**Consolidated Management Services Nepal (CMS)**
**Min Bhawan, Bansewor**
**Kathmandu**

# Indrawati River Basin Study

## Draft Report

**July 2005**
**Ashad 2062**

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**June 2005**
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**Prepared by: Ajoy Karki**
**Water Resources Engineer**

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# Acronyms

| | |
|---|---|
| **amsl** | above mean sea level |
| **AEPC** | Alternative Energy Promotion Centre |
| **AWP** | Area Water Partnership |
| **CMS** | Consolidated Management Services Nepal |
| **DDC** | District Development Committee |
| **DHM** | Department of Hydrology and Meteorology |
| **DoI** | Department of irrigation |
| **FMIS** | Farmer Managed Irrigation System |
| **GTZ** | German Technical Cooperation |
| **GWP** | Global Water Partnership |
| **ha** | Hectare |
| **HMG/N** | His Majesty's Government of Nepal |
| **IWMI** | International Water Management Institute |
| **IWRM** | Integrated Water Resources management |
| **kWh** | Kilo Watt hour |
| **lps** | Litre per second |
| **MCM** | Million cubic meter |
| **MHP** | Micro-Hydropower Plant |
| **MLD** | Million litres per day |
| **MPPU** | Multi-Purpose Power Unit |
| **mt** | Metric ton |
| **MW** | Mega Watt |
| **MWSDB** | Melamchi Water Supply Development Board |
| **MWSP** | Melamchi Water Supply Project |
| **NGO** | Non Governmental Organisation |
| **REDP** | Rural Energy Development Program |
| **SHPP** | Small Hydropower Promotion project |
| **UN** | United Nations |
| **UNDP** | United Nations Development Program |
| **VDC** | Village Development Committee |
| **WECS** | Water and Energy Commission Secretariat |
| **WUA** | Water Users' Association |

# 1. BACKGROUND

This Draft Report on "Indrawati River Basin Study" is prepared by Ajoy Karki (Water Resources Engineer and Consultant for this study) for Consolidated Management Services Nepal (CMS). This study has been undertaken to form a basis for establishing Area Water Partnership (AWP) in the Indrawati River basin. The report is based on review of literature and field visit to some parts of the river basin.

In order to address the water crisis at the global level, the international community endorsed certain water related principles in 1992 during the International Conference on Water and Environment held in Rio, Brazil. These principles are as follows:

- Fresh water is a finite and a vulnerable resource, essential to sustain life, development and the environment.
- Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
- Women play a central part in the provision, management and safeguarding of water.
- Water has an economic value in all its competing uses and should be recognised as an economic good.

Global Water Partnership (GWP) was established in 1996 with the objective of translating the "Rio-Principles" into practice. GWP is an international network open to all organisations involved in water resources management. These organisations include: government institutions, Unite Nations (UN) agencies, bi-lateral and multi-lateral banks, professional associations, research associations, NGOs and the private sector. GWP promotes Integrated Water Resources Management (IWRM) by creating fora at global, regional and local levels. IWRM is an essential component of good water governance. It consists of a common sense holistic approach to water that integrates hydrological, engineering, social and economic best practices- an approach accepted as desirable by most water professionals. IWRM is a process, which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of the vital ecosystems.

The objective of establishing AWP is to provide a platform to water-related institutions and stakeholders for interaction to achieve IWRM.

The concept of AWP was put forth by Global Water Partnership (GWP) in order to provide forums at the local levels. Such forums can then be used to debate on the Rio Principles, dissemination of knowledge on how these principles can be applied in practice and exchange of experiences and mobilisation of fiscal and human resources necessary to achieve IWRM.

However, AWP is not a total replication of GWP at the local level. GWP's mandate is to promote IWRM through global networking. As mentioned earlier, AWP provides a platform to various stakeholders for interaction in the water sector such that IWRM can be achieved at the local level. With the establishment of AWP, the interdependency of various water related institutions and other stakeholders can be identified and furthermore, necessary reforms to achieve IWRM can be put forth on the basis of stakeholders' interaction.

# 2. BASIN HYDROLOGY

The Indrawti River Basin is located in Bagmati zone, Central Development Region of the country. It originates from the Mahabharat and Himalayan Ranges at an elevation of about 5850 m above mean sea level (amsl) and discharges into the Sun Koshi River at an elevation of 626 m amsl. Both snowmelts and spring sources contribute to the base flow of the river. The total length of the Indrawati River from its origin till the confluence with Sunkoshi is about 59 km and the catchment area is about 1240 $km^2$. The basin extends from 27° 37' 11" N to 28° 10' 12" N latitudes and 85° 45' 21" E to 85° 26' 36" E longitudes.

The Indrawati Basin covers approximately 43% area of Sindhupalchowk district and 11% area of Kavrepalanchowk district. The lower reach of the river basin such as the Melamchi river (at Talamarang), Nayagaun (via Nagarkot and Kunta Besi) and Dolalghat has vehicular access.

The overall study area in relation to the river systems of Nepal and the catchment area of the Indrawati basin are presented in Figures 1 and 2 respectively.

The Indrawati River receives flow contributions from the following major tributaries:

- Larke
- Yangri
- Melamchi
- Jhyangri
- Chaa
- Handi
- Mahadev

The Indrawati River system along with all tributaries and their locations with respect to the confluence points is schematically shown in Figure 3.

