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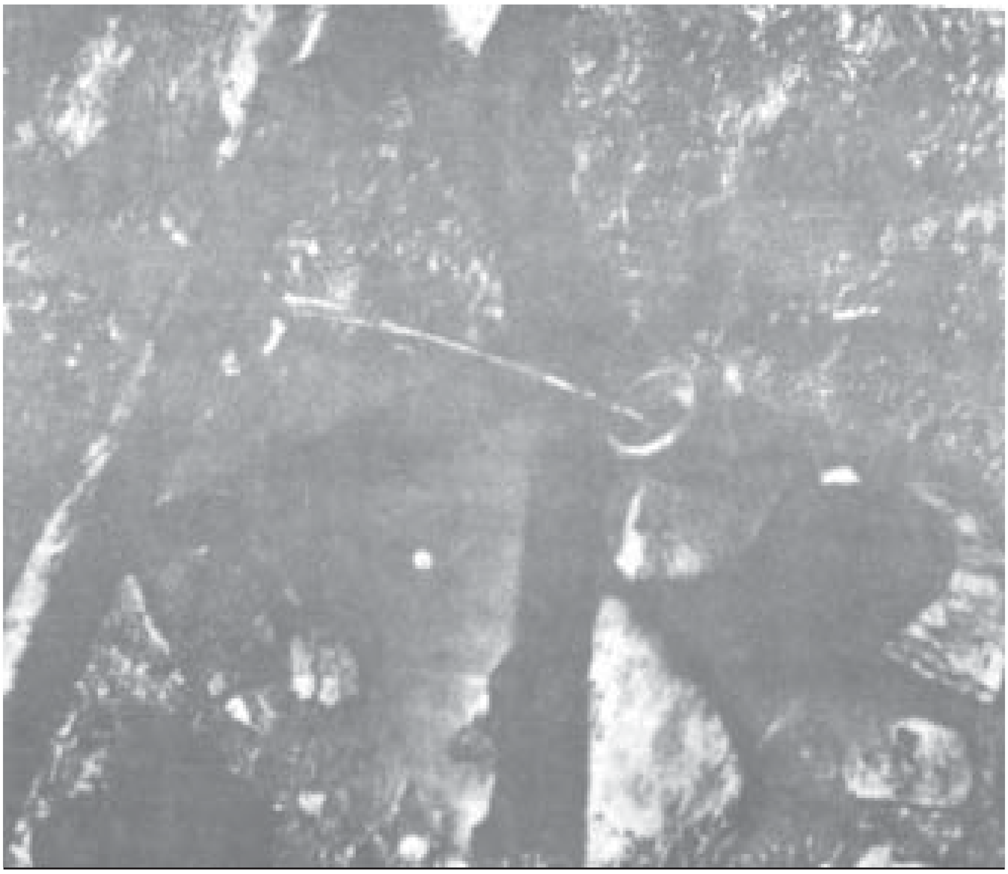
WATER DEVELOPMENT BULLETIN



IN THIS ISSUE

WATER NEPAL

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Water Nepal is published once in three months in English.
Water Nepal aims to function as a forum for sharing of experiences among technologists, engineers, and scientists engaged in different aspects of water resources development in Nepal. It is distrubuted among the institutions and individuals that are involved in development and management of water resources.
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A DROP NOT WASTED IS A DROP SAVED WATER IS LIFE. CONSERVE WATER

EDITORIAL

Human intervention in river system for water development changes its dynamics. The changes are unavoidable and have impacts, as the normal flow situations get altered. When confined to a microcosm, these changes do not create major disturbances to the natural system often, however, water development projects, especially with reservoirs cause environmental and social damages.

Siltation and riverbed erosion are two of the major environmental problems created by reservoirs storage of water can lower its quality and in a micro scale reservoirs induce climatic changes. Damming of rivers can disturb aquatic life cycle by changing of the river the environment. Storage projects, when submerge land, forces inhabitants to move away from their homes. People thus displaced are subjected to social and economical hardships.

Reservoir provides an ideal basin for sediment deposition. It changes the flow pattern in downstream river reach and devoid it of the previously flowing sediment. All reservoirs are provided with extra storage volume. Sediment inflow to the reservoir gets stored here without encroaching on the useable storage. Reservoirs will fill up in specified time period by sedimentation. As relatively sediment free water flows below the reservoir; the bed can be subjected to degradations.

Lack of silt can disturb the life system in river reaches, as the organisms that live on nutrients provided by silt die out. Dams also prevent migration of fish, and when water submerges land and / or forest areas, the natural habitat gets damaged too. Compared to economic benefits of a project, this loss of life system can appear insignificant, and may be over-looked. But studies have revealed intricate relationship between these bio-ecological processes and human life system. The processes have been found to be so complex that the effects of disruption of even small life system cannot yet be explained fully.

As land is acquired for different uses, including the area needed for reservoir, people get displaced. Together with land, resources such as grazing areas, fodder and fruit trees, local water supply sources etc., which constitute the basis of livelihood in rural areas also get affected. This disturbance in the life style of the affected families, today, is recognised as the most adverse social impact of water projects.

Dislocation of people from their traditional environment, in itself is serious. It has been made socially more stressful, because rehabilitation of the affected families have been carried out without understanding the real impact, dislocation has on peoples' lives. And all along it accepted philosophy has been 'Some one has to pay cost for the benefits of society' invariably those who paid belonged to the marginal economic strata, without education, entrepreneur skills and any exposure to development. Without appropriate rehabilitation measures, the affected families go through severe suffering, experiences indicate.

One of the rehabilitation approaches, compensating people for the property they loose by acquisition, for example has grossly under-estimated the problems associated with relocation. The approach has neglected the human factor of dislocation and treated compensation as a bureaucratic issue. Compensation amount thus provided was assumed sufficient to enable them to re-establish and better off than before. This assumption has been proved wrong.

Resettlement of the families, wherever implemented has also been afflicted by a series of drawbacks. As completion of the project becomes the overriding objective, rehabilitation of the affected families gets peripheral treatment in most water development projects. The processes are made complicated by ambiguous policies and unclear laws regarding acquisition /compensation. Administrative loopholes and inefficiencies, insufficient mandate, absence of inter agency co-ordination further compound the problems of resettlement.

Ideally, no one should be uprooted from where have lives. But, if, displacement in the larger interest of the society is unavoidable, then economic rehabilitation of the displaced population must be the main considerations, then economic rehabilitation of the displaced population must be the main consideration. Physical resettlement or compensation only has never been, and will not be the appropriate solution.

Today, as these adverse impact are understood better and every one in responsible position would agree that they do exist it is imperative to take measures to mitigate social damages and environmental disruptions caused by water projects. Undoubtedly, this necessitates an approach in which people become the major focus of development, and where any interventions become palatable to the natural system. Only wiser project implementations, which is backed by better understanding of the natural system, compared to insensitive approaches or condemnation of projects, can ensure sustainable water development.

