Environmental Impacts of Khudi Small Hydropower Project on the Fishery of the Khudi River during Operation Phase

Mohan Prasad Devkota
Amrit Science Campus, PO Box-102, Tribhuvan University, Kathmandu, Nepal
Email: mdevkota@wlink.com.np

ABSTRACT

Khudi Small Hydropower Project (3.45 MW) is a run-of-the-river generating system, located in the Lamjung District, Western Development Region of Nepal approximately 180km west of Kathmandu. The entire project structures lie along the Khudi River bank, a distance of 2.86km from weir to powerhouse, covered by small patches of shrub land and grazing land. The main environmental impacts will be on the local fish population of the river due to the project operation. During the operation of the project the 2.86km section of the river located between weir and powerhouse will experience a reduced flow during the dry season between December and May, significantly affecting the local fish population. The downstream release of 250 l/s of water is most likely to be further reduced in the dry period to augment the increasing demand of electricity. The decrease in the downstream release during dry months will be only partially mitigated by two tributaries (Painyu Khola and Rinch Khola) recharging the river approximately 509m and 2069m downstream from the weir. The combined flow of the two tributaries is only 3.5% of the river flow, which is insufficient to protect the aquatic life. In addition, the ground water recharge capacity is unknown for this section of the river. Therefore, impact of changes in the river hydrology in the dewatered section of the river during the low flow season is expected to be most severe between December and May, significantly affecting the aquatic life.

Key words: Khudi Small Hydropower, reduce flow, dry season, fish, impacts, Nepal.

1 INTRODUCTION

Although Nepal has an enormous hydropower potential, only a small fraction of it has been harnessed. As a result, today Nepal is presently facing a severe shortage of electricity. Few large hydropower projects are under consideration to fill this gap of demand. However, the government has now made it clear that smaller projects are urgently needed to meet the country’s growing demand before commencing the large projects. The Khudi Small Hydropower Project (KHP) with a power generation capacity of 3.45 MW is one of them.

The project lies in the Lamjung District, Western Development Region of Nepal, 180 west of Kathmandu Valley. The project area is located in the middle hills of Nepal which is characterized by the weathered rock with extreme variation of topography and by moderate to steep slopes, terraced land and some partly stabilized landslide debris. KHP with an installed capacity of 3.45MW is a run-of-the-river project without peaking capacity. The headworks consists of a 1.5m sloped weir, which diverts 4.5m³/s water through a 2 chambered settling basin and conveyed through a 2.5km long penstock pipe to the intake which is located 2.86km upstream of the powerhouse (Fig. 1). The intake lies approximately 4.5km upstream from the confluence of Khudi with Marsyangdi and 509m upstream from the Painyu Khola. The powerhouse is located approximately 1.6km upstream from the confluence of Khudi and Marsyangdi Rivers on the right bank of the Khudi River. Construction of the project took 17 months from August 2005 to December 2006 and came into commercial operation from January 2007.
The main impacts of the project on biotic environment in the area are expected to come from the reduced flow in the river during the dry seasons due to project operation. The local fish population of the river will be impacted by the reduced downstream flow from the weir as very little water is released in the river from December to May. This will affect half of the high fishing season which extends mainly from April to July. To protect the fish population, KHP will maintain a minimum downstream release of 250 l/s from the weir during operation phase.

Khudi River characteristics and water quality are reported to be suitable for fish feeding and spawning activities. A total of 5 species of fish including two species of Snow Trout, Sucker Head, Copper Masher and Torrent Catfish have been reported using the river. The population density of fish progressively increases downstream from the weir with the Blunt Nosed Snow Trout being the dominant species. None of the recorded fish species are included in the list of endangered species of CITES but both species of snow trout and the copper masher are reported to be vulnerable according to Shrestha (1995).

The main objectives of the paper are to investigate the existing fish population of the river, determine the potential negative impacts occurring during project operation and suggest the mitigation measures to reduce the negative impacts. The findings of the paper are based on the review of the various environmental documents of the project and the visit made during Environmental Impacts Monitoring during Operation Phase.

2 METHODOLOGY

The basic information on the Khudi River fishery were reviewed and collected from the following two documents:


KHP sites were visited in the first month of operation of the project between 20th and 26th January 2007 to monitor the impact of the operational phase of the project on the Khudi River fishery. During the monitoring field observation, fish sampling (by cast net), interviews with local people who fish in the river as well as collection and analysis of phytoplankton and zooplankton were done and project documents reviewed. Fish sampling was done at the same six stations, which were selected during EIA study, with 60 castings done in each station. These six stations are located at: 300m upstream of weir, 200m downstream of weir, Painyu Khola confluence, ḅnchi Khola confluence, the powerhouse and Marsyangdi River confluence. A cast net of 2.7m in diameter was used with a mesh size of 25mm near centre and 8mm towards circumference and provided with 110 metal pieces each weighing 25gms. Phytoplankton and zooplankton were collected near the powerhouse. The Public Relation Officer of the project was consulted and the information was collected regarding the effectiveness of the proposed mitigation measures during the operation phase.

