WEST SETI HYDROELECTRIC PROJECT

Karnali Basin

Cumulative Impact Assessment

November 2007

West Seti Hydro Limited

1611 Lamtangin Marg, Maharajgunj, Kathmandu, Nepal.

Phone: (977-1) 4720328, e-mail: westsetihydro@wlink.com.np

ABBREVIATIONS

ADB	Asian Development Bank
CBS	Central Bureau of Statistics
DHM	Department of Hydrology and Meteorology
DOI	Department of Irrigation
DoR	Department of Roads
EIA	Environmental Impact Assessment
EPA	Environmental Protection Act
EPR	Environmental Protection Rule
FMIS	Farmer Managed Irrigation System
FSL	Full Supply Level
FWDR	Far-Western Development Region
GHG	Green House Gases
GON	Government of Nepal
HEP	Hydroelectric Project
HPC	Himalayan Power Consultants
HR	Hunting Reserve
IEE	Initial Environmental Examination
IUCN	World Conservation Union
JICA	Japan International Cooperation Agency
MCM	Million Cubic Meter
MDGs	Millennium Development Goals
MHSP	Medium Hydropower Study Project
MOL	Minimum Operation Level
MWDR	Mid-Western Development Region
NLSS	Nepal Living Standard Survey2003
NP	National Park
NTFP	Non-Timber Forest Products
PA	Protected Area
PIP	Priority Investment Plan
PMF	Probable Maximum Flood
PRSP	Poverty Reduction Strategy Paper
RMDP	Road Maintenance and Development Project
ROR	Run-of-river
SMEC	Snowy Mountain Engineering Corporation
SWRP	Sector Wide Road Program
UN	United Nations
UNDP	United Nations Development Programme
VDC	Village Development Committee
WR	Wildlife Reserve
WSH	West Seti Hydro Limited

Table of Contents

ANNEXES

1. INTRODUCTION

1.1 STUDY OBJECTIVE

The Seti River is one of the principal tributaries of the Karnali River. It originates in the High Himal Zone and drains the western side of the Karnali River Basin in Nepal. The West Seti Hydroelectric Project (West Seti HEP), with a rated capacity of 750 MW, is a storage type hydroelectric project, planned for development by 2012 by West Seti Hydro Limited (WSH) with financing from China's Export-Import Bank, the Asian Development Bank (ADB) and other sources.

Environmental impacts due to the development of the West Seti HEP are evaluated in detail in the Environmental Impact Assessment (EIA) prepared by SMEC (2000), and a number of subsequent studies prepared by WSH (2007). These reports assess the West Seti HEP impacts in the Seti and Karnali River basins, particularly in the reservoir area and adjoining downstream valley. The impact of the West Seti HEP on river flows in the downstream Karnali Basin is covered in the EIA (2000), however an assessment of the cumulative impact of existing and likely development projects in the Karnali Basin was not undertaken.

This Cumulative Impact Assessment for the Karnali Basin aims to assess the main environmental and socio-economic impacts of major developments in the Karnali Basin (Mid–Western and Far Western Development Regions) for five year and twenty year development scenarios. This study also indicates the contribution of the West Seti HEP to these impacts.

1. 2 SPATIAL COVERAGE

The Karnali River, the principal river of the Basin, is an antecedent river (Hagen, 1969). It originates on the Tibetan Plateau, and flows due south cutting across the High Himal, High Mountain, Mid Hills, Mahabharat and Siwalik Ranges of Nepal, before emerging on the Terai Plain (Gangetic Plain) in the south. In India the Karnali river is known as “Ghaghara” and “Gogra”, and flows in a south-easterly direction to the town of Chapra, where after a course of 917 km it joins the Ganges.

Development in Nepal is seen progressing from east to west and from south to north, due to topographic constraints that dictate accessibility. Development activities in the Karnali Basin and their influences are envisaged to follow similar trends.

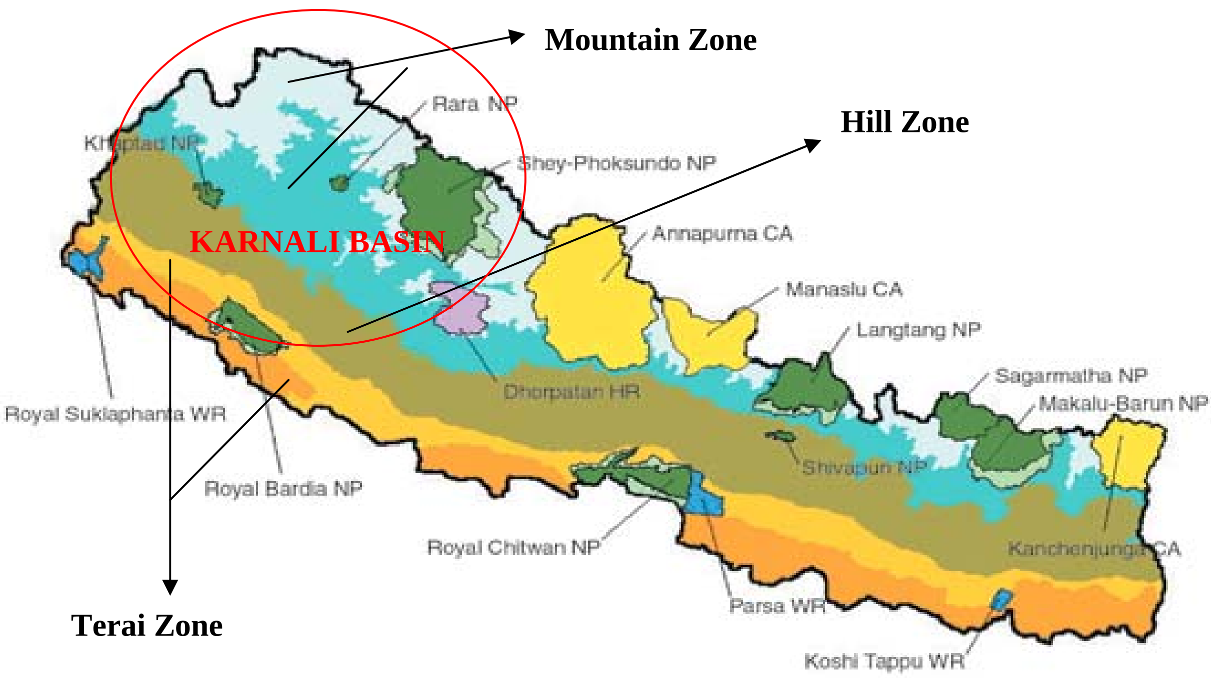
Based on the regional administrative and development framework, the Karnali River Basin is assumed to spatially cover the 20 administrative districts of Bahjang, Baitadi, Bajura, Achham, Dadeldhura, Doti, Kailali and Kanchanpur in the Far-Western Development Region (FWDR) and Humla, Mugu, Jumla, Dolpa, Kalikot, Dailekh, Surkhet, Jajarkot, Rukkum, Salyan, Bardiya and Banke in the Mid-Western Development Region (MWDR). Table 1.1 presents the administrative districts of the FWDR and MWDR in the Karnali Basin as per their ecological position within the Basin. Five of these districts are only partially within the Karnali Basin, while two districts are outside the Basin.

Table 1.1: Spatial Coverage of the Karnali Basin in the Study

Region	Terai		Hill		Mountain	
Far-Western	**District**	**Area (km²)**	**District**	**Area (km²)**	**District**	**Area (km²)**
	Kailali	3,235	Achham	1,680	Bahjang	3,422
	Kanchanpur	1,610	**Doti**	2,025	Bajura	2,188
			Baitadi	1,519		
			Dadeldhura	1,538		
Sub-total	**2**	**4,845**	**4**	**6,762**	**2**	**5,610**
Mid-Western	Bardiya	2,025	Dailekh	1,502	Dolpa	7,889
	Banke	2,337	Jajarkot	2,230	Humla	5,655
		0	**Rukum**	2,877	Jumla	2,531
		0	Surkhet	2,451	Kalikot	1,741
		0	**Salyan**	1,462	Mugu	3,535
Sub-total	**2**	**4,362**	**5**	**10,522**	**5**	**21,351**
Total	**4**	**9,207**	**9**	**17,284**	**7**	**26,961**

Source: CBS, 2001.
Note: Districts in bold indicates only partially within Karnali Basin. Districts in bold italics indicates outside Karnali Basin.

Figure 1.1: Ecological Divisions of Nepal, Protected Areas and the Karnali Basin



2. EXISTING BASIN AND DEVELOPMENT PROFILE

2.1 EXISTING BASIN PROFILE

This section describes the socioeconomic and biophysical profile of the Basin.

2.1.1 Socioeconomic Profile

Households and Population

According to the 2001 population census, the number of households and population of the districts within the Karnali Basin are estimated to be 699,281 and 4,197,441 respectively. These districts account for 16% of the total households and 18% of the total population of Nepal. Of the total Nepal population, 49.99 percent are female. The average family size in the Basin districts is recorded at 6.3 in the Terai, 5.9 in the Hills and 5.6 in the Mountains, which is slightly higher than the national average family size of 5.4. Similarly, the average population density for the Terai, Hill and Mountain districts of the Basin is estimated to be 191 persons/km^2, 107 persons/km^2 and 22 persons/km^2 respectively. The density is higher in the Terai districts and lower in the Hills and Mountains compared to the average national density of 157 person/km^2 (Table 2.1 and Annex 2.1).

Table 2.1: Household and Population Status of the Basin Affected Districts (2001 Census)

Region	No. of Districts	Population			% of Nepal Popn.	Total Number of HH	Average HH Size	Area (km^2)	Popn. Density (per km^2)	Total Number of VDCs /Munic.
		Total	Male	Female						
A. Terai	4	1,763,085	895,107	867,978	7.61	281,426	6.26	9,207	191	143
B. Hill	9	1,849,465	812,738	938,727	7.97	313,756	5.89	17,284	107	437
C. Mountain	7	584,891	297,168	287,723	2.54	104,099	5.62	26,961	22	208
Total Basin Districts	20	4,197,441	2,005,013	2,094,428	18	699,281	6.0	53,452	79	788
Nepal	75	23,151,423	11,563,921	11,587,502	100	4,253,220	5.44	147,181	157	39731
% Covered by Basin District	27	18.13	17.34	18.07	18.12	16.44		36.32	50.02	19.83

Source:
(i) Population Census 2001 National Report; CBS/UNFPA, June 2002. (includes 3,915 VDCs and 58 Municipalities)
(ii) Population Census 2001, VDC Wise Population; CBS/UNFPA, June 2002.

Ethnicity and Caste

Basin districts are dominated by Hindu caste groups mainly Chhetri and Thakuri (40%), Brahmin (10%) and Dalits (9%). Among the Janjati, Tharu are dominant (11%) and concentrated mostly in the Terai districts of Bardia (53%), Kailali (44%) and Kanchanpur 23%). Similarly, the Magar/Gurung are concentrated in Dolpa (35%), Rukum (23%), Surkhet (20%) and Salyan (17%) districts (Table 2.2 and Annex 2.2).

Table 2.2: Major Dominant Ethnic/Caste Composition, Karnali Basin

Region/District	Ethnic/Caste Group (% of District Population)							
	Thakuri	Chhetri	Magar/ Gurung	Bahun	Dalits	Tharu	Muslim	Other
Terai	0	16.9	0.0	10.4	3.7	34.0	5.3	0.0
Hill	5.44	46.09	8.83	9.66	13.57	0.00	0.00	0.00
Mountain	9.98	43.26	5.10	8.85	10.85	0.00	0.05	2.00
Average Project Districts	5.14	35.41	4.64	9.63	9.36	11.33	1.78	0.67

Source: CBS, 2001.

Migration Pattern

Two types of migration pattern prevail in the Basin districts. The first type of migration is the flow of people from their current place of residence. In the past the major flow of migration occurred from the Hill areas to the Terai (lowlands) to gain access to better agricultural land, services and trade and employment opportunities. The influx of people from the Hills to the Terai is reported to have decreased over recent years due to the official prohibition of settlement on forest land in the Terai since 1985.

According to NLSS (2003/04)[2], of the total population aged 5 years and above, 37% have migrated from other places to their current place of residence. The migration rate for females is 50%, while for males it is only 22%. The higher rate of migration is due mainly to marriages that necessitate the wife to migrate to her husband's place of residence. Regionally, the highest rate of migration is recorded in the Western Region (41%) and lowest in the Mid-Western Region (26%) (Table 2.3).

Table: 2.3: Percent of Migrant Population by Sex and Development Region

Development Region	% of Migrant Population		
	Male	Female	Total
Eastern	21.3	54.8	38.7
Central	21.1	49.2	35.6
Western	26.4	53.9	41.2
Mid-Western	17.1	33.8	25.9
Far-Western	21.1	55.9	39.9
Nepal	21.6	50.1	36.6

Source: Nepal Living Standard Survey2003/04. Statistical Report Volume I. CBS, 2004.

The second type of migration is the flow of people to foreign countries, including India, for greater earning capability and other purposes on a temporary basis. According to the 2001 Census, 5.8% of the total economically active population of the Basin districts migrate on a temporary basis. The absentee percentage of population is relatively higher in the Hill districts (8.4%) and Mountain districts (7.3%) compared to the Terai (3.2%). Among the Basin districts, the highest number absentee population is reported for Achham (16%), followed by Bajhang (14%), Baitadi (10%) and Dailekha (9%) (Table 2.4 and Annex 2.3).

Table 2.4: Population Absent from House for Earning in Basin Districts

Project Districts	Absent Population			Total Economically Active Popn.	% of Total Economically Active Population
	Male	Female	Total		
Terai	35,978	4,989	40,967	1,270,616	3.2
Hill	72,703	9,467	81,170	965,168	8.4
Mountain	16,463	3,780	20,243	278,432	7.3
Total Basin Districts	**140,083**	**19,521**	**158,604**	**2,719,448**	**5.8**
Total Nepal	**679,469**	**82,712**	**762,181**	**9,900,196**	**7.7**

Source: CBS, 2001.

The CBS estimation of migration in and out of different hill areas in the five Development Regions of Nepal reveals that the migration of people out of the regions/districts on a permanent basis is significantly higher than the migration into all Development Regions except the Central Region (Table 2.5).

Table 2.5: Migration in Different Hill Regions of Nepal (2001)

Development Region	Number of In-Migrants	Number of Out- Migrants	Net-Migrants
Eastern	70,330	403,380	-333,050
Central	362,536	176,882	185,654
Western	54,442	470,994	-416,552
Mid-Western	34,711	136,983	-102,272
Far-western	18,394	182,933	-164,539
Total	540,413	1,371,172	-830,759

Source: Population Monograph of Nepal, Volume II. CBS/UNFPA 2003.

The conflict situation, inequitable distribution of income, poor access of resources and opportunities, unemployment and food insecurity are reported to be the main pushing factors of out-migration on a permanent basis. According to NLSS (2003/04), 75% of family members reported family reasons as the main reason for migration, followed by 12% for an easier lifestyle, 7% for a better job, 3% for education/training etc (Table 2.6).

Landholding Pattern and Food Sufficiency

The average landholding size in Basin districts is less than one hectare, with the exception of Bardia district (1.01 ha). The average landholding (Agricultural Census, 2001) for Dolpa and Bajura is estimated to be the lowest (<0.5 ha). Among the three ecological regions of the Basin, the average landholding size in the Terai is 0.92 ha/household, higher than the national average holding of 0.79 ha/household, but lower in the Hills (0.54 ha/household) and Mountains (0.68 ha/household). Fragmentation of landholdings is common in the Basin districts due to the traditional system of land inheritance within the family, therefore landholdings often consist of a number of dispersed land parcels (2-7 parcels). Higher land fragmentation is found in Humla and Kalikot districts (9-7 parcels), while fragmentation is lowest in Surkhet and Kanchanpur (two parcels each) (Table 2.7 and Annex 2.5).

Table 2.6: Distribution of Migrant Population by Reason of Migration and Region

Region	Family Reason	Educat./ Training	Political reason	Natural Disaster	Looking for Job	Easier Lifestyle	Other	Total
Eastern	70.1	2.7	0.0	0.9	6.2	16.8	3.3	100
Central	76.4	3.5	0.1	0.4	8.4	8.7	2.5	100
West	78.8	2.5	0.2	0.9	5.8	9.1	2.6	100
Mid-West	77.3	0.7	0.0	0.3	7.6	12.1	2.0	100
Far-West	74.9	1.0	0.4	1.1	3.3	13.3	6.2	100
B. Rural								
Rural all	80.3	1.1	0.1	0.7	4.1	10.9	2.8	100
East/Mtns./Hills	89.0	0.4	0.1	0.0	3.4	3.6	3.6	100
West Mtns./Hills	84.2	1.2	0.1	0.8	3.3	8.4	2.1	100
Eastern Terai	72.0	1.8	0.1	1.6	4.7	17.0	2.8	100
Western Terai	77.7	1.1	0.0	0.7	4.5	13.2	2.8	100
C. Nepal								
All Nepal	75.2	2.6	0.1	0.7	6.8	11.6	3.0	100

Source: Nepal Living Standard Survey 2003/04, Statistical Report, Volume I. 2004.

Table 2.7: Average Number of Landholdings and Parcels in the Basin Districts

Project Districts	Average Landholdings (ha)			Average Number of Parcels
	Wet	Dry	Total	
A. Terai	0.75	0.17	0.92	2.28
B. Hills	0.16	4.45	0.54	2.92
C. Mountains	0.16	0.51	0.68	6.17
Total Project Districts	**0.25**	**1.71**	**0.71**	**4.10**
Total Nepal	**0.48**	**0.31**	**0.79**	**3.30**

Source: National Sample Census of Agriculture Nepal, 2001/02 Highlights. 2003.

The cultivation of cereals is the most intensive land use activity in the Basin area. Cultivation is almost exclusively practiced on private landholdings, although a minor amount of cultivation is illegally occurring on Government land.

Paddy, wheat, maize, millet and barley are the most common cereal crops grown in Basin districts, used as subsistence food items. Crop yields are higher in Terai districts for all cereal crops except millet compared to Hills and Mountains (Table 2.8 and Annex 2.6), although yields are lower than the national average for all crops except wheat. Livestock are also an integral part of cropping activities, providing draught power and producing organic fertilizer.

Fourteen of the 20 Basin districts (70%) have a food deficit, with four Terai districts and two Hill districts (Surkhet and Salyan) having a surplus. The total food deficit in the Basin district is estimated to be 50,000 metric tonnes /annum. Baitadi district has the highest food deficit (28,756 tonnes/year) while Kanchanpur district of Terai and Salyan district of Hill have the highest surpluses of edible food grains (36,062 tonnes/year and 11,788 tonnes/year respectively) (Table 2.9 and Annex 2.7).

Table 2.8: Area, Production and Yield of Cereal Crops in Basin Districts (2003/04)

Basin Districts	Paddy			Wheat			Maize			Millet			Barley			Total		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
A. Terai	171090	487236	2.85	49550	143892	2.90	37460	69282	1.85	380	360	0.9	180	210	1.2	258660	700980	2.71
B. Hills	61170	130034	2.13	89123	137264	1.54	95075	164975	1.74	14221	16810	1.18	5478	6184	1.1	265067	455267	1.72
C. Mountains	18917	32276	1.71	28321	37469	1.32	14555	22615	1.55	14586	14532	1.00	10444	12580	1.2	86823	119472	1.38
Total Basin	**251177**	**649546**	**2.59**	**166994**	**318625**	**1.91**	**147090**	**256872**	**1.75**	**29187**	**31702**	**1.09**	**16102**	**18974**	**1.2**	**610550**	**1275719**	**2.09**
Total Nepal	**1504136**	**4455722**	**2.96**	**665589**	**1387192**	**2.08**	**834285**	**1590097**	**1.91**	**258597**	**283378**	**1.1**	**27467**	**30670**	**1.1**	**3290074**	**7747059**	**2.35**

Source: Statistical Year Book of Nepal, 2005.

Table 2.9 Food Balance in the Basin Districts (2001)

Basin District	Total Edible Food Production (M Ton)						Total Requir. (M ton)	Surplus/ Deficit (M ton)
	Rice	Wheat	Maize	Millet	Barley	Total		
A. Terai	250,633	113,665	32,409	205	50	396,962	314,013	83,049
B. Hills	73,577	102,065	109,366	13,591	1,730	300,329	375,050	-74,721
C. Mountain	11,729	20,242	9,113	10,338	2,492	53,914	112,609	-58,695
Total Project Districts	335,939	235,972	150,888	24,134	4,272	751,205	801,672	-50,367
Total Nepal	2,356,646	914,885	1,001,478	231,915	8,255	4,513,179	4,430,128	83,051

Source: Agricultural Marketing Information Bulletin, Special Issue 2002. Department of Agriculture Marketing Development Directorate, 2002.

According to the Agriculture Census 2001, slightly more than half of all households in the Basin districts face a food deficit. The deficiency level is found to be higher than 60% in four Hill districts (Baitadi 68%, Dadeldhura 65%, Surkhet 63% and Doti 60%), three Mountain districts (Humla 75%, Bajura 65% and Bajhang 64%) and one Terai district (Banke 61%) (Table 2.10 and Annex 2.8).

Income and Poverty Level

Table 2.11 shows the average total household income and per capita income in different regions of Nepal for 2003/04. It is estimated that the average household income in the western part of the country has increased by 80-110% within eight years. However, the income derived by households in rural western Hills and Mountains is still lower by almost 25% compared to the national average household income.

Fifty percent or above of the total households in the Western Region derive household income from the farm income. The number of households deriving income from the farm was recorded as 59% in the Western region, 71% in the Mid-Western Region and 62% in Far-Western Region in 1996/97, but that number has reduced to 40%, 52% and 54% respectively in 2003/04. Similarly, the share of non-farm income in the Regions has increased between 21-30% in the Western Regions in 2003/04 compared to between 19-20% in 1996/97. Among the three regions, the highest increase in the share of non-farm income in the total household income is recorded in Mid-Western Region (i.e. 20% in 1996/97 to 30% in 2003/04) (Table 2.12).

Nepal is considered one of the poorest countries in the world, with a per capita income of US$240 per annum and up to 31% of its population living below the poverty line. According to the Nepal Human Development Report (2004), the country's level of human development remains the lowest in the world despite its progress in raising living standards over the last 50 years, particularly since 1990. Development outcomes have varied inequitably, manifesting themselves in gender, caste, ethnic and geographic disparities (UNDP, 2004). This is evident from the poverty incidence figures in Table 2.13.

As shown in the Table, Nepal Living Standard Survey (NLSS 2003/04), rural poverty is reported at 35% compared to 10% in urban areas and only 3% in the urban areas of the Kathmandu valley. In terms of poverty incidence across ecological belts, the Terai belt has the lowest poverty rate at 28%, compared with 33% in the Hills and 35% in the Mountains. Similarly, across the Development Region, the incidence of poverty is recorded as highest in Mid-Western (45%) and Far-Western (41%) Regions compared to the Eastern (29%), Central and Western Regions (27% each).

The poverty level is estimated to be one of the highest in the Basin districts. As estimated by CBS (2006), the percentage of population below the poverty line in 11 project districts (55%) is estimated to be between 45-54%, with only one district (Jumla) having a similar poverty level population to national average (Table 2.14).

Table 2.10: Households Reporting Sufficient Agricultural Produce in Basin Districts

Project District	Sufficient to Feed Household		Not Sufficient to Feed Household		Total Holdings	
	No.	%	No.	%	No.	%
A. Terai	121,433	53.37	106,102	46.63	227,535	100
B. Hills	144,253	45.87	170,244	54.13	314,497	100
C. Mountain	44,510	45.71	52,855	54.29	97,365	100
Total Project Districts	237,417	47.9	257,996	52.1	495,413	100
Total Nepal	1,337,965	39.8	2,026,174	60.2	3,364,139	100

Source: National Sample Census of Agriculture, Nepal 2001/02, District Summary. CBS 2004.

Table 2.11: Nominal Household Income and Per Capita Income by Development Region

Region	Average Household Size	Annual Income in 2003/04 (Rs)	
		Average Household Income	Average Per Capita Income
Eastern	5.3	68,310	13,000
Central	5.4	91,693	16,838
Western	4.8	82,568	17,172
Mid-western	5.4	74,085	13,676
Far-western	5.8	66,294	11,504
Rural	5.4	65,107	12,124
Easter Mountain/Hills	5.4	63,917	12,133
Western Mountain/Hills	5.3	64,667	13,662
Eastern Terai	4.7	59,974	10,617
Western Terai	5.6	78,002	13,015
Urban	4.8	157,550	32,573
Nepal	6.0	80,111	15,162

Source: Nepal Living Standard Survey 2003/04, Vol II. CBS, 2004.