REVIEW OF POLICY AND EXPERIENCES OF PROJECT RELATED RESETTLEMENT IN NEPAL

Dr. Harka Gurung

(*Water development projects, especially those involving reservoirs cause displacement of settlements. People displaced from their original homes are subjected to severe economic and social hardships, as experiences of different projects indicate. Social and anthropological studies of the would be displaced families, if displacement is at all unavoidable, and national experiences in resettlement are of primary importance to develop rehabilitation plans that would cause minimum hardship. Rehabilitation of population is however, extremely complex both in terms of its magnitude and nature. This article first reviews resettlement policies followed in Nepal over the different plan periods. If then compares resettlement/rehabilitation experiences of three environmental/water development projects in the country. The article should put the issues of resettlement related to development projects in proper perspective so that suitable policy guideline can be formulated.* Editor)

POLICY REVIEW

The resettlement policy of the government traditionally has been one of colonising the Tarai lowlands. This approach had little success until the mid-1950's due to endemic malaria. The period of 1955-1980, can be described as a phase of expanded land settlement much aided with malaria eradication Programme. Most of the settlers originated in the over populated hill districts. However, not all were spontaneous migrants to a new frontier. These included victims of natural calamities, political sufferers, repatriated families from abroad (particularly Burma) and some displaced by project activities.

The resettlement activities were entrusted to Nepal Resettlement company (established 1963) and Resettlement Department (established, 1968). The Company focussed on 10 locations with a more comprehensive Program including productivity increase for the settlers.[1] The department dealt mostly with management of encroachers on forest land and distribution of land made available through clear felling. Since its establishment, the company has resettled 18, 741 families on 35,070 hectares of land in the Tarai. The Department distributed 37,896 hectares of land to 53,542 families during the decade 1975-85. Another data of Resettlement Department indicates resettlement of 52,751 families on 27,074 hectares during the decade 1978/79-1887/88.[2]

The transfer of the two-resettlement agencies from the Ministry of Food and Agriculture to the Ministry of Forest in December 1977 can be best described as an

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Table 1
Land Acquisition and Resettlement in Three Projects

	Particulars	Rara	Kulekhani	Marsyangdi
1.	Purpose of acquisition	National Park	Hydro-electricity	Hydro-electricity
2.	Years of acquisition/resettlement	1978-1984	1977-82	1987-88
3.	Compensation option:			
	a. Land	Land only		
	b. Houses		Land or cash	
	c. Cash			cash only
4.	Property acquired:			
	a. Land (ha.)	106	175	60.5
	b. Houses	300	450	29
	c. Others		Water mill (50)	Fruit trees
5.	Compensation rate		Rs. 1,200 to 3,000 per ropani (1979)	Rs. 400 to 5,500 per ropani (1981)
	a. Average cost per family	-	US$ 2,900 (1979)	US$ 7,000 (1981)
6.	Affected:			
	a. Households	331	500	222
	b. Population	1,820	3,000	1,776
7.	Implementation agency	Nepal Resettlement Company	Electricity Department	Marsyangdi Hydro Development Board

exercise in conflict management. It was assumed that entrusting the resettlement responsibility to the Ministry that had jurisdiction over land to be settled, mostly to be first alienated from forest land would resolve the chronic problem of delay in land allotment for resettlement. The consequence, on the other hand, was a significant reduction in resettlement activities. The targets for families and land to be resettled for the Sixth plan (1980-85) was cut-back by 38.3 per cent and 50.0 per cent respectively compared to that during the fifth plan (1975-80)

The Sixth plan (1980-85) also introduced the ides of non-farm resettlement. One specific program for such resettlement was proposed for Dhankuta district but was later dropped due to lack of water supply and opposition of the host population. Feasibility studies in non-farm resettlement have been carried out in Jhapa, Nawal Parasi and Kanchanpur but there has been no program formulation so far. The current Seventh Plan (1985-90) has adopted an entirely new policy approach whereby there is no provision for land settlement based on agriculture.[33] The plan emphasises non-farm resettlement and also entrusts government agencies whose projects and programmes cause population displacement.

Meanwhile, the problem of forest land encroachment has increased considerably. Some estimate that squatters in government forest land exceed 50,000 households. These have all the potentials of a Sukumvasi (landless) movement.[4] Thus, in 1986, the government appointed 13 political commissions headed by a Rastriya Panchayat member to supersede the 10 regional offices of the Resettlement Department in order to deal with the illegal settlers. There has also been a significant organisational change. In early 1988, both the Resettlement Department and the Nepal Resettlement Department were transferred from the Ministry of forest to the Ministry of Housing and Physical Planning. Subsequently, in late 1988, the Resettlement Company was dissolved and Nepal Resettlement Company retained under Ministry of Housing and Physical Planning. These recent policies orientations had two negative effects. The moratorium on land based settlement has aggravated the squatter problem with various political implications in the future. And the frequent organisational tampering has paralysed the operation of the resettlement agencies.

PROJECT – AFFECTED RESETTLEMENT

The sequence of policies from one of basically land-based to non-farm resettlement referred above do not fully address the problem of project-affected resettlement. The following three cases of resettlement/ rehabilitation of the popu lation displaced by projects reveal diverse approaches. The examples include one national park and two hydro-electric projects. It is significant that each had a different compensation option: land-for land (Rara), land or cash (Kulekhani) and cash only (Marsyangdi). The agencies implementing the resettlment / rehabilitation operations were also different in each case (Table 1).

i. Rara[5]

When the area around Rara Lake (Mugu district) was gazetted as a National Park in 1978, the entire villages of Rara and Chhapru had to be vacated. The affected 331 households were compensated with land in Bardiya district in the Tarai. The rate of land compensation was set at 1 ha of hill, for 1.3 ha of Tarai and 0.7 ha for those having more than 1.3 ha but with a ceiling of maximum 2.0 ha.

The affected households were also provided with the following additional facilities:

- Air-lift of people by Nepal Food Corporation charter plane.
- Air-lift of materials by Royal Nepal Army plane
- Timber for house construction from Forest Department
- Rs. 240 per household for buying thatch grass for roofing
- Rs. 3 per person until April 1979; followed by food aid from WFP for 18 months. Provision of tube-well and school.

The original site of their resettlement was three locations at Motipur (Satabariya) in Bardiya. The number of households settled was 267 in 1978 and 289 in 1979. Soon after, the majority of 200 households deserted their land complaining of poor soil and lack of irrigation. These households moved to Chisapani and Gabhar north of Kohalpur of their own accord and were followed by others. The Nepal Resettlement Company continued to support the activities at the new location including provision of water supply. The number of households resettled in Chisapani ranged from 292 in 1980 to 331 in 1983. As of 1987, the 331 households had been given 373.2 ha. of land of which 222 households had not yet collected their land registration document.

A field visist of Chisapani in January 1989 indicated that those dislocated from Rara and Chhapru were much better-off economically support provided during the transition was multi-sectoral. The improvement in their livelihood must recognise the marginal productivity of their mountain environment in contrast to better land and other economic opportunities along the Kohalpur-Surkhet highway in the Tarai.

ii. Kulekhani

The Kulekhani Hydro-electric Project acquired about 175 hectares of land that affected about 450 households with a population of 3,000. The affected households were given two a options: cash compensation or land elsewhere. Most opted for cash compensation Land compensation was based on the quality of land according to cadastral records. Thus, a few who had earlier manipulated records during the cadastral survey for lower land tax received less compensation than their real land value. Compensation was also given for 450 houses and 50 water mills. But fruit trees, bamboo bushes and fodder trees that make the base for rural living were not considered.[6] A socio-economic survey indicated that the compensation was not at the prevailing market price nor the permanent loss of potential resource loss of production considered.[7]

The immediate effected of cash compensation was a 4 to 5 times increase in the price of irrigated land. Price escalation had its repercussion in Hetauda also, the nearest town which the affected had considered for resettlement. Those moving to Hetauda could afford only the poor marginal land south of the town. The availability of sudden cash also had adverse sociological effect on certain ethnic groups, particularly the Tamang.

