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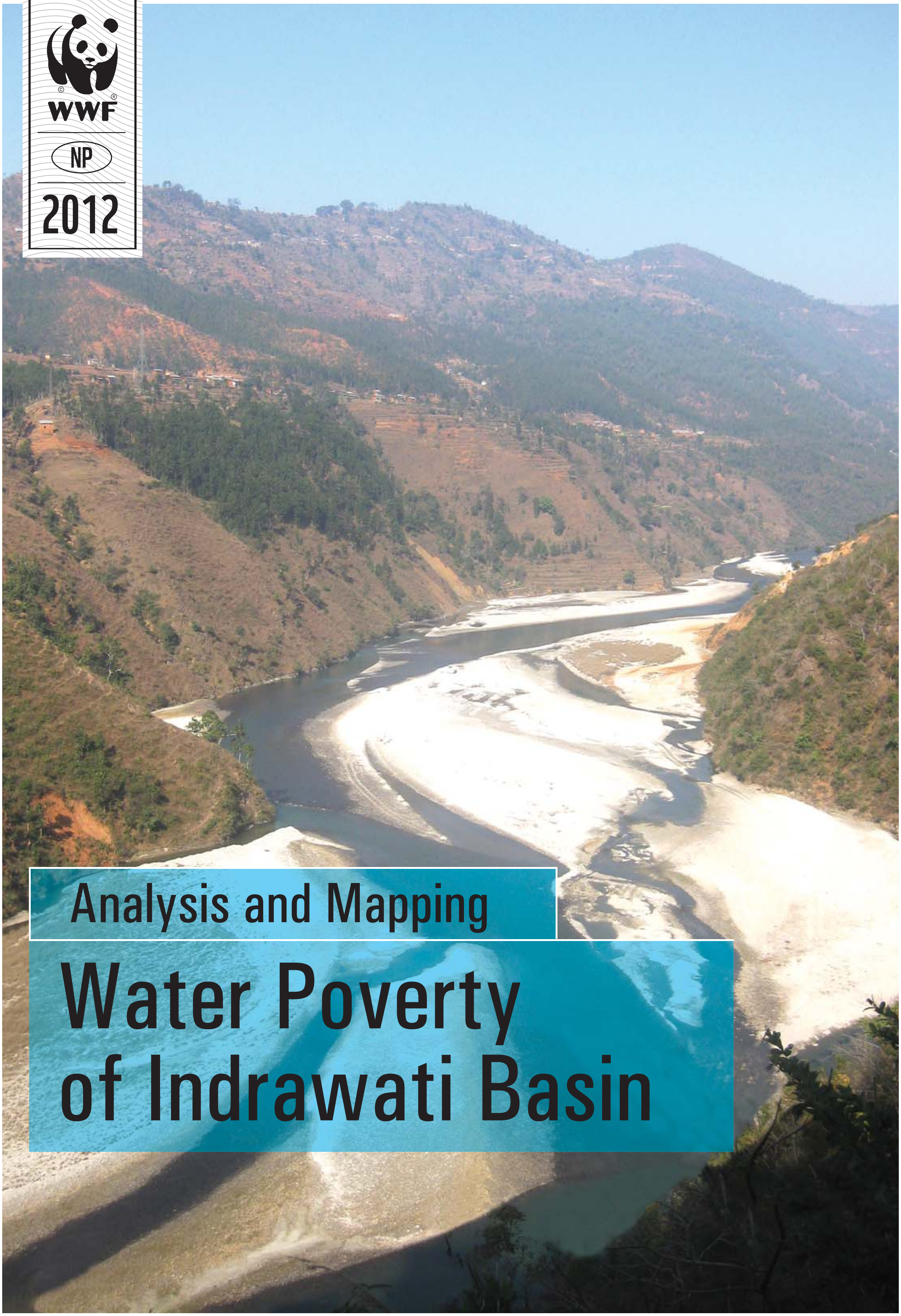

Analysis and Mapping

Water Poverty of Indrawati Basin

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Contents

Abbreviations And Acronyms

A	Access
BOD	Biological Oxygen Demand
C	Capacity
CBS	Central Bureau of Statistics
DHM	Department of Hydrology and Meteorology
DO	Dissolved Oxygen
E	Environment
eWPI	Enhanced Water Poverty Index
FC	Fecal Coliform
IPCC	Intergovernmental Panel on Climate Change
l/c/d	Liters per Capita per Day
m^3/s	Cubic Meters per Second
mm	Millimeters
MPRC	Mega Publication and Rearch Center
ppm	Parts Per Million
R	Resource
U	Use
VDC	Village Development Committee
WHO	World Health Organization
WPI	Water Poverty Index
WQI	Water Quality Index
WWF	World Wide Fund For Nature
GIS	Geographic Information System
NSF	National Sanitation Foundation, Ann Arbor, Michigan

Summary

The idea of a Water Poverty Index (WPI) with a numerical value was formulated by scientists in an effort to express the complex relationship between sustainable water resource management and poverty at all units of human organization, all the way from community to nation. The numerical values generated for the WPI are then used to create a Water Poverty Map, which presents a clear visual picture of the water situation in the given area.

Initially, 'Water Poverty' was measured as a combination of resource availability and people's ability to access the resource. Sullivan et. al. (2002) formulated the WPI to consider all the aspects involved with water management. Consequently, the WPI defines water poverty according to five components – Resource, Access, Capacity, Use and Environment.

The study area for this research project is the Indrawati River Basin in the Central Region of Nepal. The WPI is calculated for the basin and subsequently a Water Poverty Map is drawn on a High-Medium-Low category scale. The estimated average WPI for the entire basin is 52.5 points (medium water poor) out of 100. Out of a total of 20, component scores of 13.2 for Resource, 11.0 for Access, 6.7 for Capacity, 9.8 for Use and 11.8 for Environment were calculated. In the upper parts of the basin, the Resource component is high whereas Capacity is low. The reverse is true in the lower parts of the basin where Resource is 'medium low' but Capacity ranges from 'medium low' to 'medium'.

Field investigations were carried out to verify the calculated WPI with the situation on the ground. Through the course of the field investigations, local residents across the study area identified the drying up of water sources, poor capacity, poor accessibility, deforestation and chemical fertilizers as major factors causing water poverty in the Indrawati Basin.

Chapter 1 Introduction

Water poverty is a deeply entrenched and complex phenomenon across Nepal. Despite some progress in water poverty reduction in recent years, it remains a pervasive and widespread problem across the country.

Water poverty has persisted in Nepal due to increasingly poor water quality, low economic growth, inadequate water supply, poor irrigation systems, relatively high population growth, and the inaccessibility of water sources. In addition, institutional weaknesses at both the government and non-government levels as well as lack of good governance result in the continuation of water poverty.

Another significant cause of water poverty in Nepal is the harsh mountainous topography, which makes up about 70 percent of the country's total area. In the mid-hill and high mountain regions of Nepal, most households have little or no access to basic social services such as primary health care, higher education, clean drinking water and sanitation services. In addition, nearly 80 percent of the mountain labor force is engaged in agriculture despite poor irrigation facilities.

Due to a combination of the arduous topography and the population's lack of capacity, water poverty levels are far more chronic in the rural mountain regions than elsewhere in Nepal. This is reflected in the overall poverty survey conducted bythe Central Bureau of Statistics during 1994-95; while 42 percent of the total population is below the poverty line (cited Hussain I. et al 2004), the percentage rises significantly in the rural and mountain areas, with 44 percent of the total rural population and 56 percent of the rural mountain population falling under the poverty line. (CitedHussain I. et al. 2004).

Keeping in mind the direct relationship between water and poverty, this project sought to calculate the WPI and draw a Water Poverty Map of the Indrawati Basin of Nepal. The research was carried out at the VDC level, the smallest administrative unit of the country. To accomplish the above objectives, the researchers required a good diagnosis of the prevailing situation, including an index detailing the Resource, Access, Capacity, Use and Environment components of the WPI. Consequently, the data collected for this project focused on the assessment of water poverty related indicators such as water availability for agriculture and household uses, its accessibility, water stress, water utilization. Both field outcome data and published secondary data were synchronized to calculate WPI and using the GIS software, Water Poverty Maps are drawn.

BOX I: Water-based Poverty Alleviation Initiatives

Water resources development has been a key component in most poverty alleviation plans, programs and initiatives. The key role of water resources in poverty alleviation plans is evident in the highest importance accorded to irrigation development. At the village/farm level, the impact of micro-irrigation facilities which allow poor farmers to plant high-value labor-intensive cash crops is evident. This increases their income several fold, as can be observed in several districts in Nepal.

Source: Hussain I. et al 2004

1.1 The Water Poverty Index

The concept of water poverty evolved due to the work conducted on water resource assessments at a global scale. Initially, 'water poverty' was measured as a combination of resource availability and people's ability to access the resource. For instance, people were considered water poor if sufficient water for their basic needs was not available. Similarly, they were water poor if they had to walk long distances to collect water. Overall, only the availability of natural water sources at the village level was considered in calculating water poverty. Subsequently, it was realized that many other factors apart from availability and access can be responsible for water poverty. Today, it is accepted that people can be water poor because, among other reasons, they do in draw in an adequate income. People can also be water poor if they do not have the means to ensure purification of drinking water. The WPI was then developed to express the complex relationship between sustainable water resource management and poverty at all levels, whether community, village, district, region or nation. In recent times, WPI is used as a policy tool to assess the degree to which water scarcity impacts human populations.

In its first iteration, Sullivan et al (2002) formulated the WPI to consider all the aspects involved with water management. Consequently, the WPI defines water poverty according to five components – Resource, Access, Capacity, Use and Environment – which are described in detail in Section 2.2. Though it requires large micro data sets, the calculation process for the WPI is simple, cost effective and easy to understand.

Today, the WPI method is widely used to study water poverty. Cook et al (2007) used Bayesian Networks to calculate values for the above-mentioned five component of WPI, linking water and poverty in the Volta Basin of Ghana. Lawrence et al (2002) published a comparative study, presenting the WPI of different countries from across the globe. For Juarez Municipality in Mexico, Castelazo et al (2007) incorporated flood risk vulnerability as a variable into the Capacity component as part of the disaster management sub component. Van der Vyver and Dawid (2010) calculated WPI and developed Water Poverty Maps for certain areas in South Africa. To produce a holistic tool for policy makers, Garriga and Foguet (2009) combineda pressure–state–response function into the original WPI calculation.

As the Sullivan et al method demands many datasets to calculate WPI, it can often be difficult to acquire all the necessary information. To address this issue, Olotu et al(2009) developed a simpler method to calculate WPI, including three parameters:adjusted water availability (%), population with access to safe water and sanitation (%), and time and effort taken to collect water for the household. Olotu et al also introduced a time analysis approach, which assumes that water poverty is directly tied to the household's distance from the water source, to calculate the WPI.

The first to articulate the idea of a WPI, Sullivan et al tabulated 21 possible indicators to calculate WPI. Subsequently, Merz (2004) tabulated 111 possible indicators, of which 20 are required for 'Resource', four for 'Access', seven for 'Use', seven for 'Capacity' and seven for 'Environment'. Garriga and Foguet (2009) noted 17 indicators, including a climate vulnerability index in their study at JuerazMunicipality in Mexico. Meanwhile, the simplest WPI derived from Olotu et al (2009) included only time and collected volume of water as indicators to derive WPI in the Ondo State of Nigeria.

In the brief period of a decade, the scale of research carried out has ranged from the level of a small community to a country. Notable work has also been carried out in Nepal where Merz (2004), using the Sullivan et al method, calculated components of WPI for the Jhiku and Yarsha catchments, both neighboring the Indrawati Basin.

Furthermore, WPI in the form of a 'Water Poverty Map' is easily understandable, providing a visual overview of the overall water poverty situation across a large area. Cullis (2005) combined the strengths of the WPI with poverty mapping and geographic targeting to develop a Water Poverty Map of the Eastern Cape Province in South Africa. Similarly, Garriga and Foguet (2009) have developed a Water Poverty Map of the Jequetepeque River Basin based on an enhanced WPI.

BOX II:Application of WPI at the Catchments Scale

The WPI methodology has also been applied at the basin scale in sample catchments in Nepal (The Jhikhu Khola and the Yarsha Khola, both in the middle mountains), Pakistan (Hilkot) and India (the Bhetagad basin) (Merz, 2004). These WPIs were calculated using datasets from the People and Resource Dynamic Project (PARDYP), which were generated from a hydro-meteorological research network in the Hindu Kush Himalayas. Key variables were selected to represent the five main components of the WPI. The results show that although there is some similarity between these small catchments in terms of Resource availability, Jhikhu Khola (Nepal) has the lowest score on that component. Both catchments in Nepal score better than those in India and Pakistan in terms of Access and Capacity; but in terms of Environment, the Hilkot catchment in Pakistan scores the highest. Overall scores show the situation to be the worst in the Bhetagad catchment, where the WPI score is 51.6, followed by 56.6 in JhikhuKhola, 56.6 in Hilkot and 57. 7 in Yarsha Khola. The numbers suggest that although there are improvements to be made everywhere, the most urgent attention should be given to communities in the Bhetagad catchment.

Source: Sullivan et al (2006)

1.2 Advantages of the WPI

The WPI is a key tool in water management, helping to improve water management in the given areas. The WPI is also useful in identifying areas with high levels of water poverty, proving useful in the designing of water related policies. Moreover, the WPI is one of the best tools to study climate vulnerability. In fact, with the addition of just a few components, the WPI can be used to determine the Climate Vulnerable Index (CVI).

Chapter 2 Materials and Methods

2.1 Description of Study Area

The Indrawati Basin is located in the Central Region of Nepal, between latitudes 27° 37' 11" to 28° 10' 12" North and longitudes 85° 45' 21" to 85° 26' 36" East. The research area covers VDCs that lie within the Indrawati Basin in Kavrepalanchok, Sindhupalchok, Kathmandu, and Nuwakot districts. The list of VDCs included in the study are presented in Annex B-I. The Cha Khola (stream) tributary is studied separately because it joins the Indrawati River just 400 meters upstream from the merging point of the Indrawati and the massive Sunkoshi River. In addition, the Cha Khola Basin appears more as a small sub basin of the Sunkoshi Basin rather than of the Indrawati. Besides, the VDCs oriented to the Cha Sub Basin are different in make-up as compared to those oriented to the Indrawati. The position of the Cha Sub Basin is shown in Figure 2.3.

The Indrawati Basin boundary included in the study has a surface area of about 1140 km2 of which 148 km^2 are covered by snow and glaciers, and shares boundaries with Kathmandu, Nuwakot and Bhaktapur districts to the West and Rasuwa district to the Northwest. The study area has a population of about 202,000 (2001 census), with a projected population of 244,000 (Annex B- II) for 2011. Interestingly, data from the 1991 and 2001, National Census indicate a population growth rate of 1.60% per annum in Sindhuplachowk district and 1.75% in Kavrepalanchowk district, both significantly below the national average of 2.2% per annum.

Ranging from an altitude of 800 meters to more than 4000 meters above sea level (Figure 2.1), the basin enjoys tropical to tundra climate. The basin has two distinct seasons – the wet season (June-September) and the dry season (Jan-May, Oct-Dec). The relative humidity over the study area ranges between 85% and 100% during the rainy season.

Several rivers run through the basin, of which the Melamchi is the major contributor. There are other smaller rivers across the basin: Larke, Yangri, Jhyangri, Handi and Mahadev. Rainfall and snowfall are the sources of inflow into the Indrawati Basin. Since there is no river water gauging stations at higher elevations, the contribution from snowmelt alone is difficult to estimate.

A total of 56 VDCs lie within the study area, out of which 47 were considered for the study (Figure 2.2). Some VDCs were excluded from the study as only their small and uninhabited areas lie inside the Indrawati Basin. The study covers approximately 90 percent of the total area of Sindhupalchowk and 10 percent of Kavrepalanchowk, Kathmandu and Nuwakot districts each. Some socio-demographic indicators of Sindhupalchok and Kavrepalanchok are presented in Table 2.1, while the VDCs within the study area are presented in Figure 2.2 and Map No 1.

