Simply stated, it means that water (*A'po*) is life (*Na' ra' h*).

In uncontrolled state, river waters can cause wide-spread destructions of human life and property. When properly harnessed, river water becomes the source of economic well-being of a society. In reference to both the malefic aspect of uncontrolled waters and the benefic aspect of proper water resources engineering, the Maha'bha'rata, one of the ancient epics states:

"Andham balam jalam cha a' huh
Pran' etavyam vichakshan' ae"

It means that water is a blind force that has to be properly guided and channelised for human welfare. Water, not put to useful purpose is lost for ever, incurring loss of a potential wealth (*a'po'na'ra'h*) of the humanity. Water resources development for increased agricultural productions and for encouraging industrial growth, and speeding up the general economic advancement of mankind's welfare were understood even in vedic times.

The *Brihod-Aran'yak-Upanishad* offers a three step approach in order to arrive at the scientific truth, (a) hypothesis (*Shrawan'a*), (b) experiment (*Manana*), and (c) application of the theory if found true (*Nididhya' sana*) for the benefit of individuals and society. In Sanskrit, vijna'na (science) is defined as knowledge endowed with rich experiences obtained through several experiments under certain pre-requisites required for the experimentation. Hence, in general, *vijna'na* has been used to denote the studies in science and engineering as well (*Vijna'nam Shilpa-sha' strayoh*).

Hence, Calsay Raksa states:

"…the Vedas……also teach us science."

Dr. Jacolliot expresses rightly:

"Astonishing fact? The Hindu revelation (*Veda*) is of all revelations the only one whose ideas are in perfect harmony with modern science…"

Wheeler Wilax finds:

"…The great Vedas…Containing…also facts which all the science has proved true. Electricity, radium, electrons, airships, all seem to be known to the sires who found the Vedas."

Atharva-Veda (18/22) refers to the atomic theory, which was later propounded by a Rishi (scientist?) known as Gautama. Rig-Veda, Shilpa-Sanhita and *Bha'skara'cha'rya's "Siddha'nta Shiroman'i"* mention the use of telescopes known as Turiya Yantra. Noiseless watches had also been developed by Ribhu, during the Rig-Vedic age.

Va'lmiki Ra'ma'yan' a refers to the two great builders Nala and Nila who superised the construction of 128 kms wide and 1280 kms long bridge. Rig-Veda2/41/5 mentions a great golden mansion with 1000 storeys. This must have been the greatest achievement in building engineering in the early times.

In the *Rig-Vedic* times, *Ribhu* seemed to have invented a three-wheeled chariot (Ratha) without any horse, that could fly through the skies (Rig-Veda 4/36/1). *Maha-Rishi* (the great scientist) *Bha'rgava Shaunaka* had developed and operated seven-wheeled air-ship called *Vima'na* and *Ratha* which could fly through the space with the help of solar and lunar energies (Rig-Veda 2/40/3) (*Vima'na* has been defined as *Vyoma-Ya'na* or the vehicle that flies in the skies).

Rig-Veda (3/14/1) also mentions of aircraft operated electrically, which apparently was known to the ancient scientists. Three storeyed aircraft had been developed by *Janadagni* and *Bha'rgava* (Rig-Veda, 9/62/17). *Bha'radwa'ja* had developed a golden ship which could fly, navigate in the sea and also move as submarine according to *Rig-Veda* (6/58/3).

Ta'raka' sur assisted by his three sons, *Ta'ra'ksha, Kamala'ksha* and *Vidyun-malii* invented, developed, and established three flying towns called *Tri-pura Vima'na*.[1] The very name *'Vidyun Malii'* indicates relationship with electricity or electronics!

Rig-Veda (9/14/1/6) also refers a car known in Sanskrit as 'car' itself, which could move through the surfaces of both the rivers and seas. In Vedic language, 'car' means a dynamic machine or vehicle, which can run and fly. Such a multi-purpose 'car' had been designed by *Kashyap*.

According to *Va'lmiiki, Pus'paka Vima'na* – fastest-flying aircraft had been used by *Iord Ra'ma. Bha'gavat Pura'n'a* reports that *Kardama Rishi* used to travel for years by *"Bhra'jis'n'u"* aircraft. Maya, King *Ra'van's* father-in-law, had built *Saubha-Vima'na* which could be used in land, water and air as well.