Overall, the Kulakhani experience leads to three observations First those with large cash compensation in lieu of their ownership of better land and larger houses gained most as they could establish new enterprises. The marginal households with poor land received less compensation and were adversely affected. Second, the land-for-land option was not considered seriously both by the project and the affected households. Third, majority of the affected households had becomes poorer than before the land acquisition. This has relevance not only on the mechanism of compensation devised by the project but also to the regional development context. Unlike the case of the Marsyangdi area where the Prithvi Rajmarg and the project have created new economic opportunities, Kulekhani area, particularly Markhu, has lost its previous advantages of being on a high road due to the damming of the access route to Kathmandu.

iii. Marsyangdi

The Marsyangdi Hydro-electric Project acquired 60.5 hectares of land. This affected 222 households with a population of about 1,800. About 36 per cent of households lost a quarter to half of their land through acquisition. Number of households left with less than 5 ropanies was 29, including seven who lost all land through acquisition. Majority of those loosing all their land belonged to the occupational caste. In addition, 29 housing units were also affected by acquisition.

Compensation was given only in cash although a few had asked for land as compensation. Rates of compensation paid were close to the market price. But most were dissatisfied as the land acquired beside the highway were valued according to its area rather than their real value in relation to the linear foot fronting the road. The majority had no legal knowledge of their right to lodge complaint. There is evidence that later acquisitions offered better rates and this led to dissatisfaction among those who had been given lower rates earlier. No land had been acquired through negotiation despite existence of such a legal provisions. Some land had been used on lease though. Fruit tress also had been compensated but the valuation was considered on the conservative side.

Despite the time lag between the process of land acquisition and field survey, 78 per cent of the affected households could be contacted within the project area.[8] This indicated that only a few households had out-migrated from the area despite number of hardship cases. The project consultants had earlier recommended 15 per cent disturbance allowance, special assistance to hardship cases, priority for employment on the project work and assistance to increase production on remaining land.[9] None of these were implemented by the project. The project had indirectly generated employment, particularly in the project. The project had indirectly generated employment, particularly in the service sector catering to nearly 3,000 work force a day at the beginning and about 600 persons a day later. However, the project affected households seem better-off not because of any deliberate rehabilitation assistance by the project but due to the new economic opportunities along the highway around the burgeoning township of Abu-Khaireni.

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SOME RECENT EXPERIENCES IN DEVELOPMENT OF SMALL SCALE HYDROPOWER

Dr. Dagfin Lysne

(*The design of small-scale hydropower projects is difficult because the cost of civil engineering components, excluding that of the powerhouse vary considerably depending upon specific site conditions. Projects of these categories have limited funds for implementation that prohibits detailed investigations and designs. Therefore, experiences have to be brought in to compensate for the lack of funds for thorough investigations and designs. A methodology for identifying small-scale hydropower projects and their priority listing for implementations is proposed. The author also argues that classification of hydropower projects according to their investment costs could be an approach, which would be understood by most, even though it may not be the correct way.* – Editor)

INTRODUCTION

Several attempts have been made to define different categories of small-scale hydropower projects by their installed generating capacity. The attempts failed, however, for rather obvious reasons. We may compare two projects, one with a head of 200 m and a discharge of 3 m^3 /s and the other with a head of 20 m and a discharge of 30 m^3/s. Both will have installed capacity of approximately 5000 kw, but will otherwise be two very different projects.

A different approach is to identify projects according to the ranges of investment cost. This may not be an obvious approach for engineers (the author being one). But this can be an approach, which would be easily understood by most people and decision-makers.

So projects may be categorised in the following ranges of investment amount, all based on international cost level.

Category	Cost in million US $
1	3
2	3 to 15
3	15 to 75

Category 1 represents rather small projects, normally with an installed capacity of less than 1000 kw, but more likely around 500 kw. Planning and design must to a large extent be carried out at site.

Category 3 is normally referred to by the author as medium sized hydropower projects and may cover the range of installed capacity from approximately 10,000 kw to 75,000 kw. This assuming of course, that the projects are assessed according to normal economic viability criteria. Many recent projects in this category, which have been developed as run-of-river projects, have proved economically very favourable when connected to an existing grid, i.e. the hydroelectric energy is mixed with thermal energy.

Assuming that the over-all engineering design cost of projects in this category should stay within 10 to 15 per cent of the investment cost, then the total cost of the projects will include the necessary funding for proper planning, including geological investigations, hydraulic model studies, etc.

Category 2 projects have installed capacity between 100 to 10,000 kw and range of investment cost. The author finds these projects most interesting and tends to refer to them as small-scale hydro. The funding to cover engineering design cost of these projects is limited (must be kept within given limits in order not to make the project uneconomical).

The shortage in funding therefore, must be replaced by experience, A working procedure for the engineering design, though probably not very practical, could be to bring a team of (two or three) experienced water engineers to the site. The team should carry out the planning and preliminary design of the project at site and leave only when are complete!

RECENT EXPERIENCES

The planning of small-scale hydropower is an engineering challenge, sometimes more so than for large-scale projects, The time input for planning must be kept to a minimum,

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while the basis for decision-making must be established, and technically and economically sound plans developed. Recent experiences from the so far limited number of small-scale hydropower projects built in developing countries show the importance of these planning criteria. To many projects have come out with costs far exceeding the expected and some projects have developed comparatively serious operational problems within the first year of operation.

The most recent experience from a number of small-scale hydropower development programmes has revealed certain areas where improvement is possible and necessary. Important areas in this respect are:

- Technical planning with emphasis on civil works
- Cost and viability assessment.

CHARACTERISTIC CIVIL ENGINEERING FEATURES

Small-scale hydropower development have to be tailored to the river characteristics and local site conditions. Most small-scale hydropower projects involve moderate sized units which require a reasonable head. Thus most projects are found in relatively steep rivers. Locally the river slope should preferably be steeper than 1:15, otherwise the overall cost may become too high. Intake arrangement and construction of waterways along steep mountain valleys with tropical vegetation and overburden in most cases represent significant cost items. Figure 1 shows a common layout for a small-scale hydro project.

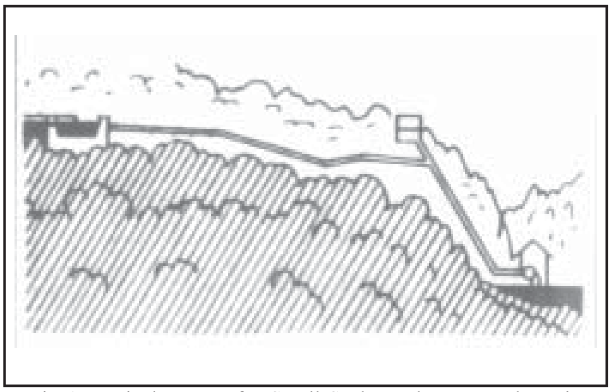

Fig 1: Typical Layout for Small-Scale Hydropower Plants in Mountain Regions.

Recent experience from projects such as indicated in Figure 1, is that serious problems have developed with respect to adequacy in design of intakes, headrace, and sometimes, penstocks.

