Nepal’s Water Resources: the Potential for Exploitation in the Upper Ganges Catchment

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Editors’ Note
This chapter treats the topic of large dams and power generation from what Thompson in Chapter 2 has termed a ‘hierarchist’ position. An alternative view follows in Chapter 6.

Introduction
The Himalayan kingdom of Nepal possesses a rich resource endowment in terms of water – which, in fact, holds the key to the country’s progress. Located between the Tibetan plateau and the Gangetic plain, Nepal’s unique physical setting along the southern Himalayan slopes has contributed to this natural wealth. Almost the entire area of Nepal (147,181 km²) lies within the Ganges basin, which is about 13 per cent of the total area of the basin. Four major left bank tributaries of the upper and middle Ganges flow southward from Nepal, and along with the other lesser tributaries, Nepal’s contribution to the Ganges flow at Farakka (West Bengal, India) amounts to about 45 per cent. The country has over 6000 rivers and streams with the total length of the water courses exceeding 45,000 km. But development of this resource is far from straightforward, mostly because of the highly seasonal nature of precipitation and discharge. In addition, inter-annual variation is also high. This hydrological uncertainty is made more complex by the problems of funding water development projects, inadequate local infrastructure and lack of a clear picture of the market for water power. Hydropower is, by far, the most important resource to be harnessed in Nepal; the other sectors of water resource utilization are irrigation and navigation. This paper focuses on Nepal’s potential for utilizing the Ganges waters for hydroelectricity generation.

An Environmental Profile of Nepal
Nepal is a landlocked and mountainous country with altitudes ranging between 200 m and 7500 m. It can be divided into five distinct ecological zones from north to south. These zones are the High Himal (literally ‘snows’), the High Mountains, the Middle Mountains, the Siwaliks and the Terai. The High Himal (over 4000 m high) is largely unpopulated, and, together with its southern zone, the High Mountains, accounts for over one-third of the total land area. The Middle Mountains zone forms the central belt of the country. It is heavily populated, covers nearly 30 per cent of the country, and is a region of rugged terrain and deep valleys. The Siwaliks comprise of a series of low ridges and settled valleys, covering 13 per cent of the country’s land area. The southernmost zone is the Terai; it is a low plain of fertile land and dense forests accounting for about 14 per cent of the land area.

The physical environment of Nepal offers a vast potential of water resources. Yet, the geological history of the Himalayas demonstrates the region’s proneness to earthquakes. Consequently, any major structural intervention for harnessing water wealth requires caution and comprehensive assessment. One other hazard to be taken note of in Nepal’s water resource utilization is glacier lake outbursts and flooding. The northern zones have a large number of these lakes, and an occasional breaching of the pondage has often caused severe flooding and destruction downstream.

The climate of Nepal varies widely and dramatically because of the extreme altitudinal range. It varies from a tundra climate in the northern High Himal zone to a hot subtropical climate in the Terai. Precipitation is in the form of both rainfall and snowfall. The mean annual precipitation is about 1500 mm – ranging from 200 mm in the northwest to about 4000 mm in the eastern sections of the country. The southwest monsoon, which lasts from June to September, brings most of the rainfall to Nepal – especially in the southern slopes of the mountains and hills. Snowfall accounts for nearly 10 per cent of the total precipitation. Snow and glaciers make significant contributions to the run-off in the major rivers of Nepal.

Surface Water Systems
Nepal’s abundant wealth of water resource is largely in the form of surface water, although there are some ground water resources in the Terai. The general alignment of the surface water drainage is toward the Ganges in the south. The drainage system is comprised of three categories of rivers (Zollinger, 1979). The most important category includes the four snow-
glacier-fed Himalayan tributaries of the Ganges, i.e. the Mahakali (also known as Sarda in India), the Karnali, the Gandak and the Kosi, and their tributaries (Figure 5.1). The flow in these four sub-basins accounts for about 75 per cent of the annual flow during the monsoon, and the dry season flows are also substantial. The next category of rivers, like the Bagmati, Rapit, Mechi, Kankai and Babai, have their sources in the Middle Mountains. They are mostly rain-fed and have low dry season flows. The rivers originating in the Siwaliks or further south belong to the third category. They have smaller catchments, dry season flows are minimal, and wet season flows often come in the form of violent spate floods with high sediment loads. The westernmost of Nepal’s four major rivers – the Mahakali – forms part of the Indo-Nepalese border. After flowing into India, it meets with the Karnali. Nearly 35 per cent of the Mahakali drainage area lies within Nepal. The Karnali river dominates the drainage area of western Nepal. The river originates in Tibet (China), forms a deep gorge at Chisapani in the Siwaliks, and, after receiving several tributaries within Nepal, meets the Mahakali in India. It is then known as the Ghagra and joins the Ganges upstream of Patna (India). The Gandak river drains central Nepal and its volume is enhanced with flows from seven major tributaries. After emerging out into the plains, the river flows in an easterly direction to meet the Ganges near Patna. The biggest river of Nepal is the Kosi, which drains the eastern third of the country. The Kosi’s headwaters come from Tibet and its major tributaries are Arun, Sunkoshi and Tamur. Following the three tributaries’ confluence at Tribeni, the Kosi (now known as Sapt Kosi) cuts through the Siwaliks, emerges into the plain near Chatra and continues its flow toward the Ganges.