Table 2.12: Share of Nominal Household Income by Sectoral Source

Region	Share of Income by Source (%)					
	Farm Income	Non-farm Income	Remittance	Own Housing Consumpt.	Other	Total
Eastern	53	26	11	7	4	100
Central	47	32	9	11	2	100
Western	40	24	17	11	8	100
Mid-western	52	30	8	9	2	100
Far-western	54	21	11	12	2	100
Rural	55	23	11	8	3	100
Eastern Mountain/Hills	61	20	7	9	3	100
Western Mountain/Hills	49	22	14	10	5	100
Eastern Terai	56	24	12	6	2	100
Western Terai	51	24	11	10	4	100
Urban	13	54	10	17	6	100
Nepal	48	28	11	10	4	100

Source: Nepal Living Standard Survey, Vol II, 2003/04. CBS, 2004.

Table 2.13: Poverty Measurement by Region (1995/96 and 2003/04)

Region	Poverty Headcount Rate (%) by Year of NLSS Survey		
	NLSS 1995/96	NLSS 2003/04	Change (%)
A. Urban/Rural			
Urban	21.6	9.6	-56
Rural	43.3	34.6	-20
B. NLSS Region			
Kathmandu	4.3	3.3	-23
Other Urban	31.6	13.0	-59
Rural Western Hill/Mountain	55.0	37.4	-32
Rural Eastern Hill/Mountain	36.1	42.9	+19
Rural Western Terai	46.1	38.1	-17
Rural Eastern Terai	37.2	24.9	-33
C. Development Regions			
Eastern	38.9	29.3	-25
Central	32.5	27.1	-17
Western	38.6	27.1	-30
Mid-Western	59.9	44.8	-25
Far-Western	63.9	41.0	-36
D. Ecological Belts			
Mountain	57.0	32.6	-43
Hill	40.7	34.5	-15
Terai	40.3	27.6	-32
Nepal	41.8	30.8	-26

Source: Poverty Trends in Nepal (1995/96 and 2003/04). CBS, 2005.

Table 2.14: Percentage of Population below the Poverty Line in Basin Districts

% Popn. Below Poverty Line	Number of Districts		District
	Nepal	Basin	
4-24	10	0	-
25-34	13	1	Jumla
35-44	27	7	Banke Jajarkot, Humla, Kanchanpur, Dadeldhura, Baitadi, Dolpa
45-54	22	11	Surkhet, Doti, Kailali, Bajura, Bajhang, Bardia, Mugu, Rukum, Salyan, Achham, Dailekha
55-60	3	1	Kalikot
Total	**75**	**20**	

Source: Four Monthly Statistical Bulletin, 2005/2006. CBS, 2006.

Overall Development Index

According to the overall development index categorised by CBS, based on 28 development indicators, 14 Basin districts (70%) fall under the “worst” category and are ranked between 58th and 75th position. Three districts, Surkhet, Bardia and Salyan, are categorised as “medium” districts and ranked as 31st, 38th and 47th positions. The remaining three Terai districts of Kanchanpur, Kailali and Banke are categorised as “best” districts and ranked in 18th, 21st and 24th positions. In reference to nine major human development and empowerment indices analysed by Nepal Human Development Report (2004), all the Hill districts except Surkhet and Dadeldhura secured lower scores in all the nine major human development and empowerment indices than the national average. Surkhet had a higher score in four human development and empowerment indices and Dadeldhura had a higher score in two human development and empowerment indices compared to the national average (Table 2.15).

Table 2.15: Development Indicators of Project Affected Districts

Project Districts	Human Development Indices					Human Empowerment Indices				Overall Development Ranking	Development Category
	Human Development Index	Human Poverty Index	Gender-related Development Index	Gender Empowerment Measure	Per Capita Income ($)	Human Empowerment Index	Social Empowerment Index	Economic Empowerment Index	Political Empowerment Index		
A.Terai	0478	39.6	0.450	0.372	221	0.476	0.362	0.392	0.674		
Banke	0.479	34.4	0.463	0.401	252	0.579	0.437	0.454	0.874	24	Best
Bardia	0.429	43.2	0.411	0.394	178	0.505	0.296	0.343	0.875	38	Medium
Kailali	0.442	39.5	0.428	0.385	217	0.486	0.409	0.403	0.647	21	Best
Kanchanpur	0.463	35.2	0.442	0.344	246	0.554	0.430	0.433	0.800	18	Best
B.Hill	0.512	38.8	0.498	0.408	261	0.451	0.476	0.310	0.568		
Achham	0.350	59.2	0.314	0.314	141	0.305	0.293	0.171	0.452	72	Worst
Baitadi	0.391	48.7	0.361	0.314	163	0.309	0.355	0.216	0.356	57	Worst
Dadeldhura	0.434	46.2	0.396	0.296	242	0.419	0.373	0.394	0.491	65	Worst
Dailekha	0.381	52.5	0.358	0.300	125	0.335	0.246	0.124	0.636	67	Worst
Doti	0.402	53.4	0.368	0.306	173	0.229	0.210	0.185	0.293	63	Worst
Jajarkot	0.343	57.2	0.328	0.366	154	0.281	0.247	0.174	0.421	62	Worst
Rukum	0.386	53.7	0.382	0.337	184	0.178	0.228	0.161	0.146	58	Worst
Salyan	0..399	48.2	0.364	0.338	145	0.336	0.368	0.223	0.418	47	Medium
Surkhet	0.486	44.6	0.475	0.380	200	0.459	0.384	0.269	0.724	31	Medium
C. Mountain	0.389	49.8	0.363	0.356	204	0.359	0.315	0.236	0.526		
Bajhang	0.331	59.9	0.289	0.323	152	0.280	0.228	0.195	0.418	73	Worst
Bajura	0.310	56.4	0.277	0.304	167	0.279	0.218	0.142	0.479	71	Worst
Dolpa	0.371	61.9	0.341	0.372	235	0.255	0.139	0.141	0.485	70	Worst
Humla	0.367	63.8	0.337	0.308	186	0.264	0.061	0.220	0.512	74	Worst
Jumla	0.348	56.8	0.316	0.362	203	0.304	0.193	0.164	0.554	68	Worst
Kalikot	0.322	58.9	0.274	0.430	142	0.273	0.218	0.158	0.444	69	Worst
Mugu	0.304	61.1	0.263	0.304	203	0.249	0.050	0.214	0.483	75	Worst
Nepal	0.471	39.6	0.452	0.391	240	0.463	0.406	0.337	0.646		

Note: The bold figure indicates the better position than the national average indicator.
Source: i) Nepal Human Development Report, 2004; UNDP 2004.ii) District Level Indicators of Nepal; CBS 2003.

2.1.2 Natural Environmental Profile

2.1.2.1 Physical Environment

Topography and Climate

Topographically the Basin rises from south to north. The southern Terai belt (50-500 m asl) is a flat land suitable for irrigated cultivation. The Siwaliks (500-2,000 m asl) to the north of the Terai, represents a young frontal foothill system (20-30 km wide) with tectonic Dun Valleys. Except for the Dun Valleys, the Siwaliks is highly rugged and fragile terrain of the Himalayan belt due to its geologic composition and tectonic dynamism. Piggy-back hill systems are a typical topographic feature of this zone.

To the north of the Siwaliks lies the 10-20 km wide Mahabharat Range (500-3,000m). This range stands out as a towering mountain belt overlooking the Siwaliks and the Terai in the south and Mid-hills and Mountains to the north. Geologically it is composed meta-sedimentary rocks with outliers of the crystalline rocks at some places. Characteristically, drainage systems originating in the Mid-hills, Mountains and High Himal take either an easterly or westerly turn in front of this range before emerging in the Siwaliks through deep gorges.

Mid-hills (500-3,000 m asl) to the north of the Mahabharat Range are subdued systems of valleys and hills elevating gradually towards north (20-40 km wide). Relatively gentler topographic forms, and ramifications of the wide and flat alluvial terraces along the major river systems, have rendered this belt as the focus area for settlements and cultivation.

The Mountains and the High Himal (15-20 km wide) stand as towering mountain systems (1,000 m to >6000 m asl) overlooking Mid–hills and Mahabharat in the south and Bhot in the north. Made up of crystalline rocks at the base and succeeded by sedimentary sequences at higher elevation, the terrain is steep and generally inhospitable for human settlement and cultivation. Permanent snow occurs above 5,000 m elevation and represents the famous Himalayas of Nepal. To the north of Mountains and High Himal, the Bhot Valley (3,000-4,500 m asl) extends up to the border of the Tibetan Autonomous Region of China. The Bhot Valley represents typical rain shadow areas of the Basin, with a wide expanse of high altitude range lands.

Except for the Terai, Basin physiographic zones are characterised by peculiar topographic forms with unique relief variations within short distances. The river valleys are deeply entrenched defining the lowest grounds, while the flanking mountains rise from the valley bottom in various shapes and forms, frequently changing slope angles. The intensity of the past and ongoing tectonic dynamism is reflected in the landforms of the river valleys and mountain slopes. The southern Siwaliks and the northern Mountains and High Himal are tectonically more active than the other Physiographic Zones in the Basin.

Although the Basin lies near the northern limit of the tropics, it has a diverse climate due to elevation variations. The southern Terai plain is tropical while the Siwaliks are tropical to sub-tropical. In the Mahabharat and Mid-hills, climate varies between tropical and temperate, whereas Mountain, High Himal and Bhot experience a temperate to alpine climate.

Elevation and exposure play an important role in the spatial variations of air temperature in the Karnali Basin. Seasonal variations in air temperature, however, are related to the influence of the monsoon and incoming solar radiation. Lower temperatures occur from November to February, with minimum yearly temperatures occurring in December and January. Maximum temperatures generally occur immediately prior to the onset of the monsoon in May and June. Summer and late spring maximum temperatures range from more than 40^0C in the Terai to about 28^0C in the Mid-hills, with May being the warmest month. Winter average maximum and minimum temperatures in the Terai vary from 23^0C to 7^0C, while the Mid-hills experience a 12^0C maximum and a below freezing minimum. Much colder temperatures are experienced in the Mountains, High Himal and Bhote Physiographic Zones.

The Basin experiences two rainy seasons: in summer from June to September, when the southwest monsoon brings about 75% of its total annual rainfall; and in winter, accounting for the remaining rainfall. Average annual Basin precipitation is 1,147 mm (JICA, 1993).

Drainage and Hydrology

The Karnali River Basin in Tibet and Nepal covers a total drainage area of 44,452 km^2, of which 773 km^2 lies in Tibet and 43,679 km^2 in Nepal. The principal sub-basins of the Karnali River Basin within the Nepalese territory are: Karnali Main (Humla Karnali + Mugu Karnali + Tila + Lohore), Seti and Bheri. The Seti River sub-basin constitutes 17.08% of the Karnali River Basin, while Karnali Main, Bheri and others make up 44.09%, 28.14% and 10.69% respectively (JICA, 1993).

The Karnali River Basin contains 1,361 glaciers and 907 lakes. Glaciers cover 1,740.2 km^2 and contain an estimated ice reserve of 127.7 km^3 (Bajracharya, et al, 2002).

The Basin hydrological cycle is maintained by rain, snow, ice and groundwater. Peak river discharges occur during the monsoon season when about 64% of all rainfall is immediately drained as surface runoff. Of the remaining 36%, some is retained in the form of snow and ice in the High Himal, some percolates to become groundwater and some is lost due to evaporation and transpiration. Snow, ice and groundwater act as a natural reservoir, supplying rivers throughout the dry season. Since there are only a few lakes, natural surface storage does not play a major role in the hydrological cycle of the Basin.

River flow rates in the Karnali Basin are highly seasonal, with over 80% of the annual total flow occurring during the months of May to October. The lowest flow occurs during the dry season months of January to May. Additionally, there are variations in daily flows, with pronounced daily flow variations occurring from May to August when the winter accumulated snow in the Mountains and High Himal release melt waters under solar radiation during the day.

The average annual discharge of the Karnali Basin is 1,378.4 m^3/s. Of this discharge, 36.5% is contributed by the main Karnali watershed, while Bheri, Seti and other sub-catchments contribute 31.1%, 20.9% and 11.5% respectively.

River Use

Streams and rivers of the Karnali Basin are used for various purposes (domestic and stock water supply, irrigation, micro-hydro, and religious rituals). White-water rafting occurs on the lower stretch of the Karnali from Dhungeshowr to Chisapani. About 20 white-water rafting companies provide services to tourists.

The main use of water by volume from the Karnali River is for irrigation. Irrigation from the Karnali River within Nepal occurs at two locations in Bardia District (2,320 ha and 18,340 ha) and at a single site in Kailali District (13,925 ha). This total demand for irrigation water from the Karnali River represents a very small proportion of existing total river flows, amounting to an average annual rate of 54 m^3/s (Himalayan Power Consultants, 1989), or 3.9% of the average annual Karnali River flow into India of 1,370 m^3/s (Sharma, 1977).

In India, water is diverted from the Karnali River at the Girijapur Barrage (located 20 km downstream of the Nepal-India border) into the Sarda Sahayak Irrigation Scheme which has a 2 million ha command area, while the Saryu Nahar Irrigation Scheme currently under construction will irrigate 1.2 million ha. The combined annual water demand from these two projects is 10,000 million m^3 (317 m^3/s), equivalent to 23% of the mean annual Karnali River flow.

Wetlands

Of the 242 wetlands in Nepal, 96 wetlands are located in the Karnali Basin (IUCN, 1996), with 72 of these on the Terai and 24 in the Hills and Mountains. Important wetlands of the Terai are Badahiya (Bardiya district), Ghodaghodi tal, Narcrodi tal, Rampur tal, Deukhuria (Kailali district), Patriyani and Betkot (Kanchanpur district). The highland wetlands of Rara and Phoksumdo Lakes are located in Mugu and Dolpa districts.

Land Use and Watershed Conditions

Forest cover occupies 40% of the total land area of the Basin districts. Agricultural land constitutes only 15% of the total land area, with bare land covering 21%, snow 19% and shrubs 5% (Table 2.16 and Annex 2.6).

Table 2.16: Land Use Pattern in the Basin District

District	Total Forest Area	Shrub	Agricult. Land/ Grassld.	Water Bodies	Bare Land	Snow	Other	Total
A. Terai	457,761	31,639	358,991	8,162	21,447	0	0	**878,090**
B. Hills	1,135,152	133,077	326,168	4,526	155,057	27,865	0	**1,781,845**
C. Mountain	551,560	103,910	143,880	3,843	944,208	972,794	0	**2,720,195**
Total	2,144,473	268,626	829,039	16,531	1,120,712	1,000,659	0	**5,380,130**
%	39.9	5.0	15.4	0.3	20.8	18.6	0.0	**100.0**
Total Nepal	5,599,760	1,283,231	4,061,631	64,664	1,683,493	1,974,003	108377	**14,775,159**

Source: Environment Statistics of Nepal, 2005.

The main factor in the formation of Basin landforms is the geo-tectonic activity. The other component that accelerates the erosion and sediment transport in the Karnali Basin, is the effects of human activities on forest, shrub, grazing and agricultural lands. Shrestha et.al (1983) proposed a rating method based on the idea of Nelson et al (1980) to evaluate the conditions of watershed in the administrative districts. According to this classification, Surkhet and Doti district are classified as Class V (very poor), Rukkum, Dolpa, Dailekh, and Jumla districts as Class III (marginal), Salyan, Jajarkot, Humal, Mugu, Bajura, Achham, Bajhang, Baitadi, Dadeldhura and Kalikot districts as Class II and Kailali, Kanchapur, Bardiya and Banke as Class I. The Hill districts have critical watershed conditions in the Karnali Basin due to population growth and related land use activities.

2.1.2.2 Biological Environment

Forest and Vegetation

The Karnali Basin lies in the Western Nepalese Bio-geographic Region and Trans-Himalayan Bio-geographic Region as classified by Dobremez (1976). Dobremez and the Nepalese researchers recognised 198 vegetation categories in Nepal. These categories have been synthesized into 36 vegetation types to give a simplified ecological picture of Nepal's vegetation (NARMSAP, 2002). Of the 36 vegetation types, 28 vegetation types are mapped within the Karnali Basin districts (Annex 2.9). These represent all three vegetation types of Alpine Zone, six out of seven of the Sub-Alpine Zone, 12 out of 17 of Temperate Zone, two out of four of the Sub-Tropical Zone, two out of two of the Tropical Zone and three out of three of the Trans-Himalayan Zone.

Bajhang district has the highest number of vegetation ecological types (18), followed by Bajura, Mugu , Kalikot (14), Humla, Jajarkot, Rukkum (13), Jumla (12), Dolpa, Achham (10), Dailekh (7), Doti (6), Dadeldhura, Baitadi (5), Salyan, Surkhet (4), Kailali, Kanchanpur, Banke and Bardiya (3) (Annex 2.9). Achham, Bazura and Kalikot are listed as the most biodiverse districts in the Karnali Basin (Resources Nepal, 1999).

Forest cover in the Terai districts of the Basin is high (61%), followed by the Hills (38%). The Mountains have the least forest cover (23%) (DFSR, 2001). Data on plant species in the Basin is not available. The compiled national database (BPP, 1995) indicates that the Terai and Siwaliks have fewer recorded species compared to the Hills and Mountains. The Hill ecological region has the highest number of plant species recorded followed by the Mountains (Table 2.17).

Table 2.17: Flora Species in Each Physiographic Zone

Floral Category	Terai & Siwaliks <1,000m	Hills to Mid-hills 1,000-3,000m	Highlands Plantae >3,000m	Total Nepal
Bryophytes	**61 (8.40%)**	**493 (66.62%)**	**347 (46.89%)**	**853**
Pteridophytes	**81 (21.32%)**	**272 (71.58%)**	**78 (20.53%)**	**380**
Gymnosperms		**16 (84.20%)**	**10 (52.63%)**	**28**
Angiosperms	**1,885 (36.53%)**	**3,364 (65.19%)**	**> 2,000 (38.70%)**	**5856**

Source: BPP, 1995f. * Approximate figure. Flora and fauna species may occur in more than one physiographic zone, therefore the cumulative percentages of the total number of species of each group found in Nepal do not necessarily equal 100.

Wildlife

The forests and the wetlands of the Basin districts shelter a wide range of wildlife species. The diversity of species in the Basin area is difficult to estimate, however, the physiographic distribution at the national level provides a glimpse of the potential wildlife diversity of the Basin (Table 2.18).

Table 2.18: Potential Wildlife Diversity of the Basin

Floral Category	Terai & Siwaliks (<1,000 m)	Hills & Mid-hills (1,000-3,000 m)	Highlands Plantae (>3,000 m)	Total Nepal
Butterflies	**325 (51.1%)**	**557 (88.0%)**	**82 (13.1%)**	**640**
Fishes	**154 (83.2%)**	**76 (41.1%)**	**6 (3.2%)**	**182**
Amphibians	**22 (57.2%)**	**29 (67.4%)**	**9 (20.9%)**	**43**
Reptiles	**68 (68.0%)**	**56 (56.0%)**	**13 (13.0%)**	**100**
Birds	**648 (77.8%)**	**691 (82.5%)**	**413 (49.6%)**	**852**
Mammals	**91 (50.3%)**	**110 (60.7%)**	**80 (44.2%)**	**181**

Flora and fauna species may occur in more than one physiographic zone, therefore the cumulative percentages of the total number of species of each group found in Nepal do not necessarily equal 100.

The Hill Physiographic Zone has the most number of species of mammals, butterflies, amphibians and birds. The Terai and Siwaliks are diverse in fishes and reptiles. The Mountains has relatively lower wildlife species diversity.

The Terai and Siwaliks of the Basin are the pristine habitats for the threatened mammalian species such as Royal Bengal Tiger, One Horned Rhinoceros, Swamp deer, Black buck, etc, whereas the Mountains/Highlands are habitat for Red Panda, Snow Leopards, Musk deer etc.

The Karnali River network is one of the least disturbed habitats for a number of aquatic species. The transitional zone or ecotone below Chisapani gorge (Terai-Siwaliks) supports an impressive richness of species, including threatened aquatic animals such as the Ganges River Dolphin (*Platanista gangetica)*, the Gharial (*Gavialis gangeticus)*, the smooth-coated Otter (*Lutra perspicillata)*, the narrow-headed soft-shell Turtle (*Chitra indica)*, and the red-crowned roofed Turtle (*Kachuga kachuga)* (Smith et al., 1996). The riparian habitat of the Karnali also supports a greater abundance of Great Indian Rhinoceroses (Rhinoceros unicornis) and Tigers (*Panthera tigris*) compared to interior forests and grasslands (Dinerstein, 1979).

Smith et al. (1996) recorded 121 fish species from the Karnali River. The cold waters of Hill region have fish fauna rich in species and numbers, while the waters of the Bhot Region have a poorer fish fauna due to low water temperature and a fast current. Fisheries have not been noted above 1,800 m in the Himalaya above sea level (asl) (Jha, 1992). However, in the Karnali Basin, fish have been recorded at the altitude of 2,990 m in Rara Lake (Rajbanshi, 2001), including (*Schizothorax macrophthalmus* (Terashima), *S. nepalensis* (Terashima), *S.raraensis* (Terashima).

The fisheries of the Karnali River represent the assemblage of Cold Water Upland Fisheries (Payne et al, 2000). In the cold waters of the Mountain region, *Schizothorax* and *Schizothoraichthys* are the dominant fish, followed by *Glyptothorax*, and the small loaches of Balitoridae Group. In the cold waters of high Hills, the above fish species are accompanied by the *Cyprinids, Tor, Neolissocheilus* and *Barilius*, followed by *Glyptothora*x, and in the Hill region besides the above species, *Chagunius, Semiplotus, Botia, Clupisoma* and *Amblyceps* appear. The overlapping of species increases towards lower altitude rather than at higher altitude and it also varies seasonally (Rajbanshi, 2001).

Numerically the Snow Trout and Mahseers dominate the fishery of the Karnali River. The Snow Trouts and Mahseers are both migratory. The Snow Trout, (*Schizothorax*), migrates upstream and is reported to spawn in March to June at water temperatures ranging from 14-21°C. It is generally regarded as tolerating waters from 8°C to 22°C. For the Mahseer (Hamilton), upstream migration takes place at the beginning of the monsoon and they may spawn during the period of July to September.

National Parks and Conservation Area

The protected area constitutes nearly 14% of the total Basin area. The Basin area includes 4 out of the 9 National Parks, 1 out of 3 Wild Life Reserves, the only Hunting Reserve, and two out of 6 Buffer Zones of Nepal ((Table 2.19). The Basin and its influence area alone constitute 27% of the total Protected Area, 63% of National Park, 25% of the Buffer Zone, 100% of the Hunting Reserve and 31% of Wildlife Reserve.

The biological and cultural significance of each Protected Area in the Basin is summarised in Table 2.20.

Table 2.19: Protected Areas in the Basin

Protected Area (PA) and District	Area (ha)	Buffer Zone Area (ha)	Ecological Zone (Altitude m)	Number of Flowering Plant Species	Number of Endemic Species
Royal Bardia NP **(1976/1988) – Bardiya**	**968**	**328**	**Terai (152-1,494)**	**839**	**0**
Khaptad NP **(1984) – Baitadi, Dadeldura, Doti**	**225**	**0**	**Hill (1,000-3,276)**	**567**	**4**
Shey Phoksundo NP	**3,555**	**449**	**Mountain (2,000-**	**1,579**	**30**

(1984) – Dopa			**6,885)**		
Rara NP **(1976)** **– Mugu**	**106**	**0**	**Mountain (1,800-4,048)**	**1,070**	**16**
Dhorpatan HR **(1987) - Rukkum , Dolpa**	**1,325**	**0**	**Mountain (2,850-7,000)**	**1,150**	**36**
Royal Suklaphanta WR **(1976) - Kanchanpur**	**305**	**0**	**Terai** **(90-270)**	**700**	**0**

Source: Nepal Biodiversity Strategy, 2002.

Table 2.20: Biological and Cultural Significance of the Protected Areas

Protected Area	Biological and Cultural Significance
Royal Bardia NP	**Sal, Pine, Acacia, Sissoo, grassland, wild Elephant, Tiger, Sloth Bear, Hispid Hare, Gangetic Dolphin, Black Buck, Crocodile, Gharial.**
Khaptad NP	**Oak, Fir, Conifer, Musk deer, Leopard, Black Bear. Ashram of late Khaptad Baba (sage), Shiva shrine, Khaptad daha - a shallow lake.**
Shey Phoksundo NP	**Tibetan plateau ecosystem, Oak, Spruce, Fir, Birch, 30 species of endemic plants, Blue Sheep, Musk deer, Red panda, Snow Leopard. Religious Buddhist site.**
Rara NP	**Blue pine, Fir, Birch, Musk deer, Leopard, Red panda, Impeyan pheasant, high altitude wetland.**
Dhorpatan HR	**Fir, Hemlock, Spruce, Birch, Junipers, grassland. Game hunting reserve.**
Royal Suklaphanta WR	**Sal, Acacia, Sisso, extensive grassland, Elephant, Swamp deer, Tiger, Hispid hare, Bengal florican.**

Source: Nepal Biodiversity Strategy, 2002.