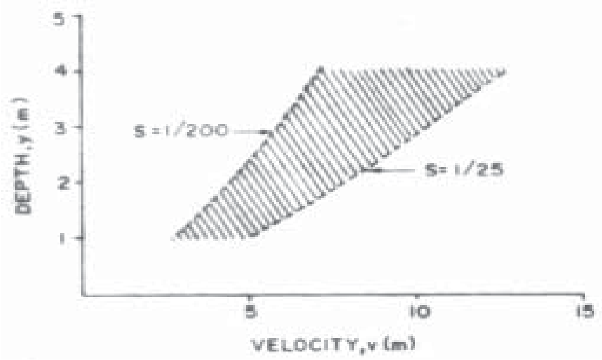

Figure 2: Characteristic Range of Velocities in Mountain Rivers.

INTAKES

The characteristic average slope of mountain rivers may vary from 1:25 (steep rapids) to 1:200 (moderately super critical flow at flood stage) The corresponding of velocities is shown in Figure 2

These rivers have an ability to transport rock in addition to finer material as illustrated in Figure 3

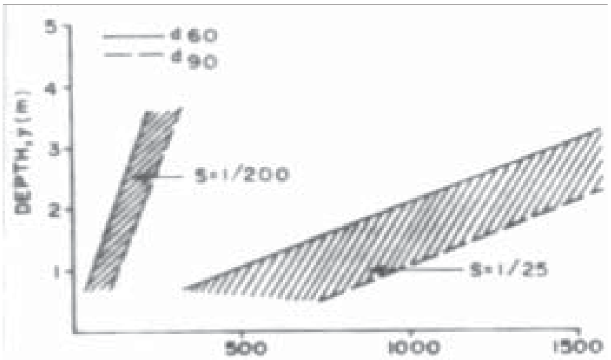

Figure 3: Rock Size versus Discharge and Water Depth in Mountain Rivers.

Mountain rivers thus have high sediment transport capacity. Normally, therefore the sediment transport volume is determined by the sediment yield from the catchment. In mountain areas with tropical vegetation and overburden, the sediment yield normally varies in the range of 200 to 2000 tonnes/year. Intensive human activity increases local scour leading to landslides, causing increased sediment yield and particularly increased rock transport.

Some characteristic features of the design of intakes are:

Major storage reservoirs normally prove to be too costly, while operate size reservoirs will fill up with sediments in a relatively short time and will thus be rendered useless. The possibility for maintaining a few hour pounding for optimum operation at low flow should be considered. However, the following should be observed:

Flushing of some of the intake pond should be provided if technically possible.

Sand exclusion is necessary to avoid excessive wear on the turbines. If feasible, flushing of the sand excluder should be possible without interruption to the operation of the power plant.

WATERWAYS

The type of small-scale hydropower plant indicated in Figure 1 normally combines relatively small discharges with medium to high heads. The size of the headrace conduit is thus relatively small, It must be placed along the steep hills where the topographical and geological conditions tend to create problems with respect to access, construction and maintenance. The headrace, therefore, represents a significant cost item and as such affects the economic viability of the project. Furthermore, the headrace conduit is frequently subjected to damages due to erosion, slides or rock fall.

The headrace may be either an open channel or a closed conduit. The conduit may be either a pipe (non-pressurised or moderately pressurised) or a tunnel.

Open channels are not recommended in steep hillsides, as the channel will fill up with debris and sediment from surface erosion. Crossing of creeks and gullies is costly and a channel offers no flexibility in the vertical alignment. Also channel reaches can get damaged by landslides.

The layout shown in Figure 1 is with a moderately pressurised headrace conduit and with surge tank (if necessary). This layout has the advantage of flexibility in vertical alignment and the size of pipe can be determined according to minimum cost criteria, i.e. velocity in the range of 3 to 5 m /s.

Many engineers prefer a design with a forebay, which then replaces the surge tank. In the authors' opinion this design has too many disadvantages.

DEVELOPMENT COST AND COST SENSITIVE COMPONENTS

Development cost data for small-scale hydro projects are available from different sources. Thus, it is possible to split the investment cost of components. The result can new summarised as follows:

a. The variation in cost for electric-mechanical equipment is very small, i.e. when the head and discharge is known, then the cost for electric-mechanical equipment can be determined with good accuracy.(within ± 10 per cent).
b. Like wise the cost for the powerhouse does not vary much. Given approximate installation, the actual cost for the powerhouse can be determined within ± 20 per cent.
c. The wide variation in the cost of civil works (power house not included) represents uncertainty when trying to make an early appraisal of a potential hydropower project. For each individual project the effort must therefore, be focused on studying the physical conditions and associated costs for civil works.

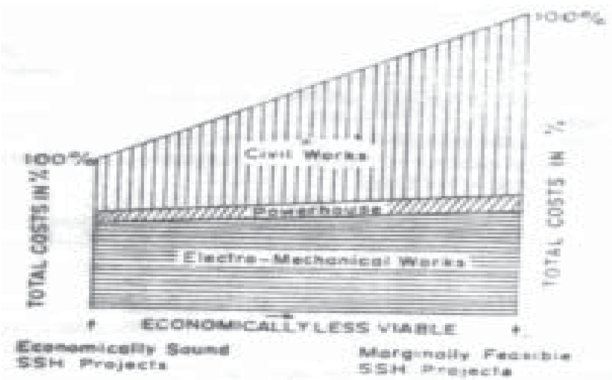

Figure 4: Cost Characteristics for small Hydro Project.

The variation in development cost for the main components is shown in Figure 4. None of the projects in the analysis include reservoirs, as provision to meet peak demand or forecasted future demand proved to be too costly.

CONCLUDING COMMENTS

The normal working procedure, also for small-scale hydro, is to start the preliminary studies and screening of possible project by technical investigations. Then cost estimates are established and economic analysis come out to reach conclusion/recommendation.

When dealing with small-scale hydro projects one known beforehand that the problem will be to keep the cost to within acceptable limits. There is thus a need for suitable methodology for efficient screening of none viable projects.

The following procedure may be worth considering in this respect:

a. Establish criteria and calculate acceptable energy cost.
b. For the area (district, region or country) of concern, make a desk study based on available maps (1:50.000) and/or aerial photographs and available hydrological data.
c. The result of the desk study will be listing of potential sites with approximate head and discharge. The cost estimate for electric-mechanical works, powerhouse (and grid connections) are thus easily determined without carrying out any design work.
d. The desk study reveals the acceptable cost for civil works at each site. With this information at hand a small team of experienced engineers can go to the field to assess the cost of civil works. i.e. intake arrangement, waterways, access road and miscellaneous cost items. Also, if necessary, check on transmission costs can be made.
e. As small-scale hydro projects are located within a rather confined area, an experienced hydropower engineer will be able to make a good assessment of the civil engineering cost based on field inspection.

Hopefully, the result will be a relatively reliable screening and priority listing of promising hydro projects. Appropriate strategies may then be chosen with respect to necessary field investigations, establishing project plans and finally construction of the project.