Table 5.1 Energy consumption in Nepal, 1990 (by fuel type).

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Percentage of total energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>94.6</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>74.5</td>
</tr>
<tr>
<td>Crop residues</td>
<td>11.8</td>
</tr>
<tr>
<td>Animal dung</td>
<td>8.3</td>
</tr>
<tr>
<td>Petroleum products</td>
<td>3.9</td>
</tr>
<tr>
<td>Coal</td>
<td>0.5</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.8</td>
</tr>
<tr>
<td>Others</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>


The Energy Scenario

The abundant supply of water and the favourable terrain offer excellent opportunities for hydropower development in Nepal. However, due to
technical and financial constraints, this advantage has been little developed so far. At present, only 11 per cent of the population have access to electricity. In order to evaluate Nepal’s potential for exploitation of the upper Ganges waters for electricity generation, it is necessary to first look into the current energy consumption pattern (Table 5.1). Nepal heavily depends on traditional non-commercial energy sources – mainly biomass. Commercial energy consumption (coal, oil and electricity) is only around 5 per cent. In fact, per capita consumption of commercial energy in Nepal is one of the lowest in South Asia; it is 25 KQ.E as compared to 57 KQ.E in Bangladesh and 231 KQ.E in India (World Bank, 1992). Biomass energy sources include fuelwood, crop residues and animal dung, and these are the dominant fuel sources in the domestic sector. Even in the industrial sector, nearly 66 per cent of the energy consumed comes from fuelwood and crop residues (IIDS, 1993). Fuelwood has traditionally been a non-commercial fuel, but it is now increasingly commercialized, especially in the urban areas.

Fuelwood primarily comes from public forest lands and some private woodlots. Overexploitation of these forest resources for fuelwood has led to adverse environmental problems in the recent decades. Rice straw is the major type of crop residue used for domestic cooking, especially in the Terai, where fuelwood is relatively scarce. Animal dung for cooking competes with manure demand in the crop fields. Nepal has, nonetheless, achieved modest success in developing small biogas plants using dung and crop residues. The value of these plants is that after the methane has been extracted and used as fuel, there still remains a valuable fertilizer residue – in contrast to the burning of dung, which leaves effectively nothing. Over 5000 family-sized biogas plants have been established so far.

The current installed capacity for electricity generation in Nepal is 249 MW, of which 227 MW is generated from water and the rest from diesel. The relief of Nepal provides sufficient scope for run-of-river hydropower generation. Within the past decade, small and micro hydropower plant development has received considerable attention among the energy planners. Both coal and oil are imported into Nepal. India is the main supplier of coal, while petroleum products are bought from the international market elsewhere.

Hydropower

The absence of fossil fuels in Nepal and the progressive depletion of forest wealth from fuelwood exploitation make it imperative that indigenous water resources be developed for the production of electricity. The water wealth in the Nepalese rivers of the Ganges basin is indeed phenomenal. The estimated volume of the annual run-off of the rivers within the country is around 175 x 10^9 m^3 (Pradhan and Shrestha, 1986). These rivers include the four perennial rivers of Mahakali, Karnali, Gandak and Kosi as well as the rain-fed rivers of the south. The volume of water in Nepal’s rivers has a theoretical hydro potential of about 83 000 MW, of which the economically feasible potential is around 42 000 MW (WECS, 1989). However, as noted earlier, the current installed capacity of electricity production is only 227 MW, which is a mere 0.27 per cent of the theoretical potential. This figure underscores the enormous water power potential of Nepal, which it is anxious to exploit. Table 5.2 shows the vast hydropower resources of the four major mountain rivers. These rivers account for almost 98 per cent of the economically feasible potential for hydropower generation.