2.2 BASIN DEVELOPMENT PROFILE

This section analyses the growth and development trends of various indicators related to demographic, socioeconomic and development programmes in the Basin.

2.2.1 Changes in Population Structure

The population of Basin districts increased from 1.9 million in 1971 to 4.7 million in 2001, almost a 250% increase over three decades (Annex 2.10). Similarly, the average population density of the Basin area increased from 87 persons/km^2 in 2001 from 53 person/ km^2 in 1981. In the same period, the density in the Terai more than doubled from 119 persons/ km^2 in 1981 to 242 persons/ km^2 in 2001. The growth in the Hill districts was modest (76 person/ km^2 in 1981 to 107 persons/ km^2 in 2001) and least in the Mountain districts (16 person/ km^2 in 1981 to 22 persons/ km^2 in 2001). The density in the Hill and Mountain districts of the Basin is recorded as the lowest compared to the national average density (157 persons/s km^2) and highest in the Terai districts (Annex 2.11).
The urban population increased from 1.6% in 1971 to 7.44% in 2001. The urban population in the Terai Basin districts grew from 4.7% in 1971 to 16.4% in 2001, compared to 5.9% and 0.0% in the Hills in the same years. But the urban population in the Mountain area of the Basin remained nil over the entire census period (Annex 2.12).

There is steady growth in the economically active population in Basin districts. The ratio of economically active population in the Basin grew from 52% in 1971 to 64% in 2001. The economically active population of the Basin districts recorded in 2001 is higher than the national average rate of 58% (Annex 2.13).

The population of the Basin districts has increased at the annual growth rate of 2.2% per annum. The population growth rate within Basin districts varies from 1.54% per annum (Achham) to 3.3% per annum (Kailali). As per the projection made by the CBS, the population of Basin districts is estimated to reach 2.2 million in 2011, 2.4 million in 2016, 2.7 million in 2021 and 2.9 million in 2026 (Annex 2.14).

2.2.2 Development of Social Services and Economic Status

The average literacy rate of Basin districts has increased from a mere 7.5% in 1971 to 45% in 2001. Among the three ecological regions, the Terai has experienced higher growth in the education sector (from 9% in 1971 to 54% in 2001) compared to Hills (from 9% in 1971 to 47% in 2001) and Mountains (from 4% in 1971 to 33% in 2001). The rate of male literacy has almost doubled in the Hills and Mountain districts of the Basin compared to female (Annex 2.15).

The social status of the households living on a permanent basis in Basin districts increased from 24% in 1991 to 31% in 2001. There is a nominal increase in the living status of households living on a semi-permanent basis, while those households living on an impermanent basis have reduced significantly (50% in 1991 to 33% in 2001) (Annex 2.16).

2.2.3 Trend of Development Expenditure in the Basin Districts

The average annual development expenditure in Basin districts is estimated at NRs 4,024 million ($58.3 million). The largest share of the development budget is spent on road construction and local development activities (35%), followed by irrigation (16%) and education (14.4%). The development budget allocation to local services such as water supply, health and electricity is less than 5%. Basin districts consume 20% of the development budget of the nation and 83% of the total development budget of the Mid-Western and Far-Western Regions (Table 2.21).

The distribution of development expenditure between Development Regions indicates that the Central Region receives the greatest share of the development budget (30%), followed by Western Region (29%), Eastern Region (16%), Mid-Western Region (15%) and Far-Western Region (10%). There is a very slow but steady increase in the development budget of the Mid-Western and Far-Western Development Regions.

Table 2.21: Allocation of Development Budget in the Basin Districts - average 1997/1998-2005/2006 (NRs in '000)

District	Water Supply	Irrigation	Road/Local Development	Education	Health	Electricity	Other	Total	%
A. Terai	30,445	465,115	267,187	169,733	31,321	35,048	268,533	1,267,382	31.5
B. Hills	89,020	122,558	727,898	275,117	50,353	82,190	287,589	1,634,725	40.6
C, Mountain	40,565	61,695	414,313	134,408	27,977	61,006	381,899	1,121,864	27.9
Total Project Districts	160,031	649,369	1,409,397	579,258	109,652	178,244	938,021	4,023,970	100.0
%	4.0	16.1	35.0	14.4	2.7	4.4	23.3	100.0	
National Average								19,864,645	
Average of Mid and Far west								4,865,178	

Source: National Planning Commission, 1997/98 to 2005/2006.

The growth of absolute development budget figures (Table 2.22) reveals that development expenditure in Basin districts and the Mid-Western and Far-Western Regions has increased at the average rate of 16% per annum, compared to 23% in the Western Region, 10% in the Central Region, 9% in the Eastern Region and 8% in the country.

Table 2.22: Development Budget in Basin Districts, Region and Nepal (NRs million)

Fiscal Year	Basin Districts				Mid-West	Far-West	Nepal
	Terai	Hill	Mount.	Total			
1998/1999	1079.8	1105.9	688.2	2874.0	2030.4	1374.6	16157.26
1999/2000	1273.2	1421.6	990.5	3685.3	2416.8	1887.8	19253.77
2000/2001	1333.5	1552.6	1098.8	3984.8	2983.4	2029.9	22869.13
2001/2002	968.2	1271.9	848.1	3088.2	2275.3	1594.2	17099.17
2002/2003	1437.7	1989.5	1203.7	4630.9	2588.7	1779.4	17924.81
2003/2004	1437.7	1989.5	1203.7	4630.9	3439.1	219.5	17730.09
2004/2005	1476.2	2253.4	1694.4	5424.1	3997.0	2471.2	21442.4
2005/2006	1790.8	2886.0	1995.9	6672.7	4647.9	3186.3	26440.54

Source: National Planning Commission, 1998/99 to 2005/2006.

Sector wise, accelerated growth has been recorded in road and local development, while growth in the health, drinking water and education sectors has been stagnant. Other sectors like irrigation and education have experienced both increasing and decreasing trends (Table 2.23).

Table 2.23: Sector-wise Development Budget Allocation in Basin Districts (NRs)

Year	Water Supply	Irrigation	Road/ Local Develop.	Education	Health	Electricity	Other	Total
1997/1998	193,338	735,329	609,609	103,336	76,479	162,516	435,276	2,315,884
1998/1999	234,590	918,479	687,195	173,759	67,852	208,670	583,476	2,874,021
1999/2000	157,898	825,010	909,899	298,397	77,603	377,442	435,276	2,964,546
2000/2001	165,407	740,980	1,267,817	421,869	100,660	180,268	1,107,841	3,984,842
2001/2002	58,497	418,247	1,144,667	539,677	87,738	55,848	783,528	3,088,201
2002/2003	54,126	395,068	1,694,626	385,110	98,348	171,400	741,107	3,539,785
2003/2004	101,020	547,856	1,788,467	959,023	104,204	142,260	988,100	4,630,930
2004/2005	230,985	596,462	1,884,308	1,267,852	159,279	106,085	1,179,108	5,424,079
2005/2006	244,416	666,887	2,697,987	1,064,296	214,701	199,704	1,584,669	6,672,659
Average /Year	160,031	649,369	1,409,397	579,258	109,652	178,244	938,021	4,023,970

Source: National Planning Commission, 1997/98 to 2005/2006

2.2.4 Trends in Infrastructure (Road and Hydropower) Development

The Basin has a total road length of 2,640 km (ISRC, 2002). The share of road length between the Basin districts of Terai, Hills and Mountains is 46.0%, 50.3% and 3.5% respectively. The pace of road development is very slow in the Basin districts. The statistical data of road network development in the Basin districts from 1989 to 1998 (CBS, 2001) indicates that 162 km of new road was constructed per year.

The pace of hydropower development in Basin districts is also very slow. Despite the high potential of hydropower development (32,000 MW) in the Basin, only 2,245 kW capacities has been developed so far (Table 2.24).

Table 2.24: Hydropower Generation by Type, Installed Capacity and Year of Commissioning in the Basin Districts

District	Station	Project Type	Installed Capacity (kW)	Unit Capacity (kW*No)	Year Commissioned
Surkhet	**Jhupra**	**Run-off-river**	**345**	**115*3**	**1977**
Doti	**Doti**	**Run-off-river**	**200**	**100*2**	**1981**
Jumla**	**Jumla**	**Run-off-river**	**200**	**100*2**	**1983**

District	Station	Project Type	Installed Capacity (kW)	Unit Capacity (kW*No)	Year Commissione d
Bajhang**	**Bajhang**	**Storage**	**200**	**100*2**	**1989**
Bajura	**Bajura**	**Run-off-river**	**200**	**100*2**	**1990**
Achham	**Achham**	**Run-off-river**	**400**	**200*2**	**1995**
Kalikot	**Kalikot**	**Run-off-river**	**500**	**250*2**	**1999**
Dolpa	**Dolpa**	**Run-off-river**	**200**	**100*2**	**1999**
			2,245		

** Leased to Private Sector
Source: Statistical Pocket Book, Nepal 2006. CBS, 2006.

2.2.5 Trends in Natural Resource Managements (Forests, Wildlife and Watershed)

The increasing population pressure in Basin districts has a direct effect on natural resources, particularly forests. The lack of livelihood diversification in the Basin, with people heavily reliant upon traditional livelihoods (subsistence agriculture), has further aggravated the problem of natural resource degradation. Population pressure is higher in Terai areas of the Basin compared to the Hills and Mountains. In Terai districts the forest is reported to have decreased at the rate of 2.69% over the 10 year period from 1990-91 to 2000-01 (Table 2.25).

Table 2.25 Annual Rate of Change in Forest Cover in Terai Districts - excluding Protected Areas (1990/91 to 2000-01)

District	Forest Cover 1990-91 (ha)	Forest Cover 2001/01 (ha)	Change (ha)	Change in %
Banke	113,074	110,820	-2,254	-1.99
Bardia	35,491	33,719	-1,772	-4.99
Kailali	210,413	205,939	-4,474	-2.13
Kanchanpur	54,546	51,933	-2,613	-4.79
Total	**413,524**	**402,411**	**-11,113**	**-2.69**

Source: Environment Statistics of Nepal, 2005.

The depletion of forest areas combined with the degradation of natural forest stock has stressed the natural habitats of both terrestrial and aquatic wildlife in the Terai. Even protected areas in the Basin are under intense pressure from the growing population (Table 2.26).

Table 2.26: Stress on the Protected Areas of the Basin

Protected Area	Main Stresses
Royal Bardia NP (1976/1988)	**Poaching, hunting, grazing, fishing using explosives and poison**
Khaptad NP (1984)	**Grazing, crop degradation by wild boars, firewood collection, fires in the chir pine forest.**
Shey Phoksundo NP (1984)	**Grazing, poaching for musk deer, hunting for blue sheep, collection of medicinal plants.**
Rara NP (1976)	**Grazing, collection of firewood and medicinal plants.**
Dhorpatan HR (1987)	**Over grazing, grass burning, firewood cutting.**
Royal Suklaphanta WR (1976)	**Collection of wood, grazing, crop-raiding by wild animals.**

Source: Nepal Biodiversity Strategy, 2002.

In the Hill and Mountain districts of the Basin the quality of forest areas is gradually improving under the influence of community forestry programs.

A total of 3,428 Community Forest User Groups involving 359,758 households (51.45% of Basin households) manage 3,147.2 km^2 of forest in the Basin (Department of Forests, 2006), about 18% of the total Basin forest area. Community Forest represents 6.0%, 29.7%, and 17.7% of the total forest area in the Terai, Hill and Mountain districts respectively. Similarly the percentage of all households involved in community forestry in the Terai, Hill and Mountain districts is 25.9%, 66.7% and 74.5% respectively.

3. BASIN PLANNING AND MANAGEMENT

3.1 POLICY

The source of government policy in Nepal is the periodic Five Year Plan Documents. The Government of Nepal (GoN) is implementing its Tenth Five Year Plan (2002-07) which is also known as Poverty Reduction Strategy Paper (PRSP) with the sole objective to bring about a remarkable reduction in the poverty level in Nepal. The PRSP/Tenth Plan has shown GoN's commitment to implementing its four strategic pillars:

i) achieve high broad-based and sustainable economic growth;
ii) improve the quality and availability of social and economic services and infrastructure
iii) ensure social and economic inclusion of the poor, marginalised groups and
iv) promote good governance.

Further, as Nepal is committed to the attainment of Millennium Development Goals (MDGs) propounded by the United Nations (UN), some policies and programmes conducive to MDGs are also incorporated in the PRSP/Tenth Plan for achieving MDG targets.

The Tenth Five Year Plan (2002–07), emphasises as a priority strategy, the development of basic physical infrastructures such as roads, irrigation, hydropower, telephone networks and electrification networks throughout the country. Specific targets on infrastructure development (Table 3.1) are set for achievement in the short term (2007) and medium term (2016-17).

Table 3.1: Main Objectives of Physical Infrastructure

Description	Tenth Plan (2002-07)	Twelfth Plan (2016/17)
1. Number of districts with access to roads	70	75
2. Irrigated Area ('000 ha)	1,417	1686
3. Distribution of telephone (per '000 of population)	40	150
4. Number of VDCs with telephone facility	All	All
5. Number of VDCs connected with computer networks	1,500	
6. Population having an electricity facility (%)	30	80
7. Number of VDCs having electricity facility	2,600	
8. Agro and Rural Roads (km)	10,000	

Source: Tenth Plan Document, 2002.

The Tenth Plan conceives national development through balanced regional development and emphasises coordinated development of infrastructure projects such as highways, air transport, communication and information systems, hydropower generation, electricity distribution systems and development centres for achieving high, sustainable and broad economic growth. To achieve these targets, it envisages government as well as private investment on highways, hydropower generation, and electricity distribution systems.

Further, the Tenth Plan reiterated its special emphasis on the development of remote areas. One strategy of the Tenth Plan, is to prioritise development plans for the remote areas of the Karnali, while emphasising the overall development of the Far Western Development Region and Mid Western Development Region, the regions lagging behind in the national context.

One of the policy strategies stressed in the Tenth Plan, is to incorporate the social and environmental components within the development projects, in accordance with the policy of sustainable development (1992, Rio Convention). Accordingly, it ensures protection of natural and social environments while undertaking infrastructure development or utilising natural resources for economic growth.

3.2 LEGISLATION

The statutory legislation for the management of social and environmental well being, promulgated by the government of Nepal, is the Environmental Protection Act (EPA) 1997, and Environmental Protection Rule (EPR) 1997. The legislation is multi-sectoral in nature and enables the concerned ministry (Ministry of Environment, Science and Technology) to prescribe legal measures affecting natural and social environments including authority to frame environmental rules, standards and guidelines, and decide on future environmental permit requirements, as appropriate.

The EPA and EPR, endorse the protection of natural and social environments while undertaking development activities of any kind. Initial Environmental Examinations (IEE) and Environmental Impact Assessments (EIA) are made mandatory for the projects listed in the Schedules 1 and 2 of the EPR. All of the projects listed in the schedules could be implemented only after the approval of the IEE and EIA by the concerned authority for IEE and the concerned ministry for EIA. The development project proponents are responsible for the implementation of the measures and monitoring of the protection of natural and social environments as a part of the project cost.

Currently, all the sectoral legislations on forest, water resources (drinking water, hydropower, and irrigation), industry, transport, communication, urban development and other local developments, incorporate natural environment and social and socioeconomic concerns within development planning, implementation and operation. All the sectoral agencies implementing the development projects play a role in the protection of natural and social environments. However, the primary role, in the protection and conservation of natural and social environments, is held by the Ministry of Environment, Science and Technology.

3.3 EFFECTIVENESS, GAPS AND WEAKNESSES

The policy of the government of Nepal is rarely complemented with the programs. This is the major bottleneck for the policy to be effective in realising the national development vision and goal. Balanced development across Development Regions and a special focus on the development of remote and least developed areas is the policy strategy of the government, but it lacks complementary development programs in these areas. This is also reflected in the share

of the development budget, as the least developed regions of FWDR and MWDR receive the minimum development budget within the Development Regions of Nepal.
Over-dependency on donors for development program design and budget expenditure is the other weakness of the government for the progression of regional development. Such dependency has been instrumental in the realisation of policy objectives at the ground level.

Every five years, there is shift in the government’s overall policy and very frequently the sectoral development policies are reframed to suit the sector development strategy. Interestingly, each sector’s policies are isolated, self standing and are not incorporated within the framework of other national sector policies. As a consequence, there is conflict between the sector policies, which hinders the implementation of development activities. Additionally, the new sector policies are not translated into sector legislations, making it difficult to regulate the sector at ground level.

Human resource development is the other area where there is a wide gap between what is required and what is available to execute the government’s policies and programs. Apart from this, authority given to the desk office by legal instruments without the development of guidelines has hampered institutional development, while promoting individualism in the decision making for policy and program execution.

Despite the above shortcomings, the government of Nepal is sincerely executing the IEE and EIA legal requirements for development activities in Nepal, to enable the protection of natural and social environments. Projects are implemented only after the approval of the IEE and EIA by the concerned authority or concerned ministry. However, the time frame for IEE and EIA approvals has taken longer to implement than envisaged by the legislation. In the last 10 years, only 67 EIAs of development projects all over Nepal have been approved by the ministry (MOEST, 2006). This has slowed the pace of development to what was originally planned.

Though IEE and EIA of the development projects are approved, there is no guideline to grant approval based on a project’s local impact and its cumulative impacts on the region and on the nation. Besides, social concerns are not adequately addressed in the IEE and EIA and these require a comprehensive national guideline on resettlement and rehabilitation measures. Currently, the concerned ministry is concentrating its focus on the approval of the IEE and EIA. Little attention is paid in the monitoring of the IEE and EIA proposed protection and monitoring measures while executing the development projects. This is a matter of concern because without monitoring and auditing by the concerned ministry, the IEE and EIA remain in paper only.

4. BASIN DEVELOPMENT SCENARIOS

Development scenarios for the main likely Basin development sectors have been predicted for the next 20 years, covering: hydropower; irrigation; water supply; roads; urban; agriculture and horticulture; tourism; and industry.

4.1 HYDROPOWER DEVELOPMENT

There is immense potential for hydropower development in the Karnali Basin. The Master Plan Study for Water Resource Development of the Upper Karnali River and Mahakali River Basins (JICA, 1993) identified 32 potential hydropower projects in the Karnali Basin (Table 4.1).

Table 4.1: Potential Hydropower Projects in the Karnali River Basin

River	Project	Installed Capacity (MW)	IERR (%)	Price (US$/ kWh)	Type of Scheme	Basin Transfer
Lohore	LR1	58	9.1	5.01	R	
	BR3A	797	14.2	3	R	
	BR3B	1192	17.6	2	R	
	BR4	667	11.4	4	R	
Bheri	BR5	1,269	14.8	3	R	
Seti	SR6	966	13.1	3	R	
	KR2	412.8	14.2	3	ROR	
	KR3	217	17.6	2	ROR	Karnali to Bheri
	KR4	87.5	6.3	5	ROR	
Karnali	KR7	243	16.8	2	ROR	
	TR1	120	10.6	4	ROR	
	TR2	53	4.8	9	ROR	
	TR3	104	10.6	4	ROR	
Tila	TR4	10.5	4.5	9	ROR	
	MKR1	90	9.5	4	ROR	
	MKR2	55	6.1	7	ROR	
Mugu Karnali	MKR3	124	11.0	4	ROR	
	HKR1	178	12.4	3	ROR	
	HKR2	77	6.6	7	ROR	
	HKR3	71	5.9	7	ROR	
Humla Karnali	HKR4	111	8.0	5	ROR	
	BR1	82	13.0	3	ROR	Bheri to Babai
	BR6	49	9.2	4.68	ROR	
	BR7	29	6.1	7	ROR	
Bheri	BR8	30	4.2	9	ROR	
	SR3	75	12.3	3	ROR	
Seti	SR7	34.9	9.8	4	ROR	
	THR1	9	5.8	8	ROR	
Budi	BS1	9	3.2	12	ROR	
	Chisapani	10,800	27.0		R	
Karnali	Upper Karnali	305			ROR	
Seti	West Seti	750			R	
Total Installed Capacity (MW)		**19,075.7**				

Source: JICA, 1993.; Note: R = reservoir; ROR = run-of-river.

Considering the pace of hydropower development in Nepal in general and in the Karnali Basin in particular (Box 1), harnessing the total hydropower potential of the Basin is envisaged to take a long time. For example, the Karnali (Chisapani) Multipurpose Project was identified in the early 1960s as a Mega Multipurpose Project, but it took nearly 30 years to undertake a feasibility study for this project, and 18 years after the feasibility study was completed no commitment to complete the project exists. Other proposed hydropower projects in the Basin whose feasibility studies have been completed are also taking time to be developed. The West Seti HEP was given environmental approval in 2000, while the Upper Karnali project has been open to private sector investment since 1998.

Box 1: Tenth Plan Targets - Hydropower Sector

Nationwide, a total of 314.6 MW capacity hydropower projects are targeted for completion by 2007 (Tenth Plan Document, 2002). Of all the targeted projects only four micro-hydro projects are located in the Basin, totalling just 1.3 MW installed capacity (Gamgad 0.4 MW, Sisegand 1 MW, Golmagad 0.4 MW and Heldung 0.5 MW).

Hydroelectric projects planned to commence construction by 2007 total 1,937.9 MW installed capacity (Tenth Plan Document, 2002). Of this total, 1,050 MW installed capacity is located in the Karnali Basin (West Seti 750 MW and Upper Karnali 300 MW). These projects are planned for development as private investments, however they have been delayed by an unstable political environment and poor security.

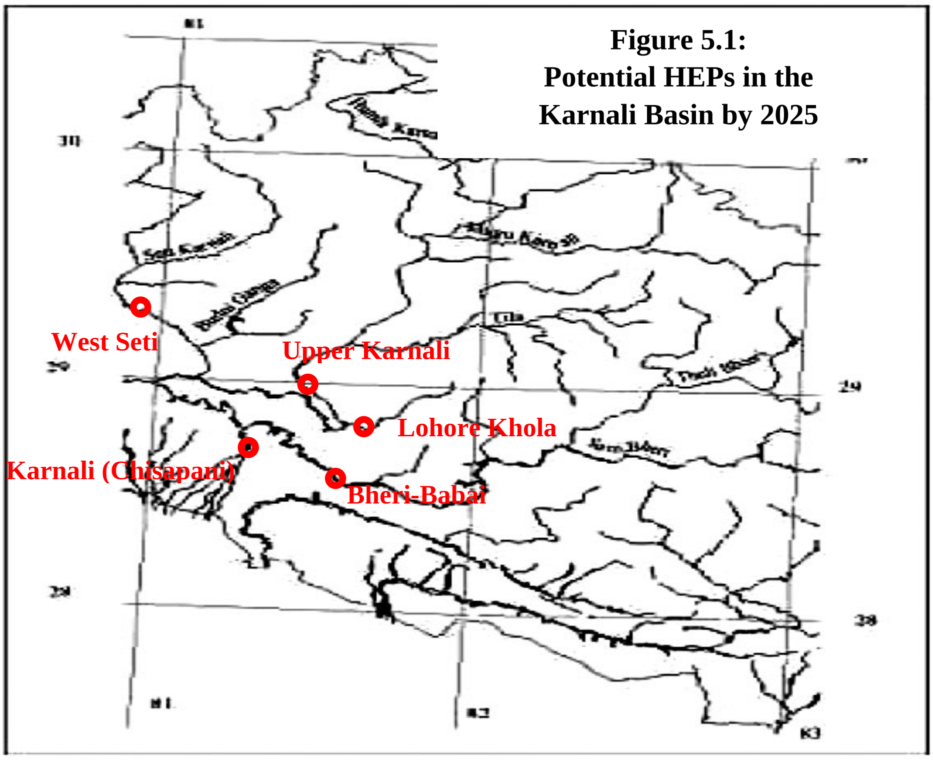
Likewise, hydropower projects planned for feasibility study completion by 2007 total 13,375.8 MW installed capacity (Tenth Plan Document – 2002). Only one of these projects, the 48 MW Bheri-Babai scheme, is planned for study in the Basin. The feasibility study for this project is yet to be initiated and it is most likely that the study will commence after 2007.

The reasons for the slow pace of hydropower development in the Karnali Basin are numerous. Financial gaps, the critical security situation and a poor infrastructure base are the key factors hindering hydropower development. With the recent improvement in security, the conditions for private sector investment in hydropower in the Basin are more conducive. In the above context, West Seti HEP and Upper Karnali HEP are likely to be developed and operational by 2015. The Bheri-Babai, Lohore Khola and Karnali (Chisapani) projects are expected to be under construction or in operation by 2025. The former two HEPs are planned for feasibility and environmental studies by the government, while the Karnali (Chisapani) Multipurpose Project requires further environmental and social studies. Other potential HEP projects of the Basin are envisaged to take longer to develop as these projects will require additional studies before decisions are made to proceed.