Mention is made of irrigation systems in some chapters of *Rig, Yajur* and *Atharva Vedas. Atharva Veda* very beautifully, describes the sweet and unbreakable relationship between a river and the main canal by stating –

"As a cow is to calf
so is a river to main canal"

The *Maha'bha'rata* epic mentions tanks and use of ground water. King *Bhagirath* was evidently successful in training even the mighty Ganges as the earlier pantheon recount. Uses of canals and wells are mentioned in *Devii Pura'n'a* and *Vishn'u Pur'n'a* and irrigation activities have been sufficiently highlighted in *Smritis*. Construction of irrigation facilities has been considered as the sole duty and righteous responsibility of the King and rich persons of a country for ensuring prosperity and happiness of the people. Irrigation as a science thus was in practice since very ancient times. The Vedas are replete with references to dams and canals, wells and tanks. Tanks were constructed for impounding rainwater and wells for tapping ground water.

As stated earlier, the *Maha 'bha' rata* declares that water is a mere blind force, and stresses the fact that right measures should be taken for properly harnessing, developing and utilising the water resources by the 'wise ones' who could be, representatives of *Viswakarma'*, the greatest scientist and engineer.

Hydrological cycle as a basic unit to understand water uses was known in the Vedic times also. *Brahma 'n'd' a Pura 'n' a* states that water goes on changing it forms (lakes, rivers, ground water, sea etc.) and that it goes up by evaporation and evapotranspiration, the water vapour again falls down as precipitation. The power or energy that keeps the hydrological cycle go on eternally has been scientifically declared by the Manu-Smriti to be the solar energy.

It states - *"A ditya't ja'yate vris'tih"*

Which means that the solar energy causes the precipitation. In ancient time, the time and space variability of water were understood.

Examples of uses of water through tanks and conduits in ancient times are found even today. Earthen dams built to create reservoirs to store runoff water or water diverted from streams were used for irrigation, more than 2000 years ago. One such tank has been discovered at Shringaverapura near Allahabad where lord *Ra'ma* began his 14 year exile, and was ferried across the Ganges by local *Nisha'da* chief.[2] Inscriptions of 1096 AD, mention series of tanks constructed at different levels of a watershed.[3] *Vara'hamihira's Brihat Samhita*' written in 533 AD cites several indicators for tapping groundwater, and methods of cleaning well water.[4] *Kautilya's* "*Arthasa'stra*" written towards the end of the 4th century BC refers to devices so measure rainfall.[5]

Scientific knowledges of developing water gained in past failed to get handed down from generation to generation. The water rich South Asia has been unable to productively harness the potential and today is bracketted with the countries having poorest quality of life. It is difficult to foresee how the water resources would usher an era in which the people acquire an improved life style. This is so, as social changes are difficult to measure. And to quantify the contribution of water development on social wellbeing is still more difficult.

If economic indicators were the only yardstick, Gross National Product (GNP) could be used to evaluate the contribution made by the water resources systems in improving the life quality. Growth in GNP, as an indicator of development however, may be misleading rich getting richer and the poor poorer.[6] It is time to seek the correct water development approach that ensures a better quality of life for the majority, when equitable benefit distribution becomes a reality. Our prosperous past must inspire us, and if we wish, we can make things happen again.

NOTES

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A NEW TYPE OF TAP FOR USE ON PUBLIC TAPSTAND

Jon Lane

(*The standpost is the central point of activity in a piped water supply system in rural areas. In many cases, taps are damaged and broken due to heavy uses. Even the sturdier bib-cocks imported from overseas have been found to be broken. This article introduces a new tap, that can be used in standposts with low residual head. Manufactured locally, it improvises on the practices of plugging flowing pipes, which is common in the rural areas. Information on availability and price of the tap can be obtained from Water Aid, P.O. Box 4231, Kathmandu. The author also welcomes readers' opinion on any aspect of the tap* -Editor)

THE TAP PROBLEM

Public tapstands in Nepal are subjected to heavy use. The actual tap itself is the central point of the entire water supply system, the point where the system and its users meet. Any observer walking in the rural areas of Nepal can see many tapstands with broken taps. This is one of the biggest causes of breakdown in the supply and dissatisfaction of the users.

There are two main problems: many of the users are unfamiliar with mechanical objects and do not understand the need to handle taps carefully, and most of the taps in use are of poor quality. Consequently many taps are broken very quickly: the average service life seems to be as little as nine months. Often the users do not have resources to keep buying new taps at this rate, and so the taps are left unreplaced and the system flows open. Apart from wasting water and causing drainage problems, broken taps discourage the users from caring for the system and can even lead to more damage.

EXISTING DESIGNS

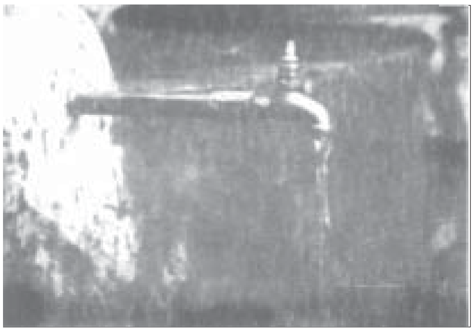
The most common design in use is the brass bib-cock. There are four main problems with this type of tap:

(a) It is designed to produce a variable flow rate and for this it needs a complex internal arrangement. This is unnecessary for public tapstands where the flow is only required to be either on or off.

