Water
Nepal

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WATER DEVELOPMENT BULLETIN

Before Collapse

After collapsed Pier

IN THIS ISSUE

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A DROP NOT WASTED IS A DROP SAVED
WATER IS LIFE, CONSERVE WATER

EDITORIAL

WATER AFTER RIO CONFERENCE

Food security, industry, human health and welfare have become more dependent on water for survival and growth. The plentiful but unevenly distributed quantum of freshwater of the planet is gradually becoming scarcer by pollution and misuse. Pollution has been degraded under-ground freshwater aquifers. As water continues to be abused, natural eco-systems are gradually being put to permanent risk.

No where else is the abuse of freshwater more evident than in Kathmandu. Rivers in the himalayan capital after years of reckless discharge of municipal and industrial wastes have been turned into sewers. The appalling and worsening situation has been brought about not because of ignorance but lack of will on the part of both the State and city's inhabitants. Death and depravatio n of freshwater by pollution ironically find no place in any political agenda though tarns-boundary water resource sharing still continues to be the source of conflict among the riparian states.

Pollution continues to kill freshwater putting extra premium in its present use further widening the gap of accessibility to safe water. It is so, not only between the richer industrialised north and the poorer south, but even between the haves and have-nots of the south. While mothers in a third world country have to spend hours to fetch water for sustenance, others have cheap and often subsidised water to wash cars and grow gardens in deserts.

Water can become economic stimulant only when the inter-sectoral issues that cut across its continuum are appreciated. Since the impacts of its uses transcend both space and time, the processes of water cycle and any interventions made in it must be continuously observed and analysed. The knowledge and experience from all over the world must come together to endure that present do not put into jeopardy the needs and rights of future generation to freshwater.

Leaders of the world have signed the Earth Charter to sustain development in the twenty first century. Rational use of water however, requires more than mere placement of signatures. Care, sensitivity and commitment are needed to ensure that this finite and most valuable resource is not freewheeled and squandered.

WATER NEPAL: MOVING AHEAD

Water Nepal was begun in 1987 by the initiative taken by its editor. It is now published by Nepal Water Conservation Foundation an NGO registered with the Government of Nepal. Eight issues of Water Nepal have been published till today which are as follows -

Vol	No	Year	Vol	No	year
1	1	1987August	2	1	1990 April
1	2	1988 Feb	2	2/3	1991 January
1	3	1989 July	2	4	1991 August
1	4	1989 October			

Pastissues of Water Nepal have covered several aspects of Water use such as regional hydrology, ground water, irrigation, water supply and sanitation, hydrxopower planning and development including environmental and social impacts of water development. Due several constraints, we have not been able to meet the frequency of its publication. From now on Water Nepal will be published three times in a year, November, March and July. It will contain more pages (about 36 pages).

We thank all our subscribers for bearing with us in our endeavor.

INDO-NEPAL COOPERATION IN MEGA PROJECTS: LEARNING FROM ITAIPU

Bhoj R. Regmi

(*Negotiation for sharing natural resources between two asymmetrically powerful nations is a complex task which takes a long time. One such negotiation for sharing the Parana river was started by Paraguay and Brazil in 1966, leading to the agreement to construct the Itaipu hydro electric project in 1973. Like all major hydropower projects, the development of Itaipu led to political, social and environmental hardships. Its negotiation history, and experience of development would be relevant and illuminating to both Nepal and India. Mega projects like Karnali, Pancheswor and the Kosi High Dam, to be implemented by bi-lateral cooperation have been on the agenda of both the governments for the last three decades. This article summarises the experience of Itaipu Hydro Power Project and touches upon some issues Nepal should understand to harness its power potential in cooperation with the larger neighbour. – Editor*)

1.0 INTRODUCTION

From 1911 AD, when the country's first 500kw plant was installed Nepal's quantum of generated electricity (in 1992) has increased by about 500 times. This achievement however, amounts to less than one per cent of the country's theoretical hydropower potential estimated 20 years ago based on Average River flow and gradient.[1] The country having such immense power potential started daily rationing of electricity supply few months ago due to its flawed hydropower planning.[2] Continued power shortages, if correct measures are not taken, would even constrain the government's new policy and affect national development.

Hydro electricity generation from its rivers and selling the energy to India has remained as Nepal's main economic hope for decades.[3] As its northern grid faces serious power shortages, the head waters has received Indian interest to fulfil the deficit. Thirty years of negotiations however, have failed to produce agreement to share the resource for the optimal benefits of both the countries. In spite of geographical proximity and socio-cultural commonness between the two countries, no progress has been made.

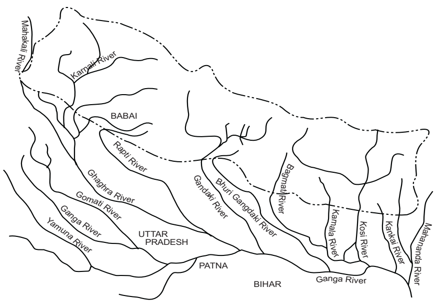


FIG. 1: THE GANGES BASIN (NORTHERN PART).

Nepalese inaction stems from its fear of losing in negotiations with the larger neighbour. The sensitivity has its roots on the past two experiences of sharing Kosi and Gandak's waters with India. The general feeling is that of losing in the bargaining with the more informed and powerful neighbour as the benefit that could have been obtained was denied.[4] A zero sum game by indefinite stalling and/ or non-response for agreement had remained the safest option.

If Nepal's tactic had been to stall in the negotiations, further intransigence resulted from a bogey Indian security perception.[5] This has failed to create conducive environment, particularly for the development of water resources. This was evident in 1991 December when the two countries signed trade and transit agreement and a Memorandum of Understanding (MOU) on water resources development, which also included the question of left afflux bund on the Tanakpur barrage in the Mahakali river. The barrage[6] built on Indian Territory, was initiated without Nepalese concurrence on the afflus bund continued to be a part of the agenda in water negotiations between the two countries since 1985. Linkages between the agreement on separate trade and transit treaties and the MOU was evident.

As per the 1991 Memorandum of Understanding, among others, Nepal permitted extension of 577m long afflux bund connecting the barrage to the Nepalese territory. As a good will, India agreed to provide to Nepal free of cost 10 million units of electric power in a year.[7] While the Government insisted that the MOU did not go to the extent of resource sharing with India, the opposition parties in Nepal disagreed. The resulting controversy has led to the formation of an the formation of an all party parliamentary committee to study the issue while the Supreme Court is also hearing the case to decide whether the MOU needs to be ratified by the Nepalese parliament as per the provision enshrined in the 2047 constitution.

For both Nepalese politicians and public, who thought that the country's new political environment would in it self be sufficient to receive magnanimous support from India in water resources development, the outcome came as a surprise. Though at a political level understanding between the two countries was improved, the much needed goodwill for water resource sharing was not apparent. This, business as usual attitude in dealings with Nepal ingrained in Indian water bureaucracy has led to uncertainty not only over the question of water resources, but even Nepal's emerging politics. Simplistic and ideal scenario, the deal showed, did not exist in the real politic of resource negotiation.

Yet, large-scale water projects in Nepalese territory to be built for bi-lateral uses have remained attractive to both the countries because of their economy of scale. Realisation of these projects however, would first require successful agreement on sharing both the cost and benefits. Project execution would come up only next. Both activities in themselves are, complex, time consuming and not only a question of technology. What lies ahead is a tortuous path of negotiation that demands mutual trust, bargaining skill, diplomacy and an astute vision for trade-offs on both sides. Even if one successfully negotiates, the projects whose investment cost exceed the country's GDP, need national institutional strength for their engineering. If the heavy financial investment, social, ecological and other implication are not understood and properly handled in the projects' long gestation period, Nepal may even face bankruptcy.[8]

Fig. 2: Location of Itaipu Project

Can Nepal understand and overcome some of these issues? Similar projects built on other parts of the world may, to some extent, serve as example for negotiation as well as engineering large projects. One such project is Itaipu, world's biggest hydropower project in South America. (Fig 2.) Itaipu was undertaken when two asymmetrically powerful states; Paraguay and Brazil, agreed to harness the potential of their common river stretch. Similar in nature to the Pancheswor Multi Purpose Project proposed to be built in the Mahakali river, Itaipu is closer in size to the proposed 10800MW Kamali Chisapani Multi Purpose Project.

PROJECT BACKGROUND

Itaipu hydro power project is constructed in the common stretch of the Parana river between Brazil and Paraguay. It generates 12,600 MW power, and its parameter is shown in Table 1.

In 1983, Itaipu's cost totalled US $ 15.3 billion, which was seven times the original estimate of US $ 2 billion done 11 years earlier. Nearly 78 per cent of the project cost was met through internal borrowing while external leading amounted to only 22

Table 1
Itaipu Dam Parameters

Type of Dam	Round headed Buttress
Dam Height	176m
Reservoir Capacity	Total 29 Mm^3 Live 19 Mm^3
Reservoir Area	1400 km^2
Spillway Capacity	6200m^3/s
Installed Capacity	12600MW
Energy Generated	75 109Kwh/year
No. of Generators	18 700 MW

per cent. The project was implemented mostly by Brazilian and Paraguayan contractors whose proportion of shares are shown in Table 2. Remaining work was handled by international contractos.

Table 2
Portion of Contract Share

Components	Percentage Share: Brazil	Percentage Share: Paraguay
Construction	78	22
Equipment	70	11
Engineering	58	30
Infrastructure	50	50

HISTORY OF NEGOTIATION

The stage for undertaking the project was set by the governments of Brazil and Paraguay in the mid-sixties. Both the countries took series of administrative and political reforms before and after signing of the agreement. The presidents of the two countries, both military generals, signed the agreement in 1973. Joint activities like construction of bridge and a road linking the two countries, and signing of the'Act of Iguacu' (June 22,1966), were taken up before agreement was reached. 'Act of Iguacu' not only paved the way for joint utilisation of Parana river's hydroelectric potential, but also settled boarder disputes between the two countries which dated back to 1872 AD.

A joint Brazilian-Paraguayan technical commission was formed in 1967 followed by setting up of a joint venture of International Engineering Company to undertake the project's feasibility in 1970. Itaipu Binacional, the company that implemented the project, was set up in 1974. An autonomous district around the dam and power house site was created under the jurisdiction of Itaipu Binacional, where the company was allowed to have its own police. Paraguay in 1967 also repealed a law that prohibited foreigners to purchase land in the 150 km wide boarder stretch with its two neighbours, though similar act also existed in Brazil and Argentina.

The negotiation process shows how these two asymmetric states established inter-linkages to arrive at an agreement. Linkages can allow weaker states; both economically and military, bargaining tools to achieve fairer deal in resource sharing even with a powerful neighbour.[9] Between Nepal and India, the impasse in negotiation may be also broken by an approach that established linkages in terms of national interests.[10] Trade-offs however, always become inevitable in resource negotiation and negotiating parties must be prepared to do so.

FINANCIAL ARRANGEMENTS

The main agreements comprising of 25 articles, 3 annexes and 6 supplementary agreement allowed national electricity companies of both countries to contribute half of Itaipu Binacional's US $ 100 million capital stock. Brazil also provided Paraguaya a loan of US $ 50 million to cover its share at six per cent interest which was to be paid back through energy production in a period of 50 years with a waiving period of 8 years until the first power generation started. The energy, according the agreement, was to be shared equally by the two countries. The terms further stipulated that each country had to declare two years before start of the generation, its own requirement of Itaipu share of energy for the first twenty years. But Paraguay, through a supplementary agreement, was permitted to vary its declared requirements by 20 per cent upwards or downwards.

The energy selling price was fixed on the basis of production costs, an appropriation of 12 per cent of capita stock, finance charges, pay back costs and royalties for the countries at the rate of US $ 65 per GWh, and an administrative costs US $ 50 per GWh. In addition, if the surplus energy was sold by one country to the other, the supplying country was to be compensated at the rate of US $ 300 per GWh. Changes were not allowed till 50 years after the first signing of the agreement.

DOMESTIC POLITICS

Though, Itaipu project improved ties between Brazil and Paraguay, the terms of negotiation was criticised in Paraguay mainly because the compensation rate based on initial cost estimates was considered unsatisfactory. It, in fact, became questionable later on, as the project cost escalated. Paying off the Brazilian loan in fifty years at a fixed cost price in the form of energy as well as the compulsions of selling surplus energy only to Brazil as per the agreement also triggered wide-spread resentment in Paraguay. It however, refused to alter the frequency of 9 of the 8 generators of the project from 50 c/s to the Brazilian standard 60c/s. Though the cost inflicted on transmitting power to Brazil went up, it was considered as the balancing act to appease the unsatisfied lobby in Paraguay.

In the seventies, two schools of thought emerged in Paraguay. One advocated the use of low energy costs, low wages and taxes to attract foreign investments to usher-in industrial development in the country using its share of Itaipu energy. The other stressed direct energy selling to earn foreign exchange to be used for the country's modernisation through comprehensive investment programmes. A critical energy analysis[11] in Paraguay argued that the price charged to Brazil should be just below the cost required to produce electricity by its nuclear power stations, instead of the cost plus basis. This, the study argued, would generate more revenue to be used to subsidy energy price to the industrial sector in Paraguay. But, slower growth of electricity consumption in Brazil than predicted made this strategy inapplicable.

The share of Paraguay from Itaipu was estimated to be 28 times more than its contemporary energy requirements. High cost of energy transmission to be used in industrial sector made use of energy from Itaipu unattractive. In absence of concrete

PICO HYDRO

Small hydropower installations that generate 100 watts to 5 kw electricity are called Pico Hydro.

These units are small enough for villagers to purchase them directly. This leads to a personal identification with the machinery it will be looked after, adaptations made, spare parts replaced by the local workshop. Not only are pico hydro units affordable, they also have the advantage of being portable. They can be installed by the villagers themselves, so cutting costs. They can later be moved to a different site or sold to a new owner. A successful technology is one which had developed slowly in a region, growing on the bsis of local initiatives. Local response to sample pico hydro can acts as a guide to the suitability of hydro in a region, and will allow familiarity with modern techniques (pressure pipes, generators) to grow. This will provide a bedrock of local support for late installations which are larger and more complex.

Even the micro hydro system involves a complex technology requiring large expenditure. Special skills are needed to design, install and operate micro hydro units. For villagers in remote areas, it is very difficult to acquire these skills, who are also unable to afford the machinary or manage the large loans needed to finance it. In man ways, pico hyro can solve the problems and serve as the stepping stone for achieving successes with larger micro installation at community level.

For further details write to Hydro net: Attn. R. Metzler stephan Blattman Str. 11 D - 7743 Furtwangen, Germany or Adam Harvey /ITDG UK

development plans, Paraguayan Government seemed prepared to sell all its share of energy that remained unused, to Brazil.

After the signing of the Itaipu agreement in 1973, Argentina, Brazil's competitor in the influence over Paraguay entered into a parallel agreement with Paraguay to construct the 4050 MW Yacycreta Hydro-project. Construction of yet another power station at Curpus between Yacycreta and Itaipu was also undertaken, jointly by the two countries. This was an interesting consequence of the Itaipu agreement, which showed that Paraguay was not prepared to show its total dependence on Brazil. The small land-locked country was dominated by both Brazil and Argentina, ever since it gained independence from the Spanish empire in the 1900. After years of domination by Argentina, Paraguay's development since 1960s is more dependent on Brazil.

Unfortunately, Nepal's geo-political context limits bar gaining leverage of this nature, though in the past, the country has been charged of playing the China card to neutralise growing Indian influence in the country. That Nepal has to deal with a solitary but the major energy buyers make the negotiation process even more difficult. Rather than a simple economic and technological issue, water development and energy marketing has become politics of resources control and bargaining between the two asymmetric neighbours.