3 RESULTS

3.1 River Hydrology

The project area lies in the subtropical region between Elevations 830m (Powerhouse) and 950m (Intake) whereas, the Khudi River basin extends up to an elevation of 5000m (Table 1). The monsoon season starts in the middle of June and lasts until the middle of August with maximum precipitation occurring between July and September. As the catchment area has no permanent snow cover or active glacier at a higher elevation, the river experiences reduced flow from December to May.
Table 1. Characteristics of Khudi River catchment area

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Area (km²)</th>
<th>Percentage</th>
<th>General Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 5000m</td>
<td>0</td>
<td>0</td>
<td>Without snow cover or active glacier</td>
</tr>
<tr>
<td>3000m – 5000m</td>
<td>33</td>
<td>27</td>
<td>Higher and Lesser Himalayas</td>
</tr>
<tr>
<td>&lt; 3000m</td>
<td>90</td>
<td>73</td>
<td>Lesser Himalayas</td>
</tr>
<tr>
<td>Total</td>
<td>123</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

The Khudi River is one of the major tributaries of the Marsyangdi River and has a catchment area of 127.3 km² located below Elevation 3000m. Mean monthly high flows on the river occur in August (25 m³/s) and low flow in February (2.8 m³/s). The river flow is less than 4.5 m³/s, between December to May, the planned capacity of the system (Fig. 2).

![Average Monthly Flow of Khudi River](image)

Fig. 2 Average monthly flow of the Khudi River at Intake

The Painyu Khola (509m below intake) and the Rinchi Khola (2069m below intake) both contribute 36 l/s and 62 l/s respectively to the Khudi River (jointly 0.098 m³/s) during the dry months when the Khudi River flow is lowest (2.8 m³/s).

3.2 River Morphology

Within the project area the Khudi River is narrow with a moderate to steep gradient having a large number of boulders scattered in the river bed and along the river, as well. The river becomes much narrower and steeper immediately upstream of the weir, where it passes through narrow gorges cut through the higher mountains. Many rearing pools and breeding grounds were identified mainly upstream of the weir and downstream near the powerhouse. Moreover, many potential spawning grounds were identified between weir and powerhouse sites. In one location the river bed was found completely altered where the penstock pipe is buried under the river bed and access for vehicle crossing was also provided. This particular location is downstream of the Painyu Khola confluence. A large amount of excavated material was deposited near the river bed. This could easily find its way to the river during monsoon time. No rapids were identified which could provide an obstruction for fish passage during migration.

3.3 Fish Diversity

As shown in Table 2 five species of fishes are reported to inhabit the Khudi River. Both species of Snow Trout as well as Copper Masheer are mid-range migrant species, whereas Torrent Catfish and Sucker Head are resident species. Although no long distance migratory fishes have been reported in the river, it has been believed by the local people that long distance migratory fishes also use the river for upstream migration during spawning season.
Table 2. Fish species reported to inhabit the Khudi River

<table>
<thead>
<tr>
<th>Fish species</th>
<th>English name</th>
<th>Peak spawning/migratory period</th>
<th>Protected status (Shrestha, 1995)</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schizothorax plagiostomus*</td>
<td>Blunt Nosed Snow Trout</td>
<td>March-April/Sept-Oct</td>
<td>Vulnerable</td>
<td>Food value</td>
</tr>
<tr>
<td>Schizothorax progastus+</td>
<td>Long Nosed Snow Trout</td>
<td>March-April/Sept-Oct</td>
<td>Vulnerable</td>
<td>Food value</td>
</tr>
<tr>
<td>Acrossocheilus hexagonolepis*</td>
<td>Copper Masheer</td>
<td>Aug-Sept</td>
<td>Vulnerable</td>
<td>Game fish</td>
</tr>
<tr>
<td>Pseudocheneis sulcatus+</td>
<td>Torrent Catfish</td>
<td>June-Sept</td>
<td>_</td>
<td>Food value</td>
</tr>
<tr>
<td>Garra gotyla*</td>
<td>Sucker head</td>
<td>Resident</td>
<td>_</td>
<td>Food value</td>
</tr>
</tbody>
</table>

* sampled during the EIA study; + reported to occur in the river by local people

A total of 41 fishes belonging to three species were sampled during the EIA study (Table 2) with Blunt Nosed Snow Trout having the highest percent of occurrence followed by Copper Masheer, and Sucker Head having the least as shown in figure 3.

No professional resident fishermen are found along the Khudi River and fishing is not identified as an important part of the economy in the impact area. Fishing is a part time activity of local people and is considered as a main source of animal protein for local community. A large part of the catch is consumed by the local people whereas a little is sold in the local market for extra income. Fishing is mostly done between March and June when the locals have no agricultural activities.