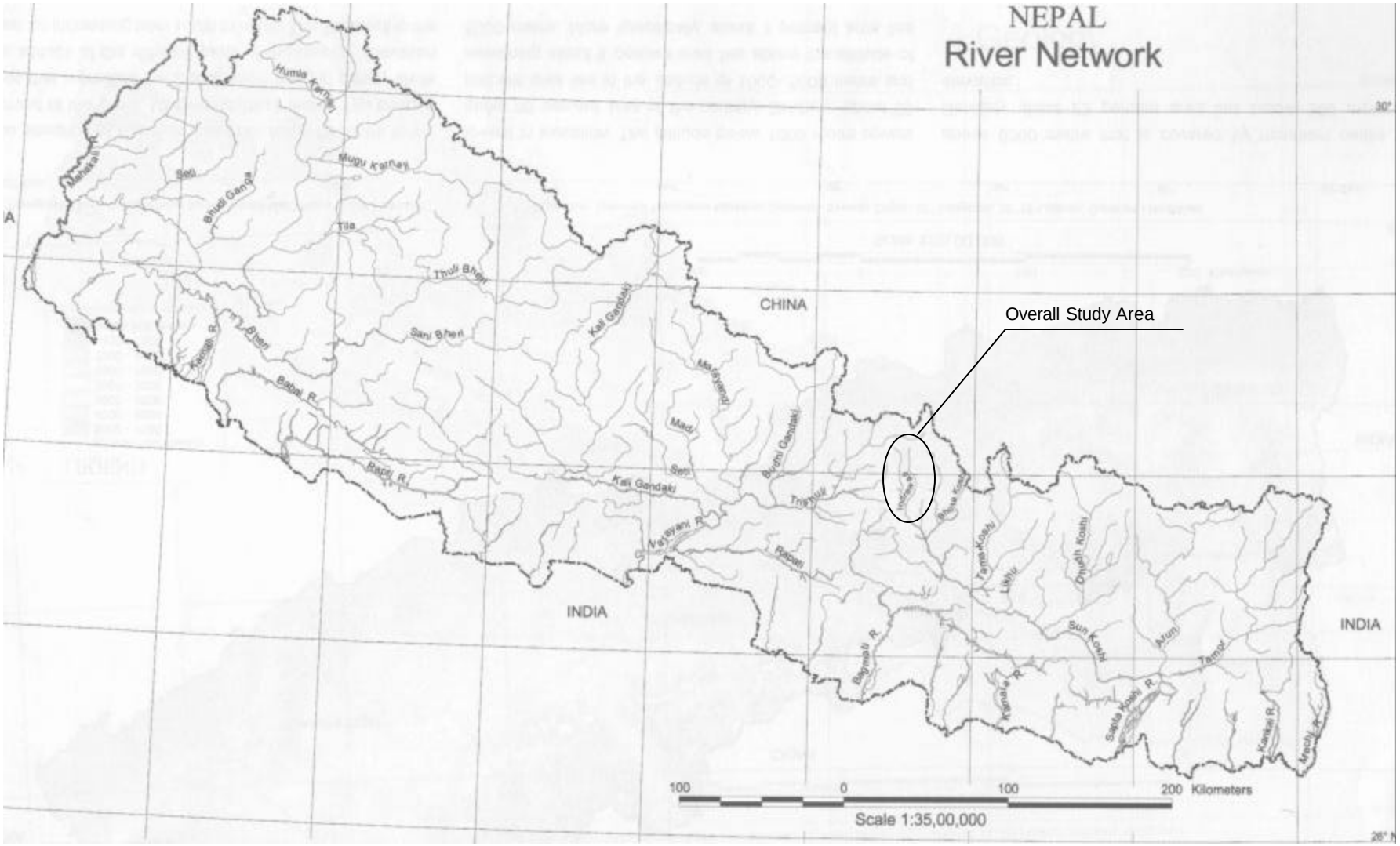


**Figure 1. The overall study area and the river systems of Nepal**

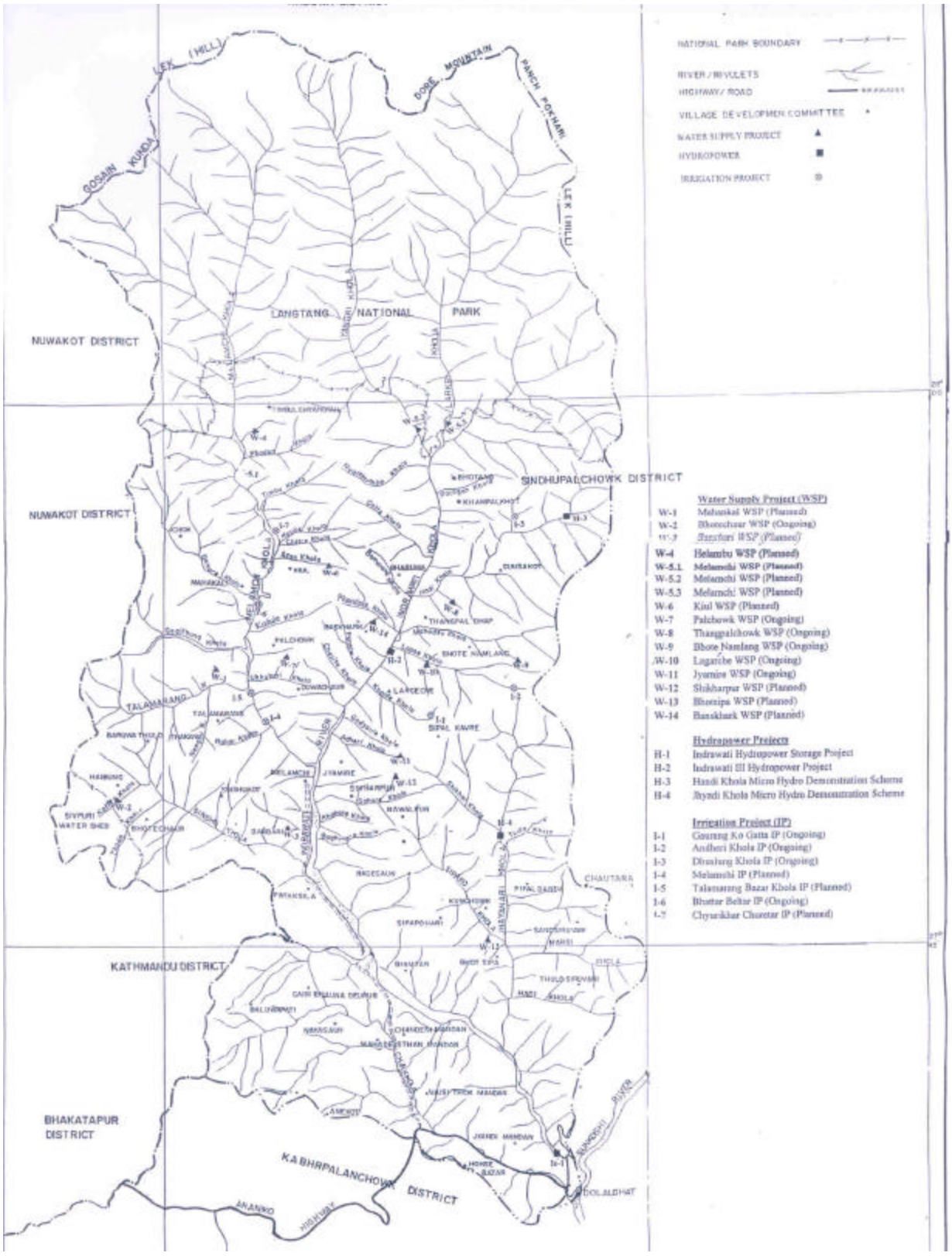


**Figure 2. Catchment Area Indrawati River**
(Source IWMI 2002)

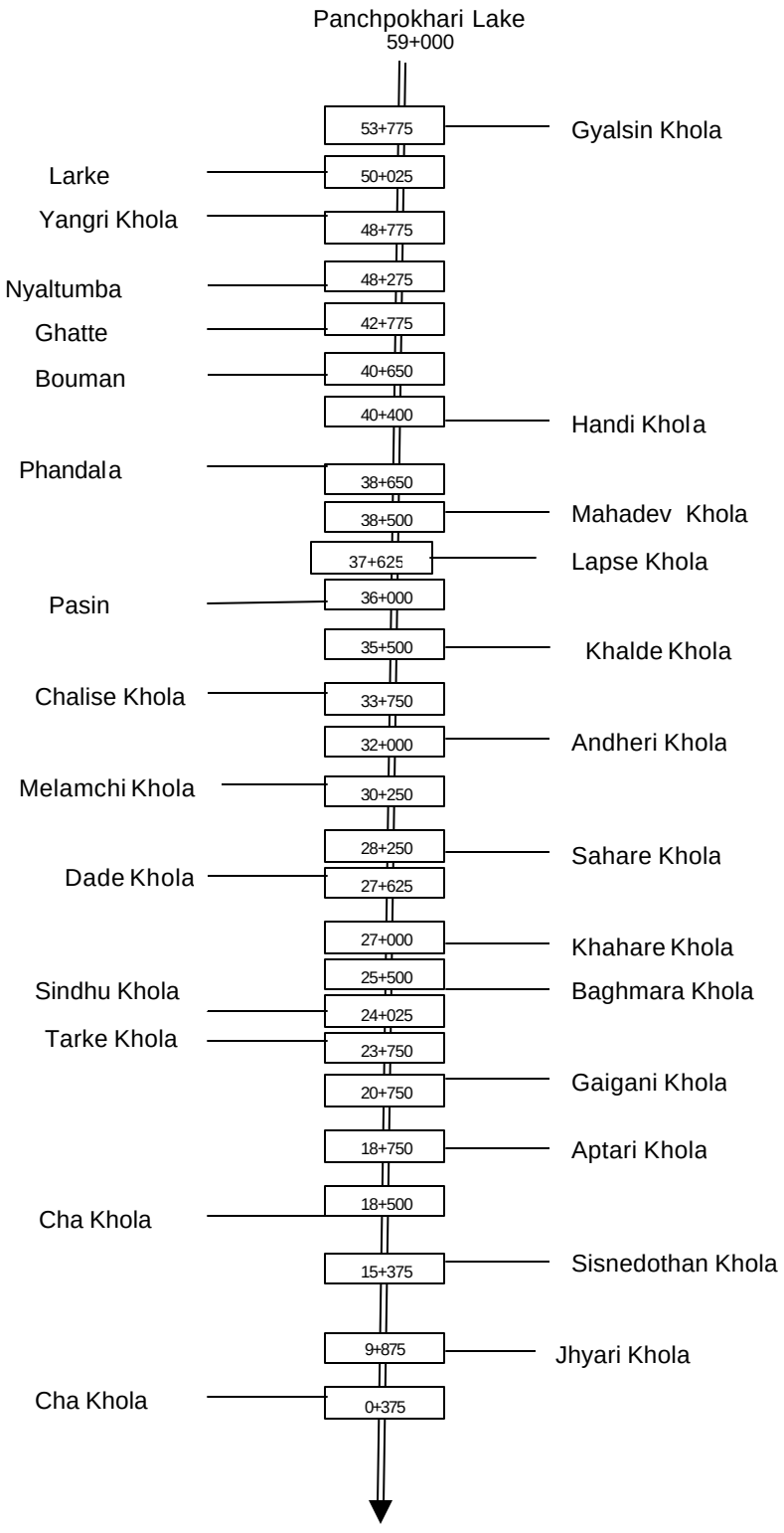


**Figure 3. Schematic view of the Indrawati River system**
(Source: IWMI 2002)

The eleven hydro-meteorological stations that have been established in the Indrawati River basin are listed in Table 2.1.

**Table 2.1 Hydro-meteorological stations within the catchment boundary**

| Index No. | Station name | Location | | Elevation (m) | Type |
|---|---|---|---|---|---|
| | | Latitude | Longitude | | |
| 1006 | Gumthang | 27°48' | 85°52' | 2000 | Precipitation Records |
| 1008 | Nawalpur | 27°48' | 85°37' | 1592 | " |
| 1009 | Chautara | 27°47' | 85°43' | 1660 | " |
| 1016 | Samarthang | 27°57' | 85°36' | 262 | " |
| 1017 | Dubachur | 27°52' | 85°34' | 1550" | " |
| 1018 | Baunpati | 27°47' | 85°34' | 845 | " |
| 1025 | Dhaap | 27°55' | 85°38' | 1240 | " |
| 1058 | Tarke Ghang | 28°00' | 85°33' | 2480 | " |
| 1062 | Sangachowk | 27°42' | 85°43' | 1327 | " |
| 627.5 | Melamchi khola at Helambu | 28°02' | 85° 32' | 2134 | Hydrological records |
| 629.1 | Indrawati River at Dolakha | --- | --- | ---- | " |

Rainfall and snowfall are the sources of inflow in the Indrawati Basin. Since there are no gauging stations at higher elevations, the contribution from snowmelt alone is difficulty to estimate. As can be seen from Table 2.1, gauging stations have been established below 3000 m elevation. A 20-year rainfall data in the eight gauging stations are presented in Table 2.1. As can be seen from the table average annual rainfall varies from 3172 mm in a wet year to 2381 mm in a dry year.