In spite of the rivalry between Argentina and Brazil over their influence over Paraguay, Itaipu agreement had however, positive spin off. Two years after signing of the treaty Brazil, Paraguay and Argentina, concluded a tripartite agreement pertaining to utilisation of flow of the Rio Parana river and its navigability, Itaipu Dam parameters, reduction of the numbers of turbines in Itaipu project from 20 to 18, and to maintain ecological equilibrium in the region. The three countries also agreed to share information on any adverse environmental effects.

SOCIAL AND ENVIRONMENTAL COSTS

Compulsory purchase of land by Itaipu Binacional for its activities affected large population in both countries. Although Intaipu agreement, which included a provision for compensation, authorised the purchase, the activity was left as national matters. Itaipu Binacional started privately purchasing land even before legal formalities were completed by the two countries to ensure welfare of the affected population as stipulated by the agreement. The affected people as result were deprived from obtaining fair compensation as well as judicial assistance to assert their right. Only after continued struggle and mass protests in Brazil, in 1982 did the power company agree to all the demands put forward by the affected population. Injustice in Paraguay was even more severe. Unlike Brazil where demonstrations were permitted, Paraguayans had to rely on church organisations to voice their cause. Several families were forced to move to forests areas severely impoverished and marginalised.

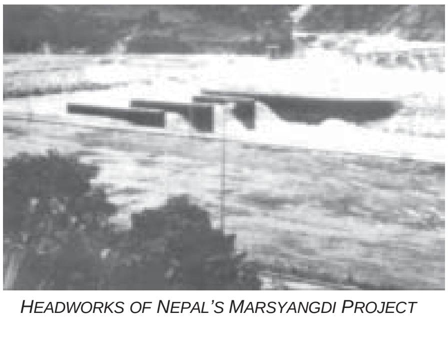
Resettlement was more difficult and led to even harsher impacts than compensation. Though the demand of land in exchange of land was rejected, Itaipu Binacional initiated small-scale programmes to resettle some 377 families in Arapoti. Poor planning for rehabilitation was distinctly evident; the quarters were inadequate to live, house livestock, store equipment, seed and agriculture produces. Settlers had to, therefore clear forest to create agriculture land and seek bank loan for sustenance.

Rehabilitation experience in South Asia, particularly, India where large-scale water development projects have been taken up, do not inspire hope. The complexity of compensation planning in Nepal was analysed only in the early 1980s,[12] which seriously suffers from constant policy tampering and organisational restructuring.[13] Projects like Karnali Chisapani will displace about 60000 people, whose relocation without fine tuning of the existing laws and rehabilitation mechanisms, will certainly lead to immense hardships, especially considering the lifestyle of ethnic communities like the Rajis living along its banks.[14]

Like all other reservoir projects in Brazil, little attention to ecological degradations was paid in Itaipu. Though the consequences were not dismissed, and an Environmental Department established in the early stages, emphasis for mitigation of the adverse impacts was muted. A $7.5 million financial package: less than 0.1 per cent of the actual cost of the project, was provided as ecological support. The consequences on local ecology, particularly bio-diversity of the region were best forgotten. Impact assessment of the project was seriously affected because long term data on climate, hydrology, seismicity including aquatic and health indicators in both the pre and post Itaipu period was not available. Assessment were based on information from similar other projects. The outcome hence, was imprecise and subjective.

CONCLUSIONS

Realisation of the Ipaipu project became possible only when the political consensus to harness Parana River came about between Brazil and Paraguay. Arriving at the mutually agreeable terms took years of negotiation, establishment of linkages, and trade-offs by the two countries. The content of the agreement however, was kept top secret until it was formally signed. No opportunity for public



A.D

HEADWORKS OF NEPAL'S MARSYANGDI PROJECT debate was allowed particularly in Paraguay on the terms of negotiations, which were conducted by its Foreign Minister and three other officials.

But, between Nepal and India however, it was such opaque dealing of the past that eroded confidence. Political will and understanding for cooperation in sharing the benefits are prerequisites, which must be supported by a national consensus. Past mistrust, has to be shed by transparent negotiations whose objective should be welfare of the people of both the countries.

Itaipu's experience is relevant to both countries, particularly Nepal, to understand that engineering of mega hydro project requires more than passions and dreams. Its complications do not go away even if the bilateral political questions are settled. The complex and linked issues of water development, cut across disciplines, which apart from sound technical workmanship, requires interdisciplinary understanding of socio-culture, finances and environmental factors. Nepal's existing compartmentalised and *adhoc* water resources management efforts need complete overhaul to build on national professional strength and institutionalisation, if water is to be a harbinger of new hope for the people.

Some of the specific experience from Itaipu would be the inadequacy of the natural database, poor rehabilitation of the affected population and inappropriate energy pricing. Energy pricing based on estimated project cost is likely to be questioned, which should be based on a more equitable approach of actual construction cost and benefits. All future projects must be initiated only after ensuring adequacy of data related to meteorology, hydrology, water quality, seismicity etc. If inadequate, efforts must be made to update the database supported by adequate financial resource allocations. Since population displacement become unavoidable, economic rehabilitation and not cash compensation must be the guiding factor.

Even though it was smaller, Paraguay was also able to derive benefits from the project by participating in the construction activities and other opportunities. For example, in its peak construction period in 1978, about one-third of the 30,000 people employed in the project were Paraguayans. Nepalese approach so far has concentrated only on power export while employment and other benefits sharing have not been thought of.

In case of Nepal and India, when large projects are implemented, it is likely that the generally more skilled Indian work force and industry will reap greater advantages. Without vision, a will to change and act, water from the Himalayas cannot be harnessed and made productive.

NOTES

[1] Shrestha, H.M. 1967. Estimated this potential.

[2] Nepal Electricity Authority in a public notice in The Rising Nepal April 1992. Announced a seven-hour load shedding on alternate days due to the prolonged dry period and reduced river flow.

[3] Rogers, P., Lydon, P. and Seckler, D. 1989. Eastern Waters Study, Strategies to Manage Flood and Drought in the Ganges-Brahamaputra Basin; ISPAN Technical Support Centre, USA.

[4] Pokharel, J.C. 1991. Breaking Impasse in Water Resource Negotiation Impasse; Editorial in Water Nepal Vol. 2 No. 8. Kathmandu

[5] Verghese, B.G. 1990. Waters of Hope; Oxford and IBH, New Delhi argues "As the central and most powerful country of the region, India need not fear the oft repeated bogey of ‘security threat’ from its smaller neighbours. It has a catalytic role to play in ushering in the transformation of South Asia though the use of water".

[6] See Gyawali, D. and Dixit, A. 1991. Righting a British Wrong; Himal, May/June Kathmandu for a brief discussion on the Sharada project.

[7] For details on the MOU see Nepal Gazette Poush 8,2048 B.S. (1992)

[8] Gyawali,d. 1991. The Troubled Politics of Himalayan Waters; Himal May/ June Kathmandu.

[9] See Pokharel, J.C. 1991. Environmental Resource Negotiation Between Asymmetrically Powerful Nations, Power of The Weaker Nation; Ph.D. Dissertation submitted to the Department of Urban Studies and Planning, Massachusetts Institute of Technology, USA, for a discussion on how small states can bargain with bigger state by establishing linkage.

[10] *Ibid.* Pokharel 1991

[11] Analysis by Paraguayan Engineer Recardo Canese one of the main critics of the government's energy policy.

[12] Pokharel, J.C.1988. Population Displacement by the Kulekhani Hydro electric Project, Some Lesson in Compensation Planning; Pashasan 51st issue Kathmandu

[13] Gurung, H 1989. Policy Review and Experience of Project Related Rehabilitation in Nepal; Water Nepal Vol. 1 No. 4 Kathmandu.

[14] Basnet, J. 1989. Rivers and Rajis; Water Nepal Vol. 1 No 4 explains about a community on the bank of the Karnali river whose life style was intricately related to river.

The author would like to acknowledge Prof. Gerd Kohlheep, Department of Geography, University of Tubingen, Germany whose book ‘Itaipu basic Geo-Political and Energy Situation - Socio-economic and Ecological consequence of Itaipu Dam and Reservoir on the Rio Parana’, published by GATE 1987 has been used for all references on the Itaipu Project.

COMMUNITY PARTICIPATION - A PRECONDITION FOR SUSTAINABLE WATER DEVELOPMENT

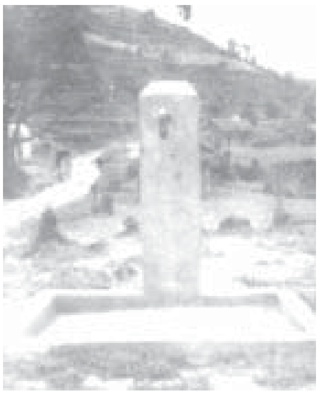
Ellen Buch-Hansen (Ms)

(The need to involve the community in development activities was realised when the paradigm of hardware dumping in the third world countries for improving quality of life failed. This article based on experience of water supply programmes in Africa, advocates for a participatory approach that is community driven instead of the usual top down one, as a precondition for the development of sustainable water supply schemes. – Editor)

Community participation or 'development by people' has become a new catchword in the international donor community. After supporting thousands of projects that failed, donor organisations began to look for alternative strategies for development.

It was obvious that the massive transfer of hardware to the developing countries in the 1950s and 1960s mainly left behind lots of physical structures, either too complex or too expensive to maintain - at least in most rural areas. Such development aid projects did not reach the majority of the rural poor or the women. In the 1970s, the new development strategy focused on 'basic needs' and deliberately aimed at reaching the poorest sectors of the community. During the UN decade for Women from 1975 to 1985, women increasingly became a specific group. It was realised that development processes are not neutral. There are both class ands gender aspects to be considered.

Throughout Africa where women are the main producers of subsistence crops training only men in modern agriculture methods helps little in the improvement of the quality of food production. And it does not secure sustainability of water supplies if women as the daily procurers of water for the family are not involved.



Gravity Flow Community Water Supply Point

However, the basic needs strategy did not appear to be very dynamic, or able to trigger off economic development. Thus the focus was shifted towards production and labour intensive sectors such as agriculture, handicraft and small-scale production. This entailed methods to involve and mobilise local communities to participate in the development and projects defined by governments and donor organisations.

The International labour Organisation (ILO) and the United Nations Research Institute for Social Development (UNRISD) developed theories on 'people's participation'. The American donor organisation, USAID, contracted Cornell University to develop a participation strategy. During the 1980s, this approach became increasingly popular in development programmes and was especially stressed by the donor organisations.

One example is the Swedish donor organisation, SIDA, which has been involved in water supply and sanitation programmes in Botswana, Ethiopia, Kenya and Tanzania for more than 20 years. Apparently, SIDA, felt that the implementation of expensive water schemes could continue for another 20 years at the same speed without the rural communities actually getting improved water. This was because projects were not maintained properly. After a phase of continuous rehabilitation of schemes earlier funded by SIDA, the donor organisation came up with a 'Water Strategy for Rural Areas'. The first edition came out in 1979 prior to the International Decade for Drinking Water Supply and Sanitation (1980 to 1989). A revised second edition came out in 1987. It stressed community participation in planning, implementation, operation and maintenance of water projects "to instil a feeling of ownership and responsibility among the consumer community". Women, children and the rural poor were mentioned as the main target groups.

THE NEED FOR PARTICIPATION

So much for development on the international donor community scene, community development or participation is a concept that has been known for long in Africa. the concept of community development conjurs up memories of colonial presence connotation amongst other negative things indicating the use of forced labour.

What then is the content of this new concept of community participation? It is obvious that the mere placement of a physical structure, be it a water project, a health clinic and so on, in a community does not secure the optimal use of the installation. Projects become meaningful and are more geared towards local needs if they are initiated and implemented together with the local communities. More than 30 years' development experience proves this fact.

How is the concept of community participation defined? Indeed there is a lot of confusion in its content.

As stressed earlier, community participation could mean the mere involvement of community members to secure a more efficient project implementation. The outlined strategies formulated by ILO, UNRISD and USAID stress participation as a way to involve and mobilise communities in programmes and projects. In most cases, community participation is an 'aspect' or a 'component' put into already designed programmes after goals have been defined and agreed on by the government and donor agencies. In this respect, community participation is a 'top-down' approach to facilitate an efficient project implementation and its acceptance by the same local communities.

M. Neupane

Community Members Learn to Cut Stones

Another variation of the concept is as a means to obtain a more self-reliant development at the local level: To mobilise local communities, to put people in charge of their own development within a framework of external support. Realising that communities know best their needs and problems, and how to overcome them best of all, community participation or development by people in this sense is a 'bottom-up' approach. It calls for a great deal of community training and awareness arising from, for example, the connection between water and health, and profound discussions in community before actual projects are defined. As such, this approach can be seen as a goal in itself to obtain a sustainable, self reliant development. The projects then become the means to attain a goal instead of the reverse, where community participation is seen only as a means to realise projects goals.

This brings in the question of power and control: who is in charge of project design, who owns the projects, who has the final say for example, in the choice of technology? The independence and self-reliance of local communities demands a certain degree of 'empowerment' to people. This touches more profound structural matters, and should be borne in mind while seeking a clearer picture of the implications of the community participations concept.

In short, the community participation approach can be described as of two main types:

1. Community or popular participation – where people get involved in already existing or defined projects and programmes.
2. Development by people or community-based development where communities play a crucial role in initiation and design of development programmes and projects.

It is essential to establish a resource-book or reference book on positive as well as negative examples of community participation in water programmes and projects. There are lessons to learn from the documentation on failure as well as success. "We should be on our guard when we hear that a programme is wokring effectively or exactly as planned. Mistakes are likely to be kept under wraps, along with ineffectual leadership and programmes often in disarray. Errors should be realised to be growing points for energising constructive action".[1] It is obvious that projects where communities have not been involved experience a lot of problems. One example from a water programme in Kenya illustrates how the implementation approach in itself defines the failure or success of the programme. In a big rural piped water scheme, fifteen communal water points (CWPs) were installed to serve those cunsumers who cannot afford their own private connection. After one year, only two were working. The Ministry of Water Development (MOWD) concluded CWPs were not sustainable.

During rehabilitation of this scheme, Kenya Water for Health Organisation (KWAHO) was involved. It later transpired that the engineers had placed the 15 CWPs at random without any consultation with the consumers. Some of the points had been placed where nobody needed them, while others were placed on private land, and the owner told to sell water to the surrounding community. Some of the landowners did that and used the proceeds from the sale of water for other purposes. The result was that the taps got disconnected by the MOWD due to non-payment. The community's hopes for access to clean drinking water came to nought. During rehabilitation consumers who wanted water were organised into committees. These committees were responsible for the management of the waterpoint, including paying the bills. Since rehabilitation the new CWPs have been very successful in providing a large group of consumers with clean drinking water.

Planning with community input demands a high degree of respect for local communities and background of local conditions. This certainly demands a lot from project staff. Technical problems must be discussed with the community and solved as fast and as sustainably as possible. When people have used time, energy and money to dig trenches for instance, there is deep commitment to ensure that their efforts are not in vain.

The main reasons for programmes to introduce community participation could be summarised as follows:

Micro Effect of Himalayan Uncertainty

Declining source yields have been severely affecting sustainability of water supply schemes in Nepalese mountains. Following observations of two springs in Pyuthan District in West Nepal demonstrate the trend

Source	Measured Flow (l/s)		% Reduction
	1987	1990	
I	0.55	0.30	45
II	0.3	0.10	67

The hydrology of small sources need elaborate study. Catchment conservation activities should be pursued, DATA Source. Nepal Consult Pvt. Ltd. Kathmandu.