(b) It contains a rubber washer, which wears and need replacement. Understanding the need, raising the money and finding a shop selling washers are all problems in rural Nepal.

(c) When the washer leaks, the users over-tighten the tap. This strips the brass threads.

(d) In intermittent systems, when the control valve at the reservoir is closed and the tap is therefore dry, the users turn the tap by force beyond the normal open position. This also strips the threads.

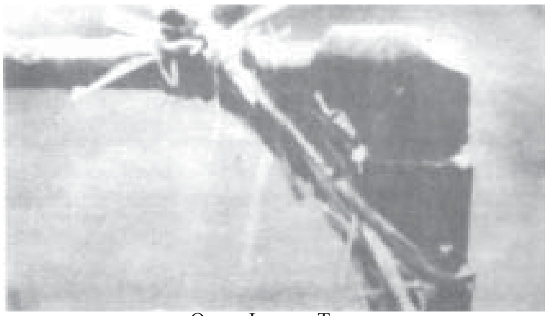


Leaking Brass Tap

The other widely used design is the self-closing tap, often known as 'Jay-cock' tap. This has a simple orifice closed by the tap body under the influence of gravity and a spring. There are four main problems with this type of tap.

(a) When water is required, the tap has to be held open continuously with one hand. This makes washing very difficult and can be very tiring, especially for children or when the flow rate is low. Therefore this type of tap is unpopular with the users.

(b) To solve this problem, the users tie open the tap with string or straw. The water flows continuously and the



Open Jayson Tap

tap serves no function.

(c) When the tap closes, an instantaneous pressure wave ("Water hammer") is set up, which causes threaded pipe connections to leak.

(d) The working parts of the tap can be damaged, and it then leaks.

THE DESIGN OF THE NEW TAP

This design is not an original idea, but simply the application of basic engineering principles and durable materials to a traditional design often seen in rural Nepal.

The design consists of a plug inserted into the open end of the pipe. When water is needed, the plug is pulled out. When it is not needed, the plug is pushed into the pipe and blocks the flow. Its traditional form uses a wooden plug, which fits into an HDPE pipe. The form developed by the author uses a tapered brass plug which fits into a short thick-walled mild steel pipe machined with a matching taper. The other end of the pipe is threaded to fit into a normal ½" socket, a strong chain prevents theft of the plug, and the pipe and chain are galvanised to prevent corrosion.

Some of the main advantages of the tap are:

(a) The method of operation can be easily understood by the users.

(b) The tap is either on or off, but does not need to be held open.

(c) It is robust and has no delicate internal parts (e.g. threads) which could be damaged.

(d) It has no wearing parts (e.g. washers) which need replacement.

(e) The action of closing the tap does not cause water hammer.

(f) It does not leak even after repeated use: in fact the brass plug tends to wear closer to the shape of the steel taper, so that the tap actually improves with the age.

(g) It can be installed either vertically or horisontally as the users wish.

(h) It can be used as a direct replacement for an existing broken tap, as it fits into the same fitting.

The New Tap

(i) Its price is similar to that of the other types, and its durability is much better: this leads to great savings over the life of the water supply.

The apparent disadvantages of the tap are:

(a) It can only be used at low heads. The limitation is not the head at which water pressure forces the plug out (which is over 20 metres) but the spray of water around the plug as the tap is closed, which is inconvenient for the user. This gives a practical limit of 2-3 metres head. Within this limit, however, there are many thousands of springs, tanks and tapstands where this tap can be used.

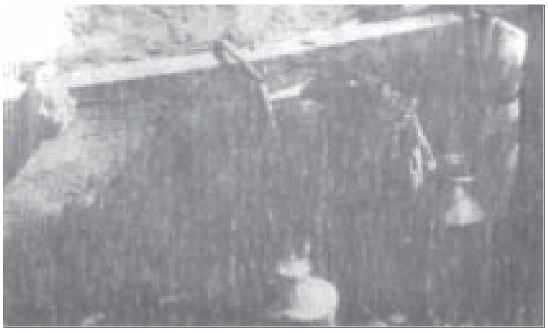
(b) If the plug is pushed in very hard, it might be difficult to open. In fact, however, experience has shown that his problem is very rare: the plug can usually be opened with a twisting action. As a last resort, the tap could be simply unscrewed from the tapstand and the plug hammered out from inside.

THE DEVELOPMENT AND USE OF THE NEW TAP

Various prototypes of the tap (using different materials, taper angles and other dimensions) have been made and tested over the past two years by being installed on tapstands in rural areas.