<table>
<thead>
<tr>
<th>River basins</th>
<th>Percentage of mean annual run-off</th>
<th>Percentage of hydropower potential (theoretical)</th>
<th>Potential of hydropower potential (identified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahakali</td>
<td>43.5</td>
<td>2.7</td>
<td>56.9</td>
</tr>
<tr>
<td>Karnali</td>
<td>23.8</td>
<td>(including Mahakali)</td>
<td>12.5</td>
</tr>
<tr>
<td>Gandak</td>
<td>28.9</td>
<td>24.8</td>
<td>25.8</td>
</tr>
<tr>
<td>Kosi</td>
<td>18.8</td>
<td>4.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Other rivers</td>
<td>24.4</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>


Nepal’s development of water power utilization had been slow due to financial constraints and the limited nature of the domestic market, both of which reflect the dual attributes of a small population and a low per capita income. Nevertheless, the peak load demand within the country has steadily increased in recent years; power demand between 1984 and 1989 increased at an annual average rate of 14 per cent (NEA, 1990) and the Nepal Electricity Authority estimates that the country is likely to experience an energy deficit by 1995. To think in terms of the domestic market alone is of course wrong. There is already a large potential market to the south for the export of hydropower to the northern Indian states where demand is high, and this will increase rapidly in future decades.

Nepal has few proven natural resources, other than its agriculture and its scenery which draws so many tourists, and its water. Hydropower development potentially holds the key to the country’s best chances of economic progress.

Development Options

The first hydroelectric plant in Nepal was constructed in 1911 (Sharma, 1983) with an installed capacity of 500 kw, about 15 km south of the capital, Kathmandu. However, because of certain technical and economic realities, Nepal was faced with a choice between developing storage-type large
projects on the one hand, and micro hydro plants and run-of-river projects on the other. The scattered nature of the rural population in the hills and mountains and the availability of a large volume of surface run-off in the rivers make micro hydro plants very attractive. In 1990, the Nepal Electricity Authority was running 29 micro plants with a capacity of 4.2 MW; also, there are smaller sites owned by the private sector (IIDS, 1993). Agro-processing and rural electrification are the main sectors of electricity consumption from these plants. But the electricity produced from micro plants can be transmitted only over a moderate distance, and there might be problems, in some cases, in linking up with the national transmission network. The economies of scale enjoyed by the medium and large plants may also make micro plants cost-ineffective in the longer run.

Nepal also faces a development option of going after run-of-river projects as against large storage-type power projects. Run-of-river projects are considered attractive from the points of view of terrain, the rainfall distribution pattern and the social disbenefits such as population relocation. Yet, these projects do not utilize the water resource optimally, and as demand for energy increases in the export sector, run-of-river projects are likely to yield to the storage-type projects for greater economic gains. The storage projects are multipurpose in nature, i.e. besides generating electricity, they also provide irrigation, navigation and flood moderation benefits. However, storing water behind dams also entails displacement of people and the need for rehabilitation.

Market Potential

Nepal's water power is its principal export commodity. The logical market is northern India, although it is often argued by some energy planners in Nepal that the country will also be able to transmit electricity across India to Bangladesh and Pakistan in the long run – assuming more stable political relations between these states. However, the immediate market for Nepal's hydropower exists in the northern region of India, especially the states of Bihar and Uttar Pradesh. The load forecast for the next 10 years in this region shows an annual growth rate of about 10 per cent. Of the current installed capacity in northern India, 43 per cent is of hydel origin and over 52 per cent is from fossil fuels. By 2005, an additional generation of about 35 000 MW will be required to meet peak load demand in northern India (HMGON, 1989). Hence, instead of constructing more thermal plants, India can import clean hydropower from Nepal to meet its growing consumption needs. The exploitation of the northern Indian market is, therefore, an essential component of Nepal's planning strategy for water resource utilization. In the long run, the interconnection of the grids of Nepal and northern India could enjoy the benefits of an integrated system. The income earned by Nepal from its sale of power to India could be used to service its debts incurred for the construction of hydropower projects. The additional benefit would be savings on fuel oil imports and diminished fuelwood consumption.