1. To instil a feeling of ownership and responsibility in community members, to avoid projects being seen as 'god-sent' deliveries beyond their influence. Problems like vandalism and breakdown of equipment are as a result avoided.
2. Community labour is believed to be cheap – so community participation could be introduced to save project costs.
3. More efficient implementation.

These seem to be the reasons mostly recognised by programme implementors. Bearing somehow the feeling that only if it pays, the community approach will be used – the satisfaction of communities is ranked much lower.

However, even if programmes and projects have been largely designed by government and donor agencies for these reasons, a genuine community involvement can still be established. By establishing a social organisation, community feelings and conditions can be communicated to the technical staff and vice versa. It should be noted that a great amount of patience and time is needed with this approach. This is not always compatible with project planning or achievement of defined physical goals. Projects governed by strict defined development plans or projects blue prints are not very open to independent local input from the so-called recipient community.

This may be one of the more important reasons to stress the role of NGOs as being able to handle more flexible and community-oriented projects. At the movement, the amount of time seems much more crucial than the amount of money to ensure success f community based development projects. Donors and governments should provide a more flexible and long-term funding for community projects. Instead of the usual 2 to 3 years project period, community based implementation needs at least 5 to 10 years to prove its sustainability. This includes preparatory planning with the community, training, implementation, organised with the community and after physical implementation continue monitoring and evaluation, preferably participative monitoring to keep the community aware of any positive or negative development.

Ironically enough, this approach demanding more time and less money at a time collides with donor organisations' need to spend funds in a situation where aid funds are growing, while administration of aid is being cut down.

DOCUMENTING AND MONITORING

In community development, not only the achieved results but also the way they are achieved results but also the way they are achieved matters. Thus the implementation is more focused to wards the process than the actual results. Focus on evaluations should be therefore more on qualitative measures than quantitative results.

The problem is how to measure qualities such as community satisfaction, inspiration to engage in other development activities or the quality of community organisation and training. Though many checklists and guidelines have been produced, they have rightly been criticised as providing a seterotype approach which does not take the special community conditions and feelings into consideration.

There is no one models which can be repeated everywhere, as assumed by the blueprint model whose relevance is shown by following comment.

"The blueprint approach with its emphasis on detailed, static pre-planning and time frames for projects is antithetical to genuine community based development. However, this approach is very popular with governments and donor agencies, because the simplistic assumption of a clear cut sense of order in development efforts, allocation of funds for precisely stated outcomes, reliance on hard data and expert judgment as well as the rigid implementation schedules make it easy to justify projects in budget presentations." [1]

Consequently, even programmes with stated objectives to apply participatory approach are dominated by such a blueprint approach.

COMMUNITY MOBILISATION

Ideally community project should not be undertaken before communities have defined their own priorities. More often than not the community participation approach has supported the local elite instead of serving the rural poor. Another well known experience is the pseudo-participation, where local chiefs call village meetings or important senior officers from outside 'inform' wananchi (local people) in top-down manner.

To create a genuine mobilisation process, facilitators and trainers from outside can act as catalysts and help the community to analyse problems and help set up possible solutions to benefit the whole community. Communities are able to choose the best solution for themselves if alternatives are properly explained in terms of costs, maintenance, output, availability and so on, and if the implementation approach is genuinely community oriented. This demands a lot of time and discussions with the community, as well as commitment from project staff. More than choice of technology and scale, this approach is the crucial precondition for economically, socially, culturally and environmentally sustainable water development projects.

[1] David C. Corten, UNICEF News: 128/986.

[This article was presented in the workshop organised by AWN in Nairobi in 1990.]

MICRO HILL IRRIGATION FIELD TESTING OF LINARES RIVER PUMP.

Kiran Dangol

(In the hilly regions of Nepal, people rely mostly on rain-fed agriculture. This article discusses field-testing and the results of a pump operated by river velocity to lift water for irrigation. The technology provides one more option to select for improving hill agriculture- Editor)

INTRODUCTION

In the mountainous regions of Nepal, majority of the population have low land holding capacity; generally less than 1 ha per house hold. They depend on rain-fed agriculture, which has low productivity. In the past, the government's hill agricultural policy has emphasised on achieving self-sufficiency in food production. Heavy investment have been made in the development of several surface water irrigation systems. The impact however, has not been encouraging.

Since, more than 90 per cent of the country's population is agricultural based, the extension of irrigation coverage is indeed important. As many hill districts are deficit in cereal grains, this would appear to be logical, and a priority. The scope for expansion of irrigable land in the hills however, is limited. Moreover, most of the low lands are already irrigated by farmers built gravity schemes. The present focus is to support these systems to improve their efficiency.

In the upper dry land, irrigation is seasonal and site specific where development of new irrigation schemes is likely to be neither cheap nor easy to maintain. The development requires overcoming topographical, geological, hydrological and seismic uncertainties, all of which have cost implications. In the past, gravity systems in the hills have been built at a cost of around $ 2000.00 per ha[1] whose average yields of 2 tonnes per ha do not justify the investment.

Even without water application possibilities more and more fragile and marginal lands in the hills continues to get cultivated are indicating a very poor land use.[2] Prevailing degradations and poverty, therefore, call for enhancement of local productivity through cultivation of cash crops like fruits and vegetables. The hill climate is conducive to accommodate such alterations, which can be accomplished by lesser water.

Scope for changes are powever, limited by technical, managerial and social constraints. A major difficulty is caused by inability to meet the crop water requirements, as the rainfall does not occur when needed. Though, energy driven pumps can be used to extract water from lower, but dependable sources, their use is limited because the technology is sophisticated and requires high operation cost. In many cases, devices that operate without external energy are desirable. One such device is the Linares River Pump.

K Dangol

Linares River Pump

TECHNOLOGY AND WORKING PRINCIPLE

Linares pump was developed by Don Jesus Linares, an Andean farmer in Colombia where it was designed fabricated and tested with support from Appropriate Technology International USA. Operated by the velocity of a river, the pump needs no external energy for pumping. Water is pumped to a higher elevation and stored in a tank, which then becomes a more reliable source. The pump is economical to maintain, and can be operated by farmers even with preliminary formal education.[3] It can be installed in medium sized rivers with depth between 0.4 and 1 metre, in which a minimum flow velocity of about 1.0 m/s would be available even in the dry periods.

The pump consists of about 1.3-metre diameter steel wheel supported on a frame. Removable blades made of galvanised sheet are fitted to the wheel that rotates about a horizontal axis. The assembly is placed in the river current whose velocity acts on the blades and rotates the wheel. Revolving along with the main shaft, the wheel drives a piston mechanism (displacement type) and starts sucking water through its suction filter pipe (strainer). With each stroke of the piston, the pump sucks and supplies water through the discharge out-lets to a higher elevation. Water can be lifted up to vertical elevation of 40-45 meters through various gradients. A modified version of the pump consists of three-piston mechanism that pumps more water to even higher elevation.

Major Nepalese rivers and their perennial tributaries meet this requirement. This device can then be used for irrigating the drier terraces on the banks. The pump thus adds one more alternative for irrigation, to choose from the options like gravity canals, storage tanks, hydrams, deep tube wells and mechanical pump sets. It has the potential of supporting and improving local agricultural practices in specific cases.

2.1 Installation

Installation of the pump in the river is a straight for ward and simple task. Three to four short iron bars should be driven into the riverbed to act as anchors. The pump assembly should be lifted and placed on the bed supported on the bars. The river section preferably should have sufficient slope to allow the river flow to attain the minimum velocity required to drive the paddle wheel. A temporary flow channeling 'Check Structure' can be also created upstream of the pump as shown in Fig 1 to get the required flow velocity.

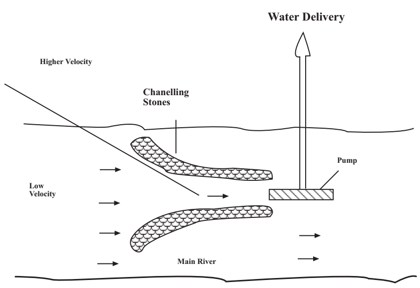


FIG 1 CHECK STRUCTURE FOR PUMP INSTALLATION

The pump can successfully operate in a river with flow velocity in the range of 0.8 m/s to 1.4 m/s. But a higher velocity range of 1.5 m/s to 2.0 m/s is more desirable to ensure appropriate revolution of the wheel at which the pump will function most efficiently. For safety, it is advisable to install the pump closer to the river bank.[4]

Water Storage

Water thus pumped should be stored in either a temporary or permanent storage tank for applications later on. The stored water can be used for irrigating specific type of crops and if the original source is uncontaminated and the users so desire, it can also be used for drinking purposes. The cost of storage tank may however, increase the investment and its different options should be evaluated. An underground pond may be cheaper in the hills, where elevation difference can facilitate water supply by the gravity to lower fields.

FIELD TESTING IN NEPAL

The Linares pump technology was transferred to Nepal and fabricated by development and Consulting Services (DCS) in Butwal. Five such units were field tested at different sites in Pyuthan and Rolpa Districts in West Nepal. The sites were located along the banks

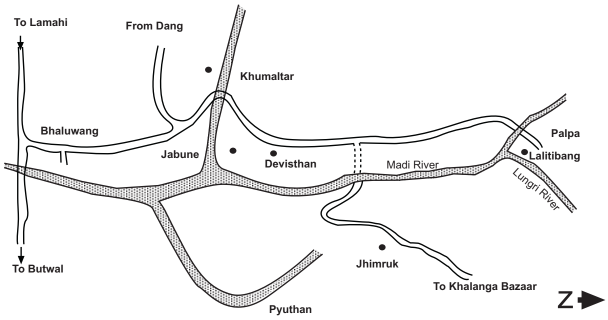


FIGURE 2: SCHEMATIC LOCATION OF VILLAGES

of Aarung, Madi and Lungri rivers in the West Rapti river basin. The villages were Kumaltar, Devisthan, Jabune, Sari and Laltibang. The first sites were situated in Pyuthan while Laltibang the fifth was situated in Rolpa District. The location of the sites is shown in Figure 2 and their physical conditions are shown in Table 1.

The pumps were installed and tested in the month of April, when the river flow was minimum. Testing was continued for more than a month. Following factors under which each pump was operated were observed to evaluate the performance.

- Discharge vs Head
- Dischage vs Wheel RPM
- Discharge vs Flow velocity

To establish the relationship following parameters were measured

- Elevation where water had to be pumped
- Frictional losses
- Wheel RPM
- River flow velocity
- Water output deliverted (1/m)

From the field test, following performance relationship of the pump were obtained.

Discharge Vs River Flow Velocity

In all the five sites, river flow velocity was the most important factor, which affected the volume of water pumped. Above 1.0 m/s flow velocity, even with a small incremental increase in flow velocity the increment increase in the volume of water delivered was larger.

Discharge Vs Head

The delivery head and the volume of water pumped showed an inverse relationship. When the delivery head increased, the discharge decreased. Increase in delivery head appeared to have greater impact in decreasing the discharge at sites where the river flow velocity was lower. On the other hand, the impact of in-

Table 1
Physical Condition of the Selected Sites

Field Conditions	Location				
	Devisthan	Khumaltar	Jabune	Laltibang	Sari
River	Madi	Aarung Khola	Madi	Madi	Lungri
Velocity of Water at pump (m/s)	1.3 - 1.5	1.0 – 1.3	> 1.5	1.5	1.5
Wheel RPM	17 – 20	12 – 14	16 - 20	17.19	15 - 17
Depth of water at pump (cm)	51	50	55	51	55
Width of River at pump (m)	20	2	25	26	24
Distance from pump to delivery end (m)	240	135	97	200	160
Vertical elevation from					
Pump to delivery end (m)	31	44	17	30	32
Delivery pipe (HDP in mm)	25	25	25	25	25
Discharge at delivery end (1/m)	5.0 – 4.0	3.5 - 4.0	6.0 - 7.0	5.0 - 5.5	5.0 -57

creased delivery head affected the output less, at higher river flow velocity.

Discharge Vs Wheel RPM

In all five sites, the volume of water pumped had a direct relationship with the RPM. The pumped discharge increased from 4 l/m with the RPM of 14 to a maximum of 7 l/m when the wheel RPM ranged between 15 to 19. At RPM of more than 20, insignificant increase in discharge was observed. At higher RPM the resulting wear and tear in rubber plungers was also pronounced.

The test showed best result when the water output ranged between 5.0 to 7.0 l/m as shown in Table 2. Following results can be generalised.

a. Discharge is directly proportional to wheel RPM and flow velocity but inversely proportional to delivery head.
b. Wheel RPM is directly proportional to river water velocity

COST-BENEFIT COMPARISION

(a) Cost

The benefit of Linares River Pump can be judged in terms of its application particularly for micro scale irrigation. Feasibility of the pump, should compare the benefits generated by its installation to the cost required.

The cost of the pump fabricated at Butwal was about Rs.16,500.00 per piece excluding operational charged in 1990. When manufactured in large-number, the cost is expected to come down to about Rs.12,000.00 again excluding the operational charges. The approximate pump related expenses, assuming large-scale production thus come to about Rs.21,305.00 including the cost of pipes and fittings but excluding storage tank. The government has been supporting the programme through the Agriculture Development Bank, which provides 40 per cent subsidy to the user of the pump. The actual cost after the subsidy would be Rs.7200.00

(b) Benefits

To estimate benefits following assumption are made.

i Site Characteristics

River flow velocity	=1.5 m/s
Water delivery elevation	=32 m.
Wheel RPM	=19
Water delivered	=7 l/m

ii Irrigation Coverage

As evident from table 2 the volume of water delivered is small to irrigate cereal crop. It can however be used for vegetable irriga-

Table 2
Field Test Performance

Site	S.No.	Velocity (m/s)	Wheel RPM	Stroke No./min	Discharge (l/m)
Devisthan	1.	1.40	15	15	5.00
	2.	1.50	18	18	6.50
	.3.	1.50	18	18	6.50
Kumaltar	1.	1.00	10	10	3.00
	2.	1.30	12	12	3.75
	3.	1.30	12	12	3.75
Jabune	1.	1.50	17	17	6.00
	2.	1.70	19	19	7.00
	3.	1.70	19	19	7.00
Laltibang	1.	1.40	14	14	4.00
	2.	1.50	16	16	5.00
	3.	1.50	16	16	5.00
Sari	1.	1.45	15	15	5.25
	2.	1.55	17	17	5.70
	3.	1.55	17	17	5.70

Note: The Piston, Cylinder, Handle bearings were daily greased.

tion. If all the water delivered is utilised, its uniform applications over 1 kattha (0.033 ha) of land requires a flow of 6 l/m over the 24 hour period. For adequate growth of vegetable a water depth of 2.5cm is needed in one day[5]. Normal irrigation interval for crops/vegetables is generally taken as 4 days assuming 75 per cent water to be retained in the soil. The discharged volume can thus irrigate 4 kattha land.

Table 3
Vegetable Production/income for One Growing *Season*

Vegetable	Production (Kg/kattha)	Farm Gate Price (Rs.)	Income (Rs.)
Cauli-flower	500	2.00	1,000.00
Cabbage	500	1.00	500.00
Tomato	700	3.00	2,100.00
Egg Plant	1,000	1.50	1,500.00
Radish	400	0.75	300.00
Cucumber	650	1.50	975.00
Potato	750	2.00	1,500.00
Average income generated per growing season			1,125.00

iii Income Estimate

Vegetable production/income for one growing season for pay-off is estimated on basis of 'The Farm Gate' concept for crops like cauliflower, cabbage, tomato, egg plant, radish, and cucumber based on 1989 prices at Dang. As the pump provides irrigation water during dry season, the prices mentioned are undoubtedly on the lower side. The estimate for season is shown in Table 3.