An optimum design has been developed, based on the observations of the professional staff and the views of the users, and is now in large scale production. Many taps of this final design have been installed.

The users are generally pleased with the tap, as they appreciate its simplicity and durability. It gives a good flow of water to fill containers. Children can play with it but not break or dismantle it. The taper angle is narrow enough to allow the plug to be closed easily and not to leak or fall out, but not so narrow to cause the plug to jam in the pipe. If, by some extreme means,



New Tap being used

the plug were to be broken or stolen, it could easily be replaced by a wooden plug cut to fit.

CONCLUSION

This new type of tap is not just an idea or a laboratory prototype, but a fully developed working item. It is not claimed to be a universal solution, because it can only be used in locations with a low head of water. In those places, however, it appears to be significantly better than the existing types of taps.

FLOOD ACTION PLAN OF BANGLADESH-THE EMBANKMENT ISSUE

M. Monirul Qader Mirza

(Every year flood hit Bangladesh with varying degree of magnitude and severity. Of all the recorded events, the 1988 flood has been the worst one that caused widespread suffering and loss of life. After its recession the Government of Bangladesh initiated a massive flood mitigation programme and the World Bank was requested to formulate a Flood Action Plan (FAP). Several studies had already been carried out by different international organisation with broader objectives of flood mitigation. All flood control approaches have emphasised on construction of embankment for flood mitigation and given less attentions to non structural measures. This article introduces flood problems in Bangladesh. It also discusses the environmental issues related to flood control by embankments. The author suggests that non-structural approaches incorporating flood preparedness measures should be pursued. – *Editor*)

INTRODUCTION

Most of Bangladesh is located within the flood plains of the Ganges, the Brahmaputra, the Meghna and their tributaries. The three rivers drain a total of about 1.5 million square kilometers area of which only 7.5 per cent lies within the country.

Rainfall over Bangladesh varies greatly both in time and location. Seventy to 85 per cent of the annual rainfall is concentrated in the monsoon season from May to September. Average total runoffs from the Ganges, the Brahmaputra and the Meghna catchments respectively are approximately 100 mm, 1200 mm, and 1500 mm.

Each year, in Bangladesh 26,000 km^2 land representing 18 per cent of the geographical area is flooded. Whenever severe floods hit the country, more than 36 per cent of the area (52,000 $km)^2$ get inundated, which is equivalent to 60 per cent of the net cultivable area of the country.

Agriculture, is the most affected sector by this annual flooding ordeal. Table 1. Though 3.166 Mha. of the agricultural land have been brought under flood protection by 1987-88,[1] the floods of 1987 and 1988 affected all of the areas where the flood control measures had been taken.

Table 1
Flooding Condition of Agricultural Land

Flood Depth (cm)	Area (in Million ha)	Percent of total	Nature of flooding
< 30	2.35	27	intermittent
30 to 90	3.68	39	seasonal
90 to 180	1.66	18	seasonal
> 180	1.46	16	seasonal/perennial
Total	9.35	100	

In an average year, from June to September 775,000 mm^3 of water flows into the country through the three main rivers. This constitutes 85 per cent of the total volume flowing into the country. During the same period, the stream flow volume generated by rainfall inside the country is only 184,800 mm^{3}[2]. The nature of the flow dynamics and flood problem in Bangladesh is influenced more by the volume of water coming into the country from catchments outside it's boundary.

CAUSES OF FLOOD

There are several causes of floods in Bangladesh. These are listed as common and uncommon causes.[3,4,5]

Common causes:

i. High rainfall in upper catchment;
ii. High localised rainfall;
iii. Synchronization of flood level in the three major rivers;
iv. Backwater effect from the major rivers to distributaries;
v. Deforestation in the catchments;
vi. Flood plain and river bed sedimentation;
vii. Bed formation and migration of thalweg;
viii. Rise of Sea level by in-monsoon and flow tide effects;
ix. Flood control activities in the upstream catchment
    a) Embankments; and
    b) Dams and barrages with operational problems.

Uncommon causes:

i) Greenhouse effect, Temperature rise, Melting of glaciers and ice resulting in increased river flow

ii) Earthquakes

a) Lower movement of glaciers below snow line increased flow of water, and
b) Landslides and failure of natural reservoirs.

FLOOD DAMAGES

Systematic record of flood damages in Bangladesh before 1954 is not available. After the consecutive floods of 1954 and 1955, the then Government of Pakistan requested the United Nations to look into the flood problem of erstwhile East Pakistan. Following the formation of Krug Mission in 1956 and its recommendation, EPWAPDA* was created in 1959. The agency was entrusted with the responsibilities of flood control, irrigation and water development. Since then BWDB** (former EPWAPDA) has been maintaining records of the annual flood damages.