**Table 2.2 Mean monthly and annual rainfall in the basin (mm)**

| Year | Month | | | | | | | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | |
| 1971 | 0 | 15 | 61 | 194 | 89 | 858 | 601 | 613 | 128 | 108 | 30 | 0 | 2697 |
| 1972 | 7 | 31 | 54 | 45 | 90 | 344 | 616 | 561 | 283 | 109 | 52 | 3 | 2197 |
| 1973 | 25 | 27 | 68 | 49 | 113 | 595 | 431 | 542 | 383 | 113 | 18 | 0 | 2365 |
| 1974 | 18 | 5 | 19 | 29 | 124 | 246 | 631 | 695 | 403 | 76 | 0 | 11 | 2259 |
| 1975 | 29 | 34 | 13 | 68 | 108 | 440 | 693 | 507 | 535 | 94 | 1 | 0 | 2522 |
| 1976 | 52 | 29 | 9 | 60 | 256 | 505 | 617 | 657 | 372 | 30 | 2 | 0 | 2590 |
| 1977 | 5 | 10 | 71 | 158 | 113 | 388 | 782 | 720 | 290 | 113 | 27 | 48 | 2725 |
| 1978 | 23 | 22 | 71 | 79 | 222 | 633 | 827 | 600 | 359 | 80 | 8 | 5 | 2929 |
| 1979 | 4 | 40 | 4 | 49 | 40 | 428 | 727 | 584 | 256 | 155 | 27 | 68 | 2381 |
| 1980 | 3 | 25 | 95 | 12 | 130 | 608 | 731 | 605 | 311 | 13 | 1 | 6 | 2541 |
| 1981 | 26 | 11 | 46 | 128 | 191 | 446 | 834 | 748 | 331 | 3 | 28 | 0 | 2791 |
| 1982 | 10 | 52 | 54 | 103 | 48 | 443 | 833 | 815 | 275 | 14 | 16 | 1 | 2664 |
| 1983 | 20 | 27 | 35 | 69 | 161 | 218 | 855 | 863 | 583 | 206 | 0 | 10 | 3048 |
| 1984 | 8 | 11 | 14 | 53 | 161 | 479 | 985 | 793 | 479 | 27 | 7 | 11 | 3028 |
| 1985 | 22 | 13 | 16 | 57 | 89 | 429 | 929 | 781 | 555 | 227 | 6 | 48 | 3172 |
| 1986 | 14 | 17 | 32 | 79 | 164 | 487 | 761 | 633 | 630 | 118 | 9 | 51 | 2994 |
| 1987 | 18 | 47 | 47 | 46 | 104 | 272 | 903 | 626 | 341 | 152 | 18 | 30 | 2604 |
| 1988 | 1 | 34 | 97 | 89 | 117 | 575 | 858 | 841 | 286 | 48 | 21 | 81 | 3049 |
| 1989 | 48 | 41 | 56 | 18 | 259 | 354 | 680 | 816 | 486 | 40 | 2 | 13 | 2813 |
| 1990 | 29 | 72 | 94 | 102 | 224 | 609 | 747 | 514 | 319 | 61 | 0 | 4 | 2775 |
| Average | 18.2 | 28.2 | 47.8 | 74.5 | 140.1 | 467.9 | 752 | 675.7 | 380.3 | 89.3 | 13.6 | 19.5 | 2707.2 |

Source: DHM station records: 1006, 1008, 1009, 1016, 1017, 1018, 1025, 1058, 1062

Similar to other basins in the country, the rainfall in the Indrawati catchment area is concentrated during the monsoon months starting from the middle of May to early October. The long term mean monthly flows of the Indrawati Basin at Dolalgaht Station (629.1) and other major tributaries as per published data of the Department of Hydrology and Meteorology (DHM) and other studies are presented in Table 2.3.

**Table 2.3 Mean monthly discharge of Indrawati River and selected tributaries**

| Tributaries | Flow ($m^3/s$) | | | | | | | | | | | | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul; | Aug | Sept | Oct | Nov | Dec | |
| Indrawati (Station 629.1) | 20.6 | 17.7 | 16.0 | 17.5 | 25.7 | 88.4 | 258.8 | 273.6 | 218.3 | 88.9 | 44.3 | 27.5 | 91.4 |
| Melamchi | 4.2 | 3.6 | 3.2 | 3.4 | 4.7 | 16.1 | 47.7 | 57.0 | 43.6 | 19.1 | 8.6 | 5.6 | 18.1 |
| Handi | 0.69 | 0.59 | 0.52 | 0.50 | 0.64 | 2.83 | 8.65 | 10.65 | 8.37 | 3.60 | 1.74 | 1.13 | 3.33 |
| Mahadev | 0.23 | 0.19 | 0.17 | 0.15 | 0.18 | 0.74 | 2.35 | 2.91 | 2.27 | 1.0 | 0.44 | 0.29 | 0.91 |

Source: Indawati station 629.1 based on average monthly flows from 1975 – 1990 and Melamchi, Handi and Mahadev Khola flows based on Ranjitkar 2000.

# 3. POPULATION AND DEMOGRAPHY

As stated earlier, the catchment area of the Indrawti River system till its confluence with Sun Koshi at Dolalghat is 1240 $km^2$ and the basin occupies 43% area of Sindhupalchowk district and 11% of Kavrepalanchok district. Since the population and demographical data exclusively of the catchment area are not available, these are interpolated based on the area ratio weighted average of the catchment area/districts areas as presented in Table 3.1.

**Table 3.1 Population and demographic data**

| Description | District | | Indrawati river baisn |
|---|---|---|---|
| | Sindhupalanchowk | Kavrepalanchowk | |
| **Area ($km^2$)** | 2542 | 1396 | 1240 |
| **Population (in 2001)** | | | |
| Total | 305,857 | 385,672 | 173,940 |
| Male | 152,088 | 188,079 | 86,167 |
| Female | 153769 | 197,593 | 87,773 |
| Estimated Current population (2005) | 325,907 | 412,574 | 185,453 |
| **Households (in 2001)** | | | |
| Total | 57,649 | 70,509 | 32,423 |
| Avg. Household size | 5.31 | 5.47 | 5.36 |
| **Estimated Households in 2005** | | | |
| **Total** | 61,428 | 75,427 | 34,569 |
| **Avg. Household size** | 5.31 | 5.47 | 5.36 |

As can be seen from the table above, the total population in the river basin on the basis of 2001 census and the percent basin area covered in the two districts is 173,940. The 1991 and 2001 national census data indicate a population growth rate of 1.60% per annum in Sindhuplachowk district and 1.75% in Kavrepalanchowk district which are low compared to the national average of 2.2% per annum. The population growth rate in the Indrawati Basin is estimated at 1.62% per annum on the basis of the population growth rates and the proportion of the area covered by the basin in the two districts. Thus, the population in the river basin (assuming 1.62% per annum growth rate) is estimated to have reached 188,300 at present (2005) with 93,200 males (49.5%) and 95,100 females (50.5%).

The total number of household in the river basin on the basis of 2001 census is 32,423 and the average household size is 5.36. Assuming that the household growth is proportional to growth in population, the total number of households at present (2005) in the Indrawati River Basin can be expected to be around 34,600.

There are various types of land use and land cover within the Indrawati River Basin as can be seen from Table 3.2.

**Table 3.2 land use and land cover in Indrawati Basin**

| S.N. | Land use/land cover | Area ($km^2$) | % of catchment area |
|---|---|---|---|
| 1. | Agricultural land | 407.3 | 32.8 |
| 2. | Irrigable Area | 70.7 | 5.7 |
| 3. | Irrigated land | 50.8 | 4.1 |
| 4. | Forest land | 5,43.3 | 43.8 |
| 5. | Ice/snow covered area | 148.1 | 11.9 |

Source: Ranjitkar 2000 and based on total catchment area of 1240 $km^2$.

Over 90% of the population in the basin area are involved in agriculture. The average landholding per household is around 1 hectare (ha). In the Melamchi area, the large

landholders are primarily from the Sherpa community whereas in other tributaries such as Handi Khola and Mahadev Khola they comprise Brahmins and Chhetris. The tenant system of cultivation is widely practiced in the river basin with more than 90% of cultivable land under tenancy in areas such as Palchowk Beltar and Bhattar irrigation systems (IWMI).