Table 2.1: Indicators in Percentages

Indicator	Districts	
	Sindhupalchok	Kavrepalanchok
% of Pipe water coverage	82	80.4
% of Toilet Facilities	18.3	9.22
% of Irrigated Area	71.7	46.1

Source: MPRC Database, (2011)

Figure 2.1: Distribution of elevation in the Indrawati Basin.

Figure 2.2: Basin with Village Development Committee (VDC) and major river system

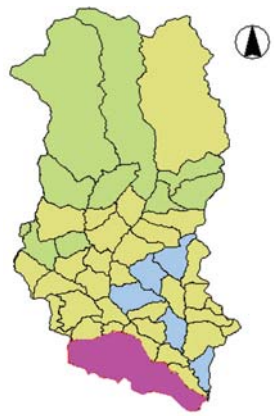

Figure 2.3: Cha Sub-Basin (yellow) in the Indrawati Basin

2.2 Theoretical Framework of WPI for the Indrawati Basin

The theoretical framework of the WPI used in this study encompasses water resources availability, people's ability to access water, people's ability to sustain access to water, people's ability to use this resource for productive purposes, and the environmental factors which impact the ecology which water sustains. In brief, it has been designed to integrate into a single value five key issues relating to water resources. The Resource (R) component combines rain, surface and groundwater availability, taking into account seasonal and inter-annual variability. Access (A) to water includes not only safe water for drinking and cooking, but also water for irrigating crops or for non-agricultural use. The Use (U) variable focuses on the purpose for which water is consumed in households as well as in different productive sectors, such as livestock and agriculture. Capacity (C) comprises a set of indicators focusing on the human development of a region or area, aiming, where possible, to capture institutional water capacity. The Environment (E) component combines variables such as biodiversity, environmental degradation, soil erosion and water quality, which are likely to impact ecological integrity.

2.3 WPI Structure

The five key components identified above are combined to calculate the WPI. The final value of the WPI for a particular location as described by Lawrence et al, (2003) is presented in Equation 1:

$$WPI = \frac{W_1 \times R + W_2 \times A + W_3 \times U + W_4 \times C + W_5 \times E}{W_1 + W_2 + W_3 + W_4 + W_5} \qquad (1)$$

The weights (W_i) applied to each of the five components (R, A, C, U & E) are constrained to be non-negative and sum to unity.

All parameters are standardized to fall in the range 0 to 1, where value 0 is assigned to the poorest level (i.e. highest degree of water poverty), and 1 to optimum conditions.

The component's index is basically determined by Equation 2:

$$Index = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \qquad (2)$$

Where,

Index = Resource, Access, Capacity and Use
X_i= Real value of each parameter
X_{max}= Real value of each parameter of the country/region with the highest value
X_{min}= Real value of each parameter of the country/region with the lowest value

The fifth parameter (Environment) is determined by averaging the values obtained for each one of its components: water quality and biodiversity. The index shows the position with relation to a country or region.

2.4 Standardization of the WPI

The value obtained for each parameter (R, A, C, U, E) through equation 2, will result in a value between 0 and 1. The indicator resulting in an inverse is deducted by 1 to harmonize it with other indicators. The resulting value for each parameter is multiplied by 20 and the results are added to obtain the final WPI, which should fall between 0 and 100.

In reality, it is almost impossible to get a WPI score of either 0 or 100 for any large settlement. To date, the lowest WPI found ranges between 15-25 and the highest between 80-85. Therefore, this range is adopted as the minimum benchmark for water poverty mapping.

2.5 Indicators Used

The Indrawati Basin lies between the mid- and high-mountains of Nepal, where the residents are completely dependent on naturally flowing water resources. The few hydrological information available for the basin do not represent the whole basin. It was also not possible to survey the resources, the degree of access and other micro data in the field within the limited project time. Therefore, looking at the local physiographic condition, as well as available socioeconomic and demographic data, indicators selected for the study are depicted in Table 2.2.

Table 2.2: Indicators Used to Calculate WPI

Component	Indicators
Resource	* Runoff potential * Rain potential * Variability of rainfall
Access	* Time required to carry water * Reliability of pipe water supply * Percentage of agricultural land with access to river for irrigation
Capacity	* Percentage of households with economic activities * Literacy rate
Use	* Total percentage of households owning only agricultural land * Totalpercentage ofhousehold with agricultural land and livestock * Water required per household, keeping household size in mind.
Environment	* Quality index of water sources with percentage of people dependant on similar water quality. * Percentage of area with natural vegetation.

2.6 Data Collection

The data collection process includes secondary data and maps from authorized sources, published books and data from field investigation. During field work, demographic, socioeconomic, meteorological and hydrological data were all collected. The basic spatial data is generated from a recent @Google Earth Image (2011).

2.7 Calculation of Components

This section will discuss the calculation method for each of the component values, the benchmark level for each, and the final score that will be used to compute the WPI. The indicators to be used for the various components as well as the benchmark levels have been selected according to data availability in the country. The process includes sub-index calculations, followed by the final WPI calculations from equation 1. The weights in the equation can be estimated as per the local condition of the VDCs.

Note For WQI, the method derived by the National Sanitation Foundation (NSF), Ann Arbor, Michigan, as detailed in section e., is adopted.*

Resource (R)

The Resource (R) component is calculated as

$$R = \frac{I_R + I_k}{2} \times 20 \qquad (3)$$

Where, I_R is rain index and I_k is runoff index.

If annual rainfall provides a surplus over water requirement for annual crop rotation in the area, the rain source is surplus i.e. Rain index (I_R) rating =1.

If rainfall is 'p' percent less than water requirement for annual crop rotation, the Rain sub index (I_R) rating is 1-p/100. As climate variability makes rainfall uncertain, the rainfall variability is multiplied to rainfall to obtain adjusted rainfall.

The rating of runoff as runoff index (I_k) is calculated by comparing present runoff with sufficient perennial runoff, which has a maximum benchmark of '1'. If surface water available for households, livestock, agriculture and other uses is in surplus or if water flow at a nearby source/tap is perennial and fulfills all demands, then the surface water rating is 1. Many settlements along the major snow fed river will get benefit from these rivers. The portion of such settlements in VDC is calculated as perennial river benefit factor 'B' (benefit for all settlements = 1). The factor is multiplied perennial runoff index value '1' and non beneficial (1-B) is multiplied to runoff index derived from rainfall to calculate corrected runoff index.

If discharge data is not available, the simple runoff formula can be used as:
$R = P \times K \times 10^3/365$
Where, K is a runoff coefficient,
P is adjusted annual rainfall in meters
R is runoff in $10^3/d/km^2$
Adjusted annual rainfall= annual rainfall x rainfall variability factor
The rainfall variability factor is

$$I_{Pv} = 1 - coef.\text{var}$$

Where; Coef.var is the coefficient of variability of annual rainfall.

Access (A)

Access (A) component is calculated as

$$A = \frac{I_d + I_i}{2} \times 20 \qquad (4)$$

Where, I_d is household water carrying time index and I_i is irrigation access index
Water carrying time is inverse to score. Thus, the water carrying time index is:

$$I_d = 1 - \frac{T}{480} \qquad (5)$$

Where, T is time required to collect (both ways) and store water. The –ve value will be adjusted to zero. Based on field investigations, the maximum time taken to carry water is 480 minutes and the minimum, with a direct pipe supply in the house, is zero.

Note At VDC scale, I_d can be computed as $I_d = (w_1 \times I_{d1} + w_2 \times I_{d2})/(w_1 + w_2)$ Where, w_1 is household that depend on a distant water source and w_2 is household that depend on pipe water source.*

I_{d2} is time index for house pipe water collection.

Walk time is calculated from an online web calculator. The calculator was designed after consultations with walkers in Walking Groups who agreed on average walk times. The parameters in the calculator are:

Walking time	=	2.5 miles per hour
Climbing Time	=	1 minute for every 10 meters ascent
Descent Time	=	1 minute for every 25 meters descent
Breaktime	=	1 minute per break minute

Source: Online walking calculator is provided by Mr. Antony Carlos and walking Englishman.

Irrigation access Index

$$I_i = \frac{T_i}{T_a} \quad (6)$$

T_i is total area with access to irrigation facility, T_a is total arable land.

Capacity (C)

The capacity component (C) is calculated as

$$C = \frac{I_c + I_{ic}}{2} \times 20 \quad (7)$$

Where, I_C is education capacity index and I_{ic} is income capacity index

Education capacity index $I_c = \frac{L}{100}$ and

Income capacity index $I_{ic} = \frac{T_e}{T_h}$

Where, L is literacy rate, T_e is household engaged in economic activities in the VDC and T_h is total number of households in VDC.

Use (U)

The Use (U) component is calculated as

$$U = \frac{S - S_{min}}{S_R - S_{min}} \times 20 \quad (8)$$

Where, S is water using by a household (l/c/d), S_{min} is assumed minimum water requirement (l/c/d) and S_R is optimum water needed in a household (l/c/d).

Again,

$$S = K/H_s \quad (9)$$

Where, H_s is household size and

$$K = \frac{L_a \times H_a + L_b H_b}{H_T}$$

Where, L_a is daily water collection in liters for households (H_a) having only agricultural land and L_b is daily water collection in liters for households (H_b), having agricultural land plus livestock, H_T is the total number of households and H_s is household size.

BOX III: WATER USE

According to the World Health Organization (WHO), a person requires roughly 25 liters of water per day to promote healthy living. According to Cullis (2005), the maximum (optimum) level for Use inthe South African environment is 160 l/c/d. A Use component score of 20 indicates an optimum consumption level of 160 l/c/d.

Source: Jordaan D. B. 2010

Environment (E)

The component E can be estimated as the average of the WQI and the natural vegetation coverage index. The Environment (E) component is calculated as

$$E = \frac{I_w + I_v}{2} \qquad (10)$$

Where, I_w = WQI is water quality index and I_v is natural vegetation coverage index.

Water Quality Index (WQI)

According to the work of the National Sanitation Foundation (NSF), WQI is the weighted linear sum of the sub-indices (I):

$$WQI = \sum_{i=1}^{9} W_i I \qquad (11)$$

Based on the ratings by respondents, the weights of the nine constituents were shown in Table 2.1.

Table 2.3: Chosen Parameters for NSF -WQI

Variable	Importance Weight ,Wi
DO	0.17
FC	0.15
pH	0.12
BOD5	0.10
NO3	0.10
PO4	0.10
Temperature Variation	0.10
Turbidity	0.08
Total Solids	0.08

Source: http://www.waterresearch.net/watrqualindex

A set of weights were derived for the index which would sum up to 1.0 but would also reflect the significance rating assigned to the variables by the panelists.

The percentage of people dependant on the particular quality can be taken as a weight to calculate the effective water quality index eWQI.

$$I_w = \text{eWQI}$$

Natural Vegetation Index

The natural vegetation index can be calculated as

$$I_V = \frac{V}{A} \qquad (12)$$

Where, I_V is Natural Vegetation Index, V is natural vegetation coverage area and A is total area of the VDC.

2.8 Scaling the Water Poverty Map

The literature survey outlined earlier confirms that the scale for WPI analysis ranges from the small community to the national level. In this project, a map at the VDC scale was deemed the most feasible because published and publicly available data exists for VDCs. The dispersal or enlargement of settlements in the future will change the features of the map.

2.9 Construction of Water Poverty Map

After calculating the WPIs, the next step in the process is the construction of theWater Poverty Map. To this end, the VDC boundary maps are collected, scanned, digitized and geo referenced. The WPI is then rescaled on a category of high-medium-low, and the Map is constructed using the rescaled WPI value and the Arc View GIS software. Practically speaking, neither a 100 nor a 0 score is possible. Based on the literature review, WPI scores ranging from 80 to 26 have been established. For the purposes of this project, we assume a maximum benchmark of 85 and a minimum of 15. The water poverty intensity scale is shown below:

75-85	Very Low
65-75	Low
55-65	Medium Low
45-55	Medium
35-45	Medium High
25-35	High
15-25	Very High

Any value above 100 or below zero will be adjusted to 100 or Zero, with any number above 75 considered very low and below 25 considered very high.

Likewise, all component scores are divided by seven with 45-55 percent the medium range used to draw component or sub-index maps.

Chapter 3 Calculation of WPI

3.1 Global Overview

Lawrence et al (2002) derived WPIs for a number of countries across the globe and found the situation to be the direst in Haiti, where all components except Capacity are far below 50 percent. Most of the other low-scoring countries are in Africa. Interestingly, most countries in the Middle East scored above 50 percent even though their Resource component is very poor. The highest WPI of 78 is found in Finland. Indeed, most of the high-scoring countries are in Northern Europe, excepting Australia and Canada. The perfect water supply management can be attributed to Germany, where, although the Resource index is just 6.5 out of 20, the Access score is a perfect 20.

Based on the WPI value, the most effective water supply management exists in the United Arab Emirates (UAE). Even though their Resource value is zero, the UAE has a WPI score of 50 with Access at 18.6 and Use at 17.1. In Nepal, the WPI score is 54.4, with Access a major issue, likely due to the harsh topography and poor government planning. The WPI in global scale is depicted in Annex B-XI.

The international WPI scores suggest that the change in precipitation patterns caused by global climate change will more severely impact those countries that rank high on Resource availability but have poor Capacity and Access.

3.2 Data and Software Used

The calculation of a WPI for the Indrawati Basin is based on published National Census Data for the VDC level, available hydrological and meteorological data, laboratory analyzed data, online software, and available authorized maps, Google Earth Images (2011) and data from field investigations. Microsoft @EXCEL was used for detailed calculations. The summary of basic information collected during field investigations is presented in Annex -A.

3.3 Calculation of WPI Components

Both desk and field work have been carried out to calculate the WPI of the Indrawati Basin. The calculation is based on available hydrological, meteorological and socio-demographic data, satellite images and data collected during field investigations. The calculated sub-indices reflect the average condition of a particular VDC rather than that of individual communities within the VDC in question. The calculated WPI component is rescaled on a category of high-medium-low,and maps are also constructed with equal seven division of component value.

3.3.1. Resource (R)

Rainfall potential index:

Thirteen meteorological stations in and around the Indrawati Basin were considered for the rainfall analysis. The monthly rainfall data with station index is presented in Annex B-III.

The estimated crop water requirement for crop rotation – rice, wheat and maize – is 2018 mm/year in Jhikhu Catchment (Merz 2004), which forms the lower part of the Indrawati Basin. Likewise, in the Yarsha Catchment, the crop water requirement for rice-potato rotation is 1801 mm/year. The Yarsha Catchment, in nearby Dolkha district, represents the higher altitude VDCs of the Indrawati Basin.

The values outlined above are considered the benchmark for rain sufficiency. Therefore, the rain index has been calculated with respect to crop rotation. If annual rainfall is greater than crop requirement it is rated as '1'.

To calculate the index, the annual non-monsoon and monsoon rainfall isohyets were constructed to estimate the average rainfall at each VDC. The average annual, monsoon and non-monsoon rainfalls estimated for the VDCs are presented in Annex B-IIIb.

Rainfall variability: The available flow data is insufficient to determine the variability of resources within the Indrawati Basin. On the one hand, gauging stations are only installed along the major rivers. Then again, the majority of the population is dependent on small rivers whose flows vary with rainfall variations. Therefore, rainfall variation was considered a sub- index of resource variation for each VDC.

Runoff potential index:

The network of hydrometric stations in the Indrawati Basin is poor, with long-term data forthcoming from only two hydrometric stations. Furthermore, the data shows runoff as 100 percent of annual rainfall. This could either be due to snowmelt or an error resulting from poor meteorological networks over the higher altitude region. For example the average annual rainfall over the basin is 2100 mm i. e. 80 m^3/s without any losses, whereas measured discharge in Indrawati is 91.4m^3/s. The annual discharges of the Indrawati with some tributaries are presented in Table 3.1.