COMMUNITY WATER SUPPLY PROJECTS COMMUNICATING WITH THE BENEFICIARIES

(Communication with the beneficiaries is one of the most important aspect of water supply development programs. This article by an American volunteer, who worked in water supply programs in Nepal recounts a few points to be kept in mind for this purpose. Though originally intended for volunteers, these thoughts would be useful to everyone involved in water supply programs. A slightly edited version of the article is presented.- Editor)

The role of a technician in water supply improvement programs involves much more than he merely being a good technician. Thorough and accurate surveying, designing and cost estimation of a project is but the first step towards a successfully built water system. The major task of a technician is to use the technical informations and transform paper theory into, quite literally, concrete reality. Whether or not he can do this depends directly on his ability to successfully and meaningfully communicate with the villagers. He following thoughts may be value to technicians in helping them establish rapport with villagers.

1. Since the technician will most probably be the only person in the entire village with an idea of the system he will build, he will be called upon to lucidly explain almost every detail of construction. This obviously necessitates the technicians possessing a fairly specialized knowledge of the system. This however, is only not enough to communicate what needs to be done. He must look beyond the technical terms and attempt to see the task as the villager do. When the villager thinks of how long, wide or deep, a tank is going to be, he is not thinking in terms of feet, but rather in terms of arm’s length. A villagers has no idea of how much sand or gravel to bring, if he is told to bring ten cubic feet, but he does understand X number of biscuit tins, burlap bags, or patis, Specialized knowledge is essential, but so is a

strong imagination.

2. It is very easy for a technician to assess the progress of the water project solely in technical terms; what may seem to be an excruciatingly slow work, pace or minor accomplishments, may be, and in fact are, normal speed and major accomplishments for the village situation. A major goal of the drinking water supply program is to introduce the concept of development to villages where community projects work and the changes brought in life patterns are constantly keep this in mind, if he is to keep his sanity and attain a sense of accomplishment. A strong sense of perspective is essential for this work.
3. The organization of work is a critical factor in the successful implementation of the water projects. The technician has to develop an ability to assess individual construction tasks in terms of actual number of people necessary to do the job. If he requests ten people for a job that only requires five, he is simply wasting the villagers' time who will soon grow to resent this and will lose confidence in him. If more people are available than a job requires, the technician should never just create "busy work" to utilize all of the people. Villagers are very quick to see through "busy work" situations and will stop coming to work if this situation prevails. The organization of work will very greatly from village to village, depending on many divergent factors such as the availability of materials, skilled labour, the planting seasons, feasts, and prevailing weather conditions. The technician must constantly be aware of these changing conditions and organize accordingly.
4. In organizing the project and helping the villagers visualize it, a good approach is to develop a plan of action in paper with the villagers help. This gives the villagers an opportunity to use their imaginations, to appreciate in the abstract certain problems that may arise, in other words, to take part in the planning process. This may help in developing among the beneficiaries a feeling that the system is theirs.
5. It also probable that the villagers may not understand how the technician has conceived of the organization of the project. Therefore, in some cases it is best to do it in the village way – even though it may seem inefficient. It is also important that the villagers have a part in things and feel they ate contributing to the project and its eventful completion. Certainly, this will have less of a chance of happening if they cannot grasp the order of the project.
6. Honesty is needed and technician must listen to what the villagers have to say.
7. Progress on any particular project, especially the early parts of administration and planning may take quite a long time. This should not be allowed to developed into procrastination.

By the way of summary, it is again emphasized that the main job of the community drinking water supply development program is that of human inter-relations. The ultimate success or failure of the program depends, not so much on technical expertise, as it does on meaningful inter-personal relationships. It is unfortunate that the words "technician" and human being have grown to have separate connotations. The role of a drinking water supply technician lies in the reconciliation of these two terms, and his success can be judged by how well he resolves this dichotomy.

AN ANALYSIS OF SEDIMENT MOVEMENT IN KALI GANDAKI RIVER, NEPAL

Sunio Matsuura

(Analysis of sediment movement in rivers provides information of land use changes in river system. These informations provide a basis for formulating rational watershed management plans. This paper highlights the nature of sediment movement in the mid land reach of Kali Gandaki River. The division of the river system into stable and unstable regions north and south of the Himalayas is evident. The author emphasises the need for detailed study of tributary river systems in the southern part. The survey work for this study was carried out by the author in 1978. –Editor)

INTRODUCTIONS

More than two third of Nepal's area is occupied by mountain and hills. For the past few decades, the population of the country has been growing at a very fast rate. This has led to serious shortages of agricultural land, which has forced people to create farmland in steep mountain slopes. Forest in the hill slopes is getting depleted at a very fast rate, which has caused problems both in the upland and the tarai. The pressure of population along with topographical features such as deep valleys, steep mountain folds, extreme precipitation and geological weaknesses as due to orogenic movements have been rapidly devastating land resources in the country. Rivers inter relate upland and lowland areas. River characteristics such as bed material, and sediment load should be analysed to understand how rivers responds to the changes in land use condition. Also, parameters to serve as link in the chain of sediment movement and flow, to be used in catchment management practices should be defined. The objectives of watershed conservation activities are to minimise accelerated erosion from land surface and alleviate flood problems. This study in the Kali Gandaki river has been carried out to understand the movement of sediment in the river so that the knowledge gained would be useful for formulating suitable conservation plans.

RESEARCH AREA DESCRIPTION

Kali Gandaki, as an antecedant river, has its fountain head in mid western Nepal, near the Tibetean border (Figure 1) The river traverses the great Himalayas and along with its sister tributaries joins the Ganges at the Indian plain.

Figure 1: Survey Route and Sampling Points

The upper reaches of Kali Gandaki valley is a separated in to two parts; southern and northern regions, at the deep gorge where the river crosses the Himalayas. The climate geology, vegetation and distribution of glacier are completely different in these two regions Figure 2 Longitudinal Profile of Kali Gandaki Valley, Topography and Geology Division Map.

RESEARCH ITEMS

Grain size distribution of bed materials in the Kali Gandaki river was measured during the survey. The trend of the main stream width and gradrent of the riverbed, were also measured. Randomly selected sampling points along the survey route were set at every 5-km. The survey route and

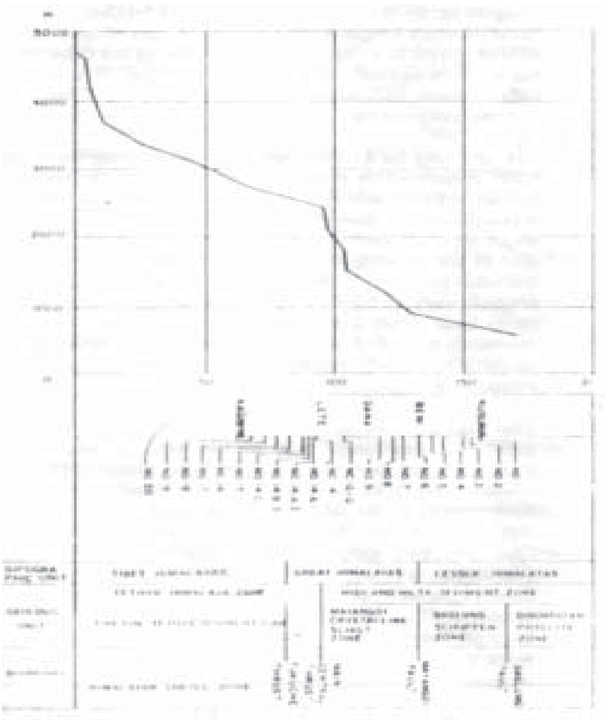

Figure 3: Relationship Between (a+b+c)/3 and (a+b)/2

sampling stations are shown in Figure 1 and the survey results are summarised in Table 1.