Paddy is the main crop grown in the basin followed by other cereals such as wheat, maize and millet. Studies (IWMI) indicate that the productivity of the main paddy and spring paddy in the area is in the range of 2.5 – 3.0 metric tons (mt) per ha and that of maize and millet are 2.45 mt/ha and 1.7 mt/ha, respectively.

In the lower altitude of the basin (1200 – 1400 m amsl), the farmers grow 3 crops a year including spring paddy (cropping intensity is as high as 300%) as year round irrigation facility is available in most areas. However, in the higher altitude (upper part of the basin), the farmers are able to grow only two crops a year, even where irrigation facility is available due to cooler temperatures, i.e., farmers cannot grow spring paddy since it matures late due to cold climate and thus delays the plantation of the main season paddy.

- **Anticipated population in the catchment area in year 2025**

As can be seen from Table 3.1 the current population (2005) in the Indrawati Basin is estimated to be around 185,500. Based on the 1991 and 2001 census data, the population growth rate in the Indrawati River Basin has been estimated to be 1.62% per annum. Assuming that the growth rate remains constant (1.62% per annum), by the year 2025 the total population in the Indrawati Basin will have reached around **256,000.** This would be an increase of about 38% from the total population in the catchment area at present.

# 4. CURRENT WATER STATUS IN INDRAWATI BASIN

## 4.1 Present water use

Similar to other basins in the middle mountain region, common water use activities in the Indrawati Basin comprise irrigation, drinking water, micro-hydropower and water mills. Furthermore, the Melamchi Water Supply Project designed to transfer water from the Melamchi River to Kathmandu valley is under construction and the 7.5 MW Indrawati III Hydropower Project is operational in the river basin. These water uses are briefly discussed hereafter.

- **Irrigation**

There are over 300 Farmer Managed Irrigation Systems (FMIS) in the Indrawati Basin. The command area of these FMIS varies from 1 ha to 186 ha and similarly the main canal length varies from 100 m to 5.6 km. These irrigation schemes have been built with support from Department of Irrigation (DoI - especially the larger ones), District Development Committees (DDCs), various (I)NGOs and the local communities. The majority of these irrigations schemes have command areas limited to 20 ha and some are only seasonal. Some irrigation schemes also have water mills and drinking water supply systems integrated. WECS with support form Ford Foundation and International Water Management Institute (IWMI) rehabilitated eighteen of the FMIS. A list of selected irrigation schemes in the river basin is presented in Section 6.5.

- **Drinking water supply schemes**

Previous studies (Gupta 2000) have identified 43 small (rural) drinking water supply schemes within the Indrawati River Basin. These water supply schemes divert flows ranging from 0.10 litre per second (lps) to over 20 lps from the tributaries of the Indrawati River. Similarly, the beneficiary population of these water supply schemes vary from around 10 to 6,500. The majority of the schemes have less than 500 beneficiaries. The District Water supply Offices (sindhupalchowk and Kavrepalanchowk) as the responsible government line agency are involved in implementing water supply projects in the river basin. A list of drinking water supply schemes in the river basin can be seen in Section 6.5.

- **Micro-hydropower schemes**

Eleven micro hydropower plants have been identified in the Indrawati River Basin as can be seen in Table 4.1.

**Table 4.1 Micro-hydro Plants identified in the river basin**

| S.N. | Owner/Scheme's Name | Capacity (kW) | Location (VDC/village) |
|---|---|---|---|
| 1. | Gambire/Krishma Thapa | 13 | Kunchok |
| 2. | Krishna B. Khadka | 14 | Musure |
| 3. | Ram B. Basnet | 12 | Jhangpalkot |
| 4. | Gora B. Thapa | 24 | Echok -6 |
| 5. | Ghatte Khola MHP | 9 | Chokati |
| 6. | Handi Khola MHP I | 27 | Thapalkot |
| 7. | Handi Khola MHP II | 26 | Thapalkot |
| 8. | Handi Khola MHP III | 20 | Thapalkot |
| 9. | Handi Khola MHP IV | 20 | Gunsa |
| 10. | Jyadi Khola MHP | 20 | Kunchowk |
| 11. | Cha Khoal MHP | 16 | Nayagaon |

Source: site visit to Cha Khloa and Micro-hydro data book published by CADEC.

Most of the plants listed in Table 4.1 such as the Handi Khola I, II, III & IV and Cha Khloa schemes have been implemented with assistance fro m Rural Energy Development Program (REDP) of the United Nations Development Program (UNDP). Handi Khloa I, II, III and IV are cascade type schemes. Cha Khloa Micro-Hydropower Plant shares the river water with irrigation, both along the headrace canal and from the tailrace outlet. Apart from funding

support, REDP is also actively involved in community mobilisation activities including promotion of micro-hydropower in the river basin as part of its rural energy program. REDP has Technical Officers and District Energy Advisors in both Sindhuplachowk and Kavrepalanchowk districts to support its activities. The Alternative Energy Promotion Centre (AEPC) of HMGN currently provides subsidy support of NRs 70,000 per kW installed capacity for micro-hydropower plants along with an additional transport subsidy of NRs 21,000 based on the remoteness of the site. AEPC also provides support for feasibility studies of micro-hydropower projects. Furthermore, the DDCs (especially Sindhuplachowk) also occasionally support the implementation of community owned micro-hydropower plants. As a result of the available support mechanisms including subsidy provision, feasibility studies of a number of micro-hydropower plants are being undertaken at present in the river basin.

In 2004 with support from Small Hydropower Promotion Project (SHPP) of German Technical Cooperation (GTZ), REDP and Energy Systems (a private consulting firm), a sediment exclusion screen called "Coanda Screen" was retrofitted in the forebay of the Cha Khola MHP as a pilot project. The manufacturer of the screen claims that this technology can exclude fine sediments from entering into the turbines and thus has the potential to minimize turbine abrasion. The Coanda screen at the Cha Khloa forebay can be seen in Figure 4.1.

**Figure 4.1 Coanda screen at forebay of Cha Khola MHP**

Apart form the micro-hydropower schemes listed in Table 4.1, there are also over 20 Peltric sets scattered in the various tributaries of the river basin. These schemes generate electricity up to 3 kW for supply to nearby households usually limited to 20, but occasionally serve up to 50 households. There are also over 50 improved water mills (Improved Ghattas) in the river basin, which are used for agro-processing. In the Improved Ghattas also known as Multi-Purpose Power Unit (MPPU), steel runners replace the traditional wooden runners, which increase system efficiency. Unlike traditional water mills, the Improved Ghattas are also capable of milling (rice de-husking) and oil expelling.