Table 3.1: Flows in the Indrawati Basin (m3/s)

River	Annual average discharge
Indrawati	*91.4*
Melamchi	*18.1*
Handi	*3.33*
Mahadev	*0.91*

Source: *Cited Karki A. (2005) [Source: Indawati station, (at Dolalghat) 629.1 based on average monthly flows from 1975 – 1990 and Melamchi, Handi and MahadevKhola flows based on Ranjitkar 2000]*

As the majority of the population in the study area is dependent on small streams for their livelihood, the runoff coefficient derived by Merz (2004) for the Yarsha and Jhikukholas(streams) is considered to estimate surface water availability. Merz (2004) has estimated the runoff coefficient as 0.62 for the Yarsha Catchment and 0.32 for the Jhikhu Catchment. Therefore, for the Indrawati Basin, a runoff coefficient of 0.62 and 0.32 were adopted for it higher and lower sections, respectively. The runoff, calculated with adjusted rainfall, was then converted into $m^3/d/km^2$.

An outcome of 100 percent runoff availability signifies a perennial flow in the nearby stream. The point of maximum annual rainfall (4585 mmTarkeghyang, St. index no 1058) in the basin is assumed to have the potential to generate sufficient perennial flow in a small river. Therefore, a runoff value of 3890 $m^3/d/km^2$ (multiplying 4585 mm by the runoff coefficient of 0.62) is considered the maximum benchmark. Similarly, as less than 100 mm of annual rainfall indicates desertification, 85$m^3/d/km^2$ (multiplying 100 by the runoff coefficient of 0.32) is considered the minimum benchmark for runoff potential ranking. Index is calculated using equation 2. But many settlements along the main river (snow fed) will get benefit from these rivers.

The portion of such settlementsin VDC is calculated as main river benefit factor (benefit for all settlements = 1) and final index calculated is shown in Annex B-IV.

3.3.2. Access (A)

Water Collection Time Index

Accessing water in the Indrawati Basin is an onerous task due to the harsh topography as well as the manner in which the settlements are located. As per gathered data, 80 percent of households have access to pipe water. At the same time, the pipe water is available only 50 percent of the time, meaning approximately three-four days a week, in the lower part of the Indrawati.

Field investigations showed that pipe water coverage stood at 90 percent in the upper part of the Basin and 70 percent in the lower part of basin. Seventy percent pipe water coverage converts into 30 percent of the population having to carry water in the lower part of the basin. Furthermore, if reliability of pipe water is 50 percent, actual coverage can be assumed as 35 percent in the lower sections of the basin. On the flip side, 65 percent of the area would not have pipe water coverage. Therefore, at the lower parts of the basin, a weight of 65 percent is given to carrying water from the source and 35 percent to available pipe water. Whereas, at the upper part of the basin, the pipe water supply reliability is 90 percent. Thus, pipe water coverage is weighed at 80 percent in upper parts of the basin.

In General 3 people go to collect water and the frequency is 2 times a day to fulfill their household demands. Therefore, carrying time taken is multiplied by 2 to calculate time index. Assuming surplus water supply from pipe i.e. 100%, the access sub index for household use is calculated as

$$I_d = \frac{w_1 \times I_{d1} + w_2 \times I_{d2}}{w_1 + w_2}$$

Where, I_{d2} = 1 and w is weight.

Further, percent irrigated land with respect to total agricultural land is considered as irrigation connectivity access sub index I_i.

The English Walkerman online software, a tool for hikers, is used to calculate average walking time as mentioned in methodology 2.7. Field investigations show that walking time nearly doubles when an individual is carrying water. Thus, the time required to cover distances estimated by the software is multiplied by two to get an approximate walk time while carrying water.

Field investigations reveal thatpeople collect water twice daily to fulfill household demands. Thus, one time carrying time is multiplied by two to calculate the time index.

Note For each VDC, the walking distance and climbing distance is estimated from @ Google Earth Browser. Further, using Google Earth images, approximate distances for a percentage of households were also estimated. The average distance and climbing distance was then calculated using the Antony Carlos and Walking Englishman online calculators.*

The final Access component is calculated as an average between household access and the irrigation connectivity access sub-index. The calculation is depicted in Annex B-V

3.3.3. Capacity (C)

The projected increase in the literacy rate within districts in the Indrawati Basin from the 2001 to the 2011 census (Database, 2011 District Development profile of Nepal, MPRC) is depicted in Table 3.2. The education component for Capacity was measured as the literacy rate. The VDC literacy rate (2001 Census) is projected for 2011 by using the district growth rate projected by the MPRC. The projected rate is presented in Annex B-VI.

The economic component was measured as the percentage of households with economic activities. It was estimated that this component increased by 10 percent in the period between 2001 to 2011 due to the peace process as well as an increase in foreign employment. The projected economic activities are depicted in Annex B-V. For the final calculation, economic growth is added to calculate the economic index. The final Capacity index (Method-2.7) is depicted in Annex B- VI.

Table 3.2: Literacy rate

District	Literacy rate (2001) census %	Literacy rate (2011) projected %	% Increase
Sindhupalchok	40	46	0.15
Kavrepalanchok	63	73	0.16
Kathmandu	77	78	0.01
Nuwakot	50	55	0.10

Source: MPRC Database, 2011

3.3.4 Use (U)

The Use component value is calculated as water needed liters/capita/day in a household. It is inverse to poverty. It is assumed that the minimum benchmark level for the 'Use' component is one l/c/d. According to Cullis (2005), the maximum (optimum) level for use in the South African environment is 160 l/c/d (cited Jordaan D. B. 2010). For the purposes of this study, however, field investigation led to the value of 500-700 l/d per household (including livestock) and estimated about 116 l/c/d as water sufficiency. The present water use falls between 200-300 l/d, which includes approximately 75 liters for two cows.

From field investigations, the estimated water use (wa)=200 l/d per household (without livestock). Water use (wb) = 300 l/d per household with land and livestock. The Use component (U) is calculated as per Method-2.7. The calculation is shown in Annex B-VII

3.3.5 Environment (E)

The Environmentcomponent is calculated from the WQI and the natural vegetation coverage index. The WQI calculation process includes: field water collection, water quality analysis at laboratory and, finally, the calculation of the water quality index as mentioned in 2.7 e. The detailed WQI is presented in Annex B-X. The coverage of natural vegetation was calculated from Google Earth Images (2011) and the methodology mentioned in method 2.7. The calculation is depicted in Annex B-VIII.

3.6 WPI for the Indrawati Basin

In the interest of clarity, the components used in the WPI framework (section 2.3 and eq. 1) are given equal weights, where ΣW =1 for equation 1. All components were multiplied by 20 (section 2.7) and added to get the WPI score of 100. The final score of the Indrawati Basin is shown in Figure 3.1 and the score of each component at the VDC level is shown in Annex IX and Figure 3.2. Out of five components, capacity (C) is the lowest in the Basin (Figure 3.1), with other components around or above 50 percent (Also in Figure 3.1). The WPI map is presented in section 3.5 and the detailed calculations are in Annex B-IX.

R	A	C	U	E	WPI
13.2	10.9	6.6	10	11.8	52.5

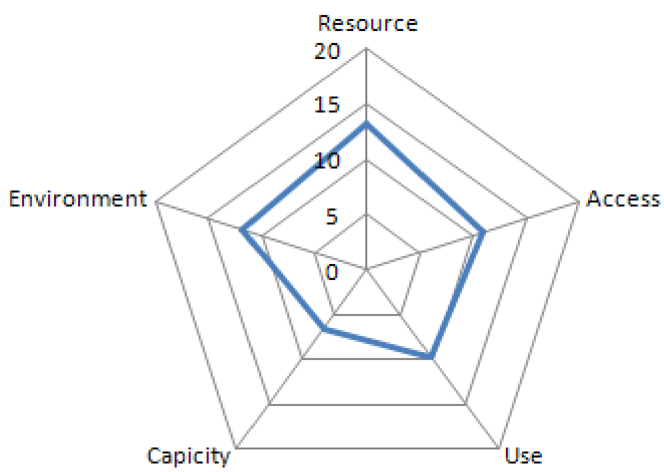

Figure 3.1: Components of WPI

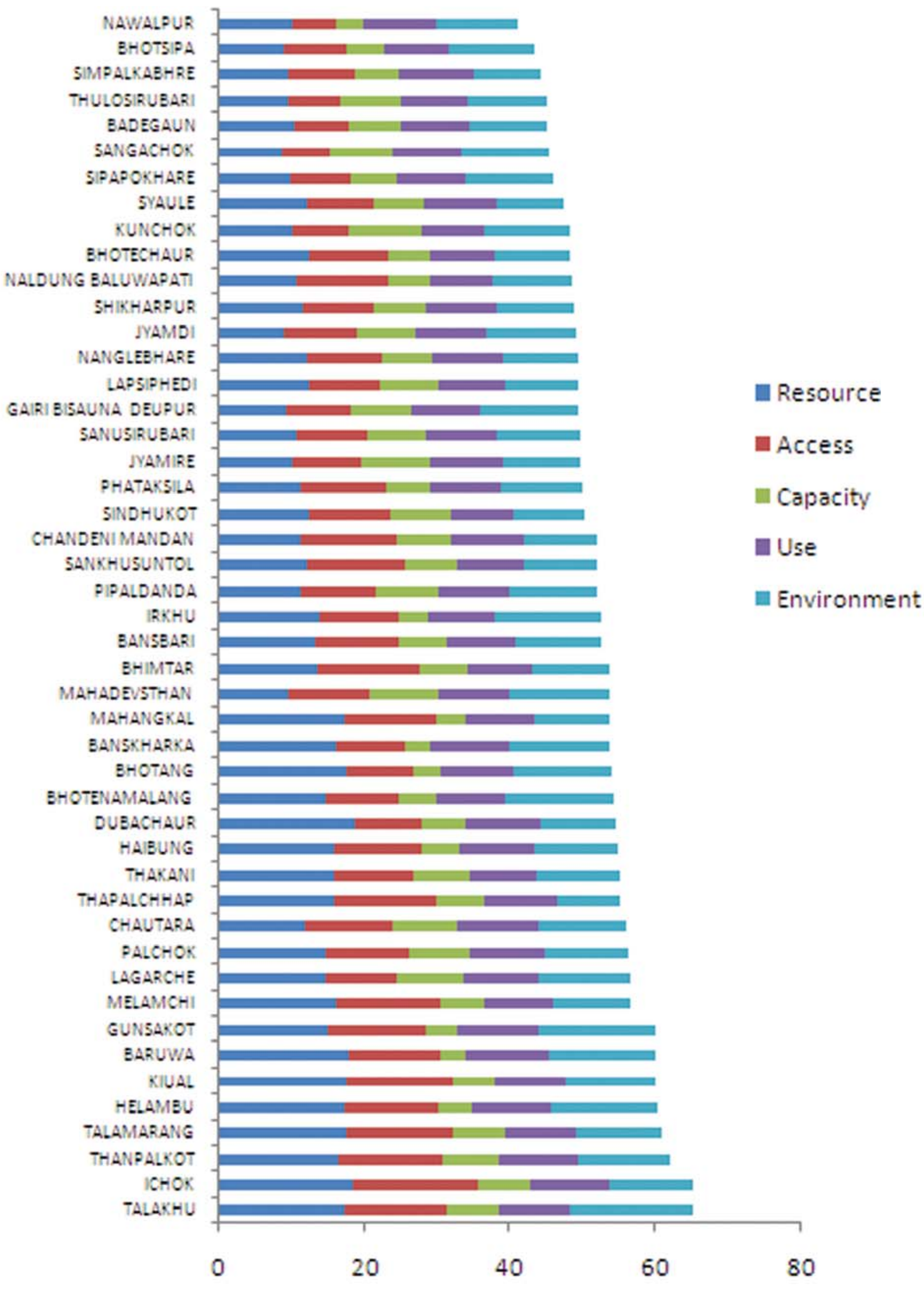

Figure 3.2: WPI components (VDC level)

3.7 Mapping Water Poverty

A map, based on the index values, has been developed to visually depict the water poverty situation in the Indrawati Basin. Maps have also been developed from the values of all five components. These will help decision-makers identify sectors with significant water needs.

Scale of Water Poverty Map

The scale of the Water Poverty Map is the administrative boundary of the Village Development Committee (VDC). A total of 47 VDC were included in the mapping. VDCs with only a small portion of the total area located in the Indrawati Basin were not included in the analysis.

3.8 Construction of Water Poverty Map

WPI values have been considered in constructing the Water Poverty Map. In this effort, the WPI was rescaled from numerical values to magnitude scales of High Medium or Low (section 2.9). As it is essentially impossible to have a WPI value of either 0 or 100 at the catchment scale, the benchmarks mentioned in section 2.4 have been taken into account in scaling the Water Poverty Map. The Water poverty map is presented in Map No. 2 and the detailed calculations are in Annex B-IX.

3.9 WPI for the Cha Khola Sub-Basin

The Cha Khola and the Indrawati River meet some 300-400 meters upstream of the Sunkoshi, with the Cha KholaBasin area covering approximately 100 sq. km. The single VDC oriented at the Cha Sub-basin is in many regards different from those oriented towards the Indrawati. For instance, Madevsthan VDC at the Cha Khola Sub-Basin has extensive agricultural land and good irrigation management systems. The WPI of the Cha Sub-Basin is shown in Table 3.3. The WPI score is also presented in Figure 3.3. The Water Poverty Map of Cha Khola (river) is constructed based on the score.

Table 3.3: WPI for the Cha Khola Sub-Basin

VDC	R	A	C	U	E	WPI
Anikot	11	14.2	7	9	13.5	54.7
NayaGaun	11.9	12	6.5	9.4	14.5	54.3
Devtar	10.7	12.5	5.5	11.2	11	50.9
Panchkhal	9.2	12	7.5	8.9	12.5	50.1
Jaisithok	10	10.2	9.7	8.1	12.3	50.3
Hokse Bazar	8.2	13	9.1	8.5	12.5	51.3
Dolalghat	11	17	9.4	10	11	58.4
Mahadevsthan	9.2	8.6	8	10	11	46.8
Jyamidi	9.2	8.9	8.1	10.3	13.5	50.0
Average	10.0	12.0	7.9	9.5	12.4	51.9

R	A	C	U	E	WPI
10	12	7.9	9.5	12.4	51.9

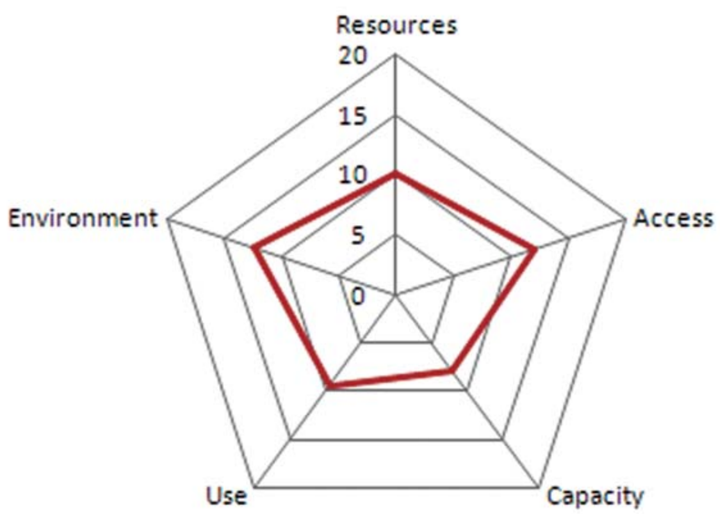

Figure 3.3: Components of WPI for the Cha Khola Sub-Basin

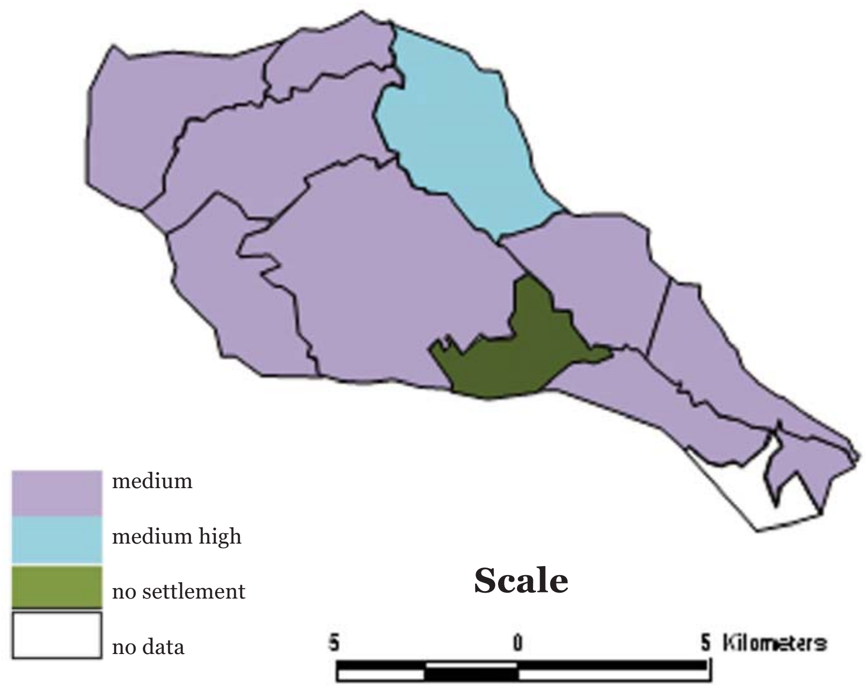

Figure 3.4: Water Poverty Map of the Cha Khola Sub-Basin

Chapter 4 Conclusion

4.1 WPI of the Indrawati Basin

The Water Poverty Map (Map-2) clearly illustrates the complexity of water issues in the Indrawati Basin. The calculated WPI in the Indrawati Basin is 52.5, with Resource at 13.2, Access at 11.0, Capacity at 6.7, Use at 9.8 and Environment at 11.8. However, the WPI in the VDCs within the Indrawati Basin range from 40.9 to 65.2 (Annex IX), with the lowest value at Nawalpur VDC (40.9) and the highest at Talakhu VDC (65.2).