The major flood damage records since 1954 are presented in Table 2.[6,7] The damages include both the direct and indirect losses calculated at 1962 price levels. The losses in agriculture, livestock, roads, railways and waterways, water control structures, utilities including underground and aerial telecommunication equipment and electricity facilities, industry, health and education, rural water supply, rural housing, urban infrastructure, and social services were considered for estimating the indirect damages. Of all the floods, the damages by the 1988 flood caused the most severe loss and was the worst in history.

1988 FLOOD DAMAGES

The 1988 flood was generated by intense rainfall, which extended over North and North East Bangladesh, India, Nepal and Bhutan. The most intense local rainfall concentration occurred over Assam, Meghalaya, Bhutan, and Arunachal Pradesh. As the resulting flood peak of the Brahmaputra unusually coincided with that of the Ganges, which was also high, the net effect on the Padma; downstream of the Brahmaputra/Ganges confluence was devastating.

Very large over-bank areas along the Brahmaputra, Ganges and Padma were flooded to an unprecedented extent. For the first time, even Dhaka, the capital city of the country was seriously affected. Adding to the flood congestion was the exceptionally high flood on the Meghna, which affected areas on it's downstream reaches.

The 1988 flood inundated parts of all of 53 of the 64 districts of Bangladesh. The calamity directly affected 45 million out of a total population of 110 million of the country. Standing crops on 2 Mha of land were damaged by the flood which also severely damaged roads, railways and water control structures. The total damage was estimated at US $ 1.1 billion.

Table 2
Chronology of flood Damage (1954 to 1988)

Year	Flooded area (sq.km.)	% of the country area	Value losses (in 1969 prices in million Taka)
1954	36778	25.54	1,200
1955	38850	26.98	1240
1956	35483	24.64	2180
1962	37296	25.90	1020
1963	35224	24.46	83
1964	31080	21.58	246
1965	28490	19.78	45
1966	33411	23.20	344
1967	25641	17.81	90
1968	37296	25.90	1645
1969	36260	25.18	330
1970	38332	26.62	1380
1974	38850	26.98	10000
1984	25900	17.98	2500
1987	54390	37.77	15000
1988	83994	58.33	50000

FLOOD ACTION PLAN

The severity of the 1987 and 1988 floods prompted the Government to comprehensively review its flood policy. This review centred on the two studies on flood policy and flood preparedness financed by the United Nation Development Programme (UNDP), which were completed in the early 1989. Additional three studies of the flood problem, and its possible solutions were also prepared in 1989. These were, Pre-feasibility Study for Flood Control in Bangladesh prepared by a team of experts representing the Governments of Bangladesh (GOB) and France, Eastern Waters Study sponsored by USAID; and a Report on Survey of Flood Control Planning in Bangladesh prepared by the Government of Japan. The studies considered the problems of flood from different perspectives, but all concurred in emphasising the importance of flood preparedness measures.

*EAST PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

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The studies financed by GOB-UNDP and GOB-France for flood control; looked at the potential of long-term structural solutions (principally embankments and drainage canals) over the next 15 to 20 years. The GOB-UNDP study has proposed embankments and drainage systems for the three main rivers, whereas the GOB-France study has taken a more ambitious approach involving construction of embankments also on many of the three major river's tributaries.

The Eastern Waters Study by USAID has considered flood control within a broad view of water resource development in the Ganges and Brahmaputra basins. The report points to the engineering problems, including costs and benefits of confining the main rivers through an extensive system of embankments. The Japanese report has examined the range of alternatives and is cautious of the structural solutions as the panacea, except where urban area are needed to be protected. All the studies agreed on the value of improvements in the natural drainage system.

Recognising that the flood problem necessitated a co-ordinated and cost-effective approach, the Government requested the World Bank in June 1989 to help in coordinating the findings of these studies and subsequently prepare an action plan for flood control. As part of its co-ordination role, and following a meeting of experts in Washington in July 1989, the Bank in late 1989 prepared the Action Plan.

The Action Plan basically draws on the findings of the past four studies and proposes a course for flood control initiatives over the next five years and beyond. The recommended initiatives encompass the programmes of non-structural measures, such as flood forecasting, flood warning, flood preparedness and disaster management, that would be undertaken in conjunction with agricultural development programmes. The Action Plan includes 26 studies and pilot project which is estimated to cost about $ 150 million over the next 2 to 3 years, and which would require an estimated investments of about $ 500 million.

THE EMBANKMENT ISSUE

The elements of flood control measures which have been considered in Bangladesh are: a) Reconstruction and strengthening of existing embankment; b) Construction of new embankments; c) Closure of distributaries; d) Flushing and drainage structure; e) Channels stabilisation; f) River training, and g) River bed management.