- **Melamchi Water Supply Project**

The Melamchi Water Supply Project comprises construction of 26.5 km long tunnel to convey 1.97 $m^3/s$ (170 million litres per day) from the Melamch River at Ribarma to Mahankal, Sundarijal Village Development Committee (VDC) in Kathmandu Valley. Along with the

tunnel, the project includes access road, a 5 m – 7m high diversion weir (dam), control systems and a water treatment plant. The estimated total project cost is about US$ four hundred and sixty four million (US$ 464 million) and a 7-year construction period is envisaged. The current completion target is 2011 - 2012. Approximately 30 percent of the total cost has been committed by multilateral and bilateral donor agencies as grant funding, 45 percent by the World Bank and the Asian development Bank as loan and the balance of 25 percent by HMG/N. Donor grant and funding is based on the condition that the management of the water supply system of Kathmandu city be undertaken by the private sector. Given its size, cost and complexity involved, this is a pioneer project with far reaching consequences that result from inter-basin water transfer.

This project is being executed by the Melamchi Water Supply Development Board (MWSDB) under the Ministry of Physical Planning and Works. The access road is being constructed at present.

A second and third stage of the Melamchi Project is also envisioned where an additional 170 million litres per day (MLD) of discharge from Yangri and Larke tributaries of the Indrawati basin are proposed to be diverted.

- **Indrawti III Hydropower Plant**

The 7.5 MW Indrawati III Hydropower Plant is a run-of-river scheme, which was commissioned in 2003. This power plant is owned, operated and managed by National Hydro Power Company Ltd., a private company. The intake of this power plant is located at the Indrawati River, about 100 m downstream from its confluence with Lapse Khloa. The waterways length (intake - tailrace) is about 3.5 km including about 3.0 km long tunnel, 100 m siphon, 300 m penstock pipe and 100 m tailrace channel.

The design discharge of Indrawati III Hydropower Plant is 14.3 $m^3/s$ and the net head is 60 m. The annual energy generation from this power plant is estimated at 51 million units (51 million kWh).

## 4.2 Present Water availability and water stress situation

Present water availability in the basin, and local areas that are experiencing water stresses are briefly discussed in this section.

Hydropower including micro-hydropower, water mills and Improved Ghattas are non-consumptive water uses, i.e., water that is withdrawn from the intake is discharged back to the river in the same quantity (and quality) after its use. Whereas irrigation and drinking water supply involve consumptive uses. Evaporation and transpiration commonly referred to as evapo-transpiration from land surface and vegetations also deplete the basin water. A detailed water accounting analysis considering hydrological data from 1971 - 1990 of the Indrawati Basin has been undertaken by IWMI. This analysis compares water availability, consumptive water uses including evapo-transpiration for average year (1981), wet year (1985) and dry year (1975). The summary of the water accounting results is presented in Table 4.2.

**Table 4.2 Summary of water accounting results**

| S.No | Component | Subcomponent | Wet Year (1985) | | Average Year (1981) | | Dry Year (1979) | |
|---|---|---|---|---|---|---|---|---|
| | | | Volume (million $m^3$) | % of Net Flow | Volume (million $m^3$) | % of Net Flow | Volume (million $m^3$) | % of Net Flow |
| 1 | Gross inflow | a) Rainfall | 3,933 | | 3,461 | | 2,952 | |
| 2 | Storage changes | a) Surface storage | 0 | | -0.05 | | 0.04 | |
| 3 | Net inflow | b) Ground storage | 0 | | -81.15 | | 88.15 | |
| | | | 3,933 | 100 | 3,373 | 100 | 3,040 | 100 |
| 4 | Process depletion | ET of agricultural and related issues | 130 | 3 | 128 | 4 | 132 | 4.5 |
| 5 | Non -process depletion (beneficial) | a) ET forest, grazing lands, homestead and others | 4.87 | 13 | 527 | 15 | 466 | 15 |
| 6 | Non -process depletion ( non-beneficial) | ET barren land, flood plain and water body | 85 | 2 | 88 | 3 | 83 | 3 |
| 7 | Outflow | Runoff | 3,513 | 89 | 3,082 | 92 | 2,622 | 86 |
| | **Sum of depletion and surface runoff** | | **4,214** | | **3,825** | | **3,302** | |
| | **Sum of net inflow** | | **3,933** | | **3,373** | | **3,040** | |
| | **Calculation error** | | **-281** | | **-452** | | **-262** | |

Source: IWMI 2002

As can be seen from Table 4.2, in an average year the net inflow in the basin is about 3,373 million cubic meter (MCM), where as the total outflow is 3082 MCM. Thus, around 90% of the annual water volume in the Indrawati Basin flows out of the basin. Process depletion which includes evapo-transpiration from crops (and indirectly irrigation water), domestic use (e.g. drinking water) and animal uses accounts for only 4.5% of the annual flow volume. Even in the dry year (1979), 86% of the net inflow flows out of the basin. Furthermore, there are no significant differences in the annual outflow from the basin between dry and wet years. During the dry year, the annual outflow form the basin decreases by 15% compared to the average year. Similarly, during wet year, the annual outflow from the basin increases by 14% compared to the average year. Form Table 4.2, it can be concluded that at present on a macro level there is no water stress in the basin as utilizable flow is available through out the year, i.e., this is an "Open Basin". It should also be noted that of the 1240 $km^2$ catchment area of the Indrawati Basin, only 20 $km^2$ area is potentially cultivable, i.e., flat cropland. Thus, consumption of water for irrigation is restricted by the fact that less than 2% of the basin area is cultivable.

With the estimated current population of 185,500 in the Indrawati Basin (Table 3.1), the water availability per capita at present based on annual outflow in an average year is around 16,600 $m^3$ per annum (~46$m^3$/day).

Although, the Indrawati basin is an open basin, on a micro level or sub-basin level, water stress is becoming an emerging issue. Some water stress examples in the basin are briefly described below.

- In irrigation systems that share water with micro hydropower schemes, sometimes there is not adequate flow during the dry season to meet both power generation and irrigation requirements. For example, in Chaa Khloa MHP, the power plant is either shut down or operated in partial capacity during the paddy plantation season, especially if the monsoon is late. Sometimes, in combined hydropower–irrigation schemes the water rights of the poor and marginalised groups of farmers are not secure as those of the others. Hydropower committee often dominates in the allocation of water among different water users, namely, irrigation and water mills. This is usually the case where the majority of the hydropower users' committee are head-reach farmers belonging to affluent groups of the communities.

- Despite increase in irrigation command area after rehabilitation of FMIS, due to technical reasons, it is not always feasible to include all farmers interested in joining the irrigation systems. For example, in Taruki Besi, rehabilitation of the system included relocating the intake further upstream at a stable reach of the river. Although, this increased water availability as the previous intake was temporary and prone to landslide damages, due to the topography it was not technically feasible to include some interested farmers (IWMI 2002).