Based on recent water resources development planning and project progress, the likely large scale hydropower projects that will be operational in the Basin by 2025 are predicted to be: West Seti HEP (750 MW); Upper Karnali HEP (300 MW); Bheri-Babai Multipurpose Project (48 MW); and Lohore Khola HEP (58 MW) (Figure 5.1).

The Karnali (Chisapani) Multipurpose Project is a potential mega multipurpose storage project on the Karnali River at Chisapani. Project planning commenced in 1960, although the feasibility study for the project was only completed in 1989. Before this project is developed a number of significant underlying issues have to be resolved. These issues include: Nepal and India reaching a bilateral agreement on the downstream benefits of regulated river flows; the resettlement of over 60,000 people; the impact on and restoration of habitat within Bardia National Park; and, above all, the financial arrangements for project funding. Accordingly, it is predicted that the chances of this project being implemented before 2025 are very slim, although increasing international pressure on reducing greenhouse gas (GHG) emissions from the energy generation sector may assist project initiation. While the likelihood of this project being developed by 2025 is low, Nepal and India could cooperate to develop this project to meet India's growing energy demand from renewable resources, therefore the Karnali (Chisapani) Multipurpose Project is considered in this cumulative impact assessment.

Figure 5.1: Potential HEPs in the Karnali Basin by 2025



West Seti HEP

The proposed West Seti HEP is located on the Seti River in the Far-Western Development Region of Nepal. The West Seti HEP catchment covers the upper 4,022 km² of the Seti River Basin.

The West Seti HEP is a large storage project with a rated capacity of 750 MW, planned for operation by 2012. The power station is located approximately 63 km upstream of the Seti River confluence with the Karnali River, with the dam site located a further 19.2 km upstream. All project sites, excluding the reservoir area and transmission line corridor, are located in either Doti and/or Dadeldhura Districts. The reservoir area is located in Doti, Dadeldhura, Baitadi and Bajhang Districts. The transmission line corridor is located in Doti, Dadeldhura, Kailali and Kanchanpur Districts.

Main Features of West Seti HEP

- A 195 m high concrete-faced, rockfill storage dam on the Seti River: the reservoir FSL at 1,284 m and the MOL at 1,225 m, resulting drawdown of 59 m.
- A base environmental flow of 4 m^3/s.
- A 200 m wide, concrete-lined, ungated chute spillway for design PMF of 11,000 m^3/s.
- The dead storage of 640 million m^3 up to MOL and 926 million m^3 of live storage totalling 1,566 m^3. Adequate dead storage volume exists for at least 50 years of project operation at full generation.
- A reservoir with a total surface area of 2,060 ha at FSL. A further 103 ha of land will be reserved along the foreshore for a flood and erosion zone (FSL to FSL+6 m).
- At FSL the reservoir will inundate 25.1 km of the Seti River up to Pathudabagar and a total of 28 km along the five reservoir tributaries. At MOL the reservoir will inundate 20.4 km of the Seti River. The reservoir will have a total foreshore length of 118 km at FSL.
- A 10 m diameter, 6.7 km long headrace tunnel.
- A power station, situated 300 m underground, 19.2 km downstream of the dam, housing five 150 MW rated turbine generator units, transformers and a switching station.
- A 620 m long tailrace tunnel to discharge the flow from the power station back into the Seti River.
- An 18 m high ungated reregulation weir of 5 million m^3 capacity, located 6 km downstream of the tailrace outlet. Capable of passing a 1 in 1,000 year flood.
- A 132.5 km long 400 kV double circuit transmission line to convey energy to the Nepal-India border near Mahendranagar (Kanchanpur District).
- Permanent access roads totalling 20.3 km.

Upper Karnali HEP

The proposed Upper Karnali HEP is located on the main course of the Karnali River and has a catchment area of 20,120 km^2. This project is one of Nepal's most economically attractive run-of-river diversion schemes (300 MW), with daily peaking capacity and high firm energy. The diversion site is located on the border of the FWDR and MWDR. Project facilities will be located in three districts: Surkhet, Dailekh and Achham.

Project hydrology is based on data from station 240 at Asaraghat. The river is snow fed and the mean annual estimated flow at the headworks is 500 m^3/s.

Main Features of Upper Karnali HEP

- A 7 km long reservoir covering a total area of 1.4 km^2.
- A spillway with a discharge capacity of 8,100 m^3/s (corresponding to the 1-in-10,000 year flood)
- Total length of dam 120 m.
- Maximum height of the dam 30 m above the foundation level.
- A desanding Basin, 100 m wide and 300 m long (including the intake works), capable of removing particles to a minimum size of 0.20 mm.
- A 9.5 m diameter diversion tunnel, 400 m long.
- A 9.5 m diameter low pressure headrace tunnel, 2.4 km long.
- An underground powerhouse comprising 5 x 60 MW generating units operating at a net head of 141 m.
- 100 km of double circuit, 220 kV transmission line from the powerhouse to Nepalgunj with 70 m right-of-way
- 55 km of 33 kV transmission line with a 6 m right-of-way for construction power.
- A 20-22 km access road connecting the powerhouse and headwork sites.
- 184 ha of land for the project facilities and 730 ha for transmission line corridors.
- 23 households to be relocated from the power house and daily pondage reservoir side slopes; another 7 households will lose some property and sheds.
- An environmental report recommends a fish passage structure at the dam.

Bheri-Babai Multipurpose Project

The Bheri-Babai Multipurpose Project is an inter-Basin water transfer project prioritised for the development of irrigation in Bardia District (JICA, 1993). The project is yet to undergo a feasibility study.

Main Features of Bheri-Babai HEP (BR-1)	
River	: Bheri (diversion to Babai)
Installed Capacity	: 82.9 MW
Type	: Run-of-river
Intake Dam Height	: 35 m
Catchment Area	: 11,815 km^2
Waterway Length	: 9.35 km

Source: JICA, 1993.

The intake of the Bheri-Babai (BR-1) diversion scheme lies on the Bheri River 45 km upstream of the confluence with the Karnali River. The tailrace outlet is located in the Babai River 20 km upstream of the existing Babai irrigation project diversion weir. The Bheri-Babai project aims to generate electricity and supply additional water to the Babai Irrigation Scheme in the Terai by diverting 40 m^3/s of water from the Bheri River into the Babai River.

Lohore Khola HEP (LR-1)

The Lohore Khola HEP is a proposed reservoir storage project situated on the Lohore Khola, a tributary of the Karnali River in Dailekh District. The project is located a few kilometres downstream from the confluence with Chham River and upstream of Dungeshowr. The project was prioritised for development for regional power balance (JICA, 1993), but it is yet to undergo a feasibility study.

Main Features of Lohore Khola HEP	
River:	Lohore
Installed Capacity:	81 MW
Type:	Reservoir
Dam Height:	120 m
Inundation Area:	1,100 ha
Catchment Area:	733 km^2

Source: JICA, 1993.

The catchment area of the Lohore River at the reservoir site is 733 km^2. Based on the isohyetal map of the Karnali River Basin, average annual rainfall for the Basin is estimated to be 1,539 mm. As there is no stream gauge on the Lohore River, its flow was estimated using data from Station 240 (1963-2000) located on the Karnali River at Asaraghat with a catchment area of 19,260 km^2. Based on the ratio of catchment area and the average annual rainfall, the estimated runoff at the Lohore Khola HEP site is estimated in Table 5.7. The sediment flow into the river is estimated to be 2.4 million tonnes per year. As the economic internal rate of return (EIRR) for the project is highest for the draft rate of 0.7, the flow for power generation was estimated for this draft rate. The riparian flow was assumed to be 10% of the monthly minimum flow (i.e.

0.53 m^3/s). From this analysis, it was calculated that reservoir live storage should be 204 million m^3.

Karnali (Chisapani) Multipurpose Project

The Karnali (Chisapani) Multipurpose Project site is located in the Karnali Gorge, immediately upstream of the Terai. The project has a catchment area of 43,679 km^2, covering nearly 30% of Nepal. The long-term average river flow is 1,389 m^3/s, with an average dry season flow (November–May) of 451 m^3/s and an average wet season flow (June-October) of 2,690 m^3/s.

Main Features of Karnali (Chisapani) Multipurpose Project

Reservoir and Hydropower Component
- Dam height: 270 m
- Dam crest length: 745 m
- Reservoir surface area: 350 km^2 and extending as much as 100 km upstream (near the Seti–Karnali confluence)
- Reservoir volume: 28.2 x 109 m^3 at FSL (415 m asl) and 12.0 x 109 m^3 at MOL (355 m asl)
- A live storage capacity of 16.2 x 109 m^3, equivalent to 37% of annual runoff
- Drawdown range: 60 m
- Number of intakes: 6
- Number of tunnels: 6
- Number of penstocks: 18
- Number of vertical shaft, Francis turbines (620 MW): 18
- Design net head: 185 m
- Maximum power discharge at MOL: 7,110 m^3/s with 18 units running
- Maximum Power discharge at FSL: 4,900 m^3/s with 15 units running
- Firm capacity: 9,000 MW
- Installed capacity: 10,800 MW

Re-regulating weir component
- Length of the weir: 6 km
- Maximum dam height: 24 m
- A regulating reservoir with a surface area of about 15 km^2, located at the head of the alluvial fan at the mouth of Karnali River
- Live storage: 100 x 106 m^3
- Drawdown: 7 m
- Power plant – 6 x 14 MW bulb turbines at 13.5 m head

Transmission Line
- A transmission line corridor extending about 80 km south and west to the Indian boarder (5 circuits of 765 kV, 1 circuit of 220 kV)

Irrigation Component
- A potential large-scale irrigation development in the Nepal Terai (gross command area 238,700 ha and net command area 19,100 ha) and India (3,200,000 ha)

Others
- Access improvements for road and rail
- Resettlement of some 60,000 people (1989 estimate) displaced by the project (primarily from the reservoir area). Resettlement area totalling 12,650 ha required.

Source: HPC, 1989.

4.2 IRRIGATION DEVELOPMENT

A study conducted for the Karnali (Chisapani) Multipurpose Project (Himalayan Power Consultants, 1989) estimated the total irrigable land from the Karnali River in the Terai to be 191,000 ha (excluding land to be occupied by irrigation infrastructure). Similarly, in the Hill and Mountain zones (north of Chisapani) the potential area for irrigation development was estimated to be 82,000 ha, requiring about 100 m^3/s diversion (7.4% of the average annual Karnali River flow), of which 50% was considered to be net consumption.

A subsequent JICA study (1993) identified a total cultivated area of 655,000 ha in the MWDR and FWDR, of which 594,000 ha is irrigable. Of the irrigable cultivation land in the Basin and its influence area, 149,512 ha has been under some type of irrigation, with the remaining 344,566 ha forming potential irrigable land. After the Terai, most irrigable land is located in river valleys and on small patches of mountain slopes.

Six potential large-scale irrigation projects were identified, four run-of-river schemes, including Sikta, Babai, Khutia II and Mahakali II, and two multipurpose schemes, including Karnali (Chisapani) and Bheri-Babai (Table 4.2). Additionally, 74 potential small schemes were identified, including 11 in the Terai, 34 in the Hills and 33 in the Mountains. Twelve valley cultivation areas were identified with high irrigation potential, including six schemes on the Bheri River system, four schemes on the Karnali River system and two schemes on the Seti River system (Table 4.3).

Table 4.2: Potential Large-Scale Irrigation Projects in the Karnali Basin

Name	District	Existing (ha)		New Scheme (ha)	Total (ha)
		DOI	FMIS		
Run-of-River Projects					
Sikta	Banke	1,250	2,890	31,930	36,070
Babai	Bardiya		5,308	8,192	13,500
Khutiya II	Kailai		1,000	2,500	3,500
Mahakali II	Kanchanpur		703	6,099	6,802
Multipurpose Projects					
Karnali	Banke	1,250	2,430	32,471	36,151
	Bardiya	960	23,527	39,682	64,169
	Kailali	3,633	28,653	58,344	90,630
	Total	5,843	54,610	130,497	190,950
Bheri-Babai	Bardiya	960	11,312	27,728	40,000
Total		**13,896**	**130,433**	**337,443**	**481,772**

Note: DOI - irrigation system managed by the Department of Irrigation; FMIS – farmer-managed irrigation system.
Source: JICA, 1993.

Table 4.3: Potential Small-Scale Irrigation Projects in the Karnali Basin

District	Number of Projects	Net Command Area (ha)		
		Overall Schemes	Existing Schemes	New Scheme
Mid-Western Development Region				
Dangdeukhuri	8	3,125	480	2,645
Bardiya	1	290		290
Total Terai	***9***	***3,415***	***480***	***2,935***
Salyan	1	70		70
Rukum	5	425		425
Surkhet	4	943	200	743
Jajarkot	4	109	67	42
Dailekh	1	477		477
Total Hill	***15***	***2,024***	***267***	***1,757***
Dolpa	2	110		110
Jumla	2	250		250
Kalikot	2	315		315
Mugu	2	201		201
Humla	2	90		90
Total Mountain	***10***	***966***		***966***
Total For MWDR	**34**	**6,405**	**747**	**5,658**
Far-Western Development Region				
Kailali	1	649	0	649
Kanchanpur	1	1,800	0	1800
Total Terai	***2***	***2,449***	***0***	***2,449***
Achham	1	142	0	142
Doti	9	1,102	313	789
Dadeldhura	4	305	0	305
Baitadi	5	227	0	227
Total Hill	***19***	***1,776***	***455***	***1,321***
Bajura	3	295	45	250
Bajhang	16	1381	965	416
Total Mountain	***19***	***1,676***	***1,010***	***666***
Total FWDR	**40**	**5,901**	**1,465**	**4,436**
Total	**74**	**12,306**	**2,212**	**10,094**

Source: Master Plan Study for Water Resources Development in Karnali and Mahakali River Basin, JICA 1993, Volume 1.

According to TAHAL (2002), cultivated areas cover 5% of the Karanli Basin, with irrigated cultivation comprising about 25% of the total cultivated area. A total of 59,305 ha of cultivated land is under irrigation, with 44% under year-round irrigation and 56% under monsoon-season irrigation supplied by about 2,321 irrigation schemes. TAHAL (2002) estimated that the average yearly irrigation demand in the Karnali Basin is 64 m^3/s (about 5% of the average annual Karnali River flow (Table 4.4).

Table 4.4: Total Water Diversion for Irrigation

Month	Existing Demand (m^3/s)	Water Diversion	
		(m^3/s)	(MCM)
January	27	29.72	79.60
February	35	41.66	100.78
March	32	26.23	70.25
April	20	24.28	62.93
May	21	121.25	324.76
June	74	283.23	734.13
July	111	111.63	298.99
August	89	71.33	191.05
September	96	106.28	275.48
October	208	92.63	248.10
November	25	51.27	132.89
December	26	35.35	94.68
Average	**64**	**83**	**217.80**
% of Total Karnali River Flow	**5%**	**6.48%**	**6.48%**

Source: TAHAL, 2002.

Only a small portion of the average annual Karnali River flow is diverted for irrigation in Nepal at present, therefore substantial water is available for additional irrigation. The pace of irrigation development, like hydropower development, is slow in the Karnali Basin and its influence area. The priority irrigation projects planned in the Tenth Five Year Plan (2002) in the Basin and its influence area include Sikta, Babai and Mahakali II and III, while other irrigation sector developments are limited to the improvement of existing irrigation systems. The big projects, Sikta, Babai and Mahakali, do not influence the Karnali River flow in Nepal.

Considering the limited budget allocated to priority irrigation projects in the Basin, it is unlikely that irrigation diversion within the Basin will increase substantially in the foreseeable future. Multipurpose projects, such as the Bheri-Babai and Karnali (Chisapani) projects are the most likely irrigation sector projects to be initiated by 2025-2030. To develop a full-scale command area in the Terai from these projects however, will take years once the hydropower components are completed. The irrigation demand however, estimated for the Karnali Basin within Nepal for 2025 and 2030 will be about 11-14% of the average annual Karnali River flow (Table 4.5) if the Bheri-Babai and Karnali (Chisapani) projects are implemented.

Table 4.5: Existing and Estimated Irrigation Demand in Nepal

Month	Irrigation Demand (m^3/s)		
	Existing*	**Proposed 2025****	**Proposed 2030****
January	27	77	62
February	35	98	72
March	32	90	258
April	20	56	322
May	21	60	271
June	74	207	146
July	111	310	304
August	89	191	179
September	96	268	258
October	208	302	288
November	25	69	34
December	26	73	51
Average	**64**	**150**	**187**
% of Karnali River Flow at Chisapani	**5**	**11**	**14**

*Source: * TAHAL, 2002-3; ** estimated.*

4.3 WATER SUPPLY DEVELOPMENT

In 2001, 79% of the MWDR and 81% of FWDR had some form of improved water supply at a community level (Tenth Five Year Plan, 2002). However, the level of water supply (drinking and livestock) was not up to standard both in terms of quality and quantity. As there is limited data on the quantity of water used for water supply, it is estimated that about 50% of the demand for improved water supply is currently being met.

The estimated water supply requirement for the Karnali Basin and its influence districts, based on TAHAL (2003) (personal needs of 45 litres of water per day and livestock needs of 0.88% of personal need per day) is 0.34%, 0.38% and 0.51% of the average annual Karnali flow for 2006, 2013 and 2026 respectively (Table 4.6).

Table 4.6: Total Domestic Water Requirement in the Karnali Basin

Purpose	Water Requirement (m^3/s)				
	2006	**2011**	**2016**	**2021**	**2026**
Drinking	2.46	2.72	2.99	3.27	3.61
Livestock	2.16	2.40	2.63	2.88	3.18
Total Domestic	**4.62**	**5.12**	**5.62**	**6.15**	**6.79**
% of Karnali River Flow at Chisapani	**0.34%**	**0.38%**	**0.42%**	**0.46%**	**0.51%**

4.4 ROAD DEVELOPMENT

The Tenth Five Year Plan (2002) proposed to develop the following category I, II and III roads in Karnali Basin districts (Table 4.7). Many of these roads have been under construction for several years Due to security issues, with very slow progress being achieved.

Table 4.7: Proposed Roads in Karnali Basin Districts

SN	Road Name	Category
1	**Karnali Highway (Surkhet/Jumla Sector)**	**I**
2	**Chincu – Jajarkot (Surkhet/Jajarkot)**	**I**
3	**Jaya Prithibi Sing Raod – (Bajhang)**	**I**
4	**Safebagar – Martadi (Achham/ Bajura)**	**I**
5	**Safebagar Mangalsen (Achham)**	**I**
6	**Devsthal Kainkada Chaurjahari – Duani (Jajarkot/ Rukkum/ Dolpa)**	**I**
7	**Karnali Highway (Manma – Kalikot) (Kalikot)**	**I**
8	**Karnali Highway – Jumla – Gamgadi (Mugu)**	**I**
9	**Surkhet – Ranimatta – Dailekh (Surkhet Dailekh)**	**I**
10	**Karnali – Binayak – Mangalsen (Dailekh, Achham)**	**II**
11	**Mahendra Nagar – Daiji – Jogbudha (Kanchanpur – Dadeldura)**	**II**
12	**Tallo Dhungeshwor – Satkhamba Dullu – Pipalkot Dailekh (Dailekh)**	**III**

13	Gumi – Patihalna (Surkhet)	III

Source: Tenth Five Year Plan, 2002.

One of the policy strategies of the Tenth Five Year Plan is to connect all district headquarters with roads. It is therefore assumed that unconnected district headquarters in the Basin (in Jumla, Dolpa, Humla, Mugu, Jajarkot and Rukkum districts) will be completed by 2012. In addition, in areas where there is a district level road or a feeder road, connecting village level earth roads are being constructed from Village Development Committee funds under people's participation programs. Similarly, the Rural Access Program (RAP) is actively engaged in the construction of district level connecting roads in the Basin districts in the Hill zone.

The GoN is preparing its Second Ten Year Sector Wide Road Program and Priority Investment Plan (SWRP & PIP) for the Department of Roads (DoR) as part of the World Bank funded Road Maintenance and Development Project (RMDP). Of the total road length of 727 km, 100 km of new road and 627 km of road upgrading.

Among the 14 PIP road sectors under study, nine of the study roads are situated in the FWDR and five in the MWDR. These roads cross 13 districts in the Basin out of the 24 districts of FWDR and MWDR (Table 4.8).

Table 4.8: Road Districts and Potentially Affected VDCs by the RMDP Roads

Road	Length (km)	Number of VDCs/ Mun./Districts Crossed		VDC/Municipality
		VDC/Mun	District	
A. New Roads				
MWDR 1. Nagma –Gamgadhi	100.0	15	3	Phoi Mahadev VDC of Kalikot district ; GhodeMahadev, MahabiPattharkhola , Kalikakhetu, Badki, Narkot, , Dhapa, Pandawagufa, Birat, Kanasundari, MalikaBota and Buvramadichaur VDC of Jumla district and Pina, Karkibada, Shreenagar VDC of Mugu district.
B. Upgrading Roads				
FWDR 2. Satbanjh – Jhulaghat	36.75	4	1	Dasrathchand municipality, Dehimandu, Gurukhola and, Basuling, VDC of Baitadi district.
3.Satbanjh – Gokuleshwar	54.08	6	1	Basulinga, Gurukhola, Sri-kot, Sri-kedar, Nwali, and Dakshintad VDC of Baitadi district
4. Khodpe - Jhota	78.0	11	2	Siddeshwor, Sikharpur, Sankarpur, Chaukham Bhumiraj of Baitadi district and Syadi, Deulekh, Sunkuda, Banjh, Rayel, Bhairabnath VDC of Bajhang district
5. Sanfe – Ekdighat	15.0	3	1	Siddheswor, Dudharukot, Babala VDC of Achham district
6. Martadi – Kolti	51.0	4	1	Martadi, Pandusen, Kotila, and Kolti VDC of Bajura district.
7. Sanfe – Mangalsen	37.87	10	1	Mastamandau, Ridikot, Bhagyaswori, Gajara, Baradadevi, Timilsain, Mangalsen, Oligaun, Janalikot and Chandika VDC of Achham district.
8. Mangalsen – Belkhet	50.0	7	1	Janali Bandali, Bannatoli, Birpath, Kuika, Binayak, Kalikasthan, Bayala VDc of Achham district.
MWDR 9. Lower Dhungeshwar – Dailekh	28.0	4	1	Khadkawada, , Dada Parajul and Belpata VDC and , Narayan Municipality of Dailekha district
10. Chhinchu – Pokhare	25.75	5	1	Chhinchu, Ramghat, Maintada, Mehelkuna, Sahare VDC of Surkhet district.
11.Tulsipur-Purandhara-Botechaur	78.0	11	3	Tulsipur Municipality and Pawan Nagar, Hekuli, Dhanauri, Shreegaun, Panchkule and Purandhara VDC of Dang district Rampur and Kalimati Kalche VDC of Salyan district and Malarani, and Sahare VDC of Surkhet District.
12.Tulsipur – Salyan	64.4	5	2	Tulsipur Municipality of Dang district and Dhanwang,, Tribeni, Chhayachhetra and Khalanga VDC of Salyan district
C. Additional Road				
14.Sitapati-Musikot	68.0	12	2	Khalanga, Kajeri, Siddeshor, Bajhkanda, Tharmare, Shivarath, and Dhakadam VDC of Salyan district and Muru, Khara , Bhalakacha , Chhiwang and Musikot of Rukkum district.
Total	**726.85**	**103**	**21**	

Source: Resettlement Action Plan, Sector-Wide Road Project and Priority Investment Plan (SWRP & PIP), SILT/TAEC etc Dec 2006.

In the above context, the improvement of existing roads and construction of new roads in the Basin is expected to accelerate in the coming years, however it is difficult to predict the spatial and temporal development of new roads.

4.5 URBAN DEVELOPMENT

The Government of Nepal has not prepared plans for guided urban development in the Basin. Despite this, there has been gradual growth in the urban population in the Basin districts over the past decade. Urban growth is higher in the Terai than in the Hill and Mountain zones.

With improvements to existing roads and the construction of new roads, urban centres at district headquarters and major road junctions are expected to grow substantially. The main district headquarters with growth potential are Dipayal, Surkhet, Dailekh, Mangalsen, Martadi, Chaipur, Kalikot, Musikot and Jumla. The market centres with the highest development potential in the Basin are Sanfebagar, Chinchu and Dhungeshwor.