In all flood alleviation approaches, constructions of embankment has been given more importance. Embankments on the major rivers in Bangladesh as now envisioned would cost about US $6 billion, which have annual maintenance costs in the order of US $ 600 million. While embankments have their utility in meeting flood control objectives, they also lead to many other problems. These can be listed as follows.

i) Moderate flooding is necessary for the cultivation of rice and jute. Rainfall is less predictable than river flows and cannot be relied upon to irrigate land.
ii) Embankment will constrict drainage of surface water flow. Rainfall behind the embankment may cause worse flooding than if the embankment had not been constructed.
iii) The movement of water transports from tributaries to main river depends on the unobstructed channel navigation. It also may affect fish migration as free flow of water from tributaries to the main river is disturbed.
iv) Embankments can fail due to a variety of reasons. This may lead to a sudden inrush of water, creating severe conditions than the normal flooding which occurs gradually.
v) As embankments confine the river flow, the induced morphological changes would be very difficult to predict.

CONCLUDING COMMENTS

The severity of floods in Bangladesh is a manifestation of its location and the excess water volume that flows into the low-land. It points to the reality that coping with the disaster inflicted by this mass of water transcends the preconceived notions of total structural solutions.

It is necessary therefore, to give equal emphasis to non-structural measures as well. The non-structural components of the Flood Action Plan are a) cyclone protection project; b) flood forecasting and early warning project; c) disaster preparedness programme; d) topographic mapping; e) geographic information system; f) flood proofing pilot project; and g) river survey project.

The reality of flood problem in Bangladesh is expressed candidly by the USAID sponsored Eastern Water Study. It narrates "Large Flood control projects involving upstream storage or embankments in or near the main channels of these rivers (includes Ganges, Brahmaputra and Meghna) are probably not feasible means of dealing with flood problems in the near future. In the meantime, the people of this region have adopted many ingenious ways of living through the floods. Resources should be allocated to helping them do this more effectively by establishing refuge areas, providing better emergency food and medical services, protecting some agricultural areas from shallow-flood damage, increasing surface drainage capacities, and the like. Most of them appear to be technically sound, economically attractive, and environmentally benign."

Extreme theory in hydrology says that however big floods get, there will always be a bigger one coming. Experiences in Bangladesh has proved this to be true. It becomes therefore, necessary to re-examine the established approaches of flood control; to improve effectiveness in combating it so that new worst flood hazards are minimised.

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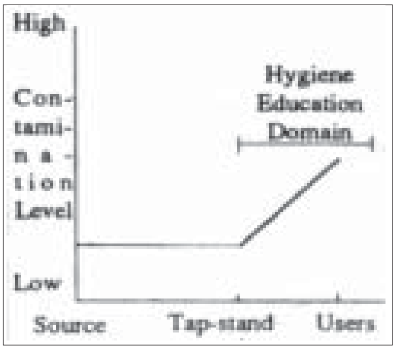
HEALTH IMPACT STUDY OF RURAL WATER SUPPLY SYSTEM

(One of objectives of water supply improvement in rural areas of Nepal is to improve health of the people. Availability of good quality and more water quantity nearer to the users is considered as an input for improved health. A 1985 study of improved water supply schemes at Pokhara in western Nepal has shown that this is not the case. The study was conducted by a group of medical students from Erasmus University Totterdam, The Netherlands and found that improved water supply is not in itself sufficient to meet the objective. More efforts are needed on issues such as proper use of water and hygiene education to miximise benefits. This article is reprinted from "Ten Years Experience" by Marieke Boot and Han Heijnen published by IRC, The Netherlands. Editor)

A study was carried out to evaluate the health impact of an improved water supply scheme implemented by the CWSS Programme, Pokhara. The study tested the hypothesis that the health impact of an improved water supply would not be significant because of other, perhaps more important, determinants. The study included water quality analysis to determine the level of faecal contamination; health determinants n children under six years of age, such as diarrhea and ascaris prevalence, nutritional status and skin and eye diseases; and assessment of the health impact of an improved water supply.

The study area was in Kaski district, a half-day walk, north of Pokhara. A village with a five-year old improved piped supply was compared with two control villages where people used unimproved sources, such as small streams and sometimes the main river directly. The villages were matched for geographic and demographic aspects such as socio-economic status, caste and literacy. The intervention village had 178 households with 129 children under six years of age; the control population consisted of 156 households with 145 children under six years of age.