- In a few selected drinking water supply projects, some beneficiaries have been excluded from the drinking water facility due to primarily scattered settlement patterns resulting in high costs of system establishment.

- There have been water incidents of conflicts between upstream and downstream irrigation water users. For example, the VDC had to intervene and allocate water proportionate to command area in Jageswor Kulo (upstream FMIS) and Tarshera Phant Kulo (downstream FMIS). Jageswor Kulo was allocated 4 days/week and Tarshera Phant Kulo was allocated 3 days/week for spring crop and paddy plantation season (IWMI).

- Several cases of water disputes between irrigation users and water mills have also been reported, mainly during the low flow season.

# 5. PROJECTED WATER SITUATION IN 2025

As discussed in section 4.1, water stressed situation does not generally exist in the Indrawati Baisn, except locally in a few tributaries. However, by the year 2025 the population may increase by about 38% (based on last 10 years trend), and this could result in water stress situation unless judicial planning and use of water (i.e., IWRM) is practiced. If the current population growth rate continues, by 2025 the water availability per capita based on annual outflow in an average year will decrease from the current estimate at 16,600 $m^3$ per annum (~46$m^3$/day) to 12,000 $m^3$ per annum (33 $m^3$/day), assuming no new water consumptive activities take place. If new water resources projects and specifically those involving inter basin transfer such as Melamchi Water Supply Project are developed, then the per capita water availability will further decrease. Projected water situation in 2025 based on information and data available at present are specifically discussed hereafter.

- **Melamch Water Supply Project**

As discussed in Section 4.1, the Melamchi Water Supply Project is expected to be completed by 2012 if construction schedules are met. Even with unforeseen delays, this project is most likely to be completed by 2025. The effect on water availability in both the Melamchi River and the Indrawati Basin due to the Melamchi Project is presented in Table 5.1.

**Table 5.1 Water availability in Melamchi and Indrawati Rivers with and without Melamchi Water Supply Project**

| Tributaries | Flow ($m^3$/s) | | | | | | | | | | | | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul; | Aug | Sept | Oct | Nov | Dec | |
| | Before Melamchi Project | | | | | | | | | | | | |
| Indrawati (Station 629.1) | 20.6 | 17.7 | 16.0 | 17.5 | 25.7 | 88.4 | 258.8 | 273.6 | 218.3 | 88.9 | 44.3 | 27.5 | 91.4 |
| Melamchi | 4.2 | 3.6 | 3.2 | 3.4 | 4.7 | 16.1 | 47.7 | 57.0 | 43.6 | 19.1 | 8.6 | 5.6 | 18.1 |
| | After Melamchi Project | | | | | | | | | | | | |
| Indrawati (Station 629.1) | 18.6 | 15.7 | 14.0 | 15.5 | 23.7 | 86.4 | 256.8 | 271.6 | 216.3 | 86.3 | 42.3 | 25.5 | 89.4 |
| Melamchi | 2.2 | 1.6 | 1.2 | 1.4 | 2.7 | 14.1 | 45.7 | 55.0 | 41.6 | 17.1 | 6.6 | 3.6 | 16.1 |

The planned diversion of 1.97 $m^3$/s by the Melamchi Water Supply Project will not significantly reduce the monthly or annual average flow of the Indrawati River at Station 629.1 (upstream of the confluence of indrawati and Sun Koshi at Dolalghat) which is also the outflow point of the basin. As can be seen from Table 5.1, the annual average flow in the Indrawati Basin would decrease by about 2.2% due to 1.97 $m^3$/s flows diverted by the Melamchi Project. Even in a dry year when the annual basin outflow is 2,622 MCM (see Table 4.2), the annual volume of 62 MCM (at 1.97 $m^3$/s) diverted by Melamchi Project is a reduction of about 2.4%. The water availability per capita (in 2056) would also decrease from 12000 $m^3$/annun to 11,800 $m^3$/annum, i.e., the Melamchi Project would reduce water availability per capita in the basin by a further 1.7%.

Although, flow diversion in the Melamchi River by the Melamchi Project will not have overall significant effect in the Indrawati Basin, the water scarcity in the Melamchi tributary will indeed be significant. As can be seen from Table 5.1, the annual average flow in the Melamchi River (downstream of the Melamchi Water Supply Intake at Ribarma) will decrease by around 11%. Furthermore during the dry months of March and April, river discharge will be reduced by 62% and 58% respectively. Thus, further development of large water

resources projects downstream of the Melamchi Water Supply Project intake will not be feasible.

- **Indrawati III Hydropower Project**

The existing Indrawati III Hydropower Plant is also likely to be effected at least one month a year (March) as it will not be able to divert the design flow of 14.3 $m^3/s$, i.e., after diverting 1.97$m^3/s$ in March, there will only be 14 $m^3/s$ flow available in the Indrawati River downstream. If Stages II and III of the Melamchi Water Supply Project are also developed, then the flow available for Indrawatri II Hydropower Plant will be further reduced by another 1.97 $m^3/s$.

Similarly, if other small hydropower projects (run-of river) are constructed within the river basin they will also impose water restrictions in the river stretches between their intakes and tailraces. For example, it will not be possible to implement relatively large water resources projects within the 3.5 km stretch along the Indrawati River between the intake and powerhouse of the Indrawati III Hydropower Plant.

- **Micro-hydropower Project**

The micro-hydropower sector in the country is growing rapidly. As a result of aggressive promotional activity, donor support and subsidy by AEPC, the number of micro-hydropower plants being built annually is increasing. In the Indrawati Basin alone, feasibility studies of more than 10 potential sites are currently being undertaken. If the current growth rate in the implementation of micro-hydropower plants continues, it is likely that most feasible sites (high head for given waterways length and close to settlements) will have been exhausted. Although, such development will not affect the Indrawati basin on a macro level, it could have the following effect in the sub-basin level.

- Competition with other uses of water such as irrigation, drinking water and water mills especially during the dry season in areas close to the functional micro-hydropower sites.

Therefore, it is likely that the catchment area will be water stressed by 2025 unless Integrated Water Resources Management (IWRM) is initiated.

# 6. POTENTIAL AREA WATER PARTNERSHIP MEMBERS

Based on limited site visit, discussions and secondary information, potential Area water Partnership (AWP) members for the basin area are proposed in this section. Except for the Non-Government Organisations (NGO), other organisation/individuals are all stakeholders of the Indrawati River Basin, i.e., they are involved in planning and/or use of the river basin water.

## 6.1 Government line agencies

The following four government line agencies within the districts of Sindhupalchowk and Kavrepalanchowk are potential AWP members:

i. Department of Irrigation, Ministry of Water Resources
ii. Department of Soil Conservation, Ministry of Forestry
iii. Department of Agriculture, Ministry of Agriculture
iv. Melamchi Water Supply Development Board.