The national WPI value for Nepal as calculated by Lawrence et al (2002) is 54.4, slightly above that of the Indrawati Basin. At the national scale, the Capacity component is higher than in the Indrawati Basin, where the Access and Resource components fare better than the nationwide average. The Use and Environment components are slightly worse than the national average in the Indrawati Basin.

Merz (2004) has estimated the WPI value as 59.2 points for the Jhikhu Catchment and 63.2 for the Yarsha catchment. These catchments are neighboring catchment of the Indrawati Basin. Both these values are higher than Nepal's national score as presented by Lawrence et al. (Figure 4.1).

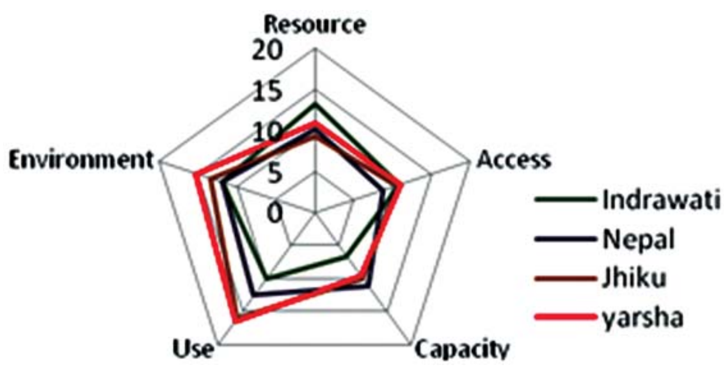

Figure 4.1: WPI of Nepal, Jikhu and Yarsha, Score in 20 Data source: Merz, J. (2004), Lawrence et al. (2002)

As mentioned in Chapter 3, the Cha Khola Basin meets the Indrawati just before the Indrawati joins the larger Sunkoshi. Wide-scale irrigation activities exist in Mahadevsthan VDC, located in the Cha Khola Basin side, which is adjacent to the Jhikhu Catchment and shares the latter's characteristics. For example, the Cha KholaBasin is flatter than any other sub basin in the Indrawati.

Nevertheless, the Cha Khola Basin's WPI value of 51.9 is comparable to that of the Indrawati, though the former scores lower on Resource and higher on Capacity than the main basin. Some VDCs within the Cha basin, such as Panchkhal, score exceedingly well on Environment as they have full forest cover. Table 3.3 illustrates that water scarcity exists in the Cha Khola Basin, with the exception of a few VDCs.

4.2 Key Findings and Conclusion

The majority of the population in the Indrawati Basin has poor access to the main river. About 80 percent of the populations living within the Indrawati Basin rely on smaller streams/tap to fulfill their water needs. Today, the drying of springs and deforestation, among other issues, are slowly reducing the population's quality of life. With water sources near the settlements drying up, people are forced to walk further downhill to collect water. In addition, the pipe water supply is consistently unreliable, especially in the dry season. As a result, some settlements pay heavy tariffs for water lifting schemes.

Through the course of the research, the available drinking water appeared to be of poor quality. Yet, people were drinking the water without any treatment, except a few who boil it during floods due to fear of diseases such as cholera and diarrhea. It is evident that the tapping of rainwater for household use as well as the installation of dry season low-water irrigation (drip) could significantly improve the WPI. Implementation of rainwater harvesting and other storage ideas will certainly improve all components of WPI. As the Cha Khola Basin is relatively flat, ground water extraction is also possible. Some key findings and suggestions are presented in Table 4.1.

The Water Poverty Map (Map-2) clearly illustrates the complexity of water issues in the Indrawati Basin, where the majority of VDCs fall in the 'medium water poor' category. A glance at the WPI map (Map-2) provides an overview of the general water poverty situation, which enables policy planners to quickly identify the VDCs requiring immediate attention. Similarly, showing the values of all five components visually (Map-3 through Map-7) helps decision makers detect sectors with significant water needs. In addition, the rainfall maps (Map-8 and Map-9) enable agriculturists and farmers in planning their crops. The maps also help managers and planners of development programs, such as flood management and rainwater harvesting, among others, at the VDC level. Map 1shows all the VDCs in the IndrawatiBasin by name along with their boundaries.

As a whole, the maps help build the Capacity of the sector stakeholders, reduce agricultural water demand by improving water use efficiency, increase domestic water consumption through adequate hygiene promotion, and raise water and sanitation coverage through building and sustaining new infrastructure.

Table 4.1: Indicators, Present Status and Suggestions

Resource	Status	Suggestion
Lower Part Middle Part Upper Part	Medium Low-Medium High Very High	Exploration of rainwater harvesting Increase storage capacity
Access	**Status**	**Suggestion**
Lower Part Middle Part Upper Part	Medium Low-Medium Medium-Medium High Medium-High	Rainwater harvesting/ forestation Proper practices in water management/ water lifting. Increase in storage capacity
Capacity	**Status**	**Suggestion**
Lower Part Middle Part Upper Part	Medium Medium Low-Medium Low	Promote education and income-generation programs
Use	**Status**	**Suggestion**
Lower Part Middle Part Upper Part	Medium Low-Medium Medium Medium	Rainwater harvesting Increase storage capacity Ground water or river water lifting
Environment	**Status**	**Suggestion**
Lower Part Middle Part Upper Part	Medium-Medium High Medium-High Medium-Very High	Promote environmental education program Promote organic fertilizers Promote water treatment programs

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ANNEXES

Annex -A Field Investigation

The field survey was carried out to discover the current water-related issues in specific VDCs in Sindhupalchok, Kavrepalanchok and Kathmandu. The main purpose of the field research was to collect information from locals regarding water sufficiency, use, accessibility, local capacity and water-borne diseases. The study team collected water samples from a number of rivers as well as from other sources for water quality analysis.

The team visited the following VDCs: Sangachok, Helambu, Chautara, Sanosiruwari, Thulosiruwari, BaluwapatiDeupur, Melamchi, Dubachaur, Lapsiphedi, Namlebhare, Suntol, Fatakshila, Bhotpisha, Jyamire, Jyamidi, Bansbari, Bhimtar and Mahankal.

Nearly 40 people in the Indrawati Basin were interviewed to get a sense of the ground reality. When asked about the Baluwapatideupur linkage between water and their livelihoods, the interviewees provided a range of different responses. Field researchers observed that the water situation was more complex in the South and Southeast part of the Basin as compared to the reality in the North and Northeast part. The responses provided by the interviewees generally matched the researchers' observation of the resources available at adjoining streams and of the rainfall in the area.

In the lower parts of the Basin, a spring or nearby stream is the major source of household water. While pipe water supply is available near homes, it is not adequate to cover farm and household uses. In addition, the reliability of pipe water supply is just 50 percent as compared to household needs. In some cases, during the dry season, the residents of some settlements have to venture a great distance to collect water, carrying 20 liters of water in eight hours. On average, three people are involved, three times daily, in carrying water to fulfill the basic demand of a household.

Field survey at Baluwapati Deupur

Consequently, local people are worried about their water sources. As an alternative, some households started rain water collection with the support of NGOs (Reported from Bhotsipa VDC) while others started lifting water with a pump. According to some responders, the payment for pumped water is high and in some cases people are paying NPR 70 per hour for pipe water supply (Jyamidi VDC).

Meanwhile, the very few VDCs with access to the main river benefit. Further, responders also noted that the flow in the Indrawati has been decreasing during the non-rainy season, a trend that bodes ill for the future.

A Settlement in Shikarpur VDC Google Earth 3-D picture

Indrawati River - Downstream of Sikarpur - Google Earth 3-D picture

With locals still building houses in the traditional style, most homes are made of clay. As a result, most families prefer to build in the dry hilly areas rather than the lower, moister areas. This matter of building location appears to be among the main factors contributing to water accessibility issues in the Indrawati Basin.

Almost all responders observed the drying-up of their water sources during the dry season as well as the discovery of turbid and bacteriological contamination in the water during the rainy season.

Spring source at Bhotsipa

Spring source at Bhotsipa

In the middle and western sections of the Basin, pipes and springs are the main sources of water. According to responders, rainwater is adequate for crop rotation (Rice, Wheat and Maize). However, responders also noticed a decrease in water at their sources. Currently, an average of three people per household are involved in water collection, with approximately 200 liters required daily to fulfill basic household demands.

According to responders, the local people are trying to revive their sources by planting Alnusnepalenses (Uttis Bot-Nepalese name). It is believed that the species can conserve water and make springs perennial

In the upper part of the Basin, there is sufficient source water and pipe water is highly reliable. In this area, a large number of households have installed water mills in their houses. Laboratory analysis also shows Helambu (in the upper Indrawati Basin) pipe water to be the best in quality of all the sampled water.

Researchers found that the economic activity of households in the middle and lower parts of the Basin increased by 10-15 percent in last five years. One of the main causes of this increase is likely due to the dramatic jump in foreign employment.

Preparation for rice plantation at Namlebhare

Uttis plantation at BaluwapateDeupur

Water mill at Helambu

Water sampling of the Melamchi river at Melamchi


A


B


C


D


E

A: Water sample collection of the Indrawati at Dubachaur
B: Bacteriological water sampling of the Indrawati at Dubachaur
C: Water sample collection of the Melamchi River at Melamchi
D: Spring water sample collection at Baluwapati Dewpur
E: Bacteriological water sampling of the Melamchi River at Melamchi

Laboratory tests noted that relatively turbid and poor quality water is flowing in the Indrawati River near Jyamidi. The quality of water is also relatively poor in the medium size rivers which pass through agricultural fields within the Indrawati Basin. In this context, responders also noted that farmers are using chemical fertilizers to increase agricultural productivity. The declining water quality may be a result of these chemical fertilizers and of soil erosion from farm land as well as from deforested areas. Light rainfall is more than adequate to carry eroded soil and fertilizer residue into the main river.

Picture cited from Karki (2005) at Jyamidi

Site visit at Jyamidi during April 2011, a few days after light rain

Annex –A-1

Reliability of pipe water supply	
Lower part Middle part Upper part	Medium Medium high High
Drying up sources	
Lower part Middle part Upper part	High High low
Rainfall variation	
Lower part Middle part Upper part	Medium High High
Increase in economic activities	
Lower part Middle part Upper part	Medium high Medium Medium
Water purification practice	
Lower part Middle part Upper part	Low Low Low
Chemical fertilizer use	
Lower part Middle part Upper part	High Medium high Medium
Crop productivity	
Lower part Middle part Upper part	Low Low Medium

Annex – B

B-I: VDC within study area

VDC Name	District	VDC Name	District
Lapsiphedi	Kathmandu	Ichok	Sindhupalchok
Nanglebhare	Kathmandu	Irkhu	Sindhupalchok
Sankhusuntol	Kathmandu	Jyamire	Sindhupalchok
Talakhu	Nuwakot	Kiual	Sindhupalchok
Chandeni Mandan	Kabhrepalanchok	Kunchok	Sindhupalchok
Gairi Bisauna Deupur	Kabhrepalanchok	Lagarche	Sindhupalchok
Jyamdi	Kabhrepalanchok	Mahangkal	Sindhupalchok
Mahadevsthan	Kabhrepalanchok	Melamchi	Sindhupalchok
Naldung Baluwapati	Kabhrepalanchok	Nawalpur	Sindhupalchok
Badegaun	Sindhupalchok	Palchok	Sindhupalchok
Bansbari	Sindhupalchok	Phataksila	Sindhupalchok
Banskharka	Sindhupalchok	Pipaldanda	Sindhupalchok
Baruwa	Sindhupalchok	Sangachok	Sindhupalchok
Bhimtar	Sindhupalchok	Sanusirubari	Sindhupalchok
Bhotang	Sindhupalchok	Sikarpur	Sindhupalchok
Bhotechaur	Sindhupalchok	Simpalkabhre	Sindhupalchok
Bhotenamalang	Sindhupalchok	Sindhukot	Sindhupalchok
Bhotsipa	Sindhupalchok	Sipapokhare	Sindhupalchok
Chautara	Sindhupalchok	Syaule	Sindhupalchok
Dubachaur	Sindhupalchok	Talamarang	Sindhupalchok
Gunsakot	Sindhupalchok	Thakani	Sindhupalchok
Haibung	Sindhupalchok	Thanpalkot	Sindhupalchok
Helambu	Sindhupalchok	Thapalchhap	Sindhupalchok
		Thulosirubari	Sindhupalchok

Source: Database (2011) District Development profile of Nepal, MPRC, Kathmandu

**Note VDC: Village Development Committee*

B-II: Demographic Statistics

VDC Name	2001 Census			2011 Projected	
	HH size	Total HH	Total .Pop	Total HH	Total .Pop
Lapsiphedi	5.33	1,051	5,603	1,945	8,976
Nanglebhare	5.21	894	4,656	1,654	7,459
Sankhusuntol	5.15	857	4,417	1,586	7,076
Talakhu	5.24	674	3,529	785	4,151
Chandeni Mandan	4.96	781	3,871	972	4,603
Gairi Bisauna	5.3	1175	6,226	1,463	7,404
Jyamdi	5.19	1022	5,303	1,272	6,306
Mahadevsthan	5.14	1674	8,612	2,084	10,241
Baluwapati	5.86	1086	6,365	1,352	7,569
Badegaun	5.37	1106	5936	1304	6953
Bansbari	5.32	904	4,811	1,065	5,635
Banskharka	4.62	537	2,649	675	3,103
Baruwa	4.39	544	2,386	641	2,795
Bhimtar	5.75	734	4,217	865	4,939
Bhotang	-	**→500**	2,750	-	-
Bhotechaur	5.71	992	5,660	1,169	6,630
Bhotenamalang	4.97	686	3,411	809	3,995
Bhotsipa	5.63	879	4,951	1,036	5,799
Chautara	4.57	1.114	5,089	1,313	5,961
Dubachaur	4.79	1,261	6,044	1,486	7,079
Gunsakot	4.46	417	1,858	491	2,176
Haibung	5.03	568	2,857	669	3,346
Helambu	4.55	589	2,679	694	3,138
Ichok	4.99	1,173	5,848	1,383	6,850
Irkhu	5.54	597	3,310	704	3,877
Jyamire	5.19	1,125	5,844	1,326	6,845
Kiual	4.9	730	3,580	860	4,193
Kunchok	5.9	879	5,183	1,036	6,071
Lagarche	4.91	536	2,634	632	3,085
Mahangkal	5.33	974	5,194	1,148	6,084
Melamchi	5.07	967	4,901	1,140	5,741
Nawalpur	5.02	727	3,647	857	4,272
Palchok	4.88	465	2,270	548	2,659
Phataksila	5.2	670	3,484	790	4,081
Pipaldanda	5.17	754	3,901	889	4,569
Sangachok	5.23	1,871	9,786	2,205	11,462
Sanusirubari	5.32	719	3,825	847	4,480
Sikarpur	5.22	490	2,560	578	2,999
Simpalkabhre	4.88	593	2,896	699	3,392
Sindhukot	5.91	644	3,807	759	4,459
Sipapokhare	5.31	819	4,347	965	5,092