4.6 AGRICULTURE AND HORTICULTURE DEVELOPMENT

The Terai ecological zone has potential for diversified cereal, vegetable, pulse and oil seed production, while the Hills and Mountains have potential for vegetable, other horticulture and herbal medicine development. The lack of year-round irrigation in the Terai and poor road infrastructure in the Hills and Mountains have restricted agricultural and horticultural development in the Basin. With the development of the Bheri-Babai and Karnali (Chisapani) projects, Terai agricultural production will increase. Himalayan Power Consultants (1989) estimated a growth in cropping intensity of up to 240% in the Terai ecological belt once associated irrigation facilities are fully developed.

The Agriculture Perspective Plan (1995) identified the Hills and Mountains as ecological belts for potential horticultural development. The topographic and climatic diversity and variability in solar radiation due to aspect makes these ecological belts suitable for diversified horticultural development. The use of traditional knowledge and recent developments in horticultural science are expected to improve horticulture in these zones. However, for such a change to occur the development of road networks deep into the hinterland is a pre-requisite for the marketing of horticultural products. This is likely to require at least another 20 years based on the current rate of road development by the government and local communities.

4.7 TOURISM DEVELOPMENT

A lack of adequate infrastructure has hindered tourism development in the Basin districts. Despite containing four National Parks, one Wildlife Reserve, one Hunting Reserve and three Buffer Zones, the Basin is visited by only a fraction of the tourists that visit Nepal. With improvements in transportation and communications, the Basin is expected to be visited by a growing numbers of tourists. White-water rafting on the Karnali River is gradually expanding, and although it is currently limited to the Dhungeshwor to Chisapani stretch of the river, it is expected to expand deep into the hinterland in the future. Rara and Phoksumdo lakes are expected to be explored by a growing number of tourists. Similarly, the ecologically and florally rich areas of Bajhang, Achham, Kalikot, Jumla, Humla, Mugu and Dolpa are likely to attract a greater number of tourists.

4.8 INDUSTRIAL DEVELOPMENT

Nepal is the least industrially developed nation in South Asia, and the MWDR and FWDR are the least industrially developed regions of Nepal. There are only limited manufacturing industries based on agriculture and forestry in the Basin, and these are confined to the urban centres of the Terai. The Hill and Mountain zones are devoid of almost all industry. Most of the industries in these ecological belts are cottage enterprises employing only a few people. A poor infrastructure base and limited power supply are the prime reasons for the lack of industrial development. The ten year long Maoist insurgency deteriorated the slowly growing industrial base of the Basin.

Given the right conditions for industrial development (power supply, road networks and communication links), the Karnali Basin has a bright future for industry based on agriculture, horticulture and non-timber forest products (NTFP). However, the pace of industrial development will only surge after the development of basic infrastructure (i.e. after 20 years).

5. CUMULATIVE IMPACTS OF BASIN DEVELOPMENT

Development in Nepal is gradually more restricted from the south to the north (i.e. from the Terai to the Hill and Mountain hinterland) due to topographic constraints. The Terai, the most favourable area for the development of industry, is the gateway to development in the Hills and Mountains. Without development in the Terai, the least topographically constrained area, development is unlikely to occur in the Hills and Mountains, hence any development in the Basin first impacts the Terai. As development activity increases, the cumulative impact of development is expected to be higher in the Terai, followed by Hills and Mountains.

Although the proposed hydropower projects lie in the Hills and Mountains and will impact these geographical areas, they will also impact the Terai. The Terai is the only potential area for large scale resettlement onto agricultural land, and is also the location for part of the transmission lines that will be used to export power from the projects.

The cumulative impact of development predicted to occur in the Basin up to 2025 is described for the main impact issues of:

- river hydrology;
- aquatic ecology;
- land use and forest cover;
- terrestrial biodiversity;
- road transport and navigation;
- social and economic impacts;
- health; and
- induced basin development.

The impact of hydropower and multipurpose water resource developments on these features is emphasised given that these are the most likely types of large scale developments to occur in the Basin by 2025.

5.1 RIVER HYDROLOGY

The main likely developments in the Basin that will affect river hydrology are hydropower and irrigation projects, as described in Sections 4.1 and 4.2, while a slight increase in water supply for domestic and stock needs will have a marginal impact on river flows (Section 4.3).

5.1.1 Hydropower Projects

A change in river hydrology will occur in the Basin from the cumulative impact of the four likely hydropower developments. The change in hydrology from each of the likely hydropower projects is described below, as well as the cumulative impact of these projects on hydrology, and the impact of the Karnali (Chisapani) Multipurpose Project if this scheme is developed.

West Seti HEP

The West Seti HEP will create a lake environment that will have a significant effect on river hydrology. The project will generate energy throughout the year, storing flows during the wet season and utilising this additional water to generate energy at peak daily demand times during the dry season (Table 5.1).

Table 5.1: Average Power Station Releases and River Flows

Month	Power Station Average Daily Operation (hours)	Power Station Peak Release (m^3/s)	Base Environmental Release and Flood Flow (m^3/s)	Combined Release (m^3/s)
January	7.45	332	4	336
February	7.94	325	4	329
March	8.39	317	4	321
April	7.60	310	4	314
May	9.00	308	4	312
June	15.81	310	4	314
July	20.33	321	25	346
August	23.46	337	190	537
September	23.20	343	78	421
October	11.59	343	10	353
November	7.36	342	4	346
December	8.91	338	4	342

Source: West Seti HEP EIA, 2000.

Proposed average daily releases through the power station, combined with the base environmental release, assumed intermediate catchment flow and mean flood flow taken as a monthly mean, are given for each month of the year and compared with existing Seti River flows in Table 5.2.

Table 5.2: Existing and Proposed Seti River Flows

Month	Mean Existing Flow (m^3/s)	Project Flow (m^3/s)					Net Change	
		Daily Power Station Release	Base Environ. Flow	Mean Intermediate Catchment Flow	Mean Flood Flow	Combined Flow	m^3/s	%
January	50	103.1	4.0	1.2	0	108	58	117
February	43	107.5	4.0	0.9	0	112	69	161
March	48	110.8	4.0	1.1	0	116	68	141
April	69	96.2	4.0	0.7	0	101	32	46
May	130	115.5	4.0	0.6	0	120	-10	-8
June	216	204.2	4.0	2.5	0	211	-5	-2
July	523	271.9	4.0	8.1	21	293	-230	-44
August	654	329.4	4.0	11.8	186	531	-123	-19
September	429	331.6	4.0	5.8	74	415	-14	-3
October	186	165.6	4.0	2.5	6	178	-8	-4
November	89	104.9	4.0	1.7	0	111	22	24
December	62	125.5	4.0	1.6	0	131	69	112

Source: West Seti HEP EIA, 2000.

The net change in downstream river flows that will be created by the West Seti HEP is summarized for flows between 1963-2000 (DHM, 2000) for Banga (station 260 located on the Seti River several kilometres upstream of the Seti-Karnali confluence) and Chisapani (station 280 located on the Karnali River immediately upstream of the Terai) in Table 5.3.

Table 5.3: Mean Karnali Basin Flows at Chisapani Before and After West Seti HEP River Regulation

Month	Banga (7,590 km^2)			Chisapani (43,700 km^2)		
	Existing Flow (m^3/s)	West Seti HEP Altered Flow (m^3/s)	Change (%)	Existing Flow (m^3/s)	West Seti HEP Altered Flow (m^3/s)	Change (%)
January	78	136	74.4	369	427	15.7
February	73	142	94.5	331	400	20.8
March	78	146	87.2	343	411	19.8
April	94	126	34.0	445	477	7.2
May	136	126	-7.4	732	722	-1.4
June	292	287	-1.7	1,454	1,449	-0.3
July	762	532	-30.2	3,112	2,882	-7.4
August	1,005	882	-12.2	4,139	4,016	-3.0
September	677	663	-2.1	2,868	2,854	-0.5
October	259	251	-3.1	1,246	1,238	-0.6
November	128	150	17.2	631	653	3.5
December	93	162	74.2	451	520	15.3

Source: West Seti HEP EIA, 2000.

The changes to river flows in Nepal that will be created by West Seti HEP flow regulation will be:

- Daily power station discharges will substantially change natural daily flows between the tailrace outlet and the re-regulation weir in all months of the year except August and September when releases will occur for almost 24 hours a day and flood flows are likely.
- Flows downstream of the re-regulation weir will be attenuated by the weir, but will still vary in rate across the day. This change will be greatest from November to May when power station discharges are lowest. Downstream flows will vary by as much as 193 m^3/s, due to re-regulation weir discharges of between 50-243 m^3/s each day.
- Power station discharges will generally be warmer than existing Seti River flows from December to February (up to 4-5^oC warmer in January), a similar temperature in March, October and November, and cooler from April to September (up to 4^oC cooler in August and September).
- The project regulation of river flows will moderate the existing flow regime over the year at the downstream Banga and Chisapani stations, reducing high flows during the wet season and increasing minimum flows during the dry season. As might be expected, this effect will be more marked at Banga station compared with Chisapani station on the Karnali River.

- River flows downstream of the tailrace outlet will decrease from May-October and increase from November-April. The greatest flow change will occur in the driest months of December to March, when flows will increase in the order of 112-161%. Corresponding mean Karnali River flows (at Chisapani) will increase by 0-21% from November to April and decrease by 0-7% from May to October.
- Mean river flow levels will be slightly increased in the dry season (by up to 0.4 m at Banga) and decreased in the wet season (by up to 1.1 m at Banga). The daily fluctuations in Seti River flow rates and depths will cause marginal daily fluctuations in flows and depths on the Karnali River at Chisapani.
- Dry season flows in the Karnali River may be extended when monsoon rains are delayed, reducing the volume of water available for irrigation during this process.

The modelled change in Karnali River flow due to the West Seti HEP downstream of Katerniaghat in India (Table 5.4) is similar to the change in flow within Nepalese territory.

Table 5.4: Modelled Change in Karnali River Flow at Katerniaghat

Month	Driest Year – 1966			80% Exceedence Year - 1977			Wettest Year – 1973		
	Flow (m^3/s)	With West Seti HEP Regulation (m^3/s)	Change (%)	Flow (m^3/s)	With West Seti HEP Regulation (m^3/s)	Change (%)	Flow (m^3/s)	With West Seti HEP Regulation (m^3/s)	Change (%)
January	296	352	19	312	356	14	423	468	11
February	290	367	27	280	356	27	377	452	20
March	273	338	24	286	347	21	449	510	14
April	266	268	1	298	294	-1	531	527	-1
May	522	531	2	493	498	1	968	973	1
June	813	724	-11	286	201	-30	3,129	3,043	-3
July	1,825	1,510	-17	3,991	3,583	-10	4,103	3,695	-10
August	3,486	2,905	-17	4,521	4,370	-3	6,417	6,266	-2
September	2,437	2,435	0	2,815	2,764	-2	5,821	5,769	-1
October	794	755	-5	1,060	966	-9	4,079	3,985	-2
November	488	501	3	602	580	-4	1,211	1,188	-2
December	987	1,019	3	1,342	1,391	4	2,360	2,409	2

Source: West Seti HEP EIA, 2000.
Note: - 1966 is the driest year on available record;
- 1977 is the 80% exceedence year for dry season flows (January-March) on available record;
- 1973 is the wettest year on available record.

The predicted environmental implications downstream of Katerniaghat are:

- The West Seti HEP regulation of river flows will moderate the existing flow regime over the year, reducing high flows during the wet season and increasing minimum flows during the dry season.
- The effect of West Seti HEP river regulation will not disrupt the supply of irrigation water to the Sarda Sahayak and Saryu Nahar Irrigation Schemes, except potentially in an extended dry season when the monsoon is delayed. The regulation of the Seti River will increase dry season flows in the Karnali River at Girijapur Barrage (20 km south of the Nepal-India

border) by up to more than 25% in a dry year, providing increased firm minimum flows. In these years, the storage of water by the West Seti HEP may reduce the June flow in the Karnali River by as much as 30% in an exceptional year, as indicated in Table 8.10 for the 80% exceedence year 1977.

Upper Karnali HEP

The diversion of the Karnali River by the Upper Karnali HEP will substantially reduce river flows along a 45 km stretch of the Karnali River between the diversion dam and tailrace outlet. Flows along this section of the river in the dry season will be limited to the environmental flow for the first 20 km, up to the confluence of the Lohore Khola. The Lohore Khola will increase the Karnali River flow by an average of 26 m^3/s, although only 6 m^3/s will discharge from this tributary into the Karnali River in the driest few months of the year.

Daily river flow fluctuations will occur downstream of the tailrace outlet, depending upon the period of power generation, however there will be no variation in the average daily and monthly flows. The expected daily flow variations in the dry season (October to June) will be between 70-500 m^3/s.

Bheri-Babai Multipurpose Project

The Bheri-Babai Multipurpose Project has a 11,815 km^2 catchment area at the intake. Average annual rainfall for the Basin is estimated at 1,191 mm. Downstream of the Bheri-Babai intake site, gauging station 270 has a drainage area of 12,290 km^2. Based on the ratio of catchment area and average annual rainfall, river flows at the gauging station were reduced to estimate flows at the Bheri-Babai diversion site (Table 5.5).

Table 5.5: Impact of the Bheri-Babai Project on Bheri River Hydrology

Month	Avg. Flow at Jamu (St. 270) (m^3/s)	Min. Monthly Flow at Jamu (St. 270) (m^3/s)	Est. Avg. Flow at Diversion (m^3/s)	Diversion (m^3/s)	Avg. Flow Below Diversion (m^3/s)	% of the Existing Flow (Avg.)	Est. Min. Monthly Flow (m^3/s)	Min. Net Flow Below Diversion (m^3/s)	% of Existing Min. Flow
January	102	64	94	40	54	58	59	19	32
February	88	48	81	40	41	51	44	4	10
March	84	40	78	40	38	48	37	-3	-8
April	105	40	97	40	57	59	37	-3	-8
May	160	55	148	40	108	73	51	11	21
June	347	67	321	40	281	88	62	22	35
July	989	140	914	40	874	96	129	89	69
August	1,363	397	1,260	40	1,220	97	367	327	89
September	990	193	915	40	875	96	178	138	78
October	379	128	350	40	310	89	118	78	66
November	183	86	169	40	129	76	79	39	50
December	125	57	116	40	76	65	53	13	24

The average diverted flow will be approximately 10.5% of the mean river flow (379 m^3/s) at the diversion site, although there will be a considerable reduction in flow downstream of the diversion site in the dry season (i.e. less than 60% of the existing flow in January, February and March). Conversely, there will be a minor change in average river flows in the wet months of the year. Under minimum monthly flow conditions, Bheri River flows will not be adequate to supply 40 m^3/s for power generation and irrigation for several months of the year. Downstream at Chisapani, the Karnali River flow will be reduced by 8-12% from December to April, whereas from May to November the flow reduction will be marginal, ranging between 1-5% (Table 5.6).

Table 5.6: Mean Karnali River Flows at Chisapani Before and After Bheri-Babai

Month	Bheri-Babai			Chisapani (43,700 km^2)		
	Average Flow at Bheri-Babai Diversion (m^3/s)	Flow Diversion (m^3/s)	Net Flow Below Diversion (m^3/s) (avg. flow case)	Existing Flow (m^3/s)	Bheri-Babai Altered Flow (m^3/s)	Change (%)
January	**94**	**40**	**54**	**369**	**329**	**-10.8**
February	**81**	**40**	**41**	**331**	**291**	**-12.1**
March	**78**	**40**	**38**	**343**	**303**	**-11.7**
April	**97**	**40**	**57**	**445**	**405**	**-9.00**
May	**148**	**40**	**108**	**732**	**692**	**-5.5**
June	**321**	**40**	**281**	**1,454**	**1,414**	**-2.8**
July	**914**	**40**	**874**	**3,112**	**3,072**	**-1.3**
August	**1,260**	**40**	**1,220**	**4,139**	**4,099**	**-1.0**
September	**915**	**40**	**875**	**2,868**	**2,828**	**-1.4**
October	**350**	**40**	**310**	**1,246**	**1,206**	**-3.2**

Month	Bheri-Babai			Chisapani (43,700 km^2)		
	Average Flow at Bheri-Babai Diversion (m^3/s)	Flow Diversion (m^3/s)	Net Flow Below Diversion (m^3/s) (avg. flow case)	Existing Flow (m^3/s)	Bheri-Babai Altered Flow (m^3/s)	Change (%)
November	**169**	**40**	**129**	**631**	**591**	**-6.3**
December	**116**	**40**	**76**	**451**	**411**	**-8.9**

Lohore Khola HEP (LR-1)

The Lohore Khola HEP will moderate the existing river flow regime over the year, reducing high flows during the wet season and increasing minimum flows during the dry season. River flows downstream of the tailrace outlet will be decreased between May-October and increased between November-April. The greatest flow change will occur in the driest months of November to March, when flow increases in the order of 62-254% will occur. A decrease in downstream flow will occur between June and August, while there will be no change in flow in September and October. The flood volume accounts for about 28% of the total flow. Live storage is estimated to be 25% of the total flow of the river at the dam site.

Table: 5.7: Flows at Dam Site Before and After Lohore Khola

Month	Average Flow at Asaraghat, Karnali (m^3/s)	Average Monthly Inflow at Dam Site (m^3/s)	Power Generation Flow (m^3/s)	Riparn. Flow (m^3/s)	Flood Flow (m^3/s)	Modified Monthly Outflow from Dam Site (m^3/s)	% Change in Flow
January	102	6.5	18.3	0.53	0.0	18.9	191.1
February	88	5.6	18.3	0.53	0.0	18.9	237.4
March	84	5.3	18.3	0.53	0.0	18.9	253.5
April	105	6.7	18.3	0.53	0.0	18.9	182.8
May	160	10.2	18.3	0.53	0.0	18.9	85.6
June	347	22.0	18.3	0.53	0.0	18.9	-14.4
July	989	62.8	18.3	0.53	0.0	18.9	-70.0
August	1,363	86.6	18.3	0.53	38.5	57.3	-33.8
September	990	62.9	18.3	0.53	44.0	62.9	0.0
October	379	24.1	18.3	0.53	5.2	24.1	0.0
November	183	11.6	18.3	0.53	0.0	18.9	62.3
December	125	7.9	18.3	0.53	0.0	18.9	137.5

Downstream at Chisapani, the Karnali River flow will increase by 4-6% in the dry season (November to April) and between 0.6-3.0% in monsoon season (Table 5.8).

Table 5.8: Mean Karnali River Flow at Chisapani Before and After Lohore Khola

Month	Lohore Khola		Chisapani (43,700 km^2)		
	Average Monthly Inflow at Dam Site (m^3/s)	Modified Monthly Outflow from Dam Site (m^3/s)	Existing Flow (m^3/s)	Bheri-Babai Altered Flow (m^3/s)	Change (%)
January	**6.5**	**18.9**	**369**	**387.9**	**5.12**
February	**5.6**	**18.9**	**331**	**349.9**	**5.71**
March	**5.3**	**18.9**	**343**	**361.9**	**5.51**
April	**6.7**	**18.9**	**445**	**463.9**	**4.25**
May	**10.2**	**18.9**	**732**	**750.9**	**2.58**
June	**22.0**	**18.9**	**1,454**	**1,472.9**	**1.30**

July	**62.8**	**18.9**	**3,112**	**3,130.9**	**0.61**
August	**86.6**	**57.3**	**4,139**	**4,196.3**	**1.38**
September	**62.9**	**62.9**	**2,868**	**2,930.9**	**2.19**
October	**24.1**	**24.1**	**1,246**	**1270.1**	**1.93**
November	**11.6**	**18.9**	**631**	**649.9**	**3.00**
December	**7.9**	**18.9**	**451**	**469.9**	**4.19**

Karnali (Chisapani) Multipurpose Project

The development of the Karnali (Chisapani) project would markedly change river flows downstream of the tailrace outlet (Table 5.9). Dry season flows (November-May) will increase substantially, by up to 262% in February and March, whereas wet season flows (June-October) will be reduced by 22-71%.

Table 5.9: Mean Karnali Basin Flows at Chisapani Before and After Karnali (Chisapani)

Month	Existing Flow (m^3/s)	Karnali (Chisapani) Altered Flows (m^3/s)	Change (%)
January	**369**	**1,162**	**214.91**
February	**331**	**1,197**	**261.63**
March	**343**	**1,244**	**262.68**
April	**445**	**960**	**115.73**
May	**732**	**985**	**34.56**
June	**1,454**	**945**	**-35.01**
July	**3,112**	**912**	**-70.69**
August	**4,139**	**1,555**	**-62.43**
September	**2,868**	**2,260**	**-21.20**
October	**1,246**	**971**	**-22.07**
November	**631**	**827**	**31.06**
December	**451**	**1,134**	**151.44**

Source: JICA (1993), West Seti HEP EIA (2000).

Cumulative Impact of Hydropower Projects on River Flows

The cumulative impact of the proposed hydropower developments on Karnali River flows have been assessed for three different development scenarios over time:

1. the West Seti and Upper Karnali HEPs - developed by 2012;
2. the West Seti, Upper Karnali, Bheri-Babai and Lohore Khola projects - developed by 2020; and

3. the West Seti, Upper Karnali, Bheri-Babai, Lohore Khola and Karnali (Chisapani) projects - developed by 2025.

Under the first scenario, operation of the West Seti and Upper Karnali HEPs will increase Karnali River flows in the dry season and marginally decrease river flows in the wet season due to the storage and regulation of flows by the West Seti HEP. The water available for irrigation will be increased in the lower Basin in the dry season, when irrigation demand is high.

Under the second scenario, despite the transfer of 40 m^3/s of water out of the Karnali Basin in Nepal by the Bheri-Babai project, there will be a minor flow increase in the Karnali River in Nepal in the dry season (December-April) due to the additional water supplied by the West Seti and Lohore Khola HEPs. During the monsoon the Karnali River flow is expected to decline marginally (Table 5.10), but this flow reduction should not adversely impact river uses due to the large volume of water that will continue to flow.

Table 5.10: Cumulative Impact of West Seti, Lohore Khola, Bheri-Babai and Upper Karnali Projects on River Hydrology

Month	Existing Flow (m^3/s)	Flow Change due to Bheri-Babai (m^3/s)	Flow Change due to West Seti HEP (m^3/s)	Flow Change due to Lohore Khola (m^3/s)	Modified Flow (m^3/s)	Change (%)
January	369	-40	58	12.4	399	8.2
February	331	-40	69	13.3	373	12.8
March	343	-40	68	13.5	385	12.1
April	445	-40	32	12.2	449	0.9
May	732	-40	-10	8.7	691	-5.6
June	1,454	-40	-5	-3.2	1406	-3.3
July	3,112	-40	-230	-44.0	2798	-10.1
August	4,139	-40	-123	-29.3	3947	-4.6
September	2,868	-40	-14	0.0	2814	-1.9
October	1,246	-40	-8	0.0	1198	-3.9
November	631	-40	22	7.2	620	-1.7
December	451	-40	69	10.9	491	8.9

Source: JICA (1993), West Seti HEP EIA (2000).

Under the third scenario, the change in Karnali River flows created by the four upstream projects will be masked by the impact of the Karnali (Chisapani) Multipurpose Project on downstream river flows (Table 5.9). The impact on downstream water availability for human use will predominantly be positive. The upstream storage HEPs in the Basin (West Seti and Lohore Khola) will increase dry season flows entering the Karnali (Chisapani) Multipurpose Project reservoir, however there will be a decline in upstream and downstream river flows in the early wet season when the reservoirs of all three storage projects are filling.

The HEPs upstream of the Karnali (Chisapani) project, however, will reduce flows in some stretches of the Karnali and its tributaries due to water diversion for power generation. Flows along these dewatered sections of river during the dry season will primarily be restricted to environmental releases of water. These dewatered sections are a 19 km stretch of the Seti River (West Seti HEP), a 45 km stretch in Karnali River (Upper Karnali HEP), a 10 km stretch in Lohore Khola (Lohore Khola HEP) and a 55 km stretch in Bheri River (Bheri-Babai Multipurpose Project).

5.1.2 Irrigation Projects

The development of additional irrigation projects that draw water from the Karnali River or its tributaries in Nepal will reduce Karnali River flows, but this potential impact will be at least partly offset by the increase in dry season flows created by large-scale storage projects developed in the upper Basin.

Existing irrigation demand in Nepal (Terai) and existing and proposed irrigation demand in India (HPC, 1989) is presented in Table 5.11 against the 75% dependable existing river flow. The development of irrigation projects in Nepal is currently constrained by investment not water availability as only 5% of the average Karnali River flow at Chisapani is extracted for irrigation. Even in the peak demand month of October irrigation extraction is only 21% of the 75% dependable Karnali River flow at Chisapani.

The proposed irrigation demand in Nepal is moderate and development of irrigation to supply this projected demand will not substantially reduce Karnali River flows. By contrast, if all proposed irrigation projects are developed in India and no water storages are installed in the upstream Basin then irrigation demand will exceed river flows during the dry season (November to March).