## 6.2 Local government body

District Development Committees (DDC), Village Development committees (VDC) and wards are the local government bodies in the districts of the country. In this case the two DDCs and the following VDCs within the river basin are proposed as potential AWP members:

i. DDC, Sindhupalanchowk and Kavrepalanchowk districts
ii. Melamchi VDC
iii. Talamarang VDC
iv. Mahankal VDC
v. Ichowk VDC
vi. Palchowk VDC
vii. Thangpaldhap VDC
viii. Thangpalkot VDC
ix. Mahadevstan VDC

Since it is not feasible to include all VDCs within the catchment area, those in the vicinity of the roadheads or major tributaries of the Indrawati Basin are proposed as potential AWP members. A few VDCs nominated by the DDCs (Sindhupalanchowk and Kavrepalanchowk) could also be included in the list. The wards are not included in the list of potential AWP members since they are too small in size and by including a VDC as AWP member a number of wards are also included by default (i.e., a ward is a sub-unit of a VDC).

## 6.3 Hydropower Sector

As discussed earlier, apart from the 7.5 MW Indrawati III Hydropower Plant, eleven micro hydropower plants have been identified in the river basin. Since it will not be feasible to include all of them, along with Indrawati III Hydropower Plant, six micro-hydropower plants that are relatively large are proposed as potential AWP members as shown in Table 6.1.

**Table 6.1 Potential AWP members from hydropower sector**

| S.N. | Owner/Scheme's Name | Capacity (kW) | Location (VDC/village) |
|---|---|---|---|
| 1. | Ghatte Khola MHP | 9 | Chokati |
| 2. | Handi Khola MHP I | 27 | Thapalkot |
| 3. | Handi Khola MHP II | 26 | Thapalkot |
| 4. | Handi Khola MHP III | 20 | Thapalkot |
| 5. | Jyadi Khola MHP | 18 | Kunchowk |
| 6. | Cha Khoal MHP | 16 | Nayagaon |
| 7 | Indrawati III Hydropower Plant | 7500 | Laspse |

## 6.4 Non Government Organisation (NGO)

As of 2002, altogether 65 NGOs have been registered in Sindhupalchowk district. The sudden increase in the number of NGOs in the river basin area is primarily due to anticipation of involvement in the Melamchi Project area. Similarly, there are a number of NGOs in Kavrepalanchowk districts. The following NGOs that are currently active within the river basin and are proposed as potential AWP members:

i. Melamchi Sarokar Kendra, Melamchi VDC

ii. Dhauleshwari Jana Utthan Samiti, Melamchi VDC

iii. Action Aid, Melamchi

iv. Amar Pratibha Yuba Club, Mahankal VDC.

v. Community Self Reliance Center, Ichowk VDC, this NGO is affiliated with World Education Community Literacy Project, Rato Pool, Kathmandu.

vi. Community Development Committee, Ichowk VDC

vii. Indarawati Sewa Samitee, Thangpaldhap VDC

viii. Panch Pokhari Yuba Samuha, Thangpalkot VDC

ix. Participatory District Development Program, Mahadevsthan VDC, this is a UNDP run program

x. Rural Energy Development Program (REDP), UNDP.

## 6.5 Water Users Association (WUA)

It will not be possible to include all Water Users' Associations (WUAs) as AWP members since are more than 300 FMIS and over 40 drinking water schemes in the river basin. Thus, an attempt is made in Table 6.2 to cover all geographical regions within the basin while selecting potential AWP members.

**Table 6.2 Proposed AWP members from WUA**

| S.N. | Name of WUA | Location (VDC) |
|---|---|---|
| 1. | Melamchi Bazaar Drinking Water Project Users Committee | Melamchi Bazaar, Melamchi |
| 2. | Jarayotar (central) Drinking Water Project Users Committee | Melamchi |
| 3. | Nuhar Shera Irrigation Project Users committee | Melamchi |
| 4. | Melamchi Multipirpose Agricultural Industries P Ltd. | Melamchi |
| 5. | Talamarang Bagarphant irrigation Canal Users Committee | Talamarang |
| 6. | Niglini Bhotekoshi Irrigation Canal Users Committee | Talamarang |
| 7. | Those Khola Drinking Water Users Committee | Talamarang |
| 8. | Tar Kulo irrigation Project Users Committee | Mahankal |
| 9. | Sherako Kulo Irrigation Project Users Committee | Mahankal |
| 10. | Rajdwali Irrigation Canal Users Committee | Mahankal |
| 11. | Pati Chour Drinking Water Users Committee | Mahankal |
| 12. | Ichowk Irrigation Users Committee | Ichowk |
| 13. | Gohare Irrigation Project Users Committee | Ichowk |
| 14. | Ichowk Drinking Water Users Committee | Ichowk |
| 15. | Kalidaha Beltar Bhattar (kendriay) Irrigation Project Users Committee | Palchowk |
| 16. | Upper & Lower Kundule Khola Irrigation Project Users Committee | Palchowk |
| 17. | Plachowk Drinking Water Users Committee | Palchowk |
| 18. | Mahadev Khloa Irrigation Users Committee | Thangpaldhap |
| 19. | Handi Khola Mahabir Irrigation Project Users Committee | Thangpaldhap |
| 20. | Mahankal Bimirebasi Irrigation Project Users Committee | Thangpaldhap |
| 21. | Dhuslung Khola Irrigation Users Committee | Thangpalkot |
| 22. | Dhuslung Khola Drinking Water Users Committee | Thangpalkot |
| 23. | Aansi Khloa Danda Gaun Majh Kulo Users Committee | Mahadevsthan |
| 24. | Mahadevsthan Drinking Water Scheme Users Committee #1 & #2 | Mahadevsthan |
| 25. | Hinguwadhara Irrigation Pond Users Committee | Mahadevsthan |

## 6.6 Workshop to formalize AWP memberships

A workshop should be conducted to formalize AWP memberships of the proposed institutions discussed in this section. This workshop should:

- Introduce the concept of AWP as well as the need to establish such a partnership to the potential members (i.e., participants).
- Establish initial networking and receive feedbacks from the stakeholders of the river basin.
- If the participants fell the need for AWP in the basin, initiate the registration process or identify means of formalizing the process of AWP establishment.
- Discuss the extent to which local water institutions are capable and willing to undertake a comprehensive basin study for use in future water resources planning activities.

The Consultant's role in the workshop will be that of the resource person and facilitator. The Consultant will introduce the concept of AWP to the participants and coordinate the discussions during the workshop. The logistics of the workshop should be arranged by a local NGO within the study area in coordination with the Consultant.

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