Syaule	4.99	837	4,177	986	4,893
Talamarang	5.24	674	2,534	794	4,139
Thakani	5.46	694	3,788	818	4,437
Thanpalkot	4.54	614	2,786	724	3,263
Thapalchhap	5.03	726	3,653	856	4,279
Thulosirubari	5.62	1,205	6,770	1,420	7,930

Source: Database (2011) District Development profile of Nepal, MPRC, Kathmandu

Note VDC: Village Development Committee, HH: households, Pop: Population,*
→: estimation using Google map household count HH: House hold,
Pop: Population

B-IIIa: Monthly Rainfall in mm and Flow in m3/s

Precipitation, Mm													
Station	St. No	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nawalpur	1008	19	26	35	56	170	399	703	720	332	68	15	9
Chautara	1009	15	21	39	58	147	371	477	573	283	63	7	9
Gumthang	1006	32	52	59	136	325	629	933	990	679	180	24	18
Timure	1001	21	22	63	32	36	108	265	271	178	42	4	8
Sarmathang	1016	23	27	46	66	173	474	916	874	454	94	10	9
Dubachaur	1017	20	29	45	68	183	395	629	643	298	64	9	9
Baunepate	1018	15	20	28	48	134	283	421	464	228	54	8	5
Dolalghat	1023	12	17	24	46	112	201	285	271	126	40	8	7
Dhap	1025	20	33	27	53	141	392	726	664	446	54	6	8
Nagarkot	1043	25	22	31	62	171	324	483	490	273	61	11	6
Dunche	1055	31	31	49	61	95	290	512	505	291	55	13	14
Tarkeghyang	1058	27	30	65	76	172	539	943	983	518	66	14	5
Sangachok	1062	14	19	30	50	150	262	374	360	181	51	7	4
Discharge, M3/S													
*Indrawati		20.6	17.7	16	17.5	25.7	88.4	258.8	273.6	218.3	88.9	44.3	27.5
*Melamchi		4.2	3.6	3.2	3.4	4.7	16.1	47.7	57	43.6	19.1	8.6	5.6
Handi		0.69	0.59	0.52	0.5	0.64	2.83	8.65	10.65	8.37	3.6	1.74	1.13
Mahadev		0.23	0.19	0.17	0.15	0.18	0.74	2.35	2.91	2.27	1	0.44	0.29

Source: Precipitation-DHM (1990-2009), Discharge-*Cited Karki A. (2005) [Source: Indawati station, (at Dolalghat) 629.1 based on average monthly flows from 1975 – 1990 and Melamchi, Handi and Mahadev Khola flows based on Ranjitkar 2000]*

B-IIIb:Seasonal and Annual Rainfall over Indrawati Basin

VDC Name	Rainfall in mm			Rain Var. index	VDC Name	Rainfall in mm			Rain Var. index
	M	N-m	A			M	N-m	A	
Lapsiphedi	1800	450	2250	0.19	Ichok	2620	540	3160	0.16
Nanglebhare	1600	400	2000	0.17	Irkhu	1550	390	1940	0.20
Sankhusuntol	1600	370	1970	0.17	Jyamire	950	240	1190	0.15
Talakhu	2350	620	2970	0.22	Kiual	2600	430	3030	0.11
Chandeni Mandan	1050	240	1290	0.12	Kunchok	1400	240	1640	0.16
Gairi Bisauna Deupur	1250	280	1530	0.13	Lagarche	1710	280	1990	0.18
Jyamdi	950	240	1190	0.13	Mahangkal	2600	520	3120	0.15
Mahadevsthan	1100	240	1340	0.1	Melamchi	1700	370	2070	0.15
Baluwapati	1450	320	1770	0.15	Nawalpur	1400	260	1660	0.14
Badegaun	1300	270	1570	0.13	Palchok	2200	460	2660	0.11
Bansbari	1530	340	1870	0.15	Phataksila	1350	290	1640	0.13
Banskharka	2200	380	2580	0.14	Pipaldanda	1530	320	1850	0.20
Baruwa	2800	320	3120	0.35	Sangachok	1020	280	1300	0.15
Bhimtar	1150	240	1390	0.12	Sanusirubari	1450	320	1770	0.19
Bhotang	3000	340	3340	0.3	Shikharpur	1480	300	1780	0.13
Bhotechaur	1800	440	2240	0.2	Simpalkabhre	1250	300	1550	0.20
Bhotenamalang	1850	280	2130	0.25	Sindhukot	1850	440	2290	0.18
Bhotsipa	1200	250	1450	0.2	Sipapokhare	1250	250	1500	0.12
Chautara	1600	350	1950	0.22	Syaule	1700	290	1990	0.22
Dubachaur	2000	400	2400	0.12	Talamarang	2020	490	2510	0.16
Gunsakot	2000	290	2290	0.27	Thakani	2100	570	2670	0.12
Haibung	2100	550	2650	0.24	Thanpalkot	2200	300	2500	0.27
Helambu	2700	420	3120	0.35	Thapalchhap	2100	310	2410	0.22
					Thulosirubari	1280	300	1580	0.16

Source: VDC rainfall extrapolated from DHM station data

**Note M=Monsoon N-m: Non-monsoon, A= Annual*

B-IV:Calculation of Resource Component (R)

VDC Name	Rain Index I_r	Main River Contribution factor 'B'	Runoff Index	Corrected Runoff Index I_k col 3 x(1-B)+1xB	Average 1 and 4	Resource (R) Col 4 x 20
	1	2	3	4	5	6
Lapsiphedi	1.00	0	0.24	0.24	0.62	12.4
Nanglebhare	1.00	0	0.21	0.21	0.61	12.1
Sankhusuntol	0.99	0	0.20	0.20	0.60	11.9
Talakhu	1.00	0	0.64	0.71	0.82	17.1
Chandeni Mandan	0.65	0.4	0.13	0.48	0.56	11.3
Gairi Bisauna Deupur	0.77	0	0.15	0.15	0.46	9.2
Jyamdi	0.60	0.2	0.11	0.29	0.44	8.9
Mahadevsthan	0.67	0.18	0.13	0.29	0.48	9.6
Baluwapati	0.89	0	0.18	0.18	0.54	10.7
Badegaun	0.79	0.1	0.16	0.24	0.52	10.3
Bansbari	0.94	0.25	0.19	0.39	0.67	13.3
Banskharka	1.00	0.15	0.55	0.62	0.81	16.2
Baruwa	1.00	0.1	0.67	0.70	0.85	17.0
Bhimtar	0.70	0.6	0.14	0.66	0.68	13.6
Bhotang	1.00	0.1	0.72	0.75	0.87	17.5
Bhotechaur	1.00	0	0.24	0.24	0.62	12.4
Bhotenamalang	1.00	0.12	0.45	0.52	0.76	15.2
Bhotsipa	0.73	0.04	0.14	0.17	0.45	9.0
Chautara	0.98	0	0.20	0.20	0.59	11.8
Dubachaur	1.00	0.7	0.51	0.85	0.93	18.5
Gunsakot	1.00	0	0.49	0.49	0.75	14.9
Haibung	1.00	0	0.57	0.57	0.79	15.7
Helambu	1.00	0.15	0.67	0.72	0.86	17.2
Ichok	1.00	0.5	0.68	0.84	0.92	18.4
Irkhu	0.97	0	0.41	0.41	0.69	13.8
Jyamire	0.60	0.2	0.24	0.39	0.50	9.9
Kiual	1.00	0.3	0.65	0.76	0.88	17.6
Kunchok	0.82	0	0.17	0.17	0.50	9.9
Lagarche	1.00	0.05	0.42	0.45	0.72	14.5
Mahangkal	1.00	0.12	0.67	0.71	0.85	17.1
Melamchi	1.00	0.3	0.44	0.61	0.80	16.1
Nawalpur	0.83	0	0.17	0.17	0.50	10.0
Palchok	1.00	0.25	0.28	0.46	0.73	14.6
Phataksila	0.82	0.15	0.17	0.29	0.56	11.1
Pipaldanda	0.93	0	0.19	0.19	0.56	11.2
Sangachok	0.65	0.07	0.13	0.19	0.42	8.4

Sanusirubari	0.89	0	0.18	0.18	0.54	10.7
Shikharpur	0.89	0.1	0.18	0.26	0.58	11.5
Simpalkabhre	0.78	0	0.16	0.16	0.47	9.4
Sindhukot	1.00	0	0.24	0.24	0.62	12.4
Sipapokhare	0.75	0.08	0.15	0.22	0.48	9.7
Syaule	1.00	0	0.21	0.21	0.61	12.1
Talamarang	1.00	0.45	0.54	0.75	0.87	17.5
Thakani	1.00	0	0.57	0.57	0.79	15.7
Thanpalkot	1.00	0.2	0.54	0.63	0.82	16.3
Thapalchhap	1.00	0.1	0.52	0.57	0.78	15.7
Thulosirubari	0.79	0.003	0.16	0.16	0.48	9.5

B-V:Calculation of Access Component (A)

VDC Name	Time (T) x 2 in Minute	collection Time Index I_{d1}	house hold Access Index I_d	Irrigation Access Index I_i	Average (4&5)	Access (A) col6 x 20
	1	2	4	5	6	7
Lapsiphedi	175.7	0.63	0.93	0.04	0.48	9.6
Nanglebhare	405.8	0.15	0.85	0.18	0.52	10.4
Sankhusuntol	99.9	0.79	0.96	0.39	0.68	13.6
Talakhu	140.2	0.71	0.95	0.47	0.71	14.2
Chandeni Mandan	69.6	0.85	0.91	0.39	0.65	13.0
Gairi Bisauna	170.0	0.65	0.79	0.10	0.45	9.0
Jyamdi	247.7	0.48	0.69	0.31	0.50	10.0
Mahadevsthan	83.0	0.83	0.90	0.20	0.55	11.0
Baluwapati	66.8	0.86	0.92	0.33	0.63	12.6
Badegaun	239.9	0.50	0.70	0.06	0.38	7.6
Bansbari	117.3	0.76	0.85	0.29	0.57	11.4
Banskharka	424.5	0.12	0.84	0.10	0.47	9.4
Baruwa	147.9	0.69	0.94	0.33	0.64	12.8
Bhimtar	162.0	0.66	0.80	0.59	0.69	13.8
Bhotang	406.4	0.15	0.85	0.07	0.46	9.2
Bhotechaur	147.6	0.69	0.82	0.25	0.54	10.8
Bhotenamalang	283.5	0.41	0.89	0.10	0.50	10.0
Bhotsipa	162.8	0.66	0.80	0.06	0.43	8.6
Chautara	89.5	0.81	0.97	0.23	0.60	12.0
Dubachaur	347.6	0.28	0.87	0.06	0.46	9.2
Gunsakot	115.2	0.76	0.96	0.40	0.68	13.6
Haibung	156.8	0.67	0.94	0.29	0.61	12.2
Helambu	151.3	0.68	0.94	0.33	0.64	12.8
Ichok	44.0	0.91	0.98	0.73	0.855	17.1
Irkhu	135.2	0.72	0.95	0.13	0.54	10.8
Jyamire	252.5	0.47	0.91	0.05	0.48	9.6
Kiual	178.2	0.63	0.93	0.54	0.73	14.6
Kunchok	221.5	0.54	0.72	0.08	0.40	8.0
Lagarche	245.5	0.49	0.91	0.08	0.50	10.0
Mahangkal	138.3	0.71	0.95	0.31	0.63	12.6
Melamchi	99.4	0.79	0.96	0.49	0.72	14.4
Nawalpur	377.1	0.21	0.53	0.07	0.30	6.0
Palchok	281.2	0.41	0.89	0.28	0.58	11.6
Phataksila	44.2	0.91	0.94	0.24	0.59	11.8
Pipaldanda	252.5	0.47	0.91	0.13	0.52	10.4
Sangachok	347.0	0.28	0.57	0.11	0.34	6.8

Sanusirubari	142.8	0.70	0.82	0.14	0.48	9.6
Shikharpur	240.0	0.50	0.70	0.25	0.48	9.6
Simpalkabhre	151.4	0.68	0.81	0.11	0.46	9.2
Sindhukot	229.2	0.52	0.91	0.22	0.56	11.2
Sipapokhare	271.3	0.43	0.66	0.18	0.42	8.4
Syaule	400.0	0.17	0.85	0.08	0.46	9.2
Talamarang	97.5	0.80	0.96	0.49	0.73	14.6
Thakani	117.0	0.76	0.96	0.15	0.55	11.0
Thanpalkot	96.4	0.80	0.96	0.49	0.72	14.4
Thapalchhap	146.0	0.70	0.95	0.45	0.70	14.0
Thulosirubari	291.4	0.39	0.64	0.07	0.35	7.0

B-VI: Calculation of Capacity Component (C)

VDC Name	Literacy % 2001	2011	Education index IC Col2/100	Economic Activity Ratio 2001 (CBS)	Projected Economic Activity index IIC (2011) Col4+Col 4x0.1	Capacity Index (Col3+Col 5)/2	Capacity (C) Col6x20
	1	2	3	4	5	6	7
Lapsiphedi	34	39	0.39	0.37	0.41	0.400	8.0
Nanglebhare	40	46	0.46	0.19	0.21	0.340	6.8
Sankhusuntol	48	56	0.56	0.13	0.15	0.360	7.2
Talakhu	39	49	0.49	0.21	0.23	0.360	7.2
Chan.Mandan	46	61	0.61	0.12	0.13	0.370	7.4
Gairi Bisauna	49	65	0.65	0.15	0.16	0.410	8.2
Jyamdi	48	64	0.64	0.14	0.16	0.400	8.0
Mahadevsthan	56	74	0.74	0.19	0.20	0.470	9.4
Baluwapati	26	35	0.34	0.19	0.21	0.280	5.6
Badegaun	46	60	0.60	0.09	0.10	0.350	7.0
Bansbari	37	49	0.48	0.16	0.18	0.330	6.6
Banskharka	24	31	0.31	0.02	0.02	0.170	3.4
Baruwa	20	26	0.26	0.08	0.08	0.170	3.4
Bhimtar	45	59	0.59	0.07	0.08	0.340	6.8
Bhotang	20	26	0.26	0.10	0.11	0.190	3.8
Bhotechaur	33	43	0.43	0.13	0.15	0.290	5.8
Bhotenamalang	35	46	0.46	0.03	0.04	0.250	5.0
Bhotsipa	30	39	0.39	0.10	0.11	0.250	5.0
Chautara	36	47	0.47	0.38	0.42	0.450	9.0
Dubachaur	30	39	0.39	0.19	0.21	0.300	6.0
Gunsakot	19	25	0.25	0.15	0.17	0.210	4.2
Haibung	21	28	0.28	0.21	0.23	0.260	5.2
Helambu	28	37	0.37	0.07	0.08	0.230	4.6
Ichok	39	51	0.51	0.18	0.28	0.395	7.9
Irkhu	31	41	0.41	0.01	0.01	0.210	4.2
Jyamire	62	81	0.81	0.12	0.14	0.480	9.6
Kiual	39	51	0.51	0.03	0.04	0.280	5.6
Kunchok	41	54	0.54	0.41	0.45	0.500	10.0
Lagarche	47	62	0.62	0.25	0.27	0.450	9.0
Mahangkal	20	26	0.26	0.13	0.14	0.200	4.0
Melamchi	31	41	0.41	0.15	0.17	0.290	5.8
Nawalpur	17	22	0.22	0.15	0.16	0.190	3.8
Palchok	59	77	0.77	0.03	0.04	0.410	8.2
Phataksila	33	43	0.43	0.17	0.19	0.310	6.2
Pipaldanda	49	64	0.64	0.19	0.21	0.425	8.5
Sangachok	49	64	0.64	0.17	0.19	0.420	8.4