Table 5.11: Irrigation Water Demand (existing and proposed) and Water Balance for 75% Dependable Karnali River Flow

Month	Karnali 75% Dependable Flow Chisapani (m^3/s)[1]	Existing Irrigation Demand Nepal (m^3/s)[2]	Existing and Proposed Irrigat. Demand in India - Sarada & Saryu[1] (m^3/s)	Water Balance (m^3/s)
January	**310**	**27**	**370**	**-87**
February	**272**	**35**	**599**	**-362**
March	**264**	**32**	**258**	**-26**
April	**378**	**20**	**226**	**132**
May	**565**	**21**	**300**	**244**
June	**1,084**	**74**	**449**	**561**
July	**2,089**	**111**	**5**	**1,973**
August	**3,896**	**89**	**0**	**3,807**
September	**2,425**	**96**	**50**	**2,279**
October	**986**	**208**	**533**	**245**
November	**552**	**25**	**573**	**-46**

Month	Karnali 75% Dependable Flow Chisapani (m³/s)[1]	Existing Irrigation Demand Nepal (m³/s)[2]	Existing and Proposed Irrigat. Demand in India - Sarada & Saryu[1] (m³/s)	Water Balance (m³/s)
December	**379**	**26**	**462**	**-109**

Source: 1 – HPC, 1989; 2 - TAHAL, 2003.

The development of the West Seti and Lohore Khola HEPs will improve water availability for irrigation in Nepal (Terai) and India, but the increase in Nepal will be partly offset by the proposed Bheri–Babai water diversion.

The development of the Karnali (Chisapani) Multipurpose Project will substantially increase the amount of water available for irrigation on the Terai in the dry season in Nepal and India (Table 5.12) due to monsoon season storage, although if this multi-purpose project is developed then any associated irrigation development is only likely to occur after 2025.

Table 5.12: Existing and Proposed Irrigation Water Demand in Nepal and India and Water Balance for 75% Dependable Flow after Karnali (Chisapani)

Month	75% Dependable Flow after Karnali Chisapani (m^3/s)[1]	Existing and Proposed Irrigation Demand in Nepal[2] + India (m^3/s)[1]	Water Balance (m^3/s)
January	**1,138**	**397**	**741**
February	**1,159**	**634**	**525**
March	**1,148**	**290**	**858**
April	**748**	**246**	**502**
May	**806**	**321**	**485**
June	**943**	**523**	**420**
July	**885**	**116**	**769**
August	**1,565**	**89**	**1,476**
September	**2,249**	**146**	**2,103**
October	**826**	**741**	**85**
November	**831**	**598**	**233**
December	**1,122**	**488**	**634**

Source: 1 - HPC, 1989; 2 - TAHAL, 2003.
Note: water flow based on seasonally varied energy generation.

The future irrigation demand in Nepal and India is estimated in Table 5.13.

Table 5.13: Future Irrigation Water Demand in Nepal and India and Water Balance with 75% Dependable Flow after Karnali (Chisapani)

Month	75% Dependable Flow After Karnali Chisapani (m³/s) [1]	Irrigation Demand Nepal 2025[2] and India[1] (m³/s)	Water Balance (m³/s)
January	**1,138**	**496**	**642**
February	**1,159**	**843**	**316**
March	**1,148**	**654**	**494**
April	**748**	**564**	**184**
May	**806**	**821**	**-15**
June	**943**	**761**	**182**
July	**885**	**364**	**521**
August	**1,565**	**233**	**1,332**
September	**2,249**	**386**	**1,863**
October	**826**	**943**	**-117**
November	**831**	**776**	**55**
December	**1,122**	**656**	**466**

Source: 1 - HPC, 1989; 2 - TAHAL, 2003. Note: water flow based on seasonally varied energy generation.

5.1.3 Water Supply

Water supply demands in the Basin within Nepal are estimated to increase from 0.34% of the average annual Karnali River flow at Chisapani in 2006 to 0.38% and 0.51% in 2011 and 2026 (Table 4.6) respectively. The diversion of this increasing volume of water will only marginally reduce Karnali River flows in the Basin given the small additional amount involved, thus no discernable impact will occur to other water uses.

5.2 AQUATIC ECOSYSTEMS

5.2.1 Potential Impacts

The development of hydropower projects (storage and run-of-river) fragments continuous riverine ecology into a number of compartments with distinct habitat features, with potential differences in flow conditions, water quantity and quality, breeding habitat (spawning and rearing) and terrestrial activities at the water-land interface.

Riverine biotic communities are relatively fragile (Naiman et al., 1986) due to the complexity of ecosystem structure and the stress experienced by species occurring at the limits of their biological tolerance. Thus, any change to a thriving aquatic ecosystem can stress existing aquatic habitats, often with fatal implications for aquatic biodiversity.

Biological activity tends to be concentrated in backwater areas or eddy counter-currents, while the mainstream flow is used as an access corridor to resources and refugia (Stalnaker et al. 1989). The attractive force of eddy currents traps primary nutrients and woody debris and gives protection to riverine organisms at all trophic levels (i.e. single cell organisms to megafauna), from the strong hydraulic force of the main flow (Smith, 1993). Regulated flows from hydropower projects break this sequence, affecting riverine organisms.

Regulated flows below the dam or tailrace outlet of hydropower projects has sufficient shear to scour fine sand and silt from the river bed, bars and banks that create counter-currents. At the same time, bedload and suspended matter mobilized during high flows are blocked behind the dam and thus prevented from replacing downstream sediments. The clear water released below the dam eliminates the hydraulic refuge and high productivity supported by counter-currents, eventually transforming the river into a biologically less productive system (Petts, 1984; Gore, 1996; Kondolf, 1997).

The quality of water released below a regulated hydropower project can be markedly altered, particularly by a high dam with a large reservoir. Variability in water temperature under natural conditions generally enhances species diversity by providing a great range of diurnal and seasonal thermal optima (Ward and Stanford, 1979). Many regulated hydropower projects suppress this variability. When temperature regimes shift from optimal ranges, some fish populations are stressed, their spawning may cease, excessive mortality of developing eggs may occur and growth in juveniles may be inhibited (Bell, 1986).

Woody debris from riparian forests provides substrate for algal primary producers and bacterial and fungal consumers. Intricate networks of logs, branches, roots and small pieces of wood create a diverse array of cover and hydraulic gradients (Everett & Ruiz, 1993; Gippel, 1995; Gurnell et al., 1995). These in turn make it possible for multi-species fish and invertebrate communities to co-exist. Dams block upstream sources of woody debris and local sources become scarce as riparian vegetation is altered and peak floods no longer uproot trees and mobilize debris.

Gas supersaturation can cause a lethal gas bubble condition in tailwater fish. The problem is most pronounced when air mixes with falling water and dissolves under hydrostatic pressure (Weitkamp, 1980).

5.2.2 Cumulative Impacts of Proposed Projects

The impact of hydropower development on aquatic ecosystems is largely expected to occur at sub-Basin level only. The impact on aquatic flora and fauna by the West Seti, Lohore Khola and Bheri-Babai projects will be limited to the networks of these tributaries only, totalling 9%, 1.6% and 26.6% respectively of the total Karnali Basin. The development of hydropower on the main Karnali River course (i.e. the Upper Karnali and Karnali (Chisapani) projects) will impact on the aquatic biodiversity of most of the upstream river system (in the Hill and Mountain zones). The Karnali (Chisapani) Multipurpose Project will create a barrier to 98.3% of Karnali Basin watershed area in Nepal and China, whereas the Upper Karnali will create a barrier to 45.3% of this watershed, although it should be noted that fish do not generally inhabit rivers and streams above 2,000 m elevation.

The diversion of water by the West Seti, Upper Karnali and Bheri-Babai projects will reduce flows along 19 km of the Seti River, 45 km of Karnali River and 45 km of Bheri River respectively in the dry season immediately downstream of each of these dam structures, with only low volume environmental flows released during this non-monsoon period. This will reduce breeding and rearing grounds and the availability of the feed base, leading to a loss of fish biodiversity and population over the medium to long term along this combined 109 km of riverine habitat.

Each reservoir will inundate river stretches, creating deeper water habitat. The Upper Karnali and Bheri-Babai run-of-river impoundments will be 7 km and 8 km long respectively along the main river course. The West Seti, Lohore Khola and Karnali (Chisapani) storage projects will inundate approximately 25 km of Seti River, 15 km of Lohore Khola, and 100 km of Karnali River plus 45 km of Bheri River respectively. Many fish and aquatic organisms (micro to mega) adapted to fast flowing rivers with high dissolved oxygen concentrations will not survive in these lake environments. A few species of fish are likely to dominate these deep water habitats, with most migratory and resident species likely to decline drastically. Snow carp (*Shizothorax sps*) may not be present in the reservoirs (Swar, 1992).

In addition, the barriers created by dam walls will prevent the upstream migration of long range and mid range migratory fish species such as *Shizothorax sps*, *Tor sps* and *Arossocheilus sps,* the dominant fish species in the Basin. Over the medium to long term this prevention of upstream fish migration will reduce fish access to upstream and downstream breeding and rearing habitats.

As very little is understood about the habitats of aquatic species in the Karnali River Basin, it is difficult to predict with certainty the impacts of hydropower development on species. However, based on the predicted changes described above, considerable risk to aquatic biodiversity is posed by the Karnali (Chisapani) Multipurpose Project. The development of the Karnali (Chisapani) Multipurpose Project is likely to have a severe impact on the endangered

Gangetic dolphin (*Platanista gangetica*) and Gharial crocodile (*Gavialis gangeticus*), whose populations in other major river basins in Nepal have declined over the last two decades. These species depend to a considerable extent, either directly or indirectly, upon production that originates on laterally linked floodplains. The Karnali (Chisapani) Multipurpose Project high dam will alter flow regimes such that habitat and food inputs provided by floodplains are lost (Junk et al., 1989).

5.3 LAND USE AND FOREST COVER

Land use and forest cover in the Basin will mainly be dictated by natural resource use over the next two decades, although hydropower developments will have a permanent impact as well.

Apart from the Karnali (Chisapani) Multipurpose Project, the infrastructure (dam, reservoir and power house) of the likely large-scale hydropower projects to be developed in the Basin by 2025 will involve a comparatively limited area of land use change and forest cover loss (Table 5.14).

Table 5.14: Estimated Permanent Land Use Change by Hydroelectric Project

Project	Land Use Change (ha)		
	Forest and Shrubland	Agriculture and Other Land Uses	Total
West Seti**	**975**	**1,351**	2,326
Upper Karnali	**75***	**110***	185
Bheri-Babai	**5***	**25***	30*
Lohore Khola	**500***	**250 + 350***	1,100
Karnali (Chisapani)	**20,500**	**7,730 + 8,270***	36,500
Total	22,055	18,086	40,141

** - estimate; ** - excludes transmission line right-of-way vegetation clearing.*
Source: HPC, 1989; JICA, 1993; West Seti HEP EIA, 2000.

Despite this, a major forest type that will be affected by these projects will be riverine forest (Mixed Open Forest), dominated by the protected species Sal, Khair and Simal, as well as Saj. In this context, the loss of the forest cover will have a long-term and irreversible impact on wildlife habitat and faunal and floral biodiversity, although it is noted that much of this forest is currently utilised for different purposes.

The construction of transmission lines and access roads, the utilisation of land for resettlement and the expansion of irrigation areas will create additional impacts on existing land use, particularly on forests. The West Seti HEP proposes to resettle displaced people to the Terai districts of Kailali and Kanchanpur, requiring an estimated 2,400 ha of agricultural land. Similarly, the Lohore Khola HEP proposes to relocate displaced people to the Terai. The Bheri-Babai and Upper Karnali projects do not require large scale resettlement.

The development of the Karnali (Chisapani) project is based on the conversion of degraded natural forest areas to agricultural land, to be irrigated as part of the project's irrigation expansion plan. The project feasibility study also proposed the clearing of 12,650 ha of natural forest in the Terai for resettlement purposes. Accordingly, the development of each major hydroelectric project in the Basin will remove forest from the project footprint, while the Karnali (Chisapani) project will also reduce forest cover on the Terai due to land conversion for resettlement purposes.

As land in the Terai districts is commonly fragmented into small holdings, land acquisition for the resettlement of displaced people has the potential to create additional resettlement of the people whose land is acquired. The induced effect of the likely hydropower developments may include the in-migration of people to project areas, particularly the poor and deprived, in search of jobs and economic opportunities. Experience has shown that these people settle along the edge of forest areas, then gradually encroach into the adjoining forests. The probability of forest encroachment is higher in the Terai where less forest is under community forest management.

The contribution of the four likely hydropower projects to Basin land use and forest cover change are likely to be easily exceeded by ongoing changes from agriculture and forestry practices.

5.4 TERRESTRIAL BIODIVERSITY

Of the five major hydroelectric projects proposed in the Basin, three projects, namely the West Seti HEP, Bheri-Babai Multipurpose Project and Karnali (Chisapani) Multipurpose Project, are located relatively close to or partly within protected areas.

The West Seti reservoir is located 8-12 km from the closest boundary of Khaptad National Park, separated by a difficult 1,600 m rise. During project construction, the potential exists for members of the project workforce to access the Park for recreation purposes or illegal activities such as poaching, but this is highly unlikely due to the difficult intervening terrain and absence of road access. Accordingly, the potential impact of the West Seti HEP on terrestrial biodiversity in Khaptad National Park is considered negligible.

The proposed West Seti HEP transmission line, running from Talkot to Mahendranagar to connect to the Indian grid, crosses Shuklaphata Wildlife Reserve. A 2.9 km section of the proposed alignment crosses the Reserve, consisting of 1.4 km of grassland and 1.5 km of degraded forest. The impact on Reserve forest will be minimised by overstringing the line above the existing forest canopy.

The Bheri-Babai Multipurpose Project powerhouse, access roads, irrigation diversion weir and part of the main trunk canal are sited within Bardia National Park. Construction of these facilities within the Park risks damaging protected flora and fauna from the project footprint and from the disposal of construction spoil. In addition, workforce activities during construction within the Park will increase the risk of damage to protected flora and fauna. As project development is in the planning phase, the nature and extent of likely damage is uncertain. The feasibility study program initiated by JICA on behalf of the Government of Nepal was postponed partly due to the conflict between Park management and the Ministry of Water Resources.

The proposed sites for the Karnali (Chisapani) Multipurpose Project dam, reservoir, re-regulating weir and main eastern irrigation canal are partly located in Bardia National Park, and project construction activities could impact on protected terrestrial flora and fauna. The area of the Park that would be affected provides habitat for a range of threatened species, including tiger, Indian rhinoceros, swamp deer, hispid hare, gharial, leopard and sloth bear. Construction and operation of the re-regulating reservoir in one quarter of the Geruwa channel is predicted to result in the loss of riparian habitat for a wide variety of wildlife species. Terrestrial mammals thrive on the high nutritional content and cover provided by the dense early and mid-succession vegetation of riparian habitat along the banks of the Karnali (Dinerstein, 1979). The peak annual discharge of rivers, which can be suppressed by dams, confers pioneer characteristics to riparian vegetation (Décamps, 1984; Stanford and Ward, 1986). Without the seasonal flood pulse, riparian vegetation comes to resemble comparatively sparse and nutritionally impoverished inland forests and grasslands. Other adverse impacts may include wildlife deaths from falling into the main irrigation canal (especially large deer species), fragmentation of wildlife habitat due to networks of wide and deep irrigation canals through forested areas, and the disturbance of vegetation and harassment of wildlife by resettled farmers and villagers along the southern Park boundary.

The Karnali (Chisapani) project may increase the conflict between man and animal due to water regulation. During the monsoon season, when crops are at peak production, animals are prevented from leaving the Park by high river flows. The dam would modify the flow regime, allowing elephants and rhinoceros to cross the river year-round on the western bank. This would most likely lead to the increased destruction of crops and the consequent loss of life as villagers defend crops and property, threatening the survival of protected wildlife in the Park (Smith, 2000).

Outside protected areas, terrestrial biodiversity is at risk from a variety of influences. The construction workforce can be the primary cause of forest degradation around the project construction site. The demand for forest products, especially fuel wood, is likely to increase in proportion to the number of workers involved in construction unless electricity or alternative fuel is provided. Private businesses that establish adjacent to construction sites, such as tea stalls, restaurants and hotels, are also likely to increase the demand for forest resources in the local area, creating pressure on accessible forests near these sites unless adequate mitigation measures are implemented.

An increase in forest resource demand and gradual degradation of forest cover has a direct effect on terrestrial wildlife habitat and ecology. Additionally, the poaching of wildlife (especially birds, deer and wild boar) by the construction workforce could further degrade the wildlife population and diversity near construction sites.

As these effects on terrestrial biodiversity relate to the construction workforce and private businesses that will establish near construction sites, the nature and extent of damage will be largely governed by workforce and project management. The project impact on terrestrial biodiversity by the West Seti, Upper Karnali and Lohore Khola HEPs are likely to be relatively small and only affect a small total area of the Basin. The impact of the Bheri-Babai and

Karnali (Chisapani) projects on terrestrial biodiversity will be significant, with broad spatial coverage.

5.5 ROAD TRANSPORT AND NAVIGATION

Although major trunk roads already exist in close proximity to the proposed hydroelectric and multipurpose projects, the Basin is likely to go through a phase of road development to improve access from the Terai into the Basin hinterland. The construction of roads in mountainous terrain poses a risk to land stability. Slope excavation, drainage obstruction and improper spoil disposal can initiate mass wasting processes. Common impacts of road construction in hilly terrain include erosion within and adjacent to the road corridor and downstream sedimentation. As cultivated land is usually avoided for road alignments, forested areas are more likely to be cleared and fragmented.

Village road developments constructed by local communities do not require IEE/EIA preparation and approval, therefore this type of road development has the potential to create the greatest environmental impact. Village roads are expected to comprise a large proportion of the roads to be constructed in the Basin over the next two decades.

The potential for navigation within the Basin only exists in relation to the Karnali (Chisapani) Multipurpose Project. Based on the likely Indian irrigation demand from the Karnali River, reduced river flows in India are likely to make river navigation from the Gaga River along the Karnali River below the Girjapur Barrage unlikely. If river navigation is developed, this will require the channelization of the river to maintain depth and width and would impact on Karnali River riparian habitat and ecology. Gangetic dolphin, Magar and Gharial, whose populations in the Basin have already declined due to the Girijapur Barrage in India, would further decline due to a loss of breeding habitat.

5.6 SOCIAL AND ECONOMIC IMPACTS

Cumulative social and economic impacts of hydropower development in the Karnali Basin have to be considered in terms of: the social and economic impacts to the people displaced by the project; and the social and economic impacts on communities affected by the projects.

Given that best practice resettlement/rehabilitation plans aim to ensure that affected people are no worse off following resettlement, it is envisaged that the affected population will not be disadvantaged by the projects (Table 5.15). However, resettling communities away from their place of birth and parental belonging, as proposed for the West Seti, Lohore Khola and Karnali (Chisapani) projects, will socially and culturally disarticulate displaced people.

Table 5.15: Likely Population to be Displaced by Hydroelectric Projects

Project	Displaced Population	Percentage Displaced (%)

West Seti	**13,100**	**12.9**
Upper Karnali	**144**	**0.1**
Lohore Khola	**1,343**	**1.3**
Bheri- Babai	**0**	**0**
Karnali (Chisapani)	**86,859**	**85.7**
Total	101,446	100

Source: JICA, 1993; HPC, 1998; West Seti HEP EIA, 2000; MHSP, 1998. Note: population adjusted to 2006.

The proposed hydroelectric development projects in the Basin will provide employment and other economic activities that will improve local socioeconomic conditions. Settlements close to construction sites will grow. Local land prices and rents are expected to appreciate and thereby benefit residents in the immediate project area, however there is a risk of a boom-bust effect after construction.

Socially and culturally, a mixed effect is expected from hydropower developments. Societies will be exposed to outside people with different social and cultural values. The changed economic environment in communities has the potential to erode traditional bonds between ethnic groups and households. Social and cultural values based on moral principles may be replaced by economic goals. Social evils such as prostitution, trafficking of girls, gender exploitation and child labour have the potential to increase in communities close to construction sites.

Despite these potential negative impacts, the overall impact on the social and economic conditions of people residing in the Basin is predicted to be positive. The local economic contribution of construction-related revenue and services is estimated to be 1.75% of the project cost (SMEC, 2000) and the projects are predicted to bring a host of economic activities into the Basin that will provide indirect economic benefits to people.

The environmental enhancement/social development programs to be instigated by hydropower projects are expected to improve the quality of life of people in the Basin, at least in the directly affected VDCs. Improvements in local water supply, communications, health and education are likely, and these improvements will open up new development opportunities. VDCs directly affected by the projects will receive a 1% share of the hydroelectricity revenue from each project for rural electrification as per the Water Resource Policy (2002).

The social and economic impacts of a hydropower project, both beneficial and adverse, are relative to the scale and type of project. Run-of-river hydropower projects generally displace fewer people than storage projects due to the smaller size of the pondage area. The Karnali

(Chisapani) Multipurpose Project would displace substantially more people than the West Seti and Lohore Khola HEPs. In term of economic benefits to affected communities and the broader area, the larger projects should produce greater benefits.

5.7 HEALTH

The health risks associated with the proposed hydropower projects in the Basin relate to the creation of standing waterbodies and the transfer of communicable diseases into the area by the outside construction workforce.

The creation of standing waterbodies poses a long-term health risk. A storage project transforms the riverine environment into a relatively stable lentic aquatic environment upstream of the dam. This may create conditions suitable for a variety of human disease vectors such as malaria, encephalitis and internal parasites. As local people normally use riverine areas as a toilet and use river water for domestic water supply for at least part of the year, the risks from waterborne disease increase when a still waterbody is created.

For storage projects (West Seti and Lohore Khola HEPs) the risk of waterborne disease is limited to the reservoir area due to the lack of prolonged contact between humans or livestock and disease vectors downstream. For multipurpose projects with an irrigation component (Bheri-Babai and Karnali (Chisapani)) the potential risk areas for waterborne disease include the associated irrigation areas. The availability of water in the irrigation command areas provides favourable conditions for parasites and disease vectors, increasing the health risks. The proposed irrigation command areas of the Bheri-Babai and Karnali (Chisapani) multipurpose projects already have problems with malaria, encephalitis and internal parasites in humans and livestock, hence the risk of waterborne disease epidemics associated with these projects is increased.

The health risks associated with the temporary in-migration of construction workers into the Basin may be greater for projects located in the hinterland (West Seti, Upper Karnali and Lohore Khola HEPs). Local communities in these areas have less exposure to the outside world than people living on the Terai, although temporary out-migration for employment is common. The incidence of some communicable diseases, particularly sexually transmitted diseases such as HIV/AIDS, is relatively low in local communities. A lack of awareness among local people about the transfer of disease may pose a greater risk.

5.8 INDUCED BASIN DEVELOPMENT

The Karnali Basin is the least developed geographical region of Nepal. The lack of year-round road access has rendered the region deficient in communications and power supply. Despite the richness of resources in the Basin it remains relatively remote. Economic activities in the Basin hinterland are subsistence-dominated, with most people living a traditional way of life.

With the development of major hydroelectric projects in the Basin over the next 20 years road access in the Basin will expand in both coverage and service. An expansion of communications and electricity supply is likely to be associated with road development. Development of these facilities will improve the conditions for manufacturing and service industries in the Basin.

Construction-induced service industries are expected to bring new skills and opportunities to the local area, particularly near construction sites. This will gradually expand to adjoining areas, providing conditions conducive to tourism within the Basin. Tourism-related services and manufacturing based on local resources are likely to follow. This will be a gradual process that will have a snowball effect on the local economy and quality of life of people living in the Basin over the long term.

Associated with development is a risk of natural resource degradation in the Basin. The over-exploitation of natural resources for short-term economic gain, particularly the utilization of forest resources, is a concern. The degradation of forests could have long-term impacts on terrestrial biodiversity, watershed health, land stability and, above all, on the productivity of terrestrial and aquatic environments. Based on the previous experiences of development works in Nepal, the rapid degradation of natural resources can occur during the initial phase of development unless robust management is implemented.

The Bheri-Babai and Karnali (Chisapani) multipurpose projects are not expected to contribute significantly to development throughout the Basin as these projects are located in the southern, relatively developed areas, hence induced development is unlikely to reach into the hinterland. The West Seti, Upper Karnali and Lohore Khola projects are expected to contribute substantially to hinterland development due to their hill locations. Although the construction-phase economic benefit of each of these three projects is likely to be small in comparison to the Karnali (Chisapani) Multipurpose Project, Basin coverage of associated induced development will be high.

6. CONCLUSIONS

Hydropower projects are the most likely large scale developments to be implemented in the Karnali Basin over the next 20 years. Developments in other sectors are likely to be subdued due to the absence of conditions for development and the likely slow improvement in these conditions over the next two decades.