Nepal's Hydropower Programme and the South Asian Dimensions

Co-operation in water power development between Nepal and India had actually started in 1920 with an agreement to construct a barrage on the Mahakali (Sarda) river along with a hydropower plant within Indian territory (Vergheese and Iyer, 1993). The agreement provided for mutual exchange of land between the two countries in order to have the project located completely within India. Nepal, under the agreement, was to receive about 28.3 cumecs (1000 cusecs) of water annually, but, since the barrage was under Indian control, Nepal never received more than 12 cumecs (400 cusecs). It serves as an example of the dangers in regional efforts at water resource development when mutual trust and transparency of action are lacking. The Kosi river basin, which has nearly one-fourth of the country’s total power potential, received early attention from both Nepal and India. In 1950, India had proposed to build a high dam at Baraksheta (near the confluence of the Sun Kosi, Arun and Tamur rivers) to produce 1800 MW of power along with providing substantial irrigation and flood attenuation benefits. However, instead of this mega project, the policy makers opted for the less ambitious Kosi barrage project in 1954, which was designed to yield power, irrigation and flood moderation benefits. The two countries amended the agreement in 1966 in order to acknowledge and ensure Nepal’s right to all kinds of upstream water uses in the Kosi basin. This was necessary as a confidence-building step and also to dispel Nepal’s fear of losing its water wealth due to earlier appropriations from trans-boundary rivers by the lower riparian, i.e. India. (Although it might seem that the upper riparian state can physically appropriate water without consideration of lower riparian states, legally it

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (MW)</th>
<th>Dam (height) (m)</th>
<th>Reservoir storage (million m³)</th>
<th>Submerged area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnali (Chisapani)</td>
<td>10 800</td>
<td>268</td>
<td>16 210</td>
<td>33 900</td>
</tr>
<tr>
<td>Mahakali (Pancheswar)</td>
<td>1 335</td>
<td>262</td>
<td>4 800</td>
<td>4 750</td>
</tr>
<tr>
<td>Poornagiri</td>
<td>1 065</td>
<td>156</td>
<td>1 240</td>
<td>6 500</td>
</tr>
<tr>
<td>Kosi High Dam</td>
<td>3 000</td>
<td>269</td>
<td>9 370</td>
<td>19 500</td>
</tr>
</tbody>
</table>

is normal that all subsequent developments have to take account of prior
developments, regardless of location on the river. In other words, historical
precedence is a legal principle). However, irrigation benefits to
Nepal from the Kosi project, in terms of areal coverage, were only one-
sixth of the projected total on account of certain locational and structural
problems.

The next project of co-operative endeavour was on the Gandak river
basin. Under the agreement between Nepal and India in 1959 (subsequently
revised in 1964), a barrage was to be constructed on the international
boundary. This was primarily an irrigation project to supply water to about
57,000 ha of land in the Terai and even larger tracts in the northern Indian
states of Uttar Pradesh and Bihar. An important part of this agreement on
the Gandak river was the recognition of Nepal’s rights of upstream water
withdrawals and negotiated trans-valley use of waters in the Gandak
basin. Nonetheless, the Gandak project too, like the earlier Kosi project,
did not bring Nepal its legitimate amount of benefits from a collaborative
water resource utilization scheme. The proportion of irrigation benefits
obtained by Nepal from the Kosi and Gandak projects amounted to only
2.4 per cent of the total area served by the two projects.

Nepal is expected to experience an electrical energy deficit by 1995, and
can power conservation through load shedding has already become a regular
nightly phenomena. An NEA study on planning the expansion of power
has considered this energy deficit situation against the projected load
demand as well as the export market potential in future, and arrived at a
sequential power development programme through utilizing the upper
reaches of the Karnali, Gandak and Kosi basins. It involves the con-
struction of five projects in varying sequences depending upon the
production cost and the export potential. These projects are Upper Arun 3,
Upper Karnali, Kali Gandaki and Burhi Gandaki. All of these are run-off
river projects except for the last one, which has a gross storage capacity of
over 3.2 x 10^9 m^3 and energy capacity of 600 MW. All five projects, if
completed, will increase Nepal’s capacity of electricity generation by over
1300 MW. This will also enable Nepal to link its national distribution
network with the northern Indian grid, and thus assure itself of regular
power export.