The income generated by a farmer with four kattha land by vegetable cultivation @Rs 1,125.00 per kattha = 4 x 1125.00 = Rs 4500.00.

The cost hence may be paid off in about five growing seasons. (21305.00/4500.00 = 4.73) within the limitations of the assumption. Detailed economic evaluation of its application is still to be carried out.

OPERATION AND MAINTENANCE

Linares pump has been deigned to function with minimum maintenance and has been found to run continuously for six months without maintenance. For efficient operation however, it must be regularly maintained. All its moving parts; handle, bearings and the piston cylinders, must be adequately lubricated and greased to prevent rust and corrosion at an interval of 24 hours. Enclosed axle bearings may be maintained once every week.

All metal parts must be removed, sand papered and repainted with rust-retardant enamel. Nust and bolts of the pump should be checked and tightened before and after installations. Bolts may even get lost during operation of the pump. Regular inspection and tightening of the bolts every 3 to 4 days are, therefore, required.

At 1.5 m/s velocity, substantial force is generated in the wheel. To make manipulations of the wheel during maintenance easier, two persons are required; one for stopping the wheel and the other for applying grease.

LOCAL PERCEPTION

Before the pump was installed, people in all the five villages did not understand its operation. Villagers were surprised that the assembly operated without electricity and/or petroleum fuel. The usefulness was appreciated only when the unit started to deliver water. Several farmers showed interest in obtaining and installing the pump as their rain-fed and sloping agricultural land could be irrigated. They also expressed that the pump could be used for supplying drinking water. But the need for water purification was also mentioned.

CONCLUSION

The success of Linares pump would depend on several factors such as cost, the quality of its fabrication and installations. Since the pump consists of several moving parts, regular maintenance is equally important. Users need to be trained to properly operate the pump and should be adequately supported for the purpose.

Several villages along the banks of Nepal's major rivers do not access to dependable water sources at higher elevation to permit gravity irrigation. People rely on rains for agriculture and the rivers also flow at lower elevations. Though the Linares River pump delivers small discharge for wide spread irrigation compared to energy driven pumps, its potential for vegetable irrigation during the dry-season has been evident. Vegetable cultivation can generate income and support the local economy. Further studies to evaluate its prospects need to be undertaken.

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The Study was supported by the Ford Foundation and Appropriate Technology International, USA. The field testing was implemented by NEW ERA, kathmandu. Installation, operation and maintenance manual of the pump in Nepali is being prepared by NEW ERA, Kathmandu.

MISUSE OF WATER RESOURCE ENGINEERS

Arthur T. Corey

(On the occasion of its 30th anniversary in 1989, the Division of Water Resources at AIT invited Arthur T Corey to deliver the key note lecture. Corey was the member of a team under Thomas H. Evans of Colorado State University which organised the Seato Graduate School of Engineering which later became the Asian Institute Of Technology. This article based on his lecture on the occasion points to the inability of many Third World bureaucracies to utilise the service of trained water resource engineers. Only good engineer, says the author, can bring about positive social changes. Graduates become good engineers only when they continuously practice what they have learned. – Editor)

The SEATO School was an idea of Mr. Pote Sarasin, then Secretary General of the SEATO organisation. Pote Sarasin recognised that water resources were a primary concern of South East Asia and for this reason water resources was the first subject taught at the SEATO School. Consequently, the institution selected to lead in the organisation of the new school was Colorado State University in the United States, which had been a leader in water resources education and research since before the beginning of this century.

From the beginning, the faculty at AIT gave much thought to the question of how best to educate students to solve problems of water supply and to protect the environment in the process. Unfortunately, much less thought has been given by governments around the world to the equally important question of how best to use the skills of those for whom so much effort has been expended.

Often developing nations have spent large sums from their limited resources to send their brightest young people abroad for advanced degrees in the water resources field. But the return from this investment often has not been what it should have been. The same problem applies for other technical disciplines as well, but it is particularly acute for professionals whose employment is primarily in the public sector.

B. Regmi

Hydraulics Laboratory AIT

Water development projects, by their public nature, are the responsibility of government agencies. When graduates of foreign institutions return to their home countries with advanced degrees in water resources engineering, they are usually as signed to a government agency, such as an irrigation department or some similar agency. Because their education is more recent, they are more likely to have current technical information than earlier graduates, including their supervisors. However, knowledge of newcomers often s not utilised effectively.

Usually, this is not the fault of the director or any individual or group. More often, it is a result of long ingrained traditions and public perceptions that are a product of another age in an undeveloped society. The public is anxious for its society to maintain its cultural traditions in the face of development and foreign influences. But the public is also anxious for development to take place.

Those of us involved in international development have been inculcated with the idea that local cultural traditions should be respected. In fact, this is a necessary rule for anyone trying to help a society bring about development. However, local traditions sometimes prevent the kind of development the people want. Unfortunately, the connection between tradition and developments is often not recognised by the people affected.

A problem frequently encountered is that the public views a director as someone who generates the ideas and initiates everything carried out by his organisation. The director may feel obliged to act as dictated by local tradition. He may reject suggestions afford by subordinates because such suggestions threaten his perceived role as a director. He may assign anyone who offers advice to a lesser role in the organisation, or even transfer him to another organisation.

The result (of this perception of the role of a director) is often tragic. It has the effect of curtailing initiative and destroying employee morale. Recent graduates have little incentive to maintain their level of technical competence by continued study. Instead of remaining current on developments in their field, they devote themselves to manipulating the system to obtain promotions. This means, among other things, making no suggestions and doing only what is specifically asked.

In a surprising short time, a young graduate who has made no effort to remain current becomes technically incompetent fit only for shuffling papers and periodically placing his initials on a document prepared by a subordinate. As a result, the agency involved does not have the technical capacity to handle design of new water development projects the government may choose to initiate. It is necessary to contract designs to foreign consulting firms, thus depriving young graduates of opportunities to practice skills acquired at great expense to their government.

Another tradition that curtails development of technical competence in government agencies is the perception that a person's social status (and economic compensation) should depend primarily on the number of his subordinates. Everyone aspires to public recognition in his society. Since the public has no understanding of technical competence – only the number of subordinates – it is understandable that a recent graduate's priorities are directed toward becoming an administrator. He will lack incentive to maintain – much less improve – his technical competence.

It often happens (especially in less developed countries) that a young graduate is promoted to an important administrative position before he has practiced his profession adequately. In some societies acquisition of a Ph.D. qualifies one for such a position. Since the administrative position provides the individual with the status and monetary compensation to which he aspired, he is anxious to accept the assignment. Unfortunately, this insures that the young graduate will never become a competent engineer. For the rest of his career he will shuffle papers and initial documents. He also will make decisions he is not competent to make and annoy those who may be more competent than himself.

Another problem often confronting a young engineer is the local bureaucracy. Usually, rules and procedures specified for initiating new projects and carrying out old projects are meant to prevent misuse of government money and discourage corruption. The rules are not always successful in preventing corruption, but they are effective in stopping progress.

Regulations to prevent misuse of government funds (though they may be necessary) can obstruct progress Beaucrats are required to enforce regulations. Once appointed, bureaucrats (like all humans) feel they should do something to justify their existence. if, for example, they find a document with a 5-cent stamp whereas

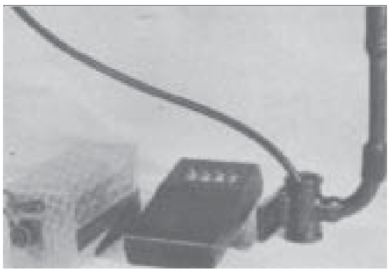
Detecting Scour at Bridge Piers

Water flowing under a bridge may scour the bed adjacent to piers or abutments. When the river is in flood, such a scouring action can become severe and may even undermine bridge piers, causing the whole structure to become unstable and possibly to collapse. River scour has emerged as the single most common cause of bridge failure; a notable example was the Ness railway bridge in Scotland in February 1989. Scouring has also led to the collapse of two major bridges in Nepal. The first one occurred in the Kankai river in East Nepal in 1987, while more recently in September 1991 the central pier of the bridge over river Bagmati between Kathmandu and Patan collapsed.

Divers inspecting bridge piers when a river is flowing quietly may see no signs of the scour holes which are excavated when the river is in spate. This is because as the flow recedes the holes may be partially or completely filled in. Bridge inspections during low flow may thus give a false impression of the potential scour threat.

High technology equipment installed on bridge piers within the flow is liable to be washed away by heavy floods and can not be relied on. Thus, decisions on whether a bridge should remain open are often made on the basis of a brief visual examination of the superstructure, while erosion of the river bed goes undetected.

HR have developed a simple and reliable 'tell-tail' device which shows what is happening below the normal surface. The system uses a series of sensors which are buried in the sediment below the river bed. Each tail is attached to a steel conduit fixed to the pier or abutment and connected by cable to a monitoring box visible on the bridge deck. Women the river is flowing normally the sensors remain buried and still. As the river rises and the scouring increases, the water rips away the sediment. Once exposed to the flow of the water, the sensors start to oscillate and then trigger the surface alarm. Sensors may be installed at different levels to react progressively, giving an indication of the depth of scouring. A prototype is under trial on a bridge over the river Trent near Newark.



Detecting Instrument

For further information contact Colin Waters, HR, Wallingford, UK (0491 35381) regulations call for a 10-cent stamp, they will not allow the document to be passed on to the next bureaucrat. Perhaps the document is a request to purchase a new part for a machine needed to carry out a construction project. The engineer in charge may wait months for the new part and never know why it has not arrived. The bureaucrat who held up the request feels he has done his duty because he has prevented an infraction of the rules.

Another constraint to progress in some societies is a distorted sense of values in regard to particular occupations. Those who direct others to perform a given task may be respected much more than those who carry out projects, especially if the task involves any physical exertion. There are societies where a minor bureaucrat, whose job is no more than initialing documents and passing them on to the next bureaucrat is respected more than, for example, an iron worker whose skills have been acquired over a lifetime of training and practice.

This mentality may also adversely affect the performance for a young water resource engineer. He may, for example, feel he need to order a poorly trained subordinate to make field measurements while he remains in his office. It is not surprising, therefore, that measurements are made incorrectly and false conclusions drawn from the data collected.

The public may even perceive certain professions as more prestigious than others. In some societies water resource engineers may be near the top of the prestige ladder, but in others they may rank much lower than, for example, doctors or lawyers.

In a few cases, water resource engineers (like agricultural engineers) may be regarded as sub-professionals. This, of course, may adversely impact the type of individuals who select water resource engineering as a profession and handicap even capable engineers in performing their duties. Public perception of the status of particular professions may have little relation to the needs of the society. It is more likely to relate to the kinds of people who held power and wealth in the country at an earlier (perhaps colonial) era.

SUGGESTIONS

Since everyone would like his community to have an adequate water supply and the environment protected in the process, citizens as well as policy makers need to be informed about what is required for water resource engineers to work effectively. Directors of government agencies need to understand that their main responsibility is to provide the best possible environment for their subordinates to work and maintain technical competence. This cannot be accomplished if directors feel their job is to provide every idea pursued by their agency. This results in one man trying to do what an entire agency is paid to accomplish.

The public and the policy makers must appreciate the contribution of the technical people who do a crucial design and planning and who are not necessarily supervising work of others. Engineers must receive compensation and other incentives to remain current in their fields so they do not feel their only road to advancement is an administrative position. One way to encourage technical competence in an agency is to require each engineering graduate to practice his profession for a sufficient period of time (and prove that he is still current in his field) before he assumes an administrative role.

Unless such policies are followed, government agencies will not have the capability of doing what they have been created to do – a huge investment in education of the nation's brightest students will be wasted. It will always be necessary to contract the work (that the agency should be doing) to foreign consulting firms.

In order to ensure that even a competent agency or a competent consulting firm has a chance to work efficiently, those charged with overseeing expenditure of public money should be held accountable also for expediting public projects. Bureaucrat must not feel their only duty is to ensure that rules are not broken. They must not assume those responsible for doing the public's work are necessarily intending to cheat the government which leads to nothing being accomplished. The government's entire investment in the projects is wasted.

Young graduates who have just returned to their countries (or are about to return) often have high expectations and dreams of accomplishing something significant for their communities at home. Unfortunately, they may become disillusioned with the system in which they must work. The danger is that they will be-

CAPITAL EXPENDITURE FOR POWER DEVELOPMENT

Unit capacity cost for composite system facilities including generation, transmission and distribution of Electricity.

Country	Cost/kW (in US$)	Country	Cost/kW (in US$)
China	1502	India	2061
Papua New Guinea	1925	Sri Lanka	4451
Nepal	4346	Thailand	2034
Malasiya	1746	Bangladesh	2815
Indonesia	1829	Burma	2719

Source: Capital Expenditure for Electric Power in Development Countries 1990s. By – Edwin Moore (IENED) of George Smith (CCI), Power Services Limited, Toronto, Canada. Feb. 1990.

come convinced there is nothing they personally can do to improve the situation. This should not be allowed to happen.

Several distinguished third world engineers, who were not always rich and influential, after returning home wondered how they could possibly do something to help. They have had moments of despair but they didn't give up and made a difference – a very important difference. The leadership of these individual, in many third world countries have taken ways to become a developed society. These men have immensely helped by establishing consulting engineering firms and giving other young men, as well as themselves, the chance to practice real engineering in the water resource field. The countries have the capacity to do much of its own design and even to provide technical skills for its neighbours.

For those who would like change things must first become a good engineer. Technical skills should be maintained and improved through continuous study. A good engineer cannot be created once and forever at the time a degree has been conferred. What has been learned is forgotten in about the same time as it took to learn it in the first place, and equally importantly, some of what has been learned becomes obsolete just as fast.

ESTIMATE OF GLOBAL SOLAR RADIATION IN NEPAL

Kamal Rijal

(Solar radiation causes movement of water in the earth surface. Its estimates are required for evaporation, snow-melt and solar energy utilisation studies. This paper discusses availability of solar energy over Nepal. Monthly solar radiation at horizontal surface over the country is estimated with the help of Armstrong's formula from the corrected extraterrestrial radiation as maximum values from 29 stations. The paper is a condensed version of the study 'Availability of Solar Energy in Nepal' undertaken by the author at the Water and Energy Commission Secretariat, in 1984. – Editor)

1.0 INTRODUCTION

Solar radiation estimate is needed for assessing evaporation from lakes and reservoirs, snow-melt studies, determination of irrigation water, study of atmospheric turbidity, and for meteorological forecasts. It is also needed for appraising the economics of solar energy conversion devices. Knowledge of global solar radiation on a horizontal surface is essential.

In Nepal, global solar radiation is measured at only one station. This limitation is due to the complexity and cost of the standard apparatus as well as the work necessary for the calibration and maintenance of the instruments. As a result, global solar radiation has to be estimated from climatic parameters, which are more easily measured in meteorological stations.

In cloudy or partly regions, global solar radiation can be estimated through climatic parameters, such as the number of hours of bright sunshine.[1,2] These observations have been concluded as the best specifies of global solar radiation in all the months of a year. The method estimates global solar radiation with the help of duration of bright sunshine collected from meteorological stations.