The development of hydropower projects in the Basin will have positive and negative impacts on the natural and social environments. Benefits, apart from the generation of hydroelectricity, will include: an accentuation of river flow variations that will increase available water for irrigation in the dry season; direct and indirect economic impacts; and the provision of other development inputs to Basin communities. The West Seti HEP will provide a large positive socioeconomic contribution to Basin development, second only to the Karnali (Chisapani) Multipurpose Project if this multipurpose project is developed. As the West Seti HEP will be the first large scale hydroelectric project constructed in the Basin and it is located in the hinterland, the induced development contribution of this project is expected to be significantly higher than that of the other three hydropower projects likely to be developed by 2020.

Key adverse impacts of hydropower developments in the basin will be the displacement of people and the degradation of the natural environment. The West Seti HEP will displace approximately 12.9% of the total people likely to be resettled by the five major hydropower developments potentially installed in the Basin by 2025. The Karnali (Chisapani) Multipurpose Project is likely to account for the majority of population displacement (about 86%) from the proposed projects.

The most significant impact on the natural environment from hydropower development will occur to the riverine ecosystem of the Karnali River network. Fragmentation of the continuous riverine ecosystem and a change in river flows, water chemistry and water temperature will impact on the cold water fishery in the Basin. The range of migratory fish species, the dominant fishery of the Basin, will be restricted by water diversion and release structures. Affected species of long and medium range migratory fish will not be able to access breeding and raring habitat above the West Seti, Upper Karnali, Bheri-Babai and Lohore Khola projects. These upper catchments make up 9%, 46%, 27% and 2% respectively of the total Karnali Basin to Chisapani, although it should be noted that riverine habitat used by fish generally does not extend above 2,000 m elevation. If the Karnali (Chisapani) Multipurpose Project is developed it will prevent the migration of long and medium range species into the Basin from the Gangetic plain, significantly changing species composition in the Karnali Basin. In addition, this project will place stress on several endangered species, including the Gangetic dolphin and Gharial crocodile, while damaging riverine habitat of the Indian rhinoceros, Asian elephant and Swamp deer.

The downstream effects of the West Seti, Upper Karnali and Lohore Khola HEPs on hydrology and aquatic ecology will principally occur between the dam and tailrace outlet of each of these projects. For the Bheri-Babai project, such effects will be severe in the dry season up to the confluence with the Karnali River 45 km downstream.

The West Seti, Lohore Khola and Upper Karnali HEPs will not directly affect National Parks and other conservation areas. Some Bheri-Babai and Karnali (Chisapani) project sites are located in Bardia National Park, therefore the footprint of these projects will directly impact this protected area.

REFERENCES

1. Bajracharya S.R., Mool P.K., and Joshi, S.P., 2002. Lakes in the identification of potentially dangerous glacial lakes of Nepal using Remote Sensing and Geographic Information Systems.

2. BPP (1995f). Biodiversity Project Profile, His Majesty's Government/Netherlands.

3. Canadian International Water and Energy Consultants (CIWEC), 1997. Upper Karnali Hydroelectric Project - Environmental Impact Assessment. October 1997. Kathmandu, Nepal.

4. CBS, 2006. Four Monthly Statistical Bulletin, 2063/64.

5. CBS, 2001.Population Census Nepal, 2001.

6. CBS, 2003. District Level Indicators of Nepal.

7. CBS, 2004. National Sample Census of Agriculture, Nepal 2001/02, District Summary.

8. CBS, 2005. Poverty Trends in Nepal (1995/96 and 2003/04).

9. CBS, 2005. Statistical Year Book of Nepal, 2005.

10. CBS, 2006. Statistical Pocket Book, Nepal 2006.

11. CBS, 2005. Environment Statistics of Nepal, 2005.

12. CBS, Dec 2004. Nepal Living Standard Survey, Vol II, 2003/04.

13. CBS/UNFPA 200. Population Monograph of Nepal, Volume II.

14. CBS/UNFPA, June 2002. Population Census 2001 National Report.

15. CBS/UNFPA, June 2002. Population Census 2001, VDC Wise Population.

16. Central Bureau of Statistics (CBS), 1998. A Compendium on Environment Statistics 1998 Nepal. HMGN. Kathmandu, Nepal.

17. Décamps, H., 1984. Biology of regulated rivers in France. Pages 495-514 in A. Lillehammer and S.J. Saltveit, editors. Regulated Rivers. Oslo University Press, Oslo.

18. Department of Agriculture Marketing Development Directorate, 2002. Agricultural Marketing Information Bulletin, Special Issue 2002.

19. Department of Forest, 2006. Database on the Community Forest.

20. Dinerstein, E. 1979. An ecological survey of the Royal Bardia Wildlife Reserve, Nepal. Part II: Habitat/animal interactions. Biological Conservation 16:265-300.

21. Everett, R.A., and G.M. Ruiz. 1993. Coarse woody debris as a refuge from predation in aquatic communities. Oecologia 93:475-485.

22. Gippel, C.J. 1995. Environmental hydraulics of large woody debris in streams and rivers. Journal of Environmental Engineering 121**:**388-395.

23. Gore, J.A. 1996. Responses of aquatic biota to hydrological change. Pages 209-230 in G. Petts and P. Calow, editors. River biota: diversity and dynamics. Blackwell Science, Oxford.

24. Himalayan Power Consultants (HPC), 1989. Karnali (Chisapani) Multi-Purpose Project Feasibility Study - Main Report. December 1989. For HMGN.

25. JICA, 1993. Master Plan Study for Water Resource Development Karnali and Mahakali River Basin. Vol. 1.

26. Kondolf, G.M., 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management 21:533-551.

27. Medium Hydropower Study Project (MHSP), 1998. Environment Impact Assessment (EIA) of the Upper Karnali Hydropower Project. Volume I. Nepal Electricity Authority.

28. Naiman, R.J., H. Décamps, J. Pastor, and C.A. Johnston. 1988. The potential importance of boundaries to fluvial ecosystems. Journal of the North America Benthological Society 7:289-306.

29. NARMSAP, 2002. Forest and Vegetation Types of Nepal, TISC Document Series No 105, HMG/ MOFSC/NARMSAP, 1-179.

30. National Planning Commission, 2002. Tenth Five Year Plan (2059-2064).

31. Nepal Biodiversity Strategy, 2002, HMG.

32. Onta, Iswer R, 1998. Large Dams and Alternatives in Nepal: Experiences and Lessons Learnt.

33. Payne, A. I., UK; Sinha, Singh, H. R., 2003. A review of the Ganges Basin its Fish and Fisheries.

34. Petts, G.E., 1984. Impounded rivers. Perspectives for ecological management. John Wiley & Sons, Chichester.

35. Rai, A.R., 2003. Of Indigenous Riverine Fish Species in Nepal**.** Fisheries Research Division, Godawari Nepal, Agricultural Research Council (NARC).

36. Rajbanshi, K.J., 2000. Zoo-geographical distribution and the status of coldwater fish in Nepal. Royal Nepal Academy of Sciences and Technology (RONAST). Kathmandu, Lalitpur.

37. Shardul Agrawala, Vivian Raksakulthai, Maarten van Aalst, Peter Larsen, Joel Smith and John Reynolds, 2003. Development and climate change in Nepal: Focus on Water Resource and Hydropower. COM/ENV/EPOC/DCD/DAC (2003).

38. Sharma, C.K., 1997. A Treatise on Water Resources of Nepal. Kathmandu, Nepal.

39. SILT/TAEC, 2006. Resettlement Action Plan, Sector-Wide Road Project and Priority Investment Plan (SWRP & PIP).

40. Smith, B.D., 1993. 1990 status and conservation of the Ganges river dolphin (Platanista gangetica) in the Karnali River, Nepal. Biological Conservation 66:159-170.

41. Smith, B.D. 2003**.** Downstream effects on biodiversity of a planned high dam in the Karnali river, Nepal.

42. Smith, B.D., B. Bhandari, and K. Sapkota, 1996. Aquatic biodiversity in the Karnali and Narayani Basins, Nepal. IUCN Nepal, Kathmandu.

43. Smith, B.D., R. Sinha, U. Regmi, and K. Sapkota. 1994. Status of Ganges river dolphins (Platanista gangetica) in the Karnali, Mahakali, Narayani and Sapta Kosi rivers of Nepal and India in 1993. Marine Mammal Science 10:368-375.

44. Snowy Mountains Engineering Corporation (SMEC), 2000. West Seti Hydroelectric Project Environmental Impact Assessment. Volume 1. Cooma, Australia.

45. Stalnaker, C.B., R.T. Milhous, and K.D. Bovee,1989. Hydrology and hydraulics applied to fishery management in large rivers. Pages 3-20 in D.P. Dodge, editor. Proceedings of the International Large River Symposium. Canadian Special Publications of Fisheries and Aquatic Sciences No. 106, Ottawa.

46. Stanford, J.A., and J.V. Ward, 1986. The Colorado river system. Pages 353-374 in B.R. Davies and K.F. Walker, editors. The ecology of river systems. Dr. W. Junk, Dordrecht, The Netherlands.

47. Swar, D.B., 1992. “Effect of Impoundment on Indigenous Fish Population in Indrasarobar Reservoir, Nepal”. In Proceedings of the Second Workshop on Reservoir Fishery Management in Asia (S.S. Desilva (ed.)). IDRC, Ottawa, 111-118 pp.

48. TAHAL, 2002. Institutional Development of Department of Hydrology and Meteorology, Nepal Irrigation Sector Project, Credit No 3009. Final Report, Technical Report No 7, Appendix VII. HMG/Department of Hydrology and Meteorology, Kathmandu.

49. Thapa, A.B., 2003. Power Export and Upper Karnali Project. Spotlight VOL. 23, NO. 13, Sept. 19-Sept. 25, 2003.

50. UNDP, 2004. Nepal Human Development Report, 2004.

51. Ward, J.V., and J.A. Stanford, 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. Pages 35-42 in J.V. Ward and J.A. Stanford, editors. The ecology of regulated streams. Plenum Press, New York.

52. Warnock, J.G. 1989. The hydro resources of Nepal. International Water Power and Dam Construction 41(3):26-30.

53. WECS, 2002. Water Resource Strategy Nepal. Water and Energy Commission Secretariat, Singha Durbar, Kathmandu.

54. Weitkamp, D.E., and M. Katz.1980. A review of dissolved gas in supersaturation literature. Transactions of the American Fisheries Society 109**:**659-702.

ANNEXES

Annex 2.1: Household and Population Status of the Basin Districts (2001 Census)

Districts	Population			%	Total Number of Households	Average HH Size	Area (km^2)	Popn. Density (person/ km^2)	Total Number of VDCs/ Municipality
	Total	Male	Female						
A. Terai									
Banke	385,840	198,231	187,609	1.67	67,269	5.74	2,337	165	47
Bardia	382,649	192,655	189,994	1.65	59,569	6.42	2,025	189	32
Kailali	616,697	312,311	304,386	2.66	94,430	6.53	3,235	191	44
Kanchanpur	377,899	191910	185,989	1.63	60,158	6.28	1,610	235	20
A. Sub Total	**1,763,085**	**895,107**	**867,978**	**7.61**	**281,426**	**6.26**	**9,207**	**191**	**143**
B. Hill									
Achham	231,285	10,998	122,287	1	44,005	5.26	1,680	138	75
Baitadi	234,418	113,538	120,880	1.01	40,387	5.8	1,519	154	63
Dadeldhura	126,162	60,965	65,197	0.54	21,980	5.74	1,538	82	21
Dailekh	225,201	110,125	115,076	0.97	41,140	5.47	1,502	150	56
Doti	207,066	103,521	103,545	0.89	36,465	5.68	2,025	102	51
Jajarkot	134,868	68,508	66,360	0.58	24,147	5.59	2,230	60	30
Rukum	188,438	95,432	93,006	0.81	33,501	5.62	2,877	65	43
Salyan	213,500	106,834	106,666	0.92	38,084	5.61	1,462	146	47
Surkhet	288,527	142,817	145,710	1.25	34,047	5.34	2,451	118	51
B. Sub Total	**1,849,465**	**812,738**	**938,727**	**7.97**	**313,756**	**5.89**	**17,284**	**107**	**437**
C. Mountain									
Bajhang	167,026	86,350	80,676	0.72	28,358	5.85	3,422	49	47
Bajura	108,781	53,834	54,947	0.47	20,378	5.34	2,188	50	27
C. Sub Total	**584,891**	**297,168**	**287,723**	**2.54**	**104,099**	**5.62**	**26,961**	**22**	**208**
Dolpa	29,545	14,735	14,810	0.13	5,812	5.08	7,889	14	23
Humla	40,595	20,962	19,633	0.18	6,953	5.84	5,655	7	27
Jumla	89,427	45,848	43,579	0.39	15,850	5.64	2,531	35	30
Kalikot	105,580	53,189	52,391	0.46	18,487	5.71	1,741	61	30
Mugu	43,937	22,250	21,687	0.19	8,261	5.32	3,535	13	24
Total Project Districts	**4,197,441**	**2,005,013**	**2,094,428**	**18**	**699,281**	**6.0**	**53,452**	**79**	**788**
All-Nepal	**23,151,423**	**11,563,921**	**11,587,502**	**100**	**4,253,220**	**5.44**	**147,181**	**157**	3973
% Covered by Project Districts	**18.13**	**17.34**	**18.07**	**18.12**	**16.44**		**36.32**	**50.02**	**19.83**

Source: I) Population Census 2001 National Report; CBS/UNFPA, June 2002. ii)) Population Census 2001, VDC Wise Population; CBS/UNFPA, June 2002.

Annex 2.2: Major Dominant Ethnic/Caste Composition

District	Ethnic/Caste Group (% of District Population)							
	Thakuri	**Chhetri**	**Magar/ Gurung**	**Bahun**	**Dalits**	**Tharu**	**Muslim**	**Other**
A. Terai								
Banke	0	12.3	0	6	0	16.4	**21.1**	**0**
Bardia	0	10.6	0	9.4	3.4	52.6	**0**	**0**
Kailali	0	17.4	0	10.7	6.2	43.7	**0**	**0**
Kanchanpur	0	27.2	0	15.4	5	23.3	**0**	**0**
SubTotal A	**0**	**16.9**	**0.0**	**10.4**	**3.7**	**34.0**	**5.3**	**0.0**
B. Hill								
Achham	0	53.22	0	10.71	23.8	0	0	0
Baitadi	8.23	48.12	0	20.2	10.75	0	0	0
Dadeldhura	0	51.3	0	17.9	12.9	0	0	0
Dailekh	14.1	34.77	9.87	11.9	15.33	0	0	0
Doti	0	52.7	0	9.2	13.2	0	0	0
Jajarkot	17	38.4	8.7	0	19.7	0	0	0
Rukum	5.1	58.4	23.1	0	4	0	**0**	**0**
Salyan	0	50.2	17.2	4.7	7.5	0	**0**	**0**
Surkhet	4.55	27.73	20.63	12.33	14.96	0	0	0
SubTotal B.	**5.44**	**46.09**	**8.83**	**9.66**	**13.57**	**0.00**	**0.00**	**0.00**
Bajhang	5.61	63.93	0	10.78	10.67	0	0	0
Bajura	6.41	55.54	0	6.89	13.44	0	0	0
Dolpa	0	43.9	**35.7**	0	5.8	0	0	0
Humla	19.6	43.8	0	6.3	0	0	0	14(Sherpa)
Jumla	4.39	48.86	0	7.38	10.62	0	0	0
Kalikot	21.7	15.1	0	27.5	21.6	0	0	0
Mugu	12.17	31.72	0	3.11	13.8	0	0.38	9.9
Sub total c.	**9.98**	**43.26**	**5.10**	**8.85**	**10.85**	**0.00**	**0.05**	**2.00**
Average Project Districts	**5.14**	**35.41**	**4.64**	**9.63**	**9.36**	**11.33**	**1.78**	**0.67**

Annex 2.3: Population absent from house for Earning in the Basin Districts

Project Districts	Absent Population			Total Economically Active Population	% of Total Economically Active Population
	Male	Female	Total		
A. Terai					
Banke	5,580	749	6,329	280,624	2.3
Bardia	7,257	911	8,168	275,985	3.0
Kailali	15,479	2,284	17,763	441,679	4.0
Kanchanpur	7,662	1,045	8,707	272,328	3.2
Sub-total A	**35,978**	**4989**	**40,967**	**1,270,616**	**3.2**
B. Hill					
Achham	18,664	3,043	21,707	133,772	16.2
Baitadi	10,502	1824	12326	124,104	9.9
Dadeldhura	6,109	685	5,794	88,790	6.5
Dailekh	8,908	901	9,809	114,640	8.6
Doti	14,435	1,512	15,947	149,206	10.7
Jajarkot	501	55	556	97,659	0.6
Rukum	3,099	315	3,414	93,306	3.7
Salyan	1006	157	1163	44,357	2.6
Surkhet	9,479	975	10,454	119,334	8.8
Sub-total B	**72,703**	**9467**	**81,170**	**965,168**	**8.4**
Bajhang	10,769	2,803	13,572	97,994	13.8
Bajura	4,382	784	5,166	63,637	8.1
Dolpa	129	24	153	16,155	0.9
Humla	146	15	161	29,158	0.6
Jumla	539	72	611	42,712	1
Kalikot	131	5	136	8,373	1.6
Mugu	367	77	444	20,403	2.2
Sub-total C	**16463**	**3780**	**20243**	**278,432**	**7.3**
Total Project Districts	**140,083**	**19,521**	**158,604**	**2,719,448**	**5.8**
Total Nepal	**679,469**	**82,712**	**762,181**	**9,900,196**	**7.7**

Source: CBS 2001.

Annex 2.4: Land Use Pattern by District:

District	Total Forest Area	Shrub	Agricultural Land/Grass	Water Bodies	Bare Land	Snow	Others	Total
A. Terai								
Banke	104269	9461	71475	1923	6296	0	0	193424
Bardia	99364	5300	85809	2548	4756	0	0	197777
Kailali	169708	14671	129769	2330	4715	0	0	321283
Kanchanpur	84420	2207	71938	1361	5680	0	0	165606
Sub-total A	**457761**	**31639**	**358991**	**8162**	**21447**	**0**	**0**	**878090**
B. Hills								
Achham	99144	16967	45102	422	6219	154	0	168008
Baitadi	72020	27751	46368	370	1229	0	0	147738
Dadeldhura	105937	11280	31359	212	1306	0	0	150094
Dailekha	88699	20705	36341	167	8812	353	0	155077
Doti	141848	17277	44839	311	2049	10	0	206334
Jajarkot	151306	1088	24126	489	43401	4095	0	224505
Rukum	174725	2130	12961	130	77148	23253	0	290347
Salyan	143786	2610	36419	526	7337	0	0	190678
Surkhet	157687	33269	48653	1899	7556	0	0	249064
Sub-total B	**1135152**	**133077**	**326168**	**4526**	**155057**	**27865**	**0**	**1781845**
C. Mountain								
Bajhang	92391	39713	43697	440	38826	139599	0	354666
Bajura	72507	23982	31414	264	32110	63897	0	224174
Dolpa	60603	3910	77	764	474881	249817	0	790052
Humla	41051	21954	12584	677	112174	421759	0	610199
Jumla	110531	1118	19819	338	98595	18566	0	248967
Kalikot	87165	3846	15560	0	48264	9588	0	164423
Mugu	87312	9387	20729	1360	139358	69568	0	327714
Sub-total C	**551560**	**103910**	**143880**	**3843**	**944208**	**972794**	**0**	**2720195**
Total Project Districts	**2144473**	**268626**	**829039**	**16531**	**1120712**	**1000659**	**0**	**5380130**
%	**39.9**	**5.0**	**15.4**	**0.3**	**20.8**	**18.6**	**0.0**	**100.0**

Total Nepal%

Source: Environment Statistics of Nepal, 2005

Annex 2.5: Average Number of Land Holdings and Parcels in the Basin Districts.

Project Districts	Average Land Holdings (ha)			Average Number of Parcels
	Wet	Dry	Total	
A. Terai				
Banke	0.75	0.17	0.92	2.6
Bardia	0.8	0.21	1.01	2.2
Kailali	0.69	0.18	0.87	2.4
Kanchanpur	0.77	0.1	0.87	1.9
Sub-total A	**0.75**	**0.17**	**0.92**	**2.28**
B. Hills				
Achham	0.15	0.29	0.44	4.3
Baitadi	0.14	0.42	0.56	4.1
Dadeldhura	0.2	0.39	0.59	4
Dailekh	0.22	37	0.59	2.3
Doti	0.23	0.3	0.53	4.4
Jajarkot	0.15	0.55	0.7	2.9
Rukum	0.14	0.41	0.55	3.7
Salyan	0.2	0.62	0.82	3.1
Surkhet	0.24	0.34	0.58	1.9
Sub-total B	**0.16**	**4.45**	**0.54**	**2.92**
C. Mountain				
Bajhang	0.17	0.33	0.5	3.7
Bajura	0.14	0.33	0.47	4.9
Dolpa	0.04	0.42	0.46	4.7
Humla	0.15	0.78	0.93	7.4
Jumla	0.06	0.48	0.54	7
Kalikot	0.41	0.57	0.98	5.5
Mugu	0.17	0.68	0.85	10
Sub-total C	**0.16**	**0.51**	**0.68**	**6.17**
Total Project Districts	**0.25**	**1.71**	**0.712**	**4.1**
Total Nepal	**0.48**	**0.31**	**0.79**	**3.3**

Source: National Sample Census of Agriculture Nepal, 2001/02 Highlights, Dec 2003.

Annex 2.6: Area, Production and Yield of Cereal Crops in the Basin Districts (2003/04)

	Paddy			Wheat			Maize			Millet			Barley			Total		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
A. Terai																		
Banke	33160	90456	2.73	10500	20853	1.99	10298	21192	2.06	0	0	0	10	10	1.0	53968	132511	2.46
Bardia	36630	114280	3.12	1700	42269	24.86	8750	17500	2.00	0	0	0	10	10	1.0	47090	174059	3.70
Kailali	57000	167690	2.94	17000	37400	2.20	12500	18750	1.50	200	180	0.9	150	180	1.2	86850	224200	2.58
Kanchanpur	44300	114810	2.59	20350	43370	2.13	5912	11840	2.00	180	180	1.0	10	10	1.0	70752	170210	2.41
Sub-total A	**171090**	**487236**	**2.85**	**49550**	**143892**	**2.90**	**37460**	**69282**	**1.85**	**380**	**360**	**0.9**	**180**	**210**	**1.2**	258660	700980	**2.71**
B. Hills																		
Achham	6910	15270	2.21	7215	12030	1.67	5195	6250	1.20	1730	2000	1.16	185	170	0.9	21235	35720	1.68
Baitadi	5325	10500	1.97	9100	10100	1.11	8400	10920	1.30	850	850	1.00	700	660	0.9	24375	33030	1.36
Dadeldhura	6900	15870	2.30	8710	12685	1.46	3930	6520	1.66	425	425	1.00	300	300	1.0	20265	35800	1.77
Dailekha	8600	17300	2.01	6568	9850	1.50	10600	19960	1.88	2500	3135	1.25	228	273	1.2	28496	50518	1.77
Doti	7175	15734	2.19	9600	13320	1.39	2620	4454	1.70	1930	1891	0.98	340	340	1.0	21665	35739	1.65
Jajarkot	3500	7900	2.26	7850	9810	1.25	8830	16510	1.87	2060	2860	1.39	760	680	0.9	23000	37760	1.64
Rukum	3570	8600	2.41	11800	18215	1.54	18650	31520	1.69	1140	1500	1.32	925	1093	1.2	36085	60928	1.69
Salyan	6750	13460	1.99	13000	21000	1.62	21560	38040	1.76	1930	2162	1.12	1000	1300	1.3	44240	75962	1.72
Surkhet	12440	25400	2.04	15280	30254	1.98	15290	30801	2.01	1656	1987	1.20	1040	1368	1.3	45706	89810	1.96
Sub-total B	**61170**	**130034**	**2.13**	**89123**	**137264**	**1.54**	**95075**	**164975**	**1.74**	**14221**	**16810**	**1.18**	**5478**	**6184**	**1.1**	**265067**	**455267**	**1.72**
C. Mountain																		
Bajhang	5930	10750	1.81	6144	8915	1.45	3650	6200	1.70	2285	2285	1.00	1500	1650	1.1	19509	29800	1.53
Bajura	3260	6010	1.84	4950	6705	1.35	1010	1820	1.80	2100	2150	1.02	1072	1425	1.3	12392	18110	1.46
Bajura	3260	6010	1.84	4950	6705	1.35	1010	1820	1.80	2100	2150	1.02	1072	1425	1.3	12392	18110	1.46
Dolpa	190	228	1.20	218	428	1.96	2000	2400	1.20	300	240	0.80	60	70	1.2	2768	3366	1.22
Humla	547	825	1.51	969	998	1.03	80	145	1.81	1351	932	0.69	1200	1440	1.2	4147	4340	1.05
Jumla	2800	4080	1.46	2800	2800	1.00	4525	6790	1.50	3750	4150	1.11	3100	3900	1.3	16975	21720	1.28
Kalikot	2080	2820	1.36	5280	7300	1.38	1730	2590	1.50	1150	1100	0.96	1040	1270	1.2	11280	15080	1.34
Mugu	850	1553	1.83	3010	3618	1.20	550	850	1.55	1550	1525	0.98	1400	1400	1.0	7360	8946	1.22
Sub-total C	**18917**	**32276**	**1.71**	**28321**	**37469**	**1.32**	**14555**	**22615**	**1.55**	**14586**	**14532**	**1.00**	**10444**	**12580**	**1.2**	**86823**	**119472**	**1.38**
Total All	**251177**	**649546**	**2.59**	**166994**	**318625**	**1.91**	**147090**	**256872**	**1.75**	**29187**	**31702**	**1.09**	**16102**	**18974**	**1.2**	**610550**	**1275719**	**2.09**
Total Nepal	**1504136**	**4455722**	**2.96**	**665589**	**1387192**	**2.08**	**834285**	**1590097**	**1.91**	**258597**	**283378**	**1.1**	**27467**	**30670**	**1.1**	**3290074**	**7747059**	**2.35**

Source: Statistical Year Book of Nepal, 2005.