Faecal coli was used as indicator of the bacteriological quality of the water. Water samples were taken from 10 tap-stands and 15 unimproved sources every two to four weeks, except between June and August because of lack of trained manpower and inaccessibility of the area during the monsoon. Millipore membrane filtration method for field tests was used for water testing. In the field, samples were placed in a holding medium to allow for up to 72 hours delay in return to Pokhara, but most were transported within 36 hours. In the laboratory, the samples were transferred to a petre dish containing the standard nutrient medium and incubated. According to the criteria adopted, water from the improved system was of almost consistently high quality. Some 88 to 98% of samples contained less than 10 E. coil per 100 ml. In the control area, only 10 to 30% of the samples were in this category. In general, water from unimproved sources was ten to a hundredfold more contaminated than water from improved sources. Occasional water was tested from a *gagri* in a household, and in most cases was of lesser quality than water from the tap or source from which it was drawn.



Each household with a child under six years of age was visited at two-weekly intervals to investigate the incidence (new case) and prevalence (presence at that time) of diarrhea diseases. Although some households lost interest in answering the same questions again and again, other gave more accurate answers with time. Throughout the year, diarrhea prevalence showed a similar pattern in the intervention and control villages, with a peak prevalence in April and May, at the end of the dry season. However, the mean incidence of diarrhea was somewhat lower in the intervention population (4.0 episodes per child over the year) than in the control population (4.5 episodes per child over the year), (statistical significance $p<0.05$). The mean duration of a diarrhea episode was nine days, with each child suffering from the diseases on average 32 days over the year. The incidence of diarrhea was related to a number of possible factors, the most important being difference in water quality. But no significant correlation was found indicating that high quality tap water alone is not sufficient to affect the incidence of diarrhea. How ever, the study did not indicate the possible influence of water contamination during transport, storage and handling. Socio-economic circumstances were also not found to have a significant effect on diarrhoea incidence. Only age with 0 and 1 year olf children being most affected ($p<0.01$), and nutritional status ($p<0.05$) were shown to be related to incidence of diarrhoea.

The nutrition status of all children in the sample was assessed four times, at three monthly intervals, by measuring the midupper arm circumference. Nutritional status was best in December with 17 % of children mildly malnourished and 3 % severely malnourished. In May their nutritional status deteriorated to 27 % being mildly malnourished and 10 % severely malnourished. Thus, the study showed that at the end of the dry season when food is scarce, the nutritional status of children declines and gradually increases after the monsoon whencrops are harvested. The study also revealed a relationship between nutritional status and prevalence of diarrhoea. Overal prevalence was 2.4 times higher in mildly and severely malnourished children. Also, the duration of an attack increased when nutritional status was lowest.

As an indicator of the level of community sanitation, the children stool were examined for the presence of ascaris infestation (roundworm)using the Kato method, in January 1985. A high prevalence of as cais was found especially in the older age groups. Over 85% of five-year olds were found to suffer from ascaris, with 5% heavily and 20% mildly infected. No correlation was found between ascaris and either latrine accessibility or nutritional ststus.

The effect of increased availability of water at a shorter walking distance was assessed as the amount of water used. Whereas 5 to 10 minutes were needed for round-trip to a tap and 15 to 30 minutes to an unimproved source, this seemed to have little effect on the amount of water collected. The average was about nine litres per person per day in both villages. However, more water may be used at the tap site itself.

The study confirms the hypothesis that an improved water supply at a shorter walking distance is not in itself sufficient to improve the health status of children. The researchers emphasise the need to pay more attention to water use practices through integrated hygiene education in order to maximise the benefits of awater supply.

BOOK REVIEW

Title : Ten Years of Experience Community Water Supply and Sanitation Programme, Pokhara, Western Development Region, Nepal.

Authors : Marieke Boot and Han Heijnen

Published by : IRC International Water and Sanitation Centre, The Hague, The Netherlands – 1988 Technical Paper No. 26

The period ten years – 1976 to 1986 – covered by the book happens to be a period in Nepalese history when the concept of Decentralisation was put into practice forcefully within the framework of Panchayat polity. The organisational structure as such vehemently supported the system. It is important to mention this because the relative successes and failures of the Community Water Supply and Sanitation Programme (CWSS) vis-s-vis the programmes and projects taken up by the Department of Water Supply and Sewerage indicate the effects decentralisation, as it was then, had on the programme.

How the community Water Supply and Sanitation programme in Nepal evolved into a workable package incorporating both the hardware as well as softer aspects of rural water supply and sanitation schemes from its beginning, is the assortment of products, of technical trials, donors' dilemma, bureaucratic lethargy and user's plight. This history is a subject that merits a thicker volume that could be inspirational to all those concerned with water supply sector in the country. This book does, however, cover part of it quite well, limited as it is to technical aspects of the development.

When the authors, in their preface, say that "sharing this experience will encourage others to view their own projects in a wider time frame" and that "sustainable achievements in community based water supply project are possible with committed effort and enthusiastic support of all those concerned," they provide ample food for thought to all those who have chosen to remain outside the ambit of community – based programmes. It forces one to see beyond the notions of creating engineering monuments for addressing the basic problems; drinking water.