2.0 DATA AVAILABILITY

Global solar radiation data is measured, since 1975 with the help of bimetallic actinograph having a seven-day chart, while 32 meteorological stations have been measuring daily duration of bright sunshine with Campbell stoke sunshine recorders from 1968 onwards. The location of the stations is shown in Fig 1.

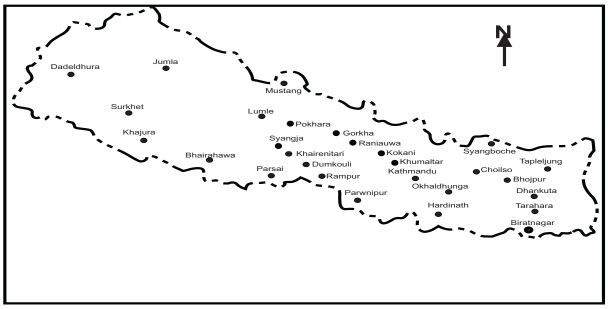


Fig. 1 : Stations Measuring Sunshine Duration

The 10-day mean daily global solar radiation for Kathmandu and the daily duration values of bright sunshine for 32 stations including Kathmandu were obtained from DIHM. Some of the sunshine recording stations either did not have continuous data or the period of observation was short. Only 29 stations were therefore, chosen to include sunshine duration data covering at least, a four-year period.

3.0 METHODOLOGY

3.1 General

A relationship[3] between the clearness index (Q/Q_a) and the percentage of possible sunshine (n/N) was first proposed as

$$Q/Q_a = a + b\,(n/N) \qquad \ldots(1)$$

Where,

Q = observed daily global radiation (W/m) falling on the horizontal plane at a particular place.

$Q_{a\,=}$ daily extraterrestrial radiation (W/m) at a particular place depending solely on its latitude.

n = daily number of hours of bright sunshine (hrs/day)

N = daily number of hours of sunshine of sunshine between sunrise to sunset (hrs/day) also known as a day length.

a, b = climatologically related regression coefficients.

Parameters such as day length and extraterrestrial radiation is calculated with the help of latitude, day of the year and solar constant using following equations.[4,5]

$$\delta = 23.45 \text{ Sin } \{360\,(284 \text{ x } n_d/365)\} \qquad \ldots(2)$$

$$W_s = \text{Cos}^{-1}\,(\text{Tan } \o \text{ x Tan } \delta) \qquad \ldots(3)$$

$$N = (2/15)\ Wa \qquad \ldots(4)$$

$$Q_a = 24/\pi\ I\ [\{1+0.033\ Cos\ (360\ x\ n_d/\ 365)\}]$$
$$x\ (Cos\delta\ Sin\ W_a + 2\pi\ W_a/360\ x\ Sin\text{ø}\ x\ Sin\delta) \qquad \ldots(5)$$

Where,

Ia = Solar Constant (w/m)
n_d = Day of the starting from January 1
W_a = Sunrise hour angle
δ = declination
ø = Latitude of the place

Since the coefficients a and b vary largely from regions to region,[6] local radiation should to be used for any particular area to establish their suitable values.

3.2 Determination of Angstrom Coefficient for Kathmandu Using Two methods.

Method 1

The 10 day mean daily measured global solar radiation (Q) and corresponding duration of bright sunshine (n) for the period 1975-80 were used to determine the two coefficients of equation (1), which is obtained as

$$Q/Q_a = 0.29 + 0.40\ (n/N) \qquad \ldots(6)$$

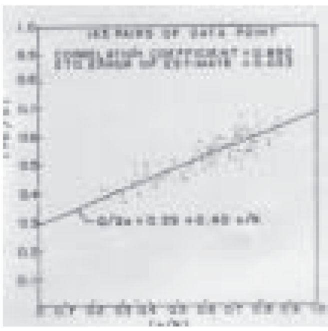


Figure 2: Regression between Q/Qa

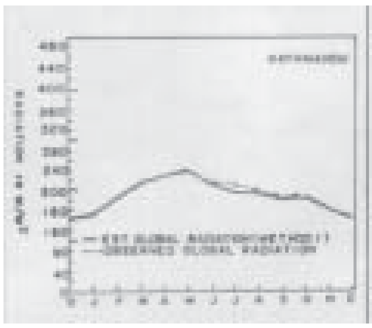


Figure 3: Estimated vs Measured Global Solar radiation

The correlation coefficient and standard error of estimate were obtained as 0.89 and 0.33 respectively as shown in Fig 2. The observed monthly mean of daily mean of numbers of hours of bright sunshine for the period 1968-82 is used to estimate the monthly global solar radiation using equation (6). The estimated and measured monthly global solar radiation showed marked deviation up to 12 per cent specifically in the months of June, July September and October (Fig 3) mainly due to the pre-monsoon, monsoon and post-monsoon periods.

Monthly wise regression relationship was not possible due to unavailability of reliable data. Hence corrections are needed and applied for the deviation obtained above by trial and error methods.

Table 1
Monthly Correction Factor for Coefficient a and b

Month	Coeff . a	Correction Factor For Kathmandu		Determined By Method 2	
		Coeff. a	Coeff. b	Coeff. a	Coeff. b
Jan	0	0.29	0.40	-0.02	-0.01
Feb	0	0.29	0.40	-0.02	-0.01
Mar	0	0.29	0.40	-0.02	-0.01
Apr	0	0.29	0.40	-0.02	-0.01
May	0	0.29	0.40	-0.02	-0.01
Jun	+0.02	0.31	0.40	0.00	-0.01
Jul	+0.04	0.33	0.40	+0.02	-0.01
Aug	+0.01	0.30	0.40	-0.01	-0.01
Sep	+0.02	0.31	0.40	0.00	-0.01
Oct	+0.02	0.31	0.40	0.00	-0.01
Nov	0	0.29	0.40	-0.02	-0.01
Dec	0	0.29	0.40	-0.02	-0.01

The monthly correction factor thus evolved for coefficient a is shown in table 1 column 1 and the coefficient for Kathmandu is shown in table 1. Coefficient a was investigated further, because coefficient b is found to be more or less constant, whereas the values of a shows a marked deviations.[7]

The estimated monthly global solar radiation with monthly varying coefficients and the measured monthly global solar radiation averaged for the period 1975-80 are shown in Fig 4. Both the data fit showed good correlation and the coefficient was obtained as 0.998.

Method 2

A graphical relationship between the coefficients a and b and the annual average of n/N as shown in Fig 5 has been proposed.[8]

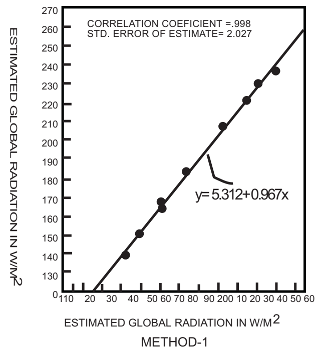


Fig 4: Estimated Global Radiation in W/m³

Following this approach, global solar radiation in Brazil[9] and Greece[10] which also used equation (1) and the method used by Frere *et al* for estimating the coefficients a and b.

Based on the annual average of n/N, from Fig 5 the values of the coefficients are obtained as 0.31 and 0.41 respectively and the equation is obtained as

$$Q/Q_a = 0.31 + 0.41\ n/N \qquad \ldots(7)$$

3.3 Comparison between Method 1 and 2

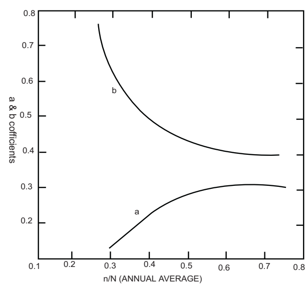


Fig 5: Relation between a and b average n/N

The calculated annual total of monthly values of global solar radiation by Method 1 and Method 2 are 2329.06 W/m² and 2444.21 W/m². The value calculated by method is 0.8 per cent higher than the measured value, while calculated by method 2 is in excess by 5.5 per cent.

3.4 Adaptation of the Method and Determination of Global Solar Radiation for Various Place.

The values derived by Method 1 hence proved more accurate than those obtained by method 2. In case of Kathmandu, the global solar radiation is estimated using Method 1, while for other stations where global solar radiation are not measured, the value of coefficients a and b derived by Method 2 could be used in equation 1. The corrected coefficients are given in Table 1 column 3.

The annul average of the percentage of the possible sunshine n/N for other 28 stations is used to determine the values of coefficient a and b from Fig 5. After determining the coefficient as shown in Table 2 monthly correction factor is applied (Table 1) to arrive at the monthly varying coefficients for each station.

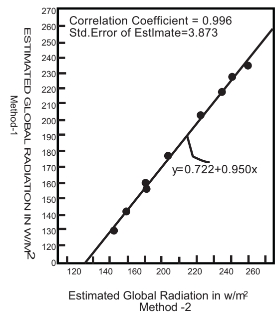


Fig 6: Correlation between Method 1 and Method 2

The monthly varying coefficients evolved thus is made on the basis of the measured global solar radiation and duration of sunshine at Kathmandu. Therefore, to overcome the

Table 2
Determination of Coefficients by Method 2

Station No.	Annual Avr. N/N	Coefficients a	Coefficients b	Range of Annual Avr
1. Hardi	0.68			
2. Parw	0.67			
3. Birat	0.66			
4. Parasi	0.66			
5. Khajura	0.66			
6. Surkhet	0.64			
7. Bhairh	0.64			n/N < 0.70 and
8. Tarah	0.63	0.31	0.41	n?N < 0.59
9. Jumla	0.62			
10. Rampur	0.61			
11. Gorkha	0.60			
12. Kathmandu	0.59			
13. Dadeldh	0.59			
14. Mustang	0.59			
15. Dhanduta	0.56			
16. Dumkauli	0.55			
17. Okhaldh	0.54			n/N < 0.56 and
18. Bhojpur	0.54	0.30	0.41	n/N < 0.54
19. Phokhara	0.54			
20. Khumal	0.54			
21. Khaireni	0.52	0.29	0.42	n/N < 0.53 and
22. Taplejung	0.51			n/N < 0.51
23. Lumle	0.50	0.28	0.44	n/N < 0.50 and
24. Syangja	0.49			n/N < 0.49
25. Jiri	0.48	0.27	0.45	n/N = 0.48
26. Chiaisa	0.46	0.26	0.47	n/N = 0.46
27. Ranipau	0.46			
28. Syangb.	0.43	0.24	0.48	n/N = 0.43
29. Kakani	0.43			

above effects, the correction of observed duration of bright sunshine for other station is carried out as follows.

Equations relating sunshine duration of each station to that of Kathmandu were established from each of these equations and the value of mean monthly sunshine duration at Kathmandu, the corresponding values of sunshine duration (n) were calculated for each of the 28 stations. With the help of the calculated day length for each stations, n/N and n'/N ratios were calculated. Regression analysis was then performed between the two values of percentage of possible sunshine; thereafter, the corrected values of percentage of possible sunshine was derived with the help of the regression equation thus obtained.

The results obtained are satisfactory; the correlation coefficient varying from 0.90 to 0.99 except in two places where they were 0.65 to 0.67. For these two places, after estimating the global solar radiation by using the actual and corrected percentage of possible sunshine, the regression analysis is performed between those two values, which evolved correlation coefficient 0.998 and 1 (see Figure 7). It therefore, verified that the corrected percentage of possible sunshine duration can be used to estimate global solar radiation even in the places where correlation coefficient is not sufficiently high.

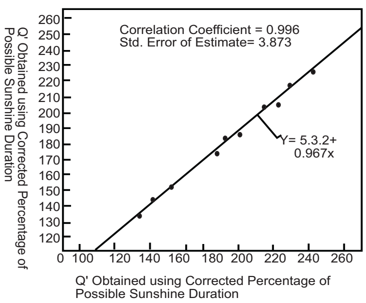


Figure 7: Regression between Q and Corrected Percentage of Possible Sunshine Duration for Mustang

After determining the monthly varying coefficient for each station equation (1) is used with the corrected percentage of possible sunshine in order to estimate monthly values of global solar radiation and maximum global solar radiation (assuming n/N=1). For example, the estimated global solar radiation maximum global solar radiation, and extraterrestrial radiation of one station for each month are shown in Table 3. Besides that Table 3 also includes the geographical position, day length, corrected percentage of possible sunshine and the a and b values for each month for the station is shown in table 4.

4.0 RESULTS AND DISCUSSIONS

Monthly variation in coefficient a is observed whereas b remains constant. While coefficient a varies during the month of June, July, August, September and October, it remains constant during other months. Table 3 also shows a large difference between the maximum global solar radiation and the global solar radiation during all those months with the exception of October. This happens during the pre monsoon, monsoon and post monsoon periods when the could covers are greater compared to other months. The same figure also shows maximum global solar radiation in July, whereas extraterrestrial radiation is maximum over Nepal during June. This can be attributed to lesser dust particles and pollutants in the atmosphere, which settle down due to rainfall in the month.

Table 3
Global Radiation of Biratnagar

Elevation: 72 meters Latitude: 26.48° Longitude: 87:27°

Mth	Global Radiation (w/m^2)	Max. Global Radiation (w/m^2)	Extra terres Radiation (w/m^2)	Day length (Hrs)	Cor. % of Sun shine (n/N)	Coeff a	b
Jan	163.99	190.50	276.08	10.54	0.76	0.29	0.40
Feb	191.79	222.78	322.88	11.09	0.76	0.29	0.40
Mar	223.70	261.61	379.15	11.84	0.75	0.29	0.40
Apr	241.88	292.80	424.35	12.64	0.70	0.29	0.40
May	252.63	307.97	446.34	13.30	0.69	0.29	0.40
Jun	228.21	320.21	451.00	13.63	0.49	0.31	0.40
July	223.46	324.95	405.14	13.48	0.43	0.33	0.40
Aug	214.56	298.00	425.71	12.50	0.51	0.30	0.40
Sep	199.30	275.30	387.75	12.13	0.41	0.31	0.40
Oct	196.98	237.04	333.87	11.34	0.70	0.31	0.40
Nov	174.00	195.54	283.39	10.68	0.81	0.29	0.40
Dec	159.57	179.33	259.89	10.36	0.81	0.29	0.40

Figure 8 shows the distribution of mean daily hours of bright sunshine for each month and the duration of sunshine for each months over Nepal The duration of sunshine is low all over the country during the months of June, August and September while for the other months, it is fairly good, ranging between 7 and 10 hours per day. During July, it is the lowest and ranges between 3 to 5 hours a day. In April and May, it is maximum which decreases from south to north and then increases again due to higher duration in some of the hill stations at higher altitude such as Mustang, Jumla and Dadeldhura. This is mainly due to less cloud cover during the monsoon period as compared to high altitude regions in eastern Nepal such as Chialsa and Jiri.

The monthly values of the estimated global solar radiation for all the 29 stations are summarised in Table 4 and plotted on a map of Nepal (Fig 9). It shows maximum monthly global solar radiation all over the country during the months of April and May and minimum during December and January. The global solar radiation is higher in the months of April and May because of longer of sunshine duration. In December and January, it is low due to lower maximum global radiation itself. The monthly global solar radiation decreases from south to north in eastern Nepal. But in the west, it first decreases from south to north and again increases.