Annex 2.7: Food Balance Situation of the Basin Districts (2001)

Project Districts	Total Edible Food Production (M.Ton)						Total Requirement (M. ton)	Surplus/Deficit (M. ton)
	Rice	Wheat	Maize	Millet	Barley	Total		
A. Terai								
Banke	51273	17483	11519	0	3	80278	69938	10340
Bardia	59894	29373	8390	8	3	97668	69853	27815
Kailali	78690	29225	8901	164	41	117021	108289	8832
Kanchanpur	60776	37584	3599	33	3	101995	65933	36062
Sub-total A	**250633**	**113665**	**32409**	**205**	**50**	**396962**	**314013**	**83049**
B. Hills								
Achham	8132	9610	2014	1651	47	21454	46966	-25512
Baitadi	4777	7774	5817	624	152	19144	47900	-28756
Dadeldhura	8991	8207	2173	439	96	19906	25723	-5817
Dailekh	9339	5742	14148	2592	143	31964	45657	-13693
Doti	8817	12662	0	1322	91	22892	41067	-18175
Jajarkot	4215	4960	11863	2360	176	23574	27431	-3857
Rukum	4597	13498	24080	1238	344	43757	38134	5623
Salyan	6898	17280	29187	1780	355	55500	43712	11788
Surkhet	17811	22332	20084	1585	326	62138	58460	3678
Sub-total B	**73577**	**102065**	**109366**	**13591**	**1730**	**300329**	**375050**	**-74721**
C. Mountain								
Bajhang	4345	7042	1899	1830	457	15573	31978	-16405
Bajura	2980	4435	0	1760	385	9560	20984	-11424
Dolpa	212	245	2024	532	16	3029	5739	-2710
Humla	422	0	0	686	0	1108	7976	-6868
Jumla	2002	1907	4432	3404	1079	12824	17286	-4462
Kalikot	1376	5810	758	899	352	9195	20352	-11157
Mugu	392	803	0	1227	203	2625	8294	-5669
Sub-total C	**11729**	**20242**	**9113**	**10338**	**2492**	**53914**	**112609**	**-58695**
Total Project Districts	**335939**	**235972**	**150888**	**24134**	**4272**	**751205**	**801672**	**-50367**

Source: Agricultural Marketing Information Bulletin, Special Issue 2002, Department of Agriculture Marketing Development Directorate, 2002

Annex 2.8: Number of Households Reporting Sufficient Agricultural Produce in Basin Districts (2001)

Project Districts	Sufficient to Feed the Household		Not Sufficient to Feed the Household		Total Holdings	
	No.	%	No.	%	No.	%
A. Terai						
Banke	19341	39.2	30034	60.8	49375	100
Bardia	24266	51.0	23254	48.9	47520	100
Kailali	43,094	55.0	33988	44.0	77082	100
Kanchanpur	34,732	65.0	18,826	35.0	53,558	100
Sub-total A	**121,433**	**53.37**	**106,102**	**46.63**	**227,535**	**100**
B. Hills						
Achham	17450	41.2	24938	58.8	42388	100
Baitadi	12612	32.3	26377	67.7	38989	100
Dadeldhura	7167	34.7	13453	65.2	20620	100
Dailekh	21857	56.3	16973	43.7	38830	100
Doti	13263	39.8	20023	60.1	33286	100
Jajarkot	12441	52.6	11230	47.4	23671	100
Rukum	22381	69.0	10118	31.0	32499	100
Salyan	19456	54.2	16444	45.8	35900	100
Surkhet	17626	36.5	30688	63.5	48314	100
Sub-total B	**144253**	**45.87**	**170244**	**54.13**	**314497**	**100**
C. Mountain						
Bajhang	9823	35.6	17784	64.4	27607	100
Bajura	6871	35.1	12686	64.9	19557	100
Dolpa	3355	62.1	2044	37.8	5399	100
Humla	1694	24.9	5088	75.0	6782	100
Jumla	8284	55.7	6591	44.3	14875	100
Kalikot	10472	67.5	5040	32.5	15512	100
Mugu	4011	52.5	3622	47.5	7633	100
Sub-total C	**44510**	**45.71**	**52855**	**54.29**	**97365**	**100**
Total Project Districts	237417	47.9	257996	52.1	495413	100
Total Nepal	**1337965**	**39.8**	**2026174**	**60.2**	**3364139**	**100**

Source: National Sample Census of Agriculture, Nepal 2001/02, District Summary, CBS 2004.

Annex 2.9: Vegetation Types in the Basin Districts

		Bajh.	Bajura	Doti	Dadeld.	Humla	Mugu	Achh.	Dailekh	Kalikot	Jumla	Jajarkot	Dailekh	Dolpa	Rukk.	Surkhet	Kailali	Bardiya
Alpine	Upper Alpine Meadows	1	1			1	1				1	1		1	1			
	Dry Alpine Scrubs													1				
	Moist Alpine Scrubs	1	1			1	1			1	1	1		1	1			
Sub-alpine	Fir Blue Pine Forest													1				
	Birch-Rhododendron Forest	1	1			1	1	1		1	1	1		1	1			
	Fir Forest	1	1			1	1	1	1	1	1	1			1			
	Larch Forest																	
	Fir Oak-Rhododendron Forest	1	1															
	Fir-Hemlock-oak Forest	1	1					1	1	1	1	1						
	Sub-alpine Mountain Oak Forest	1	1			1	1			1	1							
Temperate	Upper Temperate Blue Pine Forest	1	1			1	1			1	1	1			1			
	Temperate Juniper Forest														1			
	Spruce Forest	1	1			1	1	1	1	1	1	1						
	West Himal. Fir-Hemlock-oak For.	1	1	1		1		1		1					1			
	Temperate Mountain Oak Forest	1	1					1		1	1	1			1			
	Mountain Oak-Rhododendron forest	1		1	1													
	Cedar Forest										1			1				
	Cypress Forest	1					1							1				
	Mixed Blue Pine-Oak Forest	1					1			1								
	Lower Temperate Oak forest	1	1	1	1	1		1	1		1	1			1			
	Decid. Walnut-Maple-Alder Forest					1	1			1	1	1			1			
	Olea Forest													1				
Sub-tropical	Chir Pine Forest	1	1	1	1	1		1	1	1		1			1	1	1	1
	Chir Pine Broadleaved Forest	1	1	1	1	1	1	1	1	1		1			1	1		
Tropical	Hill Sal Forest	1		1	1			1	1	1		1			1	1	1	1
	Lower Trop. Sal & Mixed Broadl. For.															1	1	1
	Trans-Himal. Upper Caragana Step.						1							1				
	Trans-Himal. Lower Caragana Step.					1	1											
	Trans Himalayan High Alpine Veg.						1							1				
	Total	**18**	**14**	**6**	**5**	**13**	**14**	**10**	**7**	**14**	**12**	**13**	**0**	**10**	**13**	**4**	**3**	**3**

Annex 2.10: Population Development Trend of the Basin Districts in different Census Periods

Region/District	Population by Census Year			
	1971	**1981**	**1991**	**2001**
Terai				
Banke	125,709	205,323	285,604	385,840
Bardia	101,793	199,044	290,313	382,649
Kailali	128,877	257,905	417,891	616,697
Kanchanpur	68,863	168,971	257,906	377,899
Sub-total A	**593,062**	**1,097,636**	**1,606,127**	**2,225,465**
B.Hill				
Achham	132,212	185,212	198,188	231,285
Baitadi	128,696	179,136	200,716	234,418
Dadeldhura	94,743	86,853	104,647	126,162
Dailekha	156,072	166,527	187,400	225,201
Doti	166,070	153,135	167,168	207,066
Jajarkot	86,564	99,312	113,958	134,868
Rukum	96,243	132,432	155,554	188,438
Salyan	141,157	152,063	181,785	213,500
Surkhet	104,933	166,196	225,768	288,527
Sub-total B	**1,106,690**	**1,320,866**	**1,535,184**	**1,849,465**
C. Mountain				
Bajhang	108,623	124,010	139,092	167,026
Bajura	61,342	74,649	92,010	108,781
Dolpa	19,110	22,043	25,013	29,545
Humla	29,524	20,303	34,383	40,595
Jumla	0	68,797	75,964	89,427
Kalikot	0	87,638	88,805	105,580
Mugu	25,718	43,705	36,364	43,937
Sub-total C.	**244,317**	**441,145**	**491,631**	**584,891**
Total Project District	**1,944,069**	**2,859,647**	**3,632,942**	**4,659,821**
Mid-Western Region		**1955611**	**2410414**	**3012975**
Far-Western Region		**1,320,089**	**1,679,301**	**2,191,300**
Nepal	**11,555,983**	**15,022,839**	**18,491,097**	**23,151,423**

Source: I) Statistical Year Book of Nepal, 2005 for 1981-2001 data ii) Nepal Census 2001 Indicators and Trends, ICIMOD/SNV/CBS 2001.

Annex 2.11: Increase in Population Density in the Basin Districts (1981-2001)

Region/District	Area in Square Km.	Population Density(person/Sq. Km.)		
		1981	1991	2001
A. Terai				
Banke	2,337	88	122	165
Bardia	2,025	98	143	189
Kailali	3,235	80	129	191
Kanchanpur	1,610	105	160	235
Sub-total A	**9,207**	**119**	**174**	**242**
B. Hills				
Achham	1,680	110	118	138
Baiatadi	1519	118	132	154
Dadeldhura	1,538	56	68	82
Dailekha	1,502	111	125	150
Doti	2,025	76	83	102
Jajarkot	2,230	45	57	60
Rukum	2,877	46	54	65
Salyan	1,462	104	124	146
Surkhet	2,451	68	92	118
Sub-total B	**17,284**	**76**	**89**	**107**
C. Mountain				
Bajhang	3,422	36	41	49
Bajura	2,188	34	42	50
Dolpa	7,889	3	3	4
Humla	5,655	4	6	7
Jumla	2,531	27	30	35
Kalikot	1,741	50	51	61
Mugu	3,535	12	10	12
Sub-total C	**26,961**	**16**	**18**	**22**
Total Project Districts	**53452**	**53**	**68**	**87**
Total Mid Western Terai	**7,317**	**92**	**127**	**168**
Total Mid-West Hill	**13,710**	**76**	**89**	**107**
Total Mid-Western Mountain	**21,351**	**11**	**12**	**14**
Total Far Western Terai	**4845**	**88**	**140**	**205**
Total Far Western Hill	**6762**	**89**	**99**	**118**
Total Far-Western Mountain	**7,932**	**36**	**42**	**50**
Nepal	**147,181**	**102**	**126**	**157**

Source: Population Monograph of Nepal, Volume1, UNFPA/CBS 2003.

Annex 2.12: Proportion of Urban Population in the Basin Districts (%), 1971-2001

District	1971	1981	1991	2001
A. Terai				
Banke	18.71	16.57	17.04	14.91
Bardia	0	0	0	12.02
Kailali	0	10.58	10.79	17.22
Kanchanpur	0	25.94	24.21	21.39
Sub-total A	**4.68**	**13.27**	**13.01**	**16.39**
B. Hills				
Achham	0	0	0	0
Baitadi	0	0	0	7.83
Dadeldhura	0	0	0	14.58
Dailekh	0	0	0	8.63
Doti	0	0	7.33	10.65
Jajarkot	0	0	0	0
Rukum	0	0	0	0
Salyan	0	0	0	0
Surkhet	0	8.34	10.14	11.63
Sub-total B	**0**	**0.93**	**1.94**	**5.92**
C. Mountain				
Bajhang	0	0	0	0
Bajura	0	0	0	0
Dolpa	0	0	0	0
Humla	0	0	0	0
Jumla	0	0	0	0
Kalikot	0	0	0	0
Mugu	0	0	0	0
Sub-total C	**0**	**0**	**0**	**0**
Total Project Districts	**1.56**	**4.73**	**4.98**	**7.44**
Mid West		**3.5**	**4.1**	**7.7**
Far West		**3.4**	**7.1**	**11.2**
Total Mountain		**0**	**0**	**2.6**
Total Hills		**6.9**	**10.3**	**16.7**
Total Terai		**7**	**9.6**	**13.1**
Nepal	**4**	**6.4**	**9.2**	**14**

Source: I) Nepal Census Indicators and Trends, 2001, ICIMOD / SNV/ CBS ii) Population Monograph of Nepal, Vol1, UNFPA/CBS, 2003.2001.

Annex 2.13: Trend of Economic Active Rate Population (%), 1971-2001

District	1971	1981	1991	2001
A. Terai				
Banke	50.48	62.97	47.36	49.78
Bardia	53.73	79.22	51.05	55.85
Kailali	58.73	61.4	49.87	59.44
Kanchanpur	53.36	65.96	52.08	59.89
Sub-total A	**54.075**	**67.3875**	**50.09**	**56.24**
Achham	63.2	78.76	81.83	77.61
Baitadi	67.58	72.81	69.71	66.43
Dadeldhura	58.1	69.72	74.03	64.43
Dailekh	48.03	78.17	71.66	68.12
Doti	57.3	74.29	76.94	73.23
Jajarkot	63.79	78	76.54	70.08
Rukum	60.65	68.21	71.61	63.43
Salyan	63.85	71	58.63	75.55
Surkhet	46.53	64.49	55.62	54.38
Sub-total B	**51.69**	**64.94**	**64.22**	**59.75**
Bajhang	76.25	63.93	75.67	74.64
Bajura	75.88	76.71	80.85	80.69
Dolpa	54.08	95.86	78.2	77.31
Humla	70.63	83.09	82.69	80.8
Jumla	0	86.27	78.42	80.88
Kalikot	0	89.97	82.24	58.49
Mugu	85.84	86.21	85.39	81.15
Sub-total C	**51.81**	**83.15**	**80.49**	**76.28**
Total Project Districts	**52.52**	**71.82**	**64.93**	**64.09**
Nepal	**59.33**	**65.13**	**56.56**	**58.21**

Source: Nepal Census Indicators and Trends, 2001, ICIMOD / SNV/ CBS

Annex 2.14: Population Projection of the Basin Districts 2006-2021 (Medium Variant))

Basin Districts	Growth Rate		Population Projection By Year				
	1991-2001	1991-2016	2006	2011	2016	2021	2026
A. Terai							
Banke	3.01	2.64	438,608	495,943	543,486	597,096	680,186
Bardia	2.76	2.66	432,587	485,224	531,742	582,764	664,506
Kailali	3.3	2.94	714,485	811,383	908,605	995,084	1,150,219
Kanchanpur	3.09	2.77	437,125	495,762	554,607	607,393	696,308
Sub Total A.	**3.04**	**2.75**	**2,022,805**	**2,288,312**	**2,538,440**	**2,782,337**	**3,191,219**
B. Hill							
Achham	1.54	1.75	254,166	276,483	299,490	328,005	333,761
Baitadi	1.87	1.9	257,659	280,322	303,681	332,592	365,412
Dadeldhura	1.87	2.1	139,669	152,844	166,329	182,164	202,112
Dailekh	1.84	1.94	249,358	271,416	297,438	322,985	355,554
Doti	2.14	1.82	230,644	253,659	277,100	303,476	332,116
Jajarkot	1.68	1.98	148,818	161,187	176,639	191,514	211,240
Rukum	2.14	2.04	209,025	228,121	249,990	271675	300,540
Salyan	1.61	1.93	235,179	254,086	278,446	301,664	331,920
Surkhet	2.45	2.44	323,930	359,714	394,201	430,699	485,838
Sub Total B.	**1.90**	**1.76**	**2,048,448**	**2,237,832**	**2,443,314**	**2,664,774**	**2,918,493**
C. Mountain							
Bajhang	1.83	1.9	184,742	202,022	219,723	240,641	245,333
Bajura	1.67	1.91	119,899	130,738	141,878	155,384	131,795
Dolpa	1.67	1.94	32,587	35,272	38,654	41,901	46,126
Humla	1.66	2.1	44,769	48,454	53,099	57,556	63,859
Jumla	1.63	1.87	98,558	106,567	116,783	126,549	108,124
Kalikot	1.73	1.89	116,621	126,500	138,627	150,370	165,127
Mugu	1.89	1.67	48,709	53,114	58,205	63,238	68,698
Sub Total C.	**1.73**	**1.90**	**645,885**	**702,667**	**766,969**	**835,639**	**829,062**
Total Project Districts	**2.22**	**2.14**	**4,717,138**	**5,228,811**	**5,748,723**	**6,282,750**	**6,938,774**
	2.25	**2.22**	**26,005,554**	**29,060,622**	**32,218,337**	**35,387,192**	

Source: i) Population Projection of Nepal, 2001-2021, CBS 2003. ii) Population Projection for Nepal, Sub-National Projection, Volume II Ministry of Population and Environment June 1998.

Annex 2.15: Growth Trend of Literacy Rate in the Basin Districts

District	Total Literacy Rate				Male Literacy Rate				Female Literacy Rate			
	1971	**1981**	**1991**	**2001**	**1971**	**1981**	**1991**	**2001**	**1971**	**1981**	**1991**	**2001**
A. Terai												
Banke	12.3	18.16	34.6	57.84	18.5	26.17	46.4	66.01	5.1	9.58	21.8	49.24
Bardia	5.4	13.89	29.4	45.73	8.4	19.17	41.6	55.47	2	7.86	16.8	35.87
Kailali	7.1	16.04	30.3	52.6	11.9	24.4	45.3	63.97	1.6	6.59	15.1	41.05
Kanchanpur	11.6	23.76	41	60.12	18.6	33.28	58.5	72.81	3.2	12.07	23.1	47.16
Sub-total A	**9.10**	**17.96**	**33.83**	**54.07**	**14.35**	**25.76**	**47.95**	**64.57**	**2.98**	**9.03**	**19.20**	**43.33**
B. Hills												
Achham	6.1	14.98	23.9	33.79	11.9	23.86	45.3	54.11	0.6	7.26	5.5	16.04
Baitadi	14.1	20.2	35.7	51.91	25.4	32.86	60	71.5	2	8.15	13.5	33.77
Dadeldhura	14.1	21.9	36.6	51.91	27.6	32.5	62.3	72.18	1.3	10.58	13	33.3
Dailekh	8.4	18.63	29.8	48.04	16.1	29.77	48.3	64.73	0.7	7.06	11.3	32.25
Doti	7.1	12.74	28.6	43.68	13.3	19.88	48.7	61.21	1.2	5.87	9.9	26.02
Jajarkot	5.1	11.46	23.6	39.52	9	17.86	38	49.36	1	4.57	9	29.06
Rukum	6.9	13.79	28.8	40.27	12.9	23.22	46.8	51.05	1	4.02	11.3	29.02
Salyan	9.5	13.51	29.8	48.48	18.2	21.88	47.5	60.2	1.2	5.02	12.5	36.23
Surkhet	10.7	21.52	42.6	62.69	19	43.22	60.2	73.04	1.9	9.69	25.5	51.69
Sub-total B	**9.11**	**16.53**	**31.04**	**46.70**	**17.04**	**27.23**	**50.79**	**61.93**	**1.21**	**6.91**	**12.39**	**31.93**
C. Mountain												
Bajhang	9.6	12.93	27.6	35.54	17.6	20.71	50.1	57.57	1.3	4.67	7	15.25
Bajura	4.1	11.58	25.2	34.14	7.8	18.86	43.4	51.18	0.5	4.73	7.7	17.32
Dolpa	5.3	12.59	23.3	34.98	8.9	19.35	37.5	49.55	1.6	5.13	8.4	19.83
Humla	6.1	13.12	19.6	27.09	10.9	22.09	33.7	41.28	0.7	3.36	4.6	11.76
Jumla	0	18.22	25.4	32.52	0	27.19	41.5	47.02	0	8.74	8.5	16.77
Kalikot	0	8.54	19.6	38.47	0	13.83	33.6	54.19	0	2.86	5.1	17.81
Mugu	5.2	9.47	22	28	9.3	16.23	37.9	45.38	0.8	2.13	5.2	9.27
Sub-total C	**4.33**	**12.35**	**23.24**	**32.96**	**7.79**	**19.75**	**39.67**	**49.45**	**0.70**	**4.52**	**6.64**	**15.43**
Total Project Districts	**7.51**	**15.61**	**29.37**	**44.58**	**13.06**	**24.24**	**46.14**	**58.65**	**1.63**	**6.82**	**12.74**	**30.23**
All Nepal	**13.9**	**23.3**	**39.6**	**54.1**	**23.6**	**34.0**	**54.5**	**65.5**	**3.9**	**12.0**	**25.0**	**42.8**

Source: Nepal Census Indicators and Trends, 2001, ICIMOD / SNV/ CBS

Annex 2.16: Change in Households Living Status 1991-2001 (% of households in district)

District	Perman.	Perman.	Semi-perman.	Semi-perman.	Im-perman.	Im-perman.	Not Stated	Not Stated
	1991	**2001**	**1991**	**2001**	**1991**	**2001**	**1991**	**2001**
A. Terai								
Banke	22.05	29.79	17.45	25.5	59.74	42.9	0.75	1.81
Bardia	5.74	12.69	12.57	25.22	78.95	61.42	2.73	0.66
Kailali	8.17	15.24	33.13	34.2	57.86	49.67	0.84	0.89
Kanchanpur	12.08	21.73	29.14	30.56	56.66	46.5	2.12	1.21
Sub-total A	**12.01**	**19.86**	**23.07**	**28.87**	**63.30**	**50.12**	**1.61**	**1.14**
B. Hills								
Achham	62.14	68.73	31.25	26.81	6.1	4.24	0.51	0.21
Baitadi	96.84	96.72	1.72	2.69	1.16	0.43	0.28	0.16
Dadeldhura	69.54	72.94	16.76	14.81	13.07	11.98	0.63	0.26
Dailekh	38.21	52.5	33.85	40.73	27.11	6.55	0.84	0.22
Doti	73.69	79.02	11.53	15.29	13.94	5.38	0.84	0.31
Jajarkot	60.26	68.36	25.99	26.13	11.77	5.27	1.98	0.24
Rukum	21.8	33.41	73.7	49.66	4.03	16.61	0.47	0.32
Salyan	6.61	23.68	65.4	51.89	27.18	23.98	0.81	0.46
Surkhet	6.4	19.74	25.28	32.36	67.38	47.39	0.94	0.5
Sub-total B	**48.39**	**57.23**	**31.72**	**28.93**	**19.08**	**13.54**	**0.81**	**0.30**
C. Mountain								
Bajhang	59.83	66.77	22.57	25.04	17.39	8.01	0.22	0.17
Bajura	33.26	63.23	41.32	31.25	24.96	5.19	0.46	0.33
Dolpa	1.63	1.88	97.04	95.11	0.87	2.97	0.46	0.05
Humla	0.62	0.93	94.25	98.43	5.02	0.49	0.11	0.14
Jumla	1.59	3.14	97.5	95.89	0.72	0.86	0.18	0.1
Kalikot	20.54	32.08	70.38	57.26	8.25	10.66	0.83	0
Mugu	1.93	1.42	94.84	84.98	3.17	13.5	0.06	0.1
Sub-total B	**12.03**	**14.97**	**54.53**	**53.10**	**4.61**	**3.28**	**0.26**	**0.07**
Total Project Districts	**24.14**	**30.69**	**36.44**	**36.97**	**29.00**	**22.31**	**0.89**	**0.50**
All Nepal	**23.51**	**36.61**	**24.81**	**29.18**	**49.70**	**33.46**	**1.98**	**0.75**

Source: Nepal Census Indicators and Trends, 2001, ICIMOD / SNV/ CBS.