What the authors have not elaborated in the book however, is the extent to which the donor agencies and their personnel were allowed by the host government to exercise freedom in channelising funds for implementing programmes and in recording the project costs overhead costs, and thereby, the calculated cost per capita for example, hides more than it reveals.

This fact is significant in view of the possibility of replicating the concepts and approaches of community water supply schemes by government agencies while working without any external management and financial support. The book also refrains from offering suggestions as, to what extent can the concepts, technical designs and economics of Community Water Supply and Sanitation (CWSS) schemes can be applied to systems that cover a larger rural population.

Well structured objectivity is the gripping force of the book, which keeps the interested reader hooked to the 'experience'. Every one concerned and involved in water supply sector in Nepal will find the book useful.

POORNA B. ADIGA

VIEWS FROM READERS

DEVELOPMENT IS FOR PEOPLE

I have enjoyed reading the last few issues of Water Nepal. I commend your efforts to publish research and opinions on water related issues of Nepal, a critical resource. I specially admire the succinct and highly relevant technical information on this subject in the bulletin. Harka Gurung's article on 'resettlement' (vol 1. No. 4, Oct 1989), is most timely topic as Nepal is in the phase of expanding its infrastructural base, inevitably displacing people. Large- scale projects will have to minimise displacement of people, and consider their welfare as a significant aspect of the project itself. Dr. Gurung observes that among the displaced families in selected cases, only the richer were better off after the compensations for their land.

In designing future projects, it should be remembered that development project should provide a balance between its long-term benefits to the entire country, and the benefit of the people who are directly affected in the project location. The latter consideration is by no means a secondary one nor residual task, because the very purpose of development is to benefit all and by the agreement of all.

Ambika Adhikari
Cambridge, Massachusetts.

VEGETATION MINIMISES FLOOD

I find Water Nepal a good start to make people conscious and concerned with one of themost important natural resources; water. I feel that a column in Nepali version in the bulletin may be of further help.

I would like to make some comments on your editorial column Vol. 2, No. 1, April 1990. It says that the relationships between flood and deforestation has not been scientifically validated. Let me differ with you in this statement. It is a simple principle of water soil and plant relationships. When soil is covered with vegetation, it retains water and thus would reduce the release of the full volume of water that is poured into it. So, flood would be definitely minimised if forest or greenery is maintained on the earth surface.

I agree that the non-structural flood alleviation approaches have been restricted to academic discourses which should come into practical uses. Similarly, you have rightly expressed that flood problem is related to population growth. Understanding of social and cultural behaviour of local inhabitants is crucial and must be thoroughly incorporated for effective control of flood.

Dr. Govind P. S. Ghimire
Reader, Central Development of Botany, T. U., Nepal

It was a pleasure to go through "Water Nepal" Vol 2 No. 1 April 1990. The articles in the issue lucidly illustrated the degradation of soil and water. The other side of water development is indeed alarming, but the experiences also force us to be cautious in our endeavours, and to prevent adverse effects before they happen. The articles are quite appealing. Congratulations!

In recent times, drinking water supply and its efficient management in Kathmandu have drawn interests of both the allied technologists and more sensible users. The talk of the town is the mega project. Plans to channel the cool and clean water from Melamchi river, higher up in the mountains, to meet the drinking water needs of over a million Kathmanduits in about ten years time are on theanvil. Some authoritatively advocate the approach as the only alternative, which would also flush the polluted Bagmati river flowing through the city.

Water supply improvement programmes in the rural areas do not succed without support of the locals, Thelma Howard's "Experience of Developing Drinking Water System" recounts. It is yet to be seen, how interactions between users and the government would evolve in urban areas in developing sustainable water management plans. Is the proposed inter-basin transfer of a snow fed river alone, the guarantee for the woes that bedevils Kathmandu's water supply or other issues need vigorous considerations ?

If Californians have to re-think their life style of growing lush green lawns in the desert heat as Dipak Gyawali asserts in "The Other Side of California's Water Development", should not Kathmanduits pause and ask if they want to replicate paradigm.

How does one ensure balance between the multi-million dollar projects as the panacea for a presumed better life style in Kathmandu, and the Pandemoniums that exist within the capital's ring-road. Pollution of the Bagmati River, and the filth in the city, for example, are caused by known, but avoidable reasons, unregulted urban growth and resource uses. Surely debates and wisdom must,and would precede any decision.

Water development should take into consideration various ecological entities which are gradually loosing shape in the country. While meeting the growing water and energy needs of the people, the other side of development must not be forgotten. Preservation of soil and water, the two most precious natural resources, is in fact protection of human life. We have to hand over pure water and fertile soil to the future generations in the same way we received them from our ancestors.

Dr. Shree Govind Shah, Ecologist

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