On the basis of the range of the annual total values of monthly global solar radiation, annual total of daily duration of

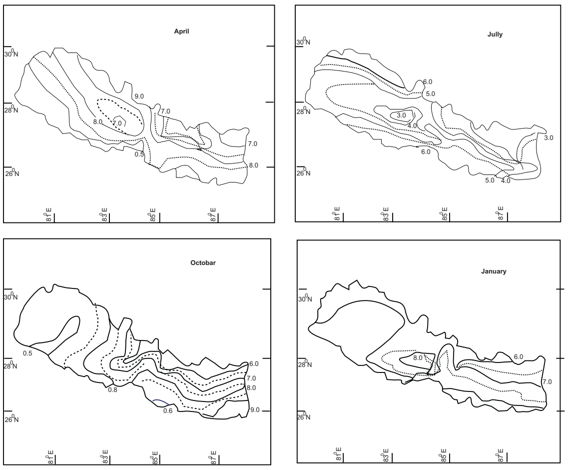


Figure 8: Mean Daily Hours of Bright Sunshine

bright sunshine and the values of coefficients a and b, the places can be identified. This allows identification of preferable places in terms of solar energy availability and, therefore, its utilisations. In the order of magnitude different regions in Nepal can be classified in to types (Table 5) and summarised in Table 6.

Type I and II regions are more preferable than the other types as the availability of solar energy in greater in these regions. 78 per cent of the land mass in Nepal falls under type I (65 per cent) and type II (13 per cent). Total global radiation falling on horizontal surface of Nepal amounts to 32.15 x 10^6MW. In terms of total global solar radiation, Nepal can be considered to possess high potential.

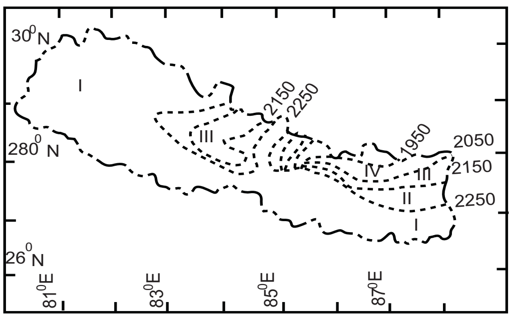


Figure 9: Global Solar Radiation in Nepal

Table 5
Distributed Types and Subtypes

Station	Coefficient a	Coefficient b	Range of Annual Total Global Solar Radiation (w/m²)	Annual Total Sunshine Duration (Hrs.)
Type 1				
Sub type 1a	0.29	0.40	2450-2550	
Sub type 1b	0.29	0.40	2350-2450	>2500
Sub type 1c	0.29	0.40	2250-2350	
Type II	0.28	0.40	2150-2250	2300-2500
Type III				
Sub type IIIa	0.27	0.41	2100-2150	2100-2300
Sub type IIIb	0.26	0.43	2050-2100	
Type IV				
Sub type IVa	0.25	0.44	2000-2050	
Sub type IVb	0.29	0.46	1950-2000	1900-2100
Type V	0.23	0.47	1850-1950	>1900

WATER HISTORY

In 1682 AD, during the reign of Titamitra Malla in Bhaktapur, Nepal, for fair distributiion of irrigation water, following arrangements were made

During the rice-planting season, all the farmers were required to participate in the construction of the water course. Every worker at the end of the day was provided with a royal token, which entitled him/her to the share of water from the course. Water was to be distributed in regular turn irrespective of rank. A farmer unable to produce the token was fined 3 Daam. (4 Daam = 1 Paisa, 50 Paisa = 1 Mohar, 100 Paisa =1 Rupee. 1 NRs = US $ 50 in 1992)

The overseer was not to charge any duty for allowing water from the course. If he did not allow water to be taken in turn, his head officer was to be fined 6 mohars.

Source: Stone inscription in the Dharmasala at Bhaktapur quoted in 'History of Nepal' Edited by Danief Wright, Published by Sushil Gupta Pvt Ltd (India), 1958, pp 130.

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Table 6
Region Classification

Type	Places
I.	Hardinath, Biratnagar, Parwanipur, Parasi, Bhairahawa, Tarahara, Surkhet, Mustang, Rampur, Kathmandu, Jumla, Gorkha and Dadeldhura.
II.	Dumkauli, Dhankuta, Okhaldhunga, Bhojpur, Pokhara and Khumaltar.
III.	Taplejung, Khairenitar, Lumle and Syangja
iv.	Jiri, Chialsa and Ranipauwa.

Table 4
Monthly Global Solar radiation in W/m²

Place	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
TYPE 1													
Sub-type 1a													
Hardinath	161.6	193.3	223.0	246.7	258.1	230.8	230.8	221.3	203.5	201.3	176.1	158.2	2495.02
Biratnagar	164.0	191.8	223.7	241.9	252.6	228.2	223.5	214.6	199.3	197.0	174.0	159.6	2470.08
Parwanipur	162.7	189.8	214.8	241.4	258.2	225.1	227.4	207.6	196.9	207.1	173.9	152.9	2457.60
Parasi	156.5	189.4	218.3	249.4	256.5	232.6	227.6	210.8	197.7	187.3	174.2	158.1	2453.50
Sub-type 1b													
Bhairahawa	151.1	183.1	215.3	244.4	256.5	239.9	222.2	205.7	203.9	199.1	165.4	148.6	2434.60
Khajura	151.1	184.9	215.5	242.2	254.9	247.6	218.9	205.5	196.8	201.2	168.6	164.6	2433.80
Tarahara	157.6	185.9	215.6	238.3	249.1	228.4	216.5	209.4	192.8	196.3	170.9	155.5	2416.30
Surkhet	150.1	179.5	212.8	243.4	255.0	242.5	208.4	295.1	200.6	203.4	163.4	149.5	2398.80
Mustang	140.6	164.0	196.7	239.4	246.2	250.2	237.3	216.9	216.3	181.1	149.3	134.4	2374.23
Rampur	146.5	181.5	215.1	244.3	253.0	234.5	204.4	198.9	194.5	196.2	158.4	138.5	2365.80
Sub-type 1c													
Kathmandu	150.5	183.8	213.4	229.0	240.5	220.1	221.6	197.2	176.7	190.7	161.4	144.3	2329.10
Jumla	146.4	174.7	202.4	224.2	242.6	228.4	214.1	194.9	197.9	199.9	157.4	143.6	2326.50
Gorkha	155.7	177.8	206.7	232.2	237.0	223.9	206.4	198.9	186.2	191.1	157.0	148.0	2320.70
Dadeldhura	142.2	168.5	195.0	241.0	249.8	233.9	210.5	179.6	170.6	197.3	153.1	141.6	2283.00
TYPE II													
Dumkauli	137.2	175.7	206.7	228.8	237.2	217.4	198.2	192.9	185.9	182.2	146.6	126.7	2235.50
Dhankuta	152.7	177.9	208.2	223.7	225.1	207.8	185.4	174.4	183.9	192.2	154.7	147.7	2233.60
Okhaldhunga	147.1	173.0	212.0	225.1	225.2	200.8	190.9	181.1	169.5	178.0	152.3	145.3	2200.30
Bhojpur	146.5	173.5	204.8	216.7	214.4	200.7	189.1	188.0	175.9	179.7	153.9	142.8	2186.00
Pokhara	138.4	167.5	195.1	214.2	220.1	214.1	202.0	185.9	180.6	179.4	151.3	134.7	2183.30
Khumaltar	140.4	175.7	196.2	211.3	223.5	197.4	205.4	196.3	172.1	173.1	153.3	136.8	2181.50
TYPE III (a)													
Taplejung	144.9	165.3	195.4	211.4	219.6	207.2	187.7	185.3	173.3	180.6	143.3	134.1	2148.12
Khairenitar	127.2	155.5	189.9	210.8	221.6	217.0	206.3	195.5	192.8	170.7	136.5	120.3	2143.60
Sub-type III (b)													
Lumle	137.0	157.5	189.7	207.6	208.6	191.4	182.1	171.2	164.7	178.1	139.9	138.0	2069.80
Syangja	127.0	166.4	193.1	207.7	204.7	199.1	1993.6	180.4	169.8	161.2	134.3	127.6	2064.90
TYPE IV													
Sub-type IV (a)													
Jiri	139.1	163.9	190.9	207.9	206.2	184.0	174.6	162.8	157.9	165.0	141.8	130.5	2024.70
Sub-type IV (b)													
Chialsa	137.6	164.9	190.1	196.8	197.7	178.1	176.3	166.9	156.6	162.5	136.4	130.3	1994.20
Ranipauwa	129.2	175.6	191.2	212.1	224.5	168.9	153.8	139.4	129.8	172.3	145.5	131.5	1974.80
TYPE V													
Syangboche	127.9	148.0	175.6	212.3	199.5	164.4	168.8	151.9	142.8	154.0	134.2	123.5	1902.00
Kakani	136.7	156.9	195.0	188.5	203.7	170.7	158.3	149.9	139.2	149.4	122.6	125.9	1897.00

INSTABILITY OF THE GANGES-JAMUNA CONFLUENCE

M. M Hossain

(Jamuna, Ganges (Padma) and Meghna, the three major rivers of Bangladesh, form world's largest river delta. The Ganges-Jamuna and the Padma-Meghna confluences lie, within this delta, forming prominent features of the complex river system. These confluences continually migrate, whose understanding is of paramount importance for many reasons. This paper describes the of shifting of the Ganges-Jamuna confluence near Aricha in Bangladesh and quantifies in with the help of maps obtained from various sources for the period 1963 to 1984. –Editor)

1.0 INTRODUCTION

River confluences have received surprisingly little attention from engineers and geo-scientists. The reason for this lack of attention is probably due to its complex nature which involves high degree of flow mixing, separation, turbulence and energy losses. Confluence is also specific in nature. Yet, correct representation of confluence hydraulics is important for reliable computation of flow in river networks.

Confluence flow characteristics have been studied mostly in a horizontal rectangular laboratory flume.[1,2,3] All these studies emphasise the need for more detailed investigations in scale river models covering various ranges of water and sediment discharge for predicting confluence behavior.

One such confluence occurs between the Ganges and Jamuna rivers in Bangladesh. Investigations have shown that this confluence is unstable which has shifted north-west ward over the years. Its movement is of importance for Bangladesh due to following reasons.

i. Continual migration of shoals and bars locally known as 'chars' create navigational problems.
ii. Townships, ports and communication, socio-economic and agricultural potential of the districts around an unstable confluence cannot be fully developed.
iii. Erosion by shifting rivers destroys human habitation and turns farmers landless and poorer.
iv. Knowledge of the characteristics of this will be also helpful in predicting the shifting behavior of other confluences having similar parameters thereby saving time and resources.

2.0 THE GANGES-BRAHMAPUTRA SYSTEM

The Ganges and Brahmaputra are largest rivers in Bangladesh whose delta covers about 59600sq. km. Area. The confluence of these rivers is continually migrating downstream.

The Ganges is predominantly a meandering river channel, whose average annual discharge is about 12,600m^3/s, but the range varies between about 600m^3/s and 7200m^3/s.[4] During flood the average water surface slope from Hardinge Bridge to Goalundo is about 5.5 cm/km. The bed slope of the Ganges is in the order of 4.6 cm/km. This slope is approximately equal to the slope of the delta towards the bay.[5] For about 35 per cent of the time, the river's flow remains below the average annual flow as evident from the flow duration curve Fig 1.

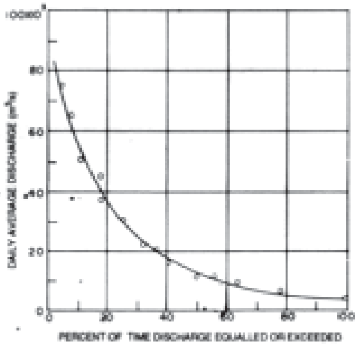

Fig. 1: Flow Duration Curve: Ganges

The dominant flow of the Ganges is about 29500m^3/s.[6] Its minimum and maximum average daily suspended sediment concentration are about 50 ppm 2950 ppm[7] respectively. The bed material consists of small percent of clay, some silt and predominantly fine sand with median diameter between 0.10 to 0.17 mm.[8] It is highly susceptible to erosion and transport processes. Segments of the river banks often slide into the channel during falling stage adding to the sediment load.

The mean annual discharge of the Jamuna is in the order of 23,000m^3/s[9,10] whose dominant discharge varies between 37,000 m^3/s to 41,000 m^3/s with an average value of 38500 m^3/s.11 The average water surface slope of the Brahmanputra is about 7 cm/km. Based on discharges and slope parameters, it is categorised as a braided river[1] . This conclusion has been supported by several field studies as well as other investigation. For 38 per cent of the

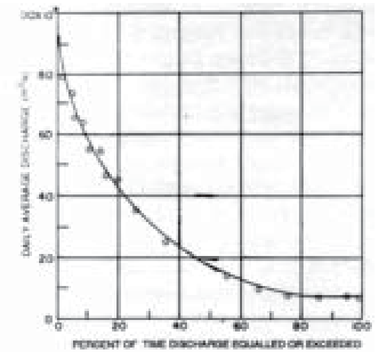

Fig. 2: Flow Duration Curve: Brahamaputra

time, the flow of the Brahmaputra as per its flow duration curve, Fig 2, remains below its average annual discharge. Composed predominantly of silt and sand, the median diameter of Brahmaputra rivers bed material varies between 0.12 to 0.22 mm.

3.0 MAJOR MORPHOLOGICAL CHANGES IN THE BRAHMAPUTRA

Some of the morphological changes at the junction of these rivers probably resulted from the effects of great seismic disturbances in the lower Himalayas and Assam hills in 1950s. Seismic activities undoubtedly subjected the hill regions to increased run off and erosion. This has led to increase in the sediment load in the Jamuna for several years and produced an unusual accumulation of the mass near the junctions leading it to be partially clogged. Massive landslide in Assam caused a rise of 3 m in lowest water level at Dibrugarh, 760 km upstream of Aricha.[12] It has been concluded that the lowest water level has gone up by about 1.5 m at Bahadurabad till 1967. Ever since a steady trend can be observed but the lowest flow remained almost steady from 1951 to 1985.

4.0 ESTIMATE OF CONFLUENCE SHIFTING

The estimate of confluence shifting is based on three maps for the years 1963, 1972 and 1984 collected from Bangladesh Space Research and Remote Sensing Organisation (SPARRSO). These maps were superimposed to detect bank lines changes around the confluence comparison of 1963 and 1984 maps showed shifting of the south bank of the Ganges near the confluence towards the north with a maximum value of about 6 km. North bank has also shifted towards the north whose maximum value at the confluence was about 6 km along the 89°40'E. West bank of the Jamuna has moved westward whose maximum value along the 23°57'3" was about 1.6 km. Between 1963 and 1984, the meeting point of West Bank of the Jamuna and North Bank of the Ganges has shifted towards north-west at the average rate of 0.5 km/year. Displacement however, may not be in the same direction every year.

5.0 DISCUSSIONS

Water levels of Jamuna on the average has been observed to rise from April through July, whilst in the Ganges the rise is observed from June through August. When the flow in the Ganges increases during flood, the sediment mass accumulated upstream of confluence adjusts itself to the combined flow of both rivers.

Valley slopes of the average and 100yr flood is shown in Table-1. It may be observed that below the confluence, the slope decreases drastically causing erosion of riverbed upstream of confluence during rising stages in the Jamuna with the eventual accretion upstream of confluence in the Ganges due to back water effect of the Jamuna upon the Ganges. When there will be flood peak in the Ganges but not in the Jamuna the back water effect caused by the flow of the Ganges causes increased sedimentation upstream of the Jamuna above the confluence. New islands are formed and consequently the channel widens considerably. All these factors have a major influence on the shifting of the confluence.