Sanusirubari	49	64	0.64	0.16	0.18	0.410	8.2
Shikharpur	31	41	0.41	0.30	0.33	0.370	7.4
Simpalkabhre	35	46	0.46	0.13	0.15	0.300	6.0
Sindhukot	50	66	0.66	0.15	0.16	0.410	8.2
Sipapokhare	34	45	0.45	0.15	0.17	0.310	6.2
Syaule	43	56	0.56	0.11	0.12	0.340	6.8
Talamarang	41	54	0.54	0.17	0.18	0.360	7.2
Thakani	47	62	0.62	0.13	0.14	0.380	7.6
Thanpalkot	34	45	0.45	0.28	0.31	0.380	7.6
Thapalchhap	37	49	0.48	0.17	0.19	0.340	6.8
Thulosirubari	54	71	0.71	0.13	0.14	0.425	8.5

B-VII: Calculation of Use Component (U)

VDC Name	Household with Ag.land only H_a	Household with Ag.. land + livestock H_b	Total House hold H_T	House hold Size H_S	Water Use l/c/d (col1x 200+col 2x300) (col3xcol4)	USE (U) col5-1 116-1x20
	1	2	3	4	5	6
Lapsiphedi	76	975	1051	5.33	54.9	9.3
Nanglebhare	31	863	894	5.21	56.9	9.7
Sankhusuntol	181	676	857	5.15	54.2	9.2
Talakhu	26	648	674	5.24	56.5	9.7
Chandeni Mandan	13	768	781	4.96	60.1	10.3
Gairi Bisauna Deupur	68	1107	1175	5.3	55.5	9.5
Jyamdi	16	1006	1022	5.19	57.5	9.8
Mahadevs-than	60	1614	1674	5.14	57.7	9.9
Naldung Baluwapati	34	1052	1086	5.86	50.7	8.6
Badegaun	34	1072	1106	5.37	55.3	9.4
Bansbari	48	856	904	5.32	55.4	9.5
Banskharka	16	521	537	4.62	64.3	11.0
Baruwa	47	497	544	4.39	66.4	11.4
Bhimtar	43	691	734	5.75	51.2	8.7
Bhotang	47	453	500	5	58.1	9.9
Bhotechaur	47	945	992	5.71	51.7	8.8
Bhotenamalang	136	550	686	4.97	56.4	9.6
Bhotsipa	21	858	879	5.63	52.9	9.0
Chautara	75	1039	1114	4.57	64.2	11.0
Dubachaur	40	1221	1261	4.79	62.0	10.6
Gunsakot	26	391	417	4.46	65.9	11.3
Haibung	20	548	568	5.03	58.9	10.1
Helambu	51	538	589	4.55	64.0	11.0
Ichok	44	1129	1173	4.99	59.4	10.2
Irkhu	22	575	597	5.54	53.5	9.1
Jyamire	43	1082	1125	5.19	57.1	9.8
Kiwool	111	619	730	4.9	58.1	9.9
Kunchok	46	833	879	5.9	50.0	8.5
Lagarche	11	525	536	4.91	60.7	10.4
Mahangkal	49	925	974	5.33	55.3	9.5
Melamchi	122	845	967	5.07	56.7	9.7
Nawalpur	25	702	727	5.02	59.1	10.1
Palchok	24	441	465	4.88	60.4	10.3

Phataksila	50	620	670	5.2	56.3	9.6
Pipaldanda	38	716	754	5.17	57.1	9.7
Sangachok	105	1766	1871	5.23	56.3	9.6
Sanusirubari	36	683	719	5.32	55.4	9.5
Sikarpur	15	475	490	5.22	56.9	9.7
Simpalk-abhre	11	582	593	4.88	61.1	10.5
Sindhukot	37	607	644	5.91	49.8	8.5
Sipapokhare	23	796	819	5.31	56.0	9.6
Syaule	32	805	837	4.99	59.4	10.1
Talamarang	32	642	674	5.24	56.3	9.6
Thakani	33	661	694	5.46	54.1	9.2
Thanpalkot	61	553	614	4.54	63.9	10.9
Thapalchhap	52	674	726	5.03	58.2	10.0
Thulosirubari	43	1162	1205	5.62	52.7	9.0

B-VIII: Calculation of Environment Component (E)

VDC Name	Forest area %	River Dependency D %			ΣD x WQI 100	I_E col1 100	Average col5 & col6	Environment (E) col7x20
		Major	Medium	Minor				
		WQI=0.92	WQI=0.80	WQI=0.85				
	1	2	3	4	5	6	7	8
Lapsiphedi	15			100	0.85	0.15	0.50	10.0
Nanglebhare	18			100	0.85	0.18	0.52	10.3
Sankhusuntol	15			100	0.85	0.15	0.50	10.0
Talakhu	85			100	0.85	0.75	0.85	17.0
C.Mandan	10	40		60	0.88	0.1	0.50	9.9
Gairi Bisauna	50		3	97	0.85	0.5	0.67	13.5
Jyamdi	35	20		80	0.86	0.35	0.61	12.2
Mahadevsthan	50	18	4	78	0.86	0.5	0.68	13.7
N. Baluwapati	25			100	0.85	0.25	0.55	11.0
Badegaun	22	10		90	0.86	0.22	0.54	10.8
Bansbari	30	25	10	65	0.86	0.3	0.59	11.7
Banskharka	50	15		85	0.86	0.5	0.68	13.7
Baruwa	60			100	0.85	0.60	0.67	14.5
Bhimtar	15	60		40	0.89	0.15	0.53	10.6
Bhotang	72	10	60	30	0.83	0.5	0.67	13.4
Bhotechaur	20			100	0.85	0.2	0.53	10.5
Bhotenamalang	50	12	39	39	0.75	0.5	0.74	14.9
Bhotsipa	35	4	20	71	0.80	0.35	0.58	11.6
Chautara	35			100	0.85	0.35	0.60	12.0
Dubachaur	10	70		30	0.90	0.1	0.51	10.2
Gunsakot	75		80	20	0.81	0.75	0.79	15.8
Haibung	30			100	0.85	0.3	0.58	11.5
Helambu	60	15	0	85	0.86	0.60	0.73	14.6
Ichok	37	50	25	25	0.87	0.37	0.57	11.4
Irkhu	60			100	0.85	0.6	0.73	14.5
Jyamire	20	20		80	0.86	0.2	0.54	10.7
Kiual	35	30		70	0.87	0.35	0.62	12.3
Kunchok	35		20	80	0.84	0.35	0.60	11.9
Lagarche	40	5		95	0.85	0.4	0.63	12.6
Mahangkal	19	12	20	68	0.85	0.19	0.52	10.5
Melamchi	18	30		70	0.87	0.18	0.53	10.6
Nawalpur	25		5	95	0.85	0.25	0.55	11.0
Palchok	28	25		75	0.87	0.28	0.58	11.6
Phataksila	25	15	8	77	0.86	0.25	0.56	11.1
Pipaldanda	37		12	88	0.84	0.37	0.61	12.2
Sangachok	30	7		97	0.89	0.3	0.60	11.9
Sanusirubari	30		5	95	0.85	0.3	0.57	11.5
Shikharpur	20	10		90	0.86	0.2	0.53	10.6

Simpalkabhre	5			100	0.85	0.05	0.45	9.0
Sindhukot	15		10	90	0.85	0.15	0.50	10.0
Sipapokhare	35	8		92	0.86	0.35	0.60	12.1
Syaule	5			100	0.85	0.05	0.45	9.0
Talamarang	30	45	10	45	0.88	0.3	0.60	11.9
Thakani	30			100	0.85	0.3	0.58	11.5
Thanpalkot	40	20		80	0.86	0.4	0.64	12.7
Thapalchhap	30	10	50	40	0.83	0.3	0.43	8.6
Thulosirubari	25	0.3		99.7	0.85	0.25	0.55	11.0

B-IX: Water Poverty Index and Its Components (Indrawati Basin)

VDC Name	Resource	Access	Capacity	Use	Environment	WPI
Lapsiphedi	12.4	9.6	8.0	9.3	10.0	49.3
Nanglebhare	12.1	10.4	6.8	9.7	10.3	49.3
Sankhusuntol	11.9	13.6	7.2	9.2	10.0	51.9
Talakhu	17.1	14.2	7.2	9.7	17.0	65.2
Chandeni Mandan	11.3	13.0	7.4	10.3	9.9	51.9
Gairi Bisauna Deupur	9.2	9.0	8.2	9.5	13.5	49.4
Jyamdi	8.9	10.0	8.0	9.8	12.2	48.9
Mahadevsthan	9.6	11.0	9.4	9.9	13.7	53.6
Naldung Balu-wapati	10.7	12.6	5.6	8.6	11.0	48.5
Badegaun	10.3	7.6	7.0	9.4	10.8	45.1
Bansbari	13.3	11.4	6.6	9.5	11.7	52.5
Banskharka	16.2	9.4	3.4	11.0	13.7	53.7
Baruwa	17.7	12.8	3.4	11.4	14.5	59.8
Bhimtar	13.6	13.8	6.8	8.7	10.6	53.5
Bhotang	17.5	9.2	3.8	9.9	13.4	53.8
Bhotechaur	12.4	10.8	5.8	8.8	10.5	48.3
Bhotenamalang	14.7	10.0	5.0	9.6	14.9	54.2
Bhotsipa	9.0	8.6	5.0	9.0	11.6	43.2
Chautara	11.8	12.0	9.0	11.0	12.0	55.8
Dubachaur	18.5	9.2	6.0	10.6	10.2	54.5
Gunsakot	14.9	13.6	4.2	11.3	15.8	59.8
Haibung	15.7	12.2	5.2	10.1	11.5	54.7
Helambu	17.2	12.8	4.6	11.0	14.6	60.2
Ichok	18.4	17.1	7.2	10.9	11.4	65
Irkhu	13.8	10.8	4.2	9.1	14.5	52.4
Jyamire	9.9	9.6	9.6	9.8	10.7	49.6
Kiual	17.6	14.6	5.6	9.9	12.3	60
Kunchok	9.9	8.0	10.0	8.5	11.9	48.3
Lagarche	14.5	10.0	9.0	10.4	12.6	56.5
Mahangkal	17.1	12.6	4.0	9.5	10.5	53.7
Melamchi	16.1	14.4	5.8	9.7	10.6	56.6
Nawalpur	10.0	6.0	3.8	10.1	11.0	40.9
Palchok	14.6	11.6	8.2	10.3	11.6	56.3
Phataksila	11.1	11.8	6.2	9.6	11.1	49.8
Pipaldanda	11.2	10.4	8.5	9.7	12.2	52
Sangachok	8.5	6.8	8.4	9.6	11.9	45.2
Sanusirubari	10.7	9.6	8.2	9.5	11.5	49.5
Shikharpur	11.5	9.6	7.4	9.7	10.6	48.8

Simpalkabhre	9.4	9.2	6.0	10.5	9.0	44.1
Sindhukot	12.4	11.2	8.2	8.5	10.0	50.3
Sipapokhare	9.7	8.4	6.2	9.6	12.1	46
Syaule	12.1	9.2	6.8	10.1	9.0	47.2
Talamarang	17.5	14.6	7.2	9.6	11.9	60.8
Thakani	15.7	11.0	7.6	9.2	11.5	55
Thanpalkot	16.3	14.4	7.6	10.9	12.7	61.9
Thapalchhap	15.7	14.0	6.8	10.0	8.6	55.1
Thulosirubari	9.5	7.0	8.5	9.0	11.0	45

B-X: Water Quality Index (WQI) score in 100

Source/VDC/ Sample No	DO	TC	FC	pH	BOD	NO3	PO4	Tur.	TSS	WQI
Pipe/Suntol/ Sample 1	6.5	10	0	7.90	0.7	1.0	0.27	4.0	8.0	85
Pipe/Suntol/ Sample 2	7.0	5	0	8.0	0.9	0.8	0.25	2.0	5.0	87
Indrawati River at Jyamidi/ Sample 1	7.2	50	5	8.0	2.3	3.0	0.8	15	100	72
Indrawati River at Jyamidi/ Sample 2	8.0	<200	7	7.1	2.0	2.7	0.9	12	49	77
Pipe/Baluwapati/ Sample 1	9.0	50	0	7.7	1.0	0.21	0.07	5.0	7.6	93
Pipe/Baluwapati/ Sample2	7.2	100	0	7.9	2.0	0.12	0.8	4.0	7.0	82
Pipe/Jyamidi/ Sample 1	5.5	180	0	7.8	2.0	0.15	1.0	3.0	5.0	77
Pipe/Jyamidi/ Sample 2	6.9	150	0	8.1	1.0	0.19	1.0	3.0	9.0	81
Pipe/Sangachok/ Sample 1	7.0	150	2	8.0	2.0	0.11	0.1	5.0	8.0	85
Pipe/Sangachok/ Sample 1	6.88	0	0	7.0	1.0	0.15	0.4	5.0	14	85
Pipe/Helambhu / Sample 1	6.0	10	0	7.8	0.2	0.06	0.32	3.8	14.0	91
Pipe/Helambhu / Sample 1	6.05	5	0	7.7	0.1	0.05	0.20	1.0	4	92
Pipe/Chautara/ Sample1	7.0	100	0	7.4	0.8	0.3	0.34	5.0	5.0	80
Pipe/Bhotpisa/ Sample 1	7.0	100	0	8.0	1.0	0.29	0.4	4.0	6.0	87
Pipe/Bhotpisa/ Sample 2	7.5	150	0	8.0	1.0	0.22	0.5	2.0	6.0	86
Melamchi River/ Melamchi/	6.08	0	0	7.7	0.2	0.07	0.6	3.0	12	86
Indrawati River/ Dubachaur	6.65	0	0	7.8	0.1	0.1	0.19	3.0	40	90
Pipe/Lapsiphedi/ Sample 1	7.0	0	0	7.3	1.0	0.9	0.4	4.0	13	86
Pipe/Bhotpisa/ spring	5.5	0	0	8.0	0.3	0.62	0.279	4.8	5.0	86
Jhayanru River/ Thulosiruwari	8.6	0	5	7.1	0.7	4.0	0.5	6.0	17	79
Sindhu River /	9.0	40	0	7.43	2.29	5.0	0.9	10	30	81

Note DO-Dissolve Oxygen in ppm, TC-Total Coliform, count in 100 ml, FC-Fecal Coliforn, count in 100 ml,pH=Percent Hydrogen, NO3 Nitrate in ppm, PO4 Phosphate in ppm, Tur-Turbidity in NTU, TSS-Total suspended Solids in ppmWater sample are tested at Lifeline laboratory and Research centre, Thapathali*