4 DISCUSSION

Downstream flow from the weir, especially during the dry months, is very important for the local fish population of the Khudi River. The project is designed to use a maximum of 4.5m$^3$/s of water for power generation. The 2.86km section of the Khudi River located between weir and powerhouse will experience noticeable dewatering during the low flow period from December to May during the operation phase due to the diversion of 4.5m$^3$/s of water for power generation. The total flow of the river is less than 4.5m$^3$/s during the low flow season from December to May and this will be the most crucial time period for the survival of the local fish population and power production, as well. The river flow will be augmented only after the beginning of the monsoon reaching a maximum flow of 28.7m$^3$/s in August and after September it will decrease sharply.
Every year the country faces a severe shortage of power supply during the dry months and the diversion of 4.5 m³/s of water for power generation by KHP will have a severe impact on the aquatic life within the river. It has been proposed that 250 l/s water be released from the weir at all times throughout the year to maintain the aquatic life in the river, however, the minimum release from the weir depends upon the effective implementation of the Environmental Monitoring and Management Plan of KHP. Complete diversion of the Khudi River during the dry months will be only partially mitigated by the inflow of two tributaries (Painyu and Rinchi Khola) which respectively meet the river at 509 m and 2069 m downstream from the weir. The total flow of these two tributaries is not sufficient to maintain the aquatic ecosystem of the river. Since the groundwater recharge capacity of this dry section of the river is unknown the aquatic life in the river will be most likely seriously impacted in 2.86 km section of the river between weir and powerhouse during the dry months.

Fig. 4 Dry months release from weir and Khudi recharge from tributaries

The Khudi River contributes a very small fraction of the total fish species (186 species) reported from the various river system and water bodies of Nepal (Shrestha, 1994). Compared to the EIA study the fish diversity of the river is already reduced (Figure 5). Only 40 fishes belonging to two species were recorded during the impact monitoring study in the operational phase clearly indicating the impacts of KHP on fish diversity during the dry months.

Fig. 5 Composition of fish species recorded during impact monitoring
Diversion of water for power generation will also severely affect the fish population by drying up the rearing pools, breeding grounds and spawning grounds during the peak spawning season, however, it will not hinder the migration as it occurs during high flow. As a result, the 2.86km dry section of the river will separate the fish population upstream and downstream during the spawning season negatively affecting their reproduction. The KHP weir is designed in such a way that it will not pose a potential threat for fish migration. The construction of Lower Marsyangdi Hydropower Project (69MW), approximately 65km downstream from the KHP, without a fish passage leaves no opportunity of upstream migration for long distance migratory fish species.

The Sucker Head is expected to be least affected during the dry months as it is more adapted to low flow conditions. Therefore, it is most likely that it may replace Snow Trout and Copper Masheer in near future thus changing the fish species composition of the Khudi River.

The installation of 2.5km long above ground penstock will further increase the water temperature downstream of tailrace especially during low flow period. In addition, the water temperature will also significantly increase in the 2.86km long section of river during the low flow season. Water quality parameters are very closely interrelated and a modification of one usually results in changes of many others. The rise in water temperature could result in reduced dissolved oxygen and accrued dissolution of non-ionized ammonia in water. Temperature and dissolved oxygen are the two parameters to which fishes are most sensitive and ionized ammonia is toxic for them. Reductions in flow can result in increased concentration of pollutants already discharged into the water course such as pathogens and/or nutrients from natural or chemical fertilizers and animal waste or of sediments from soil erosion. However, the long term changes in water characteristics are unlikely to happen since the monsoon will bring a renewal of downstream water each year. Reductions in river flows downstream will certainly reduce the abundance of local aquatic invertebrates during dry months and the invertebrate loss will be supplemented only after the spring rain, which washes down insects from the upper reaches.

Effects on local fish populations will significantly reduce the fishing activities of the local people thus affecting the demand of local fish supply and extra source of income for poor people in long term.

5 RECOMMENDATIONS

Based on the findings of this paper the following suggestions have been proposed to reduce the negative impacts on the fishes of the Khudi River:

- Carry out fishery studies twice a year in March/April and October/November to evaluate the impacts after the first year of its operation;
- Ensure that the recommended mitigation methods suggested in the Environmental Monitoring and Mitigation Plan of KHP are effectively implemented and followed;
- Downstream release of 250l/s from the weir during the dry months should be closely monitored everyday; and
- River water analysis and bacterial tests should be also done before and after the monsoon in the first year of its operation.

The above recommendations should be carried out over the next several years of station operation.

6 CONCLUSION

It seems that the construction of KHP is a result of inconsiderate and injudicious decisions due to the pressure of ever increasing demand of power supply. The overall long term impact of seasonal reduction of flow in the 2.86km section of the Khudi River is difficult to determine and too early to evaluate at present. However, if complete sections of the river lose all flows due to its high intensity, regional extent and long term duration, the impacts on fish resources in the Khudi River are expected to be high even if seasonal.
ACKNOWLEDGEMENT

I would like to thank the KHP for providing me an opportunity to work as a Biologist for the Environmental Impact Monitoring during Operational Phase. My sincere thanks also go to the organizing committee of the Hydro Sri Lanka Conference for sponsoring most of my expenses.

REFERENCES


Katle (Copper mahseer) caught in the Khudi River

Snow trout caught in the Khudi River