In the light of the prospects of an energy market in northern India (and
possibly even in Bangladesh), Nepal feels encouraged to utilize its water
potential through large and mega projects. Nepal is unable to embark on
the construction of such projects alone and must, therefore, seek funds
from multilateral donors. The latter, in turn, will finance the projects only
if they are assured of a market for the surplus power as well as of the water-
sharing rights between Nepal and India. The role of India is very crucial in
this context – it needs to make genuine efforts to remove past wrongs and
to help to create a climate of trust, and collaborate in the establishment of

projects through technical and financial support. In the past three decades,
India has demonstrated its interest in developing large water resource
projects in Nepal. The principal potential sites for mega projects are in the
river basins of Karnali (at Chisapani), Mahakali (at Pancheswar) and Kosi
(at Barakshetra) (Table 5.3). All of these projects involve large storage dams
and are multipurpose in nature, i.e. besides power generation they are
expected to yield irrigation benefits and to moderate flood effects
downstream. The power potential of these three basins was investigated in the
mid-1950s, and both Nepal and India showed eagerness to develop it.

Nepal undertook feasibility surveys in the Karnali basin in the 1960s and
Chisapani was identified as the most suitable site for a major hydropower
plant. Subsequently, several other studies were conducted in the Karnali
basin and, finally, a comprehensive feasibility study of the basin
recommended in 1989 a hydro plant at Chisapani with an installed capacity
of 10,800 MW. The project will consist of a 270-m-high dam with active
storage volume in the reservoir exceeding 16 km^3. The capacity of this
project to produce electricity far exceeds Nepal’s need in the foreseeable
future, but by the year 2007 – when the Karnali is expected to be
commissioned – it would be able to meet the increased demands for power
in northern India as well as displacing some of the coal- and gas-fired
generators there. The Karnali project, therefore, plans to link up with the
northern Indian electricity grid through over 300 km of cables. Besides
power generation, the Karnali project would also bring vast irrigation
benefits to both countries. For Nepal, irrigation potential would extend over
190,000 ha of undeveloped land, while India would receive irrigation facilities
in about 3 x 10^6 ha of land. The cost of the project would be around $5
billion at 1989 prices. The handsome benefits that India would derive from
this project make it an eager partner in developing the Karnali potential.

The Kosi basin is the next important basin with potential for mega
projects. The earlier plan for a high dam at Barakshetra is now being
revived. The storage reservoir would not only produce power, but could
also moderate floods in Nepal and northern India. The current scheme of
the Kosi high dam project at Barakshetra includes a 269-m-high dam with
an installed capacity of over 3000 MW. As the previous Kosi barrage project
and flood control embankments did not yield projected benefits, the Kosi
high dam seemed more promising as a multipurpose venture. The project
would also irrigate lands in eastern Nepal and Bihar state (India).

The Mahakali (Sarda) river, which marks the boundary between western
Nepal and India, offers yet another site for a large high dam project. The
feasibility studies recommended a cascade development of the potential
with two dams – one at Pancheswar and another at Poornagiri – having a
combined installed capacity of 2400 MW. This project would be another
exercise in the often difficult and sensitive field of Indo-Nepalese joint
ventures in water power development.
Role of Seismicity

The building of high dams for mega projects in Nepalese rivers is, however, not without problems. One such area of concern is related to the vulnerability of the dams to seismic hazards in the Himalayan region. Moreover, dams themselves have been known to trigger earthquakes – a famous case being the filling of the Koyra reservoir in Maharashtra, which triggered an earthquake in 1967. Although the weight of water on or near a fault is sometimes cited as the causal factor, the increase in overburden is negligible in most cases; it seems mostly that the reservoirs cause changes in ground hydrology, and that they increase the chances of lubricating a fault, thus activating it. Changes in hydrology can also destabilize hill slopes – and there have been several dam disasters in which a massive landslide has occurred into a reservoir, causing tidal waves which have overtopped the dams, and also of course reducing reservoir capacity, and in some cases damaging the dam structure itself. The Himalayan belt and its foothills as well as northeastern India are active seismic zones. In fact, this area has experienced four great earthquakes (with magnitude of over 8 on the Richter scale) during the past 100 years in Assam (1897), Uttar Pradesh (1905), Bihar/Nepal (1934) and Arunachal Pradesh/Assam (1950). Earthquakes with a lesser intensity, but devastating in terms of loss of lives and property, also hit this belt in 1988 (Bihar/Nepal) and 1991 (northeastern India/western Nepal). Thus seismic proneness of the Nepalese Himalayas has often been cited as a limiting factor in the construction of large dams. The Chisapani (Karnali) dam is projected in a highly seismic zone, although it is designed to withstand an earthquake of magnitude greater than 8 on the Richter scale. However, concern about seismicity should not be the principal factor limiting the development of such dams. Better and comparative studies and data are required for a fuller assessment of earthquake hazards in the Himalayas. It would improve the identification of the seismic source zones and the designs of earthquake-resistant dams. The International Commission on Large Dams (ICOLD) has formulated certain principles or guidelines for the design, construction, maintenance and operation of high dams (Verghese and Iyer, 1993). Technologically it is now possible to design and build stable and earthquake-resistant high dams.