B-XI: International Water Poverty Index Components

Country	Resource	Access	Capacity	Use	Environment	WPI
Algeria	3.4	11.7	14.5	12.2	7.8	49.7
Angola	11.3	5	7.4	6.7	10.9	41.3
Argentina	12.4	11.9	15.3	8.5	12.8	60.9
Armenia	7.6	15.1	14.2	7.1	9.8	53.8
Australia	11.9	13.7	17.6	6.5	12.5	62.3
Austria	10.1	20	18.8	10.1	15.6	74.6
Bahrain	1.2	19.4	17.4	7.3	10.9	56.1
Bangladesh	9	13.8	10.1	12.3	9.0	54.2
Barbados	6.4	20	18	10.7	10.9	66.0
Belarus	8.8	13.7	17.5	10.8	10	60.8
Belgium	6	20	18.5	8.8	7.3	60.6
Belize	14.9	14	15.9	10.6	10.9	66.3
Benin	7.5	5.6	8.7	6.6	10.9	39.3
Bhutan	14	12.8	9.9	8.1	11.2	55.9
Bolivia	13.6	14.7	11.6	11.4	11.4	62.7
Botswana	9.1	9.7	15.4	9.7	12.6	56.6
Brazil	13.5	14.6	12.5	9.7	11	61.2
Bulgaria	11.2	16	16.9	8.7	9.8	62.5
Burkina	6.1	5.4	8.6	10.9	10.5	41.5
Burundi	3.8	7	9.4	10	9.9	40.2
Cambodia	12.8	4.9	10.8	8.1	9.5	46.2
Cameroon	11.8	10	12.1	8.7	10.9	53.6
Canada	15.5	20	18.7	6.9	16.5	77.7
CapeVerde	4.6	5.6	14.5	5.2	10.9	40.8
Cafrican	13.6	4.6	6.7	8.4	10.9	44.2
Chad	8.3	3.1	7.8	8.4	10.9	38.5
Chile	13.1	18.8	13.8	11	12.1	68.9
China	7.1	9.1	13.2	12.1	9.7	51.1
Colombia	12.6	17	12.9	11.6	11.5	65.7
Comoros	6.1	7.6	11.3	8.6	10.9	44.4
Congo	17.1	10.3	11.8	7.3	10.9	57.3
CongoDR	2	6	8.4	8.7	10.9	46
CostaRica	12.5	18	15.2	9.8	11.3	66.8
Croatia	11	20	13.3	12.9	10.6	67.7
Cyprus	5.5	15.9	18.1	11.3	10.9	61.8
CzechRep.	6.2	13.5	18.2	10.4	12.7	61
Denmark	5.5	15.9	17.6	7.6	14.7	61.3
Djibouti	3.7	9.7	10.6	3.5	10.9	38.4
Dominica Rep.	7.3	14.3	15.4	11.4	10.9	59.4
Ecuador	12.6	14.4	15.4	12.4	12.3	67.1
Egypt	3.4	18.3	13.3	12.5	10.5	58

ElSalvador	7.6	15.6	12.6	9.1	11.0	55.9
Equatorial	14.8	14.9	12.7	14.3	10.9	67.7
Eritrea	6.2	2.8	9.8	7.6	10.9	37.4
Ethiopia	6.6	3.1	8	8.1	9.5	35.4
Fiji	13.4	16.9	16.5	7.4	7.7	61.9
Finland	12.2	20	18	10.6	17.1	78
France	7.9	20	18	8	14.1	68
Gabon	16.5	8.8	13.2	12.2	10.8	61.5
Gambia	8.6	10.6	10.9	7.3	10.9	48.3
Georgia	11	17.5	13.1	7.6	10.9	60
Germany	6.5	20	18	6.2	13.7	64.5
Ghana	6.9	8.1	12.7	7.2	10.4	45.3
Greece	9.3	20	17.4	8.9	10	65.6
Guatemala	10.9	16	13.8	6.6	12	59.3
Guinea	13.1	7.7	9	11	10.9	51.7
Guinea-Bissau	11.8	8.9	6.1	10.3	10.9	48.1
Guyana	18.1	17.9	14	14.9	10.9	75.8
Haiti	6.1	6.2	10.5	6.5	5.8	35.1
Honduras	11.4	15	14.2	9.2	10.5	60.2
Hungary	9.5	13.5	16.9	8.9	12.6	61.4
Iceland	19.9	20	19.2	6.7	11.2	77.1
India	6.8	11	12.1	13.8	9.5	53.2
Indonesia	11.2	13.4	13.9	15.7	10.7	64.9
Iran	6.8	14.8	15.5	13.5	9.8	60.3
Ireland	11.2	19.8	19.1	10.5	12.8	73.4
Israel	0.8	16.7	16.8	10.9	8.6	53.9
Italy	7.7	19.8	17.4	5.3	10.7	60.9
Jamaica	8.2	17.5	15	7.5	9.5	57.7
Japan	8.1	20	18.9	6.2	11.6	64.8
Jordan	0.4	13	14.9	10.8	7.3	46.3
Kazakhstan	10	13.3	15.6	10.1	9.4	58.3
Kenya	4.9	8.7	11.5	11.7	10.5	47.3
Korea(Rep.)	6.1	19.3	17.7	8.4	10.9	62.4
Kuwait	0	18.1	17.1	10.3	8.1	53.5
Kyrgyzstan	10.5	17.7	13.8	13.5	8.8	64.2
Laos	13.9	6.2	12	10.5	10.9	53.5
Lebanon	6.1	15.7	15.8	10.5	7.7	55.8
Lesotho	7.3	6.8	12.3	5.9	10.9	43.2
Madagascar	12.2	6.6	9.8	11.2	7.6	47.5
Malawi	6.4	3.7	6.7	10.1	11.1	38
Malaysia	12.7	17.2	14.3	11.6	11.5	67.3
Mali	9.8	5	6.2	8.7	11.1	40.6

Mauritania	7.1	7.7	9.8	14.3	10.9	49.8
Mauritius	6.6	19.8	15.5	11.1	6.8	59.8
Mexico	8.1	14.5	14.1	10.7	10.1	57.5
Moldova	6.1	8	13.6	10.4	10.8	48.9
Mongolia	11.1	8.8	12	11.2	11.8	55
Morocco	5.4	9.3	12.3	12.5	6.7	46.2
Mozambique	10	8.1	7.5	8.5	10.7	44.9
Myanmar	12.2	10.3	12.1	8.5	10.9	54
Namibia	11.4	9.7	15	12.9	10.9	60
Nepal	10.2	8.7	11.2	12.6	11.8	54.4
Netherlands	7.9	20	18.2	8	14.4	68.5
NewZealand	15.9	19.7	17.4	4.8	11.3	69.1
Nicaragua	13.4	9.7	11.6	11.2	12.3	58.2
Niger	6.4	4.4	4.4	9.9	10	35.2
Nigeria	7.4	7.5	8.5	10.4	10.1	43.9
Norway	15.5	20	17	8.8	15.8	77
Oman	3.1	17.5	16.2	11.7	10.9	59.4
Pakistan	7.3	13.5	11.5	14	11.5	57.8
Panama	14.3	17.6	13.6	9.2	11.8	66.5
PapuaGuinea	17	11.5	10.3	7.7	8.1	54.5
Paraguay	13.5	7.7	13.2	11	10.5	55.9
Peru	15	13.9	13.9	11.3	10.3	64.3
Philippines	9.5	15.9	13.6	12.7	8.8	60.5
Poland	6.2	13.4	16	8.9	11.8	56.2
Portugal	9	20	17.1	6.3	13	65.4
Qatar	1.2	18.4	17.4	9.4	10.9	57.2
Romania	9.2	14.5	15.8	9.4	9.8	58.7
Russia	13	12.6	16.1	9.1	12.5	63.4
Rwanda	4.8	3.7	9.7	9.9	11.3	39.4
SaudiArabia	0.2	14.9	16.1	13.7	7.7	52.6
Senegal	8.2	7.2	9.9	8.7	11.3	45.3
SierraLeone	13.3	4.5	4.3	9	10.9	41.9
Singapore	1.2	20	16.8	7.8	10.3	56.2
Slovakia	10.3	20	18.1	9.1	13.8	71.2
Slovenia	10.4	20	17.9	9.7	11.2	69.1
SouthAfrica	5.6	12.2	12.7	10.1	11.6	52.2
Spain	7.6	18.3	19	6.8	11.8	63.6
SriLanka	7.5	12	15.3	10.6	10.8	56.2
Sudan	7.9	9.1	9.8	14.6	7.9	49.4
Suriname	19.4	17.8	16.2	10.7	10.9	74.9
Swaziland	8.2	11.4	10.8	12	10.9	53.3
Sweden	12.1	20	17.9	7.6	14.8	72.4
Switzerland	9.5	20	18	9.6	15.1	72.1

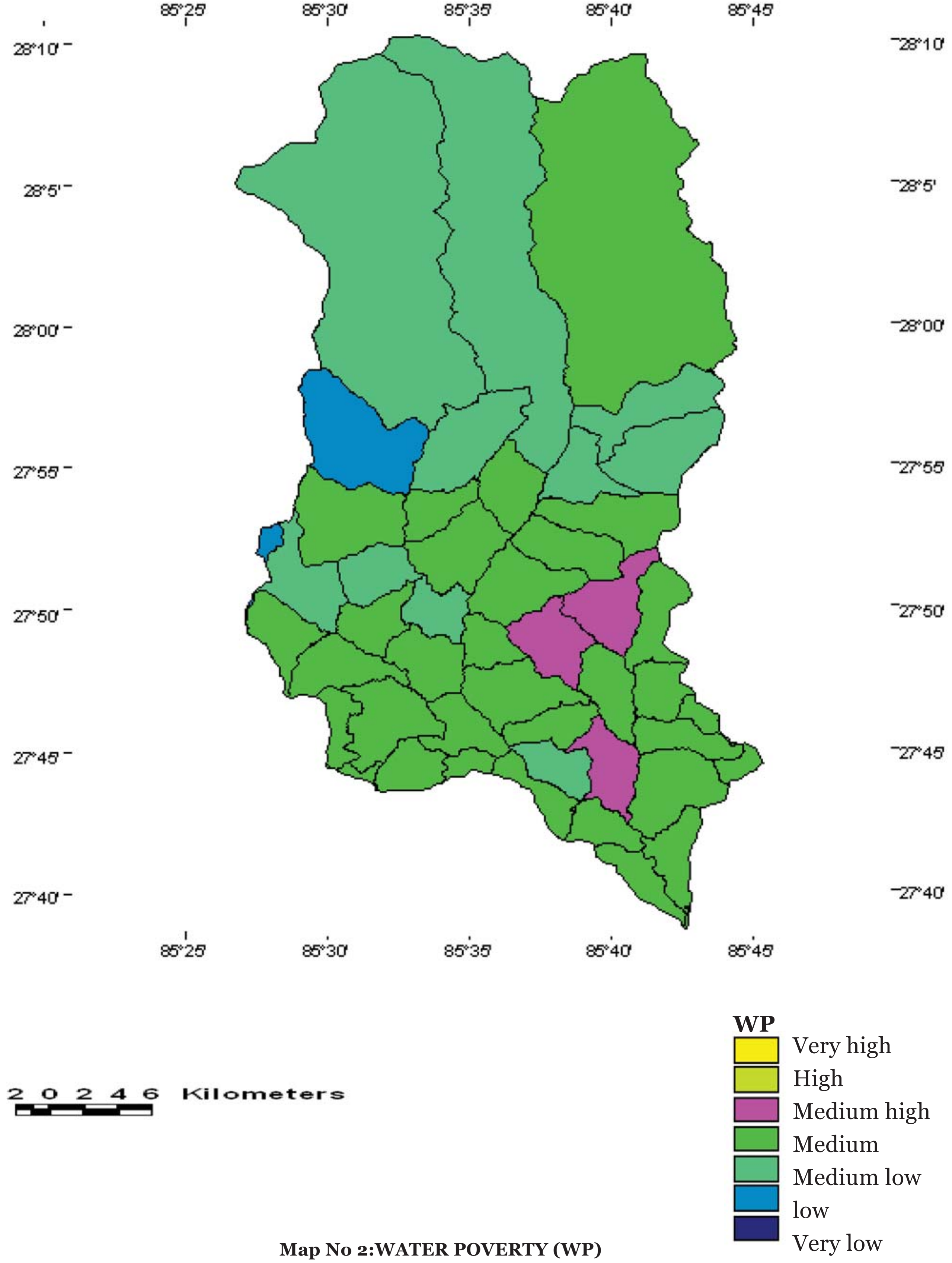
Syria	6.3	11.8	14.9	14	8.1	55.2
Tajikistan	10.9	12	13.7	11.9	10.9	59.4
Tanzania	7.4	10.5	10.4	8.2	11.8	48.3
Thailand	9	17.7	15	11.9	10.8	64.4
Togo	7.4	6.6	11.1	9.8	11	46
Tri&Tob	8.4	17.6	15.4	8.3	9.2	59
Tunisia	3.2	12.4	15.3	12.2	7.8	50.9
Turkey	7.8	14.8	13.1	10.7	10.1	56.5
Turkmeni-stan	10	17.7	14.7	16.7	10.9	70
Uganda	7.3	7.1	10.9	6.7	12	44
UAE	0	18.6	17.1	5.5	10.9	52
UnitedKing-dom	7.3	20	17.8	10.3	16	71.5
Uruguay	12.8	19	15.6	8.8	10.8	67.1
USA	10.3	20	16.7	2.8	15.3	65
Uzbekistan	6	19.3	14.6	12.7	8.2	60.8
Venezuela	14	13.7	14.9	10.5	11.9	65
Vietnam	10	6.4	14.4	13.3	8.3	52.3
Yemen	1.9	7.8	10.5	12.8	10.9	43.8
Zambia	10.7	7.4	8.5	13.4	10.5	50.4
Zimbabwe	6.1	9.1	14.2	11.8	12.1	53.4

Source: Lawrence, P., Meigh, J., and Sullivan, C., (2002)