RESULT OF MEASUREMENTS

Three axes of the bed material, the long radius (a), the median diameter (b), the and short radius (c) were measured to analyse distribution of the sediment size. If it was not possible to measure all the three dimensions, only the long radius (a), and short radius (c) were measured. The mean of three axes measurements and that of the two axes were calculated. These were plotted as shown in Figure 3.

When the mean of the two and three axes were equal, they overlapped along the line y = x indicating good correlation. In such cases, it would be possible to deal with the data by using the mean of the two axes only. As every sampling point coincided comparatively well, it was decided to use the mean of the two axes. The standard deviation and mean sediment size at every sampling points are summarised in Table 1

The research area as explained earlier, was divided into two regions considering the differences in their

Table 1
Result of Measurements at sampling points

No.	L (km)	B (m)	ϕ (')	N	N1	N2	N3	D(cm)	O(D)	Y	F	Vc	Qc	Qb/B
20	0	15	0.5	100	76	24	64	4.8	2.1	0.69	0.52	1.1	13.2	0.9
19	5	25	5	97	48	51	39	5.5	3.5	0.74	0.61	1.1	1.5	0.9
18	10	20	0.5	99	6	31	57	4.8	2.9	0.6	0.52	1.1	10	0.8
17	15	20	0.5	100	58	41	3	19.6	12.5	0.61	0.52	2.2	60.7	4.1
16	20	20	0.5	101	50	51	38	5.5	3	0.68	0.5	1.1	12.1	0.9
15	25	20	0.5	104	62	42	40	5.4	2.8	0.69	0.54	1.1	10	0.8
14.C.1	26	-	0.5	232	94	105	91	4.9	3.5	0.67	0.53	1.1	-	-
14.B.3	26	20	0.5	100	56	43	24	5.8	3.1	0.62	0.45	1.2	11.6	0.9
14.A.3	27	-	0.5	100	47	53	20	4.3	2.2	0.74	0.64	1	-	-
14.A.1	29	20	0.5	100	56	37	54	4	2.3	0.71	0.56	1	0.1	0.6
14	30	15	0.5	100	78	22	57	4.7	2.4	0.65	0.45	1.1	7.6	0.8
12.G	43	30	1.5	100	77	22	30	31.2	22.4	0.7	0.53	2.7	265.2	29.4
9	55	25	1	69	53	15	7	57.5	41.6	0.76	0.67	3.7	434	42.4
8	60	25	1	67	63	3	10	34.2	42.8	63	0.42	2.9	187	16.1
7	63	20	2	58	47	11	11	80.5	70.3	0.7	0.53	4.4	787.2	169.5
6	70	20	1.5	52	52	0	23	49.9	37.1	0.66	0.49	3.4	356.4	58.9
5	75	40	0.5	64	41	23	4	47.8	29.9	0.79	0.68	3.4	308	6.8
4	79	40	0.5	56	51	5	6	40.1	27	0.7	0.47	3.1	256	5.9
3	8	40	1	60	59	1	18	27.3	17	69	0.55	2.6	224	12
2	90	35	1	53	48	4	0	77	62.3	-	-	4.3	820.8	47.5
1	93	40	0.5	67	53	12	0	50.7	68.8	-	-	3.5	331.2	7.2

environmental conditions; area north of Lete and region south of Late i.e. sampling points 13 and 14. By using Strenberg's abrasion formula of sediment transportation, abrasion parameter, C, for each region was calculated from the grain size (diameter), and also from longitudinal slope of the river. The result showed that, C, from diameter of rocks, which are dominant in the region, and gradients were almost similar. In the southern part of Lete, however, the value of C, calculated from above factors were different.

Attempts were also made to estimate shape factors such as flatness ratio, F, and spheriuty Y of the sediment. These factors are useful for the study of distance of sediment from source, type of mother rocks, settling velocities and transportation of sediments. Table 1 shows that F and Y do

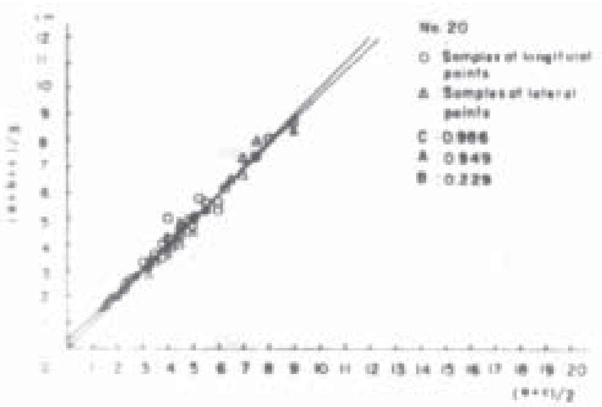

Figure 3: Relationship between (a+b+c)/3 and (a+b)/2

not vary much in the two regions, but standard deviation of the diameter is smaller in the northern region.

Considering the mean diameter and the standard deviation as shown in Fig. 4, it can be assumed that Lete plays the role of a the dam. The riverbed rises at Lete, where the flow is also shower. Kali Gandaki upstream of Lete behaves like lower river reaches, while the river reach south of Lete behaves like upper reaches.

The amount of bed load transported by a river also provides an understanding of its behaviour. Bed load in the river was calculated from the grain size, bed slope and width with following order of calculation

Critical velocity (Vc) —> critical depth (Hc) —> Critical rate of flow (Qc) —> Quantity of bed load per unit width (Qb/B)

Bed load thus calculated at each sampling points are summarised in Table 1.

CONCLUSIONS

It can be thus concluded from the study that Lete area acts like a natural dam. The river behaves differently before and after Lete. In the upper part, the bed materials have

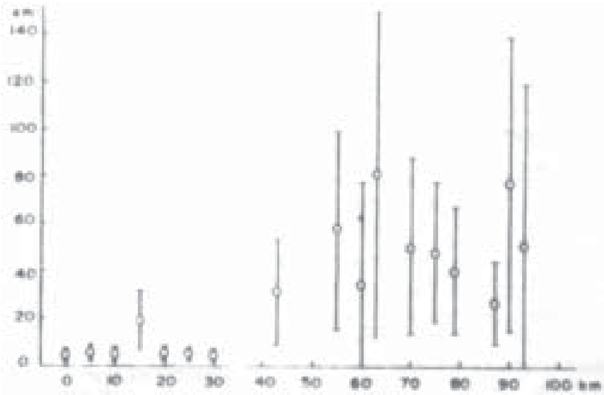

Figure 4 Mean Diameter and Standard Deviations.

equal diameters, sphericities and flatness ratios. Flow is unstable in this reach with possibilities of river meandering, as the bed is composed of sand and conglomerates. The similarities also indicate that the change in environment has relatively small influence in the northern region and that geology is also homogenous. It is however, possible that flow very high tractive force is likely to occur as No. 17 indicates Figure 5.

In the southern part, the standard deviation of the grain diameter is widely scattered as already shown in Figure 4. This indicates that the river bed is composed of mixture

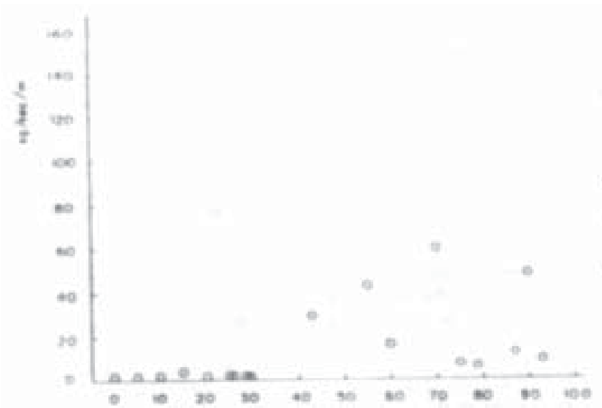
Figure 5: Bed Load per Unit Width at Each Sampling Points

of rocks, boulders, cobbles and gravels. The flow also becomes voilent during floods.

The terraces in the river bank have progressed as a result of the upheaval movement of the crust surface. Vertical and side erosion are frequent in these regions. As a result, the river banks have been severely deteriorated. Also, the distribution of glaciers is concentrated in the southern side of the Himalayas, where glacier erosion is extensive. The region further consists of small to medium fault belts. As a result sediment production is very high and also transferring to lower reaches occurs immidiately.

Lete area also forms the boundary between the stable and the deteriorated part of the Kali Gandaki valley. The reasons can be attributed to orogenic and crustal movements. Another reason could be the effects of high differences in precipitation between the northern and southern side of the himalayas. Rainfall on the southern side is very high, while the northern side, which lies in the rain shadow receives very little rainfall.

Two conclusions are drawn from this study

a) The northern part of Lete is stable
b) In the souther part, the effect of environmental factors such as precipitation (flow rate) and glaciers are extremely high. It is therefore, necessary to lay a detailed plan for each tributary of the river

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RIVER AND RAJIS

Jagat Basnet

"We can survive without our ferrying occupation which has been adversely affected by the two suspension bridges built at Jamu Kuine and Thika Kuna. But we can not survive on taps or spring water. We sleep in sand in the river band, live with fishing net on rivers." This was the collective concern expressed by the Raji community to us when I as a member of New Era team, was collecting information for the socio-economic study of the households that would be affected by the reservoir created by the proposed Karnali Chisapani high dam in western Nepal.

Rajis seemed to have special attachment with rivers. Though the settlements are located in river terraces, their economic life depended mainly on river environment. They hunt, fish collect yams and tubers, and ferried people across the Karnali and Bheri. River also seemed to have very important role in their social life. Marriages are sometimes solemnised on river banks. The couples to be married take a dip in the river holding each other's hands. This practice though universally not followed is believed by the Rajis to have same significance as sindoor (Vermillion on Hindu wife's forehead) has among the Brahmin and Chhetri communities. " Our open roomed house offer very little privacy, especially when we have a joint family system. Married couples sometimes spent night in the river bank" the Rajis confide.

The Rajis are fishermen community living on the banks of the river Karnali and Bheri,. Though their leaders, who are locally, called 'Gauru,' claim that they have been living along rivers for centuries, it is believed that they originally were nomads. Rajis were introduced to farming when they came in contact with the people from upper Karnali, who started moving down some twenty-five years ago. Settlers brought with them agricultural skill. Rajis were not attracted to agriculture and depended mostly on fishing. They however, soon learned that agricultural produce like mustard, chilly, and lemon made fish tasty to eat. They also developed a bartering system with the new settlers. The changed food habit induced some of them to hold land, and start farming activities in a limited scale. Rajis did not like to be regarded as farmers, and it appeared to us that they prefer to maintain their nomadic reverie life style.

Rajis seemed very worried that they would be taken away from the river side and asked to resettle else where. Their collective demand was "If we are all going to be resettled, then it must be at the bank of a big river."

Deputy Research Officer New Era Kathmandu

BOTTOM RACK INTAKE IN MOUNTAIN STREAMS

Kamlayan Shrestha, BE, ME

(Abstract: Development of intake structures in streams in mountain regions is difficult because of unstable nature of the rivers Bottom rack intakes can be built to suit these conditions, and when designed and constructed properly, can reduce operational problems. This paper highlights the use of bottom rack intakes in small-scale hydropower projects in Nepal. The design aspects and limitations of the intake are also discussed.)

INTRODUCTION

Extraction of water from rivers for power generation, irrigation or water supply development requires an intake in the river. In mountaineous stream, a number of factors affect the selection of a particular type of intake and its location in the river. A major problem is caused by the watershed and river conditions.

These problems in the small-scale hydropower projects implemented in Nepal over the last ten years have been addressed by selecting bottom rack type of intake. While the considerations for locating this intake in river, are almost same as that for any other type, special attentions are needed in the design of the intake system. It is also important to construct the intake according to the designs, so that operational problems are reduced and maintenance needs are minimised. The names of the small-scale hydro projects built in Nepal, which have bottom rack type of intake are listed in table 1

Table 1
Bottom Rack Intakes in Nepal.

Sn.	Projects	Capacity Kw	Catch Area Km^2	Flow m^3/s Designed	Flood
1	Khandbari	250	121	1.20	544.0
2.	Bhojpur	250	60	0.55	350.0
3.	Taplejung	125	42	0.40	280.0
4.	Rammechap	75	15.6	0.20	150.0
5.	Bajhang	200	103	0.74	350.0
6.	Serpodaha	200	40	0.11	150.0
7.	Jumla	200	30	0.30	
8.	Helambu	50	6.2	0.15	46.50
9.	Bajura	200	27	0.11	100.00
10.	Manag	80	46.5	0.39	68.00
11.	Okhaldhunga	125	16.5	0.55	155.0
12.	Namchebazar	600		0.38	
13.	Tatopani	2000	213	3.60	1400.0
14.	Accham	400	255	2.20	570.0

12 and 14 under construction

WATERSHED AND RIVER CONSITION

All the projects listed in Table 1 are located in middle mountain regions of the country. The rivers have small drainage areas, and their watersheds, like rest of the country, are subjected to climatic variations. Also, the landscape is undergoing gradual changes due to deforestation. The prevailing physical conditions and the pressure of population have greatly aggravated the problems of soil erosion landslides.

These watersheds have high runoff response, which create significant, stream flow variations. Rivers are generally narrow, steep, and flow velocity during floods can go as high as 3 to 5 m/s. In the generally narrow section of the river in the hills, this variation in discharge can result in wide fluctuations in water levels. The transporting capacity of the rivers is also high and carry sediment mass both in the form of suspended and bed load.

In any river, if the input of sediment into the reach balances the output over a period of time, it would be in a semi state of equilibrium. If the sediment input exceeds the output, the river becomes unstable. The bed of an unbalanced river can either rise or fall, and the river also moves laterally.

These hydrauic regimes greatly complicate the methods of extracting water from mountaineous streams. Improper selections of intake site and the type of intake in such circumstances can lead to malfunctioning, of the intake itself, river training and desalting works, cocking of water conveyance systems, and even damaging of the turbines. These problems are more evident in case of a side canal intake, in which the fluctuations in water level also causes difficulties as the operating heads vary greatly.

BOTTOM RACK INTAKE

An intake should permit extraction of water from a river at its all flow stages, while excluding major portions of sediments from getting into the conveyance system. Bottom rack or the Tyrolean intake, as it is commonly known, appears to be suitable for mountaineous streams. The intake is particularly suitable in rivers having slopes in the ranges of 1 to 10 per cent. It can also be constructed in rivers having slopes greater than 10 per cent.