Land Submergence and Population Displacement Associated with Large Dams

Another area of concern for Nepal in water resource development is the spectre of population displacement due to storage reservoirs and this displacement caused by the submergence of houses and agricultural land has, of late, become a major human rights issue of dramatic proportions. Even though the proposed reservoirs in Nepal are located in low-density remote areas, they would, nonetheless, inflict traumatic hardships on many people. The reservoir behind the Chisapani (Karnali) dam would displace more than 60,000 people over a period of 10 years. It would also submerge about 8000 ha of cultivated land in the valley and over 20,000 ha of forests. The displacement of people and their relocation on other lands are inseparable parts of water development, although the costs of rehabilitation along with provision for land and alternative employment are high in both social and economic terms. For Nepal, it is an extremely challenging task that needs careful assessment of costs and benefits before the implementation of any large project. One brighter aspect of the problem is that most large water resource projects have a gestation period of 8-12 years or even more. This gives the planners a breathing time to prepare and implement relocation measures in phases so that the ordeal of displacement among the affected people can be minimized.

Conclusions

Nepal possesses water wealth of immense proportions, which, if developed for power, can usher in an economic miracle. Besides power generation, the tributaries of the Ganges within Nepal offer opportunities for irrigation in the dry season. However, three-quarters of the irrigable lands are concentrated in the southern Terai region of the country. Small irrigation systems, managed by farmers, have operated in Nepal for centuries. In the present century, irrigation from surface water has increased through barrage construction, and the building of large multipurpose projects in the future would provide perennial irrigation in the country (CIWEC, 1989). Inland navigation in the Nepalese rivers had always been minimal due to the terrain and draft problems. As a landlocked country, Nepal needs transit through India and Bangladesh for outlet to the sea. The Ganges tributaries – as they emerge from the hills – may be developed for inland water transport in order to gain maritime access through the Ganges, through the use of navigation locks at appropriate places. Although hydropower is Nepal’s major natural resource, its development faces several problems, including the international character of the market, seismic hazards, population displacement and rehabilitation, and the loss of agricultural lands and forests. The debate on whether Nepal should go for some or all of its hydropower potential through mega projects could be a never-ending exercise. Yet the ideal combination of an energy generation potential at home and a market for energy export in the neighbouring region seems a sufficient justification for the exploitation of Nepal’s water asset without delay. The mega projects would no doubt be expensive, yet the income earned from the sale of energy would help to invigorate Nepal’s sluggish economy. Moreover,
the price of delaying hydropower generation efforts would be even greater because of increasing infrastructural, environmental and social costs. It may, therefore, be prudent for Nepal to plan for a mix of medium and large projects with the aim of obtaining an optimal scale of utilization.

Another dimension of Nepal’s hydropower development relates to genuine and equitable regional co-operation, which, in fact, is germane to the utilization of a trans-boundary resource like water. It was noted earlier that Indo-Nepal co-operation in water resource development had not always been at the most satisfactory level. It started with a bilateral agreement for the Mahakali (Sarda) project. But Nepal was unable to obtain her allocated share of irrigation facilities for decades, and the co-operative spirit was, thus, stillborn. Next followed the Kosi and Gandak projects of the 1950s which, too, did not bring dividends to Nepal in proportion to the projects’ potentials. In recent years, India has demonstrated active interest in participating in Nepal’s water resource development for mutual benefits. However, this new dimension has also been clouded by a controversy regarding the Tanakpur project (120 MW) on the Mahakali river. This project involves some cession of Nepalese territory, and Nepal also feels aggrieved by the promise of getting only one-sixth of the generated power. These misgivings could have been avoided if Nepal had been adequately consulted at the pre-planning stage and a consensual atmosphere created through trust and transparency. Nonetheless, these hurdles are not insurmountable. And, despite the thorny nature of the co-operative path, the future of the Nepalese economy lies in the upper Ganges waters.

References