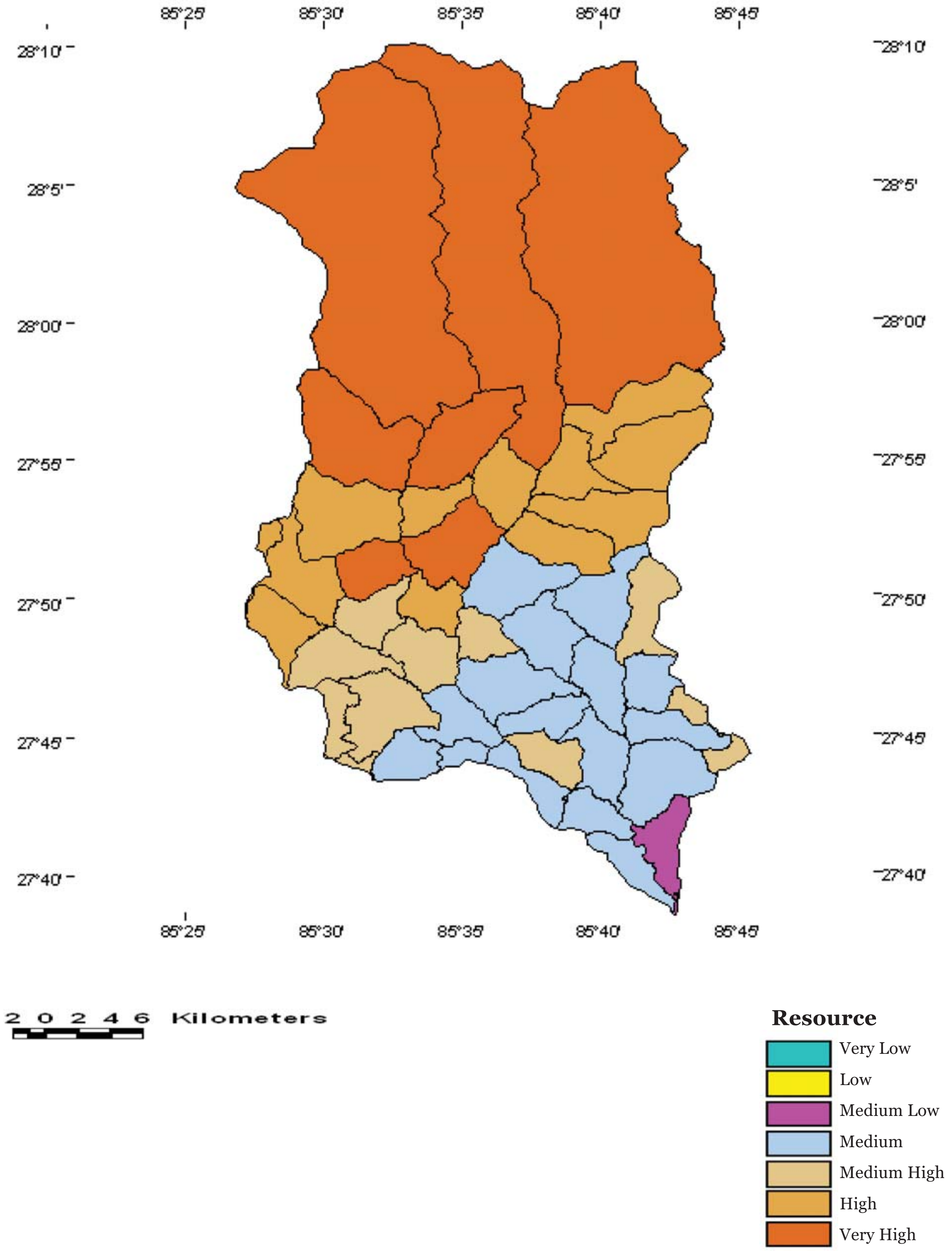
MAPS

VDC, Water Poverty & Its Components

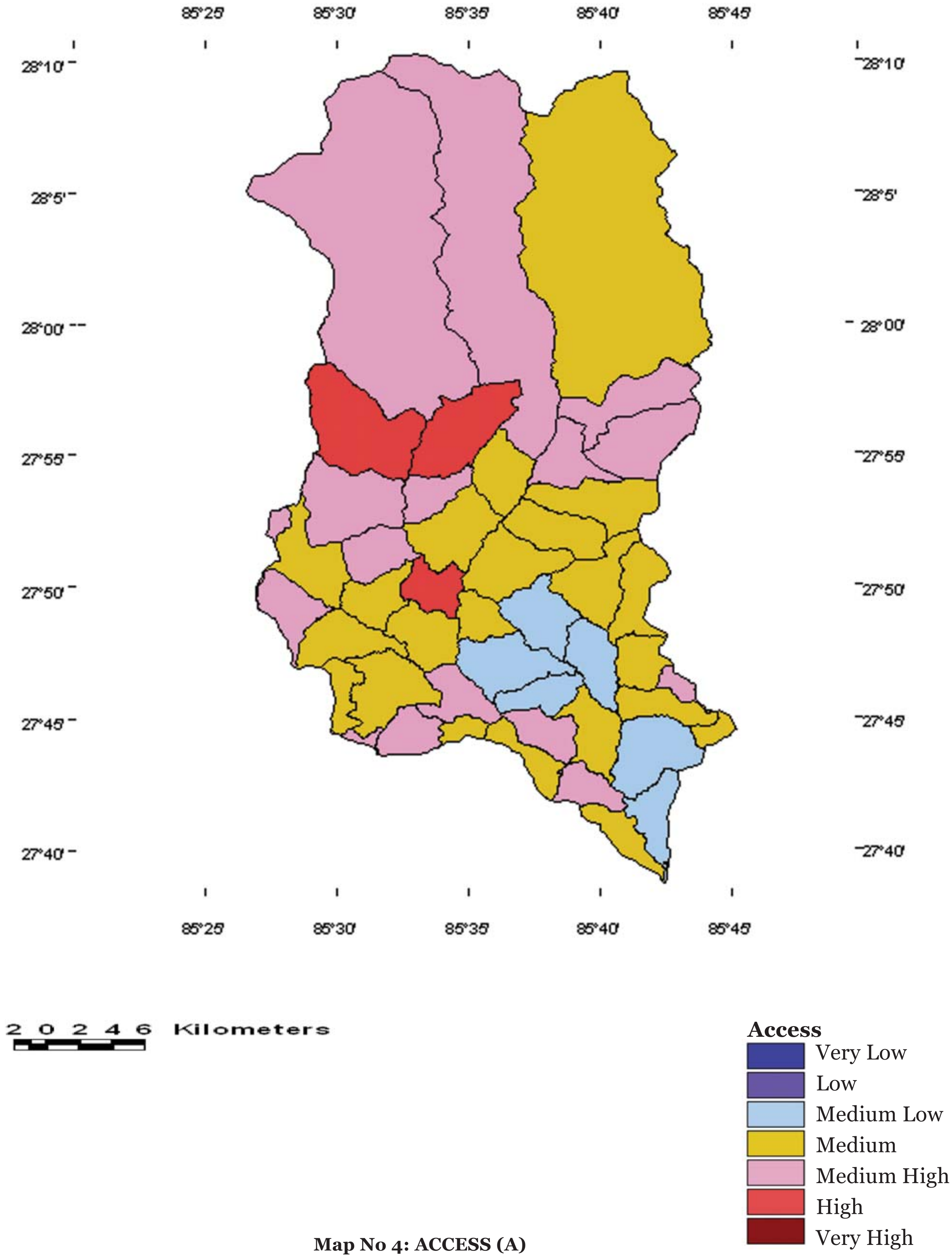
Map No 1: VDC Map of Indrawati Basin



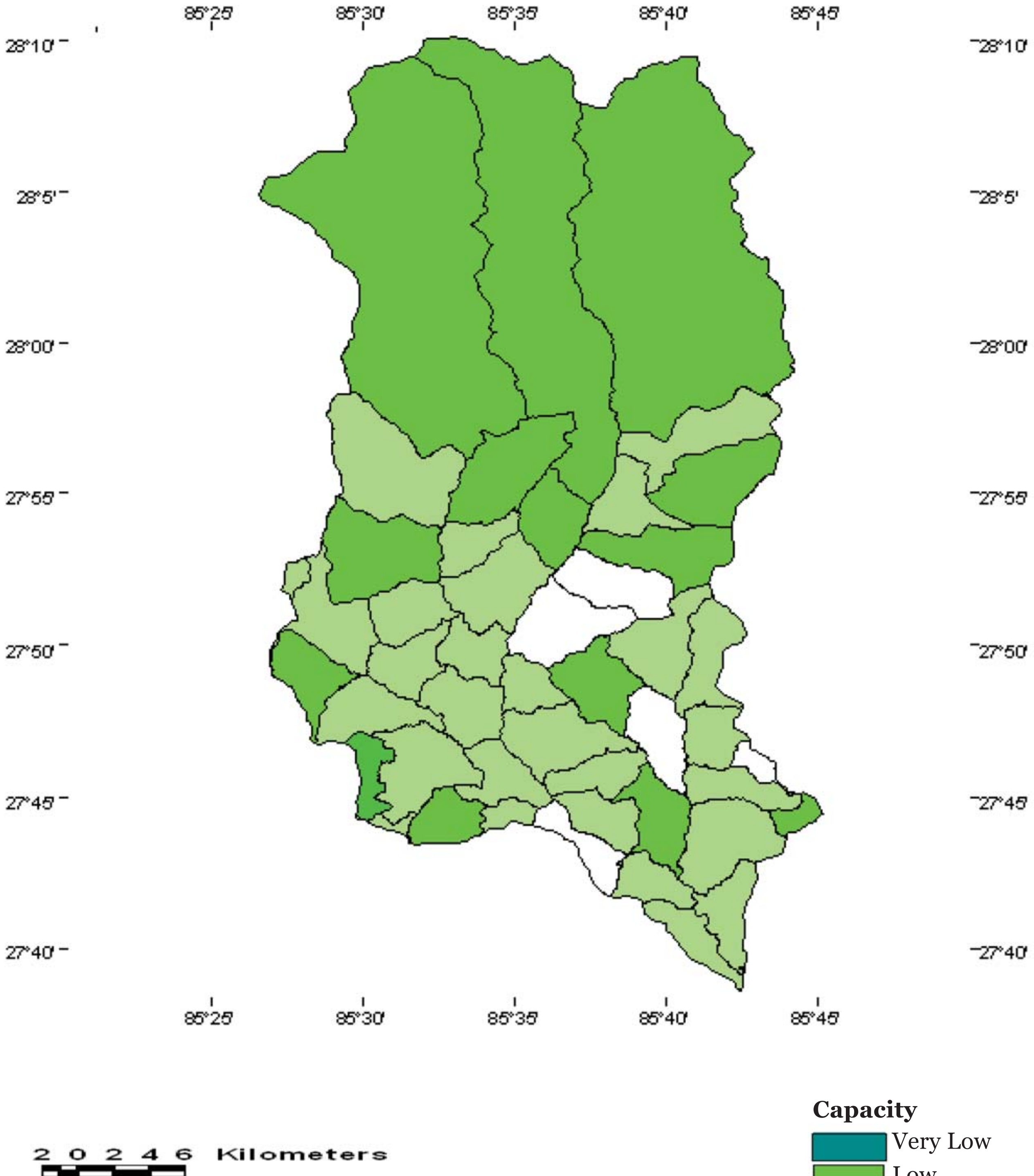
Map No 2:WATER POVERTY (WP)



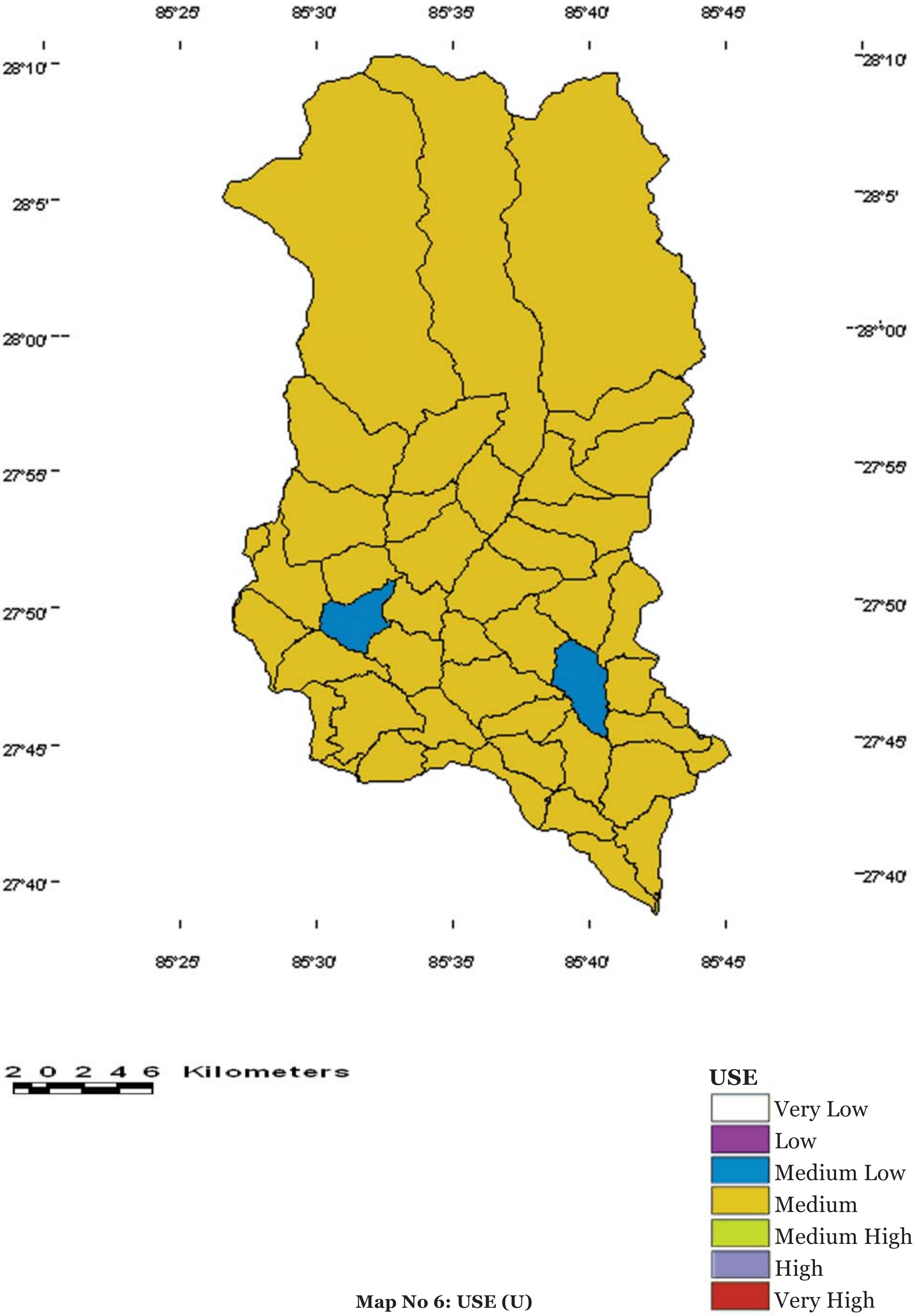
Map No 3: RESOURCE (R)



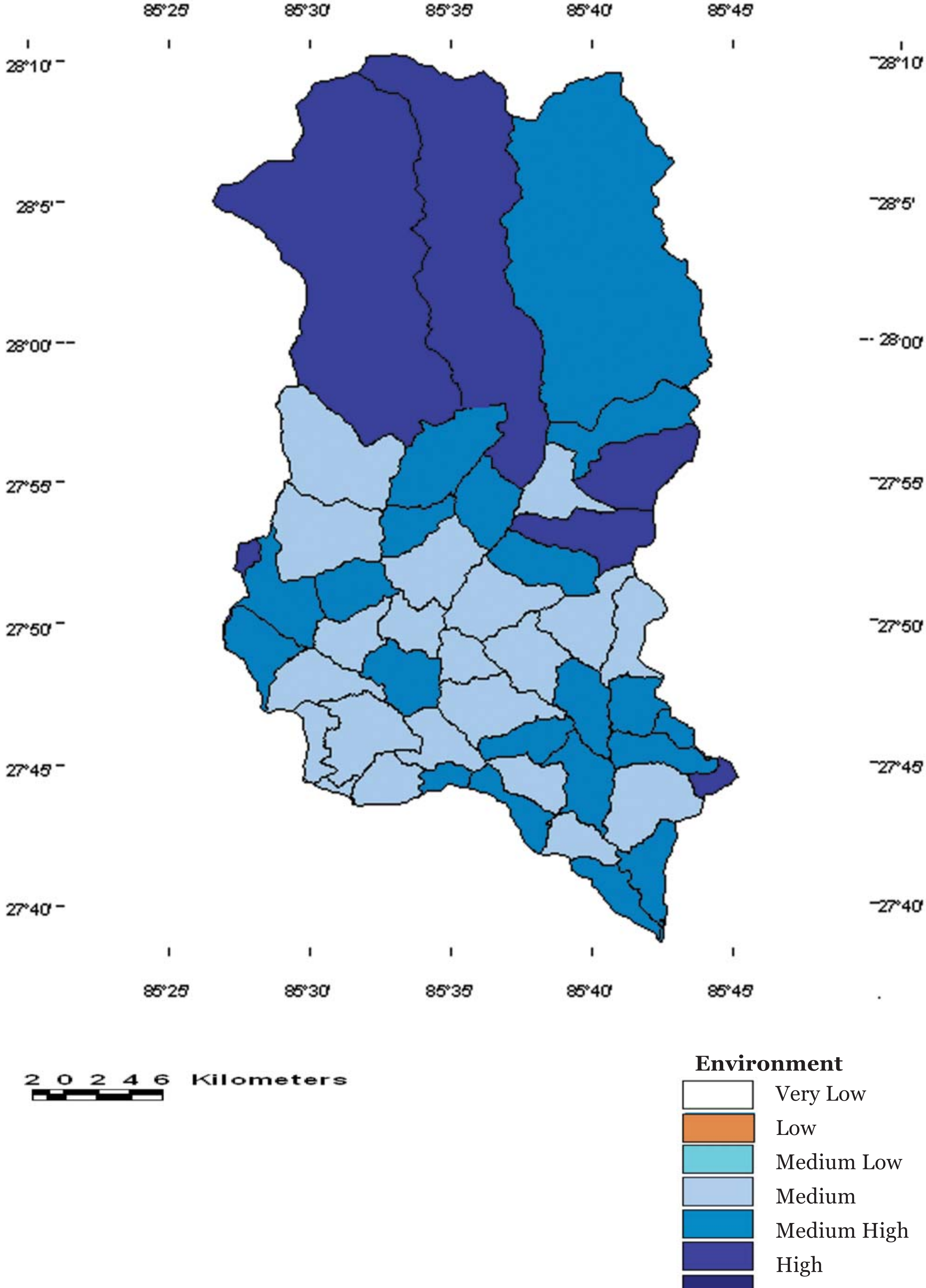
Map No 4: ACCESS (A)