When flood peaks of both the rivers occur simultaneously around the confluence, worst drainage congestion takes place both at the upstream and downstream of the confluence. In such case, the origin of flood wave comes into consideration and channels get silted up by the sediment load brought down by the flood water. This situation occurred in 1988 flood. It is worth mentioning that the average yearly sediment transported in the Jamuna is in the order of 600 million tons while that in the Ganges is in the order of 450 million tons.[13]

Table 1
Valley Slopes Along Jamuna and Padma Rivers (cm/km)

Station	Chainage (km)	Valley slope	
		Average flood	1:100 Year Flood
Bahadurabad	156.4		
Sirajganj	76.8	6.8	7.3
Nagarbari	13	7.1	7.4
Confluence (Aricha)	0		
Mawa	60	3.7	3.3

Backwater effects strongly depend on the relative size of the confluencing streams. The effects along the Ganges, upstream of the confluence due to a flood-peak in the Jamuna can be seen by comparing stages at different gauges along the Ganges just before and after the flood-peak in the Jamuna. The same procedure can be applied to ascertain the effects of backwater of the Ganges flood peak on the water level of the Jamuna.

The geological properties of bank materials of the Ganges and the Jamuna near the confluence also play important role in its migration. A well defined stable convex shaped east bank deposit just downstream of Aricha exists in the Ganges. This portion contains clayey silt that is more resistant to erosion.

CONCLUDING REMARKS

The confluence of the Ganges-Jamune is unstable and has shifted towards north-west by about 10.5 Kms between 1963 to 1984; a 21 years period. Cross-sectional profile around the confluence changes year to year because of this shifting. The instability results from variable discharges, catastrophic monsoon floods, abrupt rise and fall in river stages, high sediment load and the inability of the rivers to transport it, and the formation and movement of unstable sandbars.

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NOTE

[1] Based on the analyses by Leopold and Wolman (1957), Lane (1957), and Schumm (1977).

A PARTNER IN IRRIGATION DEVELOPMENT

(The International Irrigation Management Institute (IIMI) hosted a workshop from 8-10 January 1992 in Colombo. Top-level government officials and specialists in irrigation and water management from Asia and Africa attended the workshop. The workshop was help to discuss the Institute's strategy and medium-term plan (1993-97) and to obtain the views of IIMI's clients, direct users of the institute's work, comprising of agencies responsible for policy making or management of irrigated agriculture in developing countries. the Director General of the Department of Irrigation (DOI), Nepal also attended the workshop and made following observation about the role of IIMI in Nepal to its staff. – Editor)

Recently, the government of Nepal adopted a working policy for the development of the irrigated agricultural sector. Participatory management or joint management and system turnover are the linchpins of the government's thrust in making farmers partners in development.

The Department of Irrigation, according to the Director General, Shiva Raj Pant has embarked on a joint management program for medium and large systems (above 500 hectares) and system turnover for small scale systems (below 500 hectares). DOI has already turned over the Hande Tar system (100 hectares) to farmer management while the Sirsia System of 1500hectares has been brought under joint management. DOI is considering 15 more such systems to b either turned over or to be brought under joint management, "IIMI can be very useful in giving new ideas on not only participatory management and turnover but also on other subjects like main canal management and we are looking forward to more collaborative efforts in the future" he said.

Pant said; "IIMI has a five year records of collaborative work with the government of Nepal. The major focus of the Institute's work has been on farmer-managed irrigation systems including those aspects relating to participatory management and management transfer or system turnover. Recently, IIMI signed a Memorandum of Irrigation (DOI) covering the next five years, which puts the Institute in a strong position to continue its work in the country."

The director General was of the opinion that the results of the action research activities of IIMI in collaboration with the Department of Irrigation and other agencies, would be very useful in formulating policies designed to overcome irrigation development difficulties presently encountered in Nepal.

Said Pant, "One of the tasks Nepal faces in irrigation management is the reorientation of irrigation systems managers, most o whom are young civil engineers, towards understanding farmers behavior and appreciating Nepal's time tested traditional skills and experiences of the farmers. It is understandable that such exposure was not available to them during their schooling in classrooms and labs. In the real world, the young professionals have to be sensitized towards farmers oriented approaches so that they can successful in persuading farmers to engage in either joint management of systems or system takeover. A research and training institute like IIMI whose mission is to strengthen national capacity to improve the performance of irrigation systems through improved management can help with this process."

FARMER-MANAGED IRRIGATION

In April 1991, the United States Agency for International Development (USAID) Mission in Nepal, entered into a cooperative agreement with IMMI with the endorsement of the Department of Irrigation to develop effective approaches to increasing water user participation in large scale irrigation systems. Initial results from the study being conducted at the Banganga Irrigation System indicate that farmer-to-farmer or peer training is an effective way of organizing farmers for operation and maintenance.

Pant said; *"Irrigation System Manager has to play an active role in organizing farmers to carry out system management in the larger systems."* Nepal has a long tradition of farmer-managed irrigation systems but these farmer-managed irrigation systems have been small scale systems utilizing local building material and traditional skills. Farmers in large scale and medium scale irrigation systems need assistance and encouragement it they are to take over management of their systems.

Farmers in Nepal pursue many activities within survival strategies. Environmental degradation in the form of forest resource depletion has been problematic for the management and repair of irrigation systems. As part of the program to assist farmer-managed systems through the irrigation sector support program, the government through the Agriculture Development Bank of Nepal has been providing loans and technical assistance to small scale farmers and farmer groups for irrigation development. New technologies have been provided as alternatives to surface of run-of-river diversion systems. Keeping these issues in mind the government should consider a more holistic watershed approach towards irrigation development in Nepal.

In 1991, IIMI completed a study to document the experience and evaluate these various Agricultural Development Bank of Nepal financed irrigation projects with respect to their process of development, procedures for implementation, and the impact on the well-being of the irrigator families, the farmer community and the nation as a whole. The study examined different forms of irrigation technologies including shallow tube-wells, farmer-managed surface irrigation systems, rower pumps and lift irrigation.

Overall findings indicate that with a packaged program for assisting farmers, irrigation development could be undertaken in a cost effective way. The Agricultural Development Bank not only provided financial aid, but also organizational as well as technical support. This resulted in increased production at effective costs. further expansion of investment for irrigation by the Agricultural Development Bank has been highly recommended.

The study also identified several areas where IIMI could be of more effective assistance of the bank to further strengthen its capability to assist small scale farmer-managed irrigation systems. IIMI has thus continued t work with the Bank in providing planning, design and process documentation assistance to small scale farmer-managed irrigation projects.

To enable it to continue playing a pivotal role in Nepal. IIMI-Nepal has also been provided with a grant from the Ford Foundation. This program will encompass a wide range of activities including strengthening the decentralized irrigation offices, documenting innovative lending programs for farmers and studies in turnover.

The director general was optimistic about the future of irrigated agriculture in Nepal with international agricultural research centers like IIMI providing a broad overview and assisting in the development process.

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FEASIBILITY OG SUB SURFACE RESERVOIR IN KIRTIPUR MACCHEGAUN VALLEY

G.K. Rao and S.R. Pant

(The depression between Kirtipur and Macchegaun in Kathmandu valley was investigated by electrical resistivily surveys method for its groundwater potential. Geophysical investigation showed the presence of boulder and gravel bed at depth forming a confined aquifer. The prospect of using this aquifer as a subsurface reservoir through artificial recharge is explored preliminarily which has to be supported by more detailed and sophisticated studies. –Editor)

1.0 INTRODUCTION

In many parts of the world, the provisions of safe water to the urban communities have not kept pace with its run away growth. The growing water demand, in many cases, is met by exploitation of the underground water. Some times, the underground aquifers are artificially recharged to augment the storage. It is a process by which the volume of water that enters an aquifer is increased. Artificial recharge was carried for the first time in 1890 AD by the East London Water Company[1] through wells. Artificial recharge systems are currently operating in the United States, Germany, Holland, Israel, Sweden and Australia. In many Asian countries it is not considered as a viable option though more recently in the Philippines, artificial recharge is being contemplated as water supply source.

As an option, artificial recharge and use of the ground water system seems rather remote and impractical in Kathmandu to meet its growing water supply deficit. The generally low natural recharge characteristic of the valley floor further supports this argument. Preliminary investigation indicate the prospect of an aquifer, where such an option might be considered. An electrical resistivity investigation [2] of the depression between Kirtipur Macchegaun in south west of the valley shows that artificial recharge might be a possibility. However, detailed study in and around the depression needs to be undertaken to understand the aquifer behaviour and evaluate the prospects of artificial recharge.

2.0 PHYSICAL SETTING

The depression is situated between the Chandragiri hill range and the Chovar-Kirtipur-Nayabhsnjyang ridge on the south-western part of the Kathmandu Valley (Figure 1). Having a length of 8km in the NW-SE direction, the depression has a width of 2.5 km in the NE-SW direction. It is closed on the north-western side by the Dahachok Dara hill and bounded on the south-eastern side by the Bagmati river downstream of Chovar. The depression has a gentle south-eastern slope, and lies between altitudes 1300 to 1400 m above msl. It is carved into gullies and broad depressions along the major drainage course.

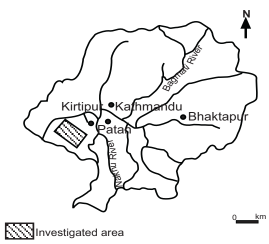


Fig. 1: Study Area

The depression has a sub-tropical climate, with an average minimum temperature of 0.4° Cand a maximum of 31° C. The average annual rain fall is 1400mm, 90 per cent of which falls between June-October.

3.0 REGIONAL GEOLOGIC SETTING

The hills around the Macchegaun valley are constituted of Paleozoic rocks, while the valley floor is underlaid by fluviolacustrine sediment of Plio-Pleistocene age (Figure.2). Chandragiri hill range and the eastern ridge at Chovar are composed of yellowish brown limestone interceded with marly phyllites and banded white quartzite. Chandragiri Limestone strikes in NW-SE i.e. parallel to the depression and dips due SW. The same trend is recorded at Chovar hill but the dip is reversed to NE at the northern part of Kirtipur, which may be due to the presence of a minor fold.

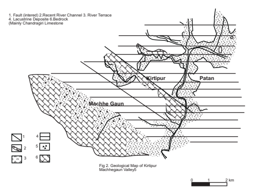


Fig. 2: Geological Map of Kirtipur Machhegaun Valley[5]

3.1 Valley Fill Sediment

Lacustrine sediment of Pliocene age constitute the valley fill sediment in the study area which forms a contiguous part of the central valley [3] Colluvium derived from the Chandragiri hill is deposited along the foothill forming fan deposits overlying and in some places inter fringing with the lacustrine sediment.[4] The breaks in the eastern ridge are filled with alluvium and colluvium in some parts, while the river terrace deposits occur along the BalkhuKhola.[5] The lacustrine sediment consist of clay, silt and fine to medium sand. The clays are gray to black in colour and carbonaceous in some parts.

3.2 Bore Hole Section

The exact nature of the sediment distribution in the valley is represented by the bore hole logs of two tube wells drilled at Satungal and Chovar; two extreme ends of the study area.[6]

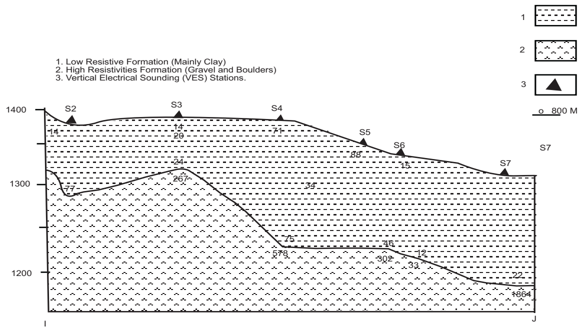
At Satungal, the bore hole was drilled down to a depth of 156m. The litho-log revealed a thick clay deposit from the ground surface to a depth of 108.5 m with a sand layer from 52 to 62 m bgl. Gravel was encounter below the depth of 108.5 m. A thin layer of boulders lies between 116.5 and 117 m bgl (Figure 3). At Chovar, the bore hole was drilled down to 153 m. Clay bed continued from 4.5 to 118 m bgl. Sand and gravel with boulders occurred from 118 to 148m bgl below which only boulders were encountered. Thin layers of sand and gravel occurred within the clay bed between 17.5 to 19.3 m, 23.0 to 26.0m, 36.8 to 89.0m and 94.0 to 105m below ground level. (Figure 3a)

Fig. 3: Lithologs of Tube wells at (a) Himal Cement Factory, Chovar and (b) Dugar Food and Beverage (P) Ltd. Satungal[4]

3.3 Geo-Electric Section

Geo-electrical section in the study area (Figure 4) showed that the valley fill sediment can be classified broadly into three categories; low resistive (<50 hm/m.), medium resistive (50-100 Ohm/m and high resistive (>100 Ohm/m). These can be correlated to the clays, clayey sands to sands, and gravel and boulders respectively.[7] In general, the valley sediment consist of two layer sequence with low resistive clayey formations at the surface and high resistive gravel and boulder deposits at the bottom. Thickness of the clay varies from 50 m to more than 100 m with the maximum recorded in the maximum recorded in the northern most and southern most parts of the study area. Medium resistive sandy sediment occurred in the northern most part as major surface deposit, as layers and lenses at the foothill and as lenses within clays in the remaining parts of the valley.

4.0 GROUNDWATER CONDITION



Note : Digit within the formation indicates true resistivities in Ohm.m. obtained by interpretation of VES curves

Fig. 4: Geoelectric Section along l-j

Lithological setting in the study area suggests a confined aquifer system with the gravel and boulder bed forming the aquifer at depth. The aquifer is relatively deeper in the northern and southern parts and shallower in the middle part of the valley.

The two tube wells at Satungal and Chovar pierce the aquifer at depths of 108 and 118 m respectively. Screens were placed below 120m depth. Static water level (piezometric surface) in the tube wells was reported to be 1.5 to 2.0 m bgl. Piezometric head, therefore, is about 106 to 116m. Flowing condition were reported during post monsoons period. Details of the actual discharge of these tube wells and aquifer parameters were not available.

The depression forms a box like closed groundwater basin. The surface clay bed in the valley is very thick extending up to the foothills. It allows little infiltration of the surface waters. The possible recharge areas are the fan deposits along the Chandragiri hill range. However, their continuity into the bottom gravel bed is still to be ascertained.

5.0 POSSIBILITY OF ARTIFICIAL RECHARGE

In view of limited potential for natural recharge of the confined aquifer, scope for artificial recharge can be explored. The highly permeable gravel and boulder bed, high rainfall in the basin area and the Balkhu Khola which traverses through the basin, show prospects for artificial recharge of the sub surface reservoir.

To ascertain the feasibility, the aquifer's storage capacity though it is capable of transmitting high amount of groundwater by virtue of its permeability, need to be estimated. The aquifer in the study area is under confined conditions with piezometric surface nearly at the ground surface limiting the scopes for recharge. The piezometric surface however, may be allowed to drop by 50 m though pumping to facilitate recharge artificially.

Volume of water that can stored for 50 m of piezometric head would be only about 0.1 Mm^3 (at a storage coefficient of 1.0 x 10^{-4}) which is low. On the other hand, the total annual discharge of the Balkhu Khola estimated from its catchment area (37 km2) and monsoon rainfall (1180 mm) comes to about 43.7 Mm3. The topography of the depression is not favourable for a surface reservoir to impound this water volume.

The confined aquifer may be converted into an unconfined one by initial over-pumping. The resulting compression of the aquifer and confinement of the bed may not be significant considering the nature o the constituting materials i.e. boulders and clays. The storage capacity of the unconfined aquifer will be then governed by the specific yield (S_y) factor that for a gravel and boulder bed ranges from 15 to 30 per cent or even more.