LAYOUT

The bottom rack intake Figure 1 consists of a low head weir (1) constructed across the river. On top of this weir, an intake gallery (2) is provided. This gallery is sloped towards a riverbank and is led to an intake chamber (3), which is provided with sluice operators (5,6) to regulate the flow system. The intake gallery is covered on the top by bottom rack bars (4). Spaces is left between each bottom bars, and are installed in an inclined position towards the direction of flow.

As water flows over the weir, it passes through the space between the bars. Flow occurs partially during dry periods where as during floods, full flow occurs through

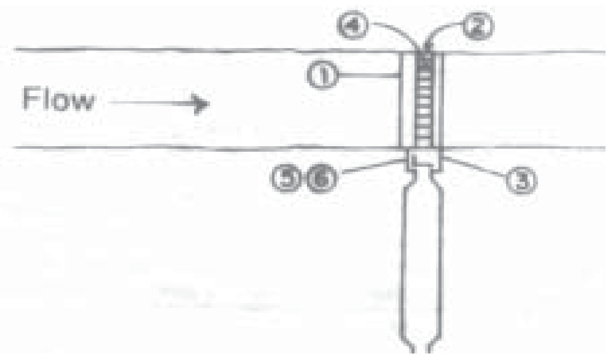


Figure 1 Layout of Bottom Rack Intake

the bars into the gallery. The bars prevent entry of large sized sediment into the gallery and also allows them to move to the down stream reach. Suspended sediment and bed load however, enters into the gallery, which must be flushed out.

Generally, the wire is constructed across the entire width of the river. The intake gallery on top however, can extend either fully or partially. If the gallery does not extend fully, the remaining portion of the weir can also serve as an overflow spillway.

DESIGN OF BOTOM INTAKE.

In this intake, water can be extracted until the maximum capacity limit of the bottom rack is reached. If the flow is less than the limiting capacity, entire flow is taken in. If the river flow exceeds the limit, the intake permits extraction of maximum flow. The amount of water needed for any purpose can be thus extracted more safely in this type of intake than a side canal intake. Flow situations during the full and partial extraction stages are shown Figure 2.

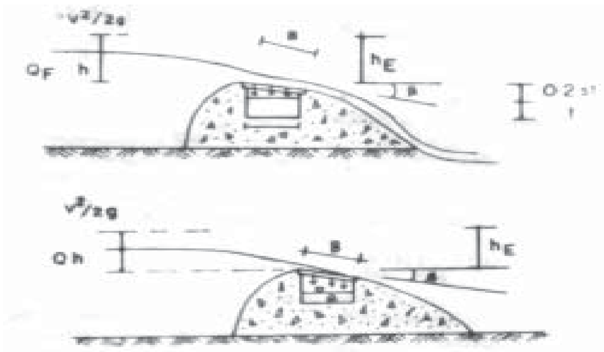


Figure 2: Full and Partial Flow Situations

In a bottom rack intake, the design of the gallery and the bottom rack are the two main issues as these directly affect the amount of flow getting into the system. The flow diverted into the gallery is obtained by

$$Q = 2/3\, C\, \mu L\, B\sqrt{2gh} \qquad (1)$$

in which $h = 2/3\, Kh_E$ (2)

and $c = 0.6\, a/b\, (\cos ß)^{3/2}$ (3)

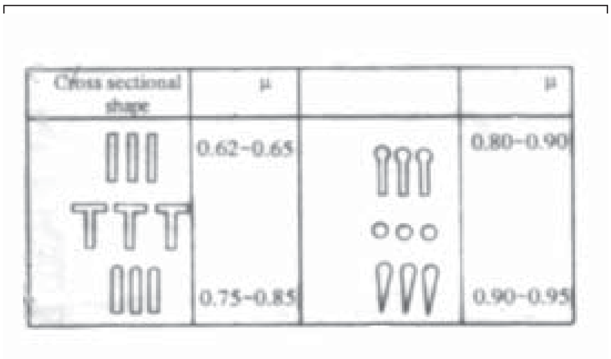
where Q = Discharge (m^3/s), hE = Initial water depth (m), a = Internal width between trash rack bars (m), d = Centre distance between bars (m), ß = Inclination of bottom rack with horizontal, b = Inside width of intakes gallery (m), L = Length of intake (m), B = Length of trash rack (m), K = Factor depending on inclination of bottom rack as shown in Table 2, μ = Discharge coefficient for different shaped bars as shown in Table 3

The bottom rack is made of metal bars of different shapes as shown in Table 3, which normally have a length

Table 2
Factor K For Different Inclination

ß	K	ß	K
0	1.00	14	0.879
2	0.980	16	0.865
4	0.961	18	0.851
6	0.944	20	0.837
8	0.927	22	0.825
10	0.910	24	0.812
12	0.894	26	0.800

Table 3
Coefficient μ For Different Shapes.



Cross sectional shape	μ		μ
	0.62–0.65		0.80–0.90
	0.75–0.85		0.90–0.95

of 1 to 2 m. The rack is laid at a slope of 0.1 to 0.2 per cent while the clearance between the bars is kept between 6 to 12 mm. The inclined arrangement of the bottom rack bars also prevents them from getting clogged. Flow into the gallery is reduced whenever stones, leaves and branches get stuck in the rack. To guarantee diversion of maximum discharge the width between the bottom racks should be fixed as

$$Bs = 1.2\, B_C \qquad (4)$$

where Bs = selected width, Bc = calculated width

The intake gallery should be designed considering following guidelines:

(a) The diversion structure should withstand severe abrasive forces.
(b) The angle of inclination, ß, should be between 5° to 35°
(c) The formation level of the bars should be stable
(d) The difference in level between water surface in the gallery and upper end of the bars should be at least 0.25 t, where t = maximum depth of flow in the collection gallery.
(e) The gallery should be laid at sufficient slope to carry both water and sediment getting in through the rack. If water can not be passed as assumed, either the gradient or flow depth must be raised.
(f) The depth should approximately be equal to width i.e t =b
(g) The width should correspond approximately to the length of the rack i.e. B = b cosß

LIMITATIONS

Inspite of the advantages this intake has, it still suffers from following limitations.

(i) 90 to 97 per cent of the sediment having size smaller than opening dimension of the bottom rack, gets into the gallery.
(ii) Plugging and freesing of racks decreases the throughput capacity.
(iii) The initial section of the bottom gallery can get chocked by sediment.
(iv) The downsteams reach of the river can be subjected to aggravations as significant portion of the flow is diverted.
(v) During high floods, as there is no control over flow, the depth becomes high and results in entry of greater discharge into the system. This requires additional flushing structures.

CONCLUSIONS

Bottom rack intake facilitates extraction of water form mountaineous rivers at all regimes of flow. The design of the bottom rack and gallery, need special attentions in this intake system. The major shortcoming of bottom rack intake is the clogging of the space between the racks, which reduces the throughput capacity. Trapezoidal or T shaped bars made of narrow gauge rails with flanges cut off get clogged less than other types.

Studies have been carried out to eliminate some of the shortcoming of the intake to improve its functioning by focussing on analysis of hydraulic and sediment regimes. When the bed load is reduced, considerable improvement in the performance of the intake has been observed.

Bottom rack intakes, that have been built in Nepal so far, need to be studied, to evaluate their effectiveness. The improvements in design thus brought about, suitable to the specific environment, can ensure uninterrupted operation of small-scale hydropower and irrigation projects.

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