Thickness of the unconfined aquifer required to store the entire Balkhu water i.e.. 43.7 Mm^3 would be 7.3 to 14.5m depending on the specific yield factor.

The study area appears suitable for creating such an underground reservoir as the aquifer is surrounded on three sides by rock. The fourth side on the south is also closed at depth to prevent any leakage, since the gravel and boulder bed comes in juxtaposition with the thick clay bed of the southern Central Valley. (about 60 m. at the exit point of the Balkhu Khola) One of the following methods may be adopted for diverting the Balkhu Khola water underground:

a. Water spreading
b. Recharge pits and channels cut down to the gravel bed,
c. Construction of trench and drain at regular intervals and
d. Injection wells shafts

6.0 CONCLUSIONS

Preliminary investigations show that the monsoon flow of Balkhu Khola from Nayabhanjyang and Kirtipur ridge watershed has a volume of 43.0 Mm^3. This water may be stored in the identified underground basin, which can be accomplished by depressurising the aquifer and converting it into an underground reservoir.

Although, a simple concept, the undertaking of artificial recharge requires detailed studies to determine the effects of sediment, pollution and environmental problems, operation, and maintenance requirements, and the economics of uses. Additional studies on the source and method of treatment of recharge water, the depth and the nature of the formation and the design of the particular type of recharge system for a particular situation are also required.

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Ground Water Facts

- Three-quarters of the cities in the U.S. use groundwater as part of their water supply
- Rainfall is the main source of fresh groundwater. About 25% of the rainfall in the U.S. becomes groundwater-equalling about 3000 trillion gallons per year.
- About 30% of streamflow in the U.S. in from groundwater discharge.
- More than 800,000 new water wells are drilled in the U.S. each year. In the state of Michigan, over 18,000 new wells are drilled each year.

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ANALYTICAL FRAMEWORK FOR AN ECONOMIC APPRAISAL OF COOPERATIVE DEVELOPMENT OF INDO-NEPAL WATER RESOURCES – A SUGGESTION

K.M. PRASAD and D.M. DIWAKAR,

(In spite of its rich water resources potential, Nepal and North Bihar continue to be the poorest in the Indian sub-continent. Economic integration of the region through water resources development can tackle the region's poverty. The integrated approach, the authors caution, should regard water as a finite resource and take into account both its supply and demand. This paper was presented the seminar' Indo-Nepal cooperation in Water Resources Development, Prospects, Constraints and Challenges organised by the Water Resources Study Centre, Bihar College of Engineering, Patna 29th to 30th May 1992 – Editor)

For the development of India and Nepal, where agriculture is the main contributor in the national income, management of land and water resources is not only a determinant in the transformation of society and agrarian structure, but also a common ground of interest for both. More or less the countries are agriculturally, socially, culturally and hydrologically, in the same plane. They also have the advantages of proximity in distance to be traversed, similar tastes, more or less a common history, and an awareness of the common interests. The adjacent countries hence, have strong willingness to coordinate their policies.[1] The cooperative effort will also have a geographical dimension which will help in surmounting transport cost, tariff barriers and other hindrances.[2] This paper attempts to explore the possibilities of interactions between India and Nepal in terms of maximisation of the use, and exploitation of water resources in a broader economic and analytical framework.

Mode of interactions between two or more states may be seen in two perspectives; competitive or cooperative. Taking relative imperfections of interactions into account, one may not deny the fact that a big operator is capable of dominating over the other(s). The outcomes of the interactions are obviously dictated by the larger state. This situation is akin to that of a duopolistic or oligopolistic market, where price leadership, cartel and collusion stem as center – pieces of model to resolve the disputes of sharing in the market. Because, in aiming at injuring others through competition one is liable to injure himself, the competing operators may enjoy monopoly profit, maximise joint gain, if they agree to coexist and share the market. The game of coexistence, in this specific context, would suggest that each party seeks to maximise its own long-run advantage on the assumption that the other operator(s) continue(s) to survive and participate in the process.[3]

Nepal, although a country of upper reaches, is poor and dependent on India in many ways despite its rich water potential. As a result, it has a weak bargaining power. But outside forces like World Bank and other international institutions may intervene to support one of the countries and handle the issues to safeguard their interests. This approach may not be a healthy scenario. Competitive interactions may not be the ideal for developing nations like India and Nepal. Instead to competing with each other as guided by the goal of maximising profit through independent market decisions, the underlying constraints before the two developing nations demand an approach of economic integration and cooperation. The second approach may be a more expediment means of interaction which would amount to a kind of conscious cooperation. Both nations in such an approach would be equal partners where the convergent motive (mutuality of interests) in the mind of the two nations would perfectly balance.[4] The main goal of economic integration here is suggested as a means to overcome the disadvantages of small size and to make possible a greater rate of economic growth and development.[5]

The regions under purview of cooperation are poverty ridden, while the sub-regions are characterised by market deficiency. In such as a situation, nations act as cooperators, step in as producer and create supply and wage bill. These efforts lead to generate effective demand and therefore, the project becomes self financing and cost liquidating in the long run. Poor nations are not capable of investing sufficient amount on an individual basis and under investment does not prove efficient since it remains below the critical minimum effort. When two nations come together for a collaborative and cooperative venture, their effort in terms of investment assumes a bigger dimension and shoves the economy of its dead center by imparting it a big push so that it not only takes-off is continuous in a self sustaining manner.[6]

Cooperative and collaborative ventures are also the part of economic integration. The difference between integration and cooperation is both qualitative as well as quantitative. Cooperation includes actions aimed at lessening discriminations, whereas integration comprises of measures entailing suppression of some forms of discrimination. To sum up, economic union or cooperation is a common market with some provisions or common economic policies.[7] Moreover, healthy cooperative venture is based on the inherent philosophy of voluntary involvement of the nations in a democratic form.

The advantages of cooperation may be briefly outlined as follows:

(i) cooperation gives better economic results by exploiting the underlining complementarities – linkages – in the processes of production and marketing;

(ii) it helps in reaping advantages of scale economies, chiefly through overcoming of indivisibilities of factors of production via their more intensive use, in pooling of resources and bulk transactions which lead to lower costs of operation;

(iii) it eventually lends support to the growth of externalities;

(iv) it draws upon both collective and individual incentives; and

(v) it leads to emotional integration through commonness of the end, which culminate in the unification of hearts, where by the base of cooperation becomes more stable and determinate.

Emotional integration is better regarded as the by-product of economic integration, which builds up a sense of self-help and mutual aid on the part of two or more nations. This, to an extent reduces reliance on external aid. On the emotional plane, its most evident fruit is the sense of solidarity, which symbolises the will to change and to cooperate by consensus or consent given the democratic norms.[8] The recent treaty between India and Nepal is a good herald of improved interaction in terms of both cooperation and integration, though just only in trade and transit spheres. In the proposed cooperative/integrative efforts a multiple of goals would face the two nations, with a shift of emphasis between flood control, power supply, irrigation and navigation, geographically as well as temporally.

Socio-economic proximity between North Bihar and Nepal is reflected in Table-1. Dependency on agriculture in the case o North Bihar is almost equal to Nepal. But the distribution of land holdings is more skewed in Bihar than in Nepal.[9] Interestingly, the percentage of the area irrigated is more or less the same in both the regions. As the two regions, hydrologically, fall in the same basin, sufficient scope exists for mutual cooperation and interactions to develop more efficient water management for the development of agriculture. From the point of view of socio-economic characteristics, such as dependency on agriculture, work-force engaged therein, distribution of landholding of the farm size, per capita availability of the food grain and the level of poverty, North Bihar is even more closer to Nepal than other regions of India. For economic transformation of this region agriculture has to be developed on a priority basis. It will only be possible through effective management of land and water leading to improvement in the production, cropping pattern, cropping intensity, employment and earnings.

Land (inclusive of water) is the 'free gift of nature'. Land has to be managed (since it has become a scarce commodity) with respect to concentration of holdings, participation in agriculture, growing population and to ensure land to the tillers. To improve productivity and attain distributive justice, water, (even though its potential is inexhaustible through recharging) should be considered as an economic good, but a scarce commodity. Engineers, hydrologists and social scientists have been concerned mainly with the designs, discharge, materials, management and costs of water development, but not enough with the intangible social and economic costs. Water as a scarce resource has not been looked at from this perspective in the past.

However, the role of water resource as a determinant for the economic emancipation and growth of developing nations have been realised[14] Water resource management will not be meaningful as long as land reform is not effectively implemented. Today, there is a common ground of agreement among the various academic disciplines that optimum use of water resource maximises the welfare and development of poorer countries.


A.D.

Kosi Barrage at Nepal-India Boarder.

When two developing nations come together with same spirit and philosophy of cooperation to interact, undoubtedly partial optimality becomes the ideal point of equilibrium. This refers to the situation where no one can be made better off without making someone worse off. Theoritically, the optimality can be attained. Empitically however, it will be difficult to be tested and needs to be quantified with the precautions of abstract and qualitative biased ranking and weightages. As long as quantification is not done, offer curves which reflect the preference of country concerned cannot be drawn empirically and hence the terms of trade will not be possible to be determined.[15] In such situation, mutual cooperation may determine the cooperative and competitive terms of trade for the development as an indicative and proxy even if quantification is not specifically done. Obviously, the coalition of the two nations that would emerge would be the means to maximise the welfare jointly. (which is the goal of economic integration).

In market sharing, the benefits would be localised so as to overcome the barriers of transport costs and costs of flow of

Table 1
Socio-Economic Features Of India And Nepal

Description	India	NorthBihar	Nepal
Dependency on agriculture (%)	76.7	93.5	94.0
Work force engaged in agriculture (%)	66.5	85.7	93.0
Distribution of Farm Size			
a. Marginal (%)	56.5	75.9*	63.5
b. Small (%)	18.0	10.8*	19.5
Area Irrigated (%)	31.0	16.0	13.0
Food grain availability per person/day (kg)	0.47	0.39	0.41
Land-Man Ratio	0.40	0.35	0.197
Population below Poverty line (%)	40.0	51.4*	66.6
*Figures relate to Bihar			

Source: 10 ,11 ,12 ,13

intelligence and movement of factors.[16] Though the broad goal of cooperation is overall development, specific needs should be identified in the priority list. Water use in the developing nations is mainly focused on drinking, irrigation, fisheries, navigation, forestry, horticulture and power generation. Undoubtedly, agriculture which is the mainstay in these regions need to be placed at the top. Power generation may come side by side. With the development of agriculture, cooperation and collaboration may be extended to allied sectors and then to industry. The starting point is such case could be agro-industry. What criteria should be set so that the cooperation gets on a healtheir ground is the most crucial question of using the water.


A.D.
KOSI EASTERN CANAL

The rationalisation of water use starts with the requirements of the people and area of the national landuse, both of which are interdependent. Therefore, an approach based on the actual needs may lead to a healthy cooperation between the two nations. Priority of the needs however, may be different. For the Nepalese, irrigation may take a back seat in bi-lateral cooperations, in preference of hydropower development Bihar, on the other hand, may opt for irrigation and flood control as top priority.

Since large portion of the rivers' catchment area fall in Nepal; about three times more than that in Bihar, the responsibility of undertaking afforestation and soil conservation measures in the basin rivers lies more with the Nepal than Bihar. But owing to diplomatic reasons, Bihar is finding it difficult to ask Nepal to pursue the matter more seriously. Here again cooperative spirit may be a suitable approach to maintain ecological balance.

The degree of cooperation in agriculture development, power and other sectors is determined by the cost benefit analyses. Cost and benefit calculations with respect to reciprocal interests should include the tangible physical and material costs, as well as other intangible economic and social costs which have been ignored for quite some time. Underestimated calculations and biased designs where social costs were overlooked, have resulted in controversy over the construction of big dams (which proved misnomer of cost effectiveness), due to environmental degradation, depletion of rare species etc.[17] On the other hand, estimate of advantages also suffer form miscalculation of intangible benefits from irrigation and water management. Moreover, internalisation of external economies should also not be overlooked in the analysis. To arrive at the net returns from water resource development, one should be aware of the danger of bad estimations.

Conservation and consumption of water should be rationalised with the demand and supply. This was not given enough attentions in the past. Conservation deserves emphasis on the ground of large-scale unattended wastage of water, as water is a scarce commodity in this region. a distinction must be made between availability and supply of water, because the latter involves cost of production. For specific regions, the availability for the time being may not be the constraints in a true sense. Long term planning of water resource development must also keep this aspect in view. Man-soil-animal-plant ecological balance will be maintained only by rationalised water use.

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VIEWS FROM READERS

Hydropower system Design Under, Multiple Criteria-A Case Study of the Karnali River Basin, by Dinesh L. Shrestha and Guna N. Paudyal published in Water Nepal Vol-2 No. 4, August, 1991 clearly demonstrated how modern technique may be used in hydro power development planning. All the five upstream reservoirs, considered in the analysis however, are not alternatives from the point of view of optimum basin development. Even the various project configuration taken in the analysis may not be considered alternatives to the Karnali Chisapani project. Each in itself is a candidate project which can independently be developed in the basin

ALTERNATIVE WITH LESS ADVERSE IMPACTS IS DERIRABLE

Hydropower development proposal should be sequenced by comparing several available alternatives. The use of Multi Criteria Decision-Making Framework in fact, make the selection process more objective, hence rational as economic merits as well as social and environmental impacts can be evaluated. Small-scale alternatives with lesser environmental impacts to the proposed gigantic project like Chisapani, undoubtedly would be most desirable.

Leela Nath Bhattarai, Engineer Water and Energy Secretariat
Kathmandu.

ANALYSIS MUST BE BASED ON SCIENTIFIC INFORMATION

The article on Watershed Management in Himalayan Region by Keshav M. Shakya published in Water Nepal Vol.2, No, 4 August1991 discussed one of the most critical issue facing Himalayan landscape; degradation. Several natural and anthropogenic factor have exacerbated the deterioration process over the year. Not only has this lowered the insitu land quality, hence productivity, but also led to excessive generation and transfer of sediment mass to lower reaches.

The author has rightly questioned the efficacy of land classification concept in the Himalayan mountains where agricultural activities, carried out by the hills farmers in the steep slopes, are more because of compulstion for seuvival than fashion. the farmers must be supported in such a way they become the central actors in any development intervention, where land cen be optimally used.

In spite of its importance from the point of view of maintaining in-situ land quality and mitigation of consequential sedimentation effects, watershed managment activities continue to be tackled in a piecemeal basis. Management actions must be coordinated with other sectors, particularly water resources development.

In the Himalaya mountains, the effects of vegetation on floods are however, convenient conjectures than analysis based on the actual quantitative assessment of the flow response of different watersheds. It is not too late to initiate moni toring of the natural processes so that logic become more scientifically based and less concenient interpretations. Of course, sufficient resources have to be allocated for the purpose.

Jitendra Bothara
Siddhi Shtestha
Engineers, Kathmandu

The cover picture in **Water Nepal** August 1991issue, which was titled "Pine Wood Water Tanks at Jumla" was very meaningful. Unfortunately, details were not available and through this letter, I would like to request to you to give us nore information about those water tanks, if you can, in your later volumes.

I feel that such local technologies are very important in Rural Water Supply (RWS) projects in the hill and mountain areas because, conventional R.C.C. and Stone masonry tanks are costly, difficult to construct and maintain. They may not be technically feasible in many situations.

LOCAL TECHNOLOGY IS MORE APPROPRIATE

I am sure that the importance of the message in that picture is seriously taken up by agencies involved in RWS projects in our country.

Surya Man Shakya
Environmental Engineer
Kathmandu

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Research Focus, October 1990

Water Aid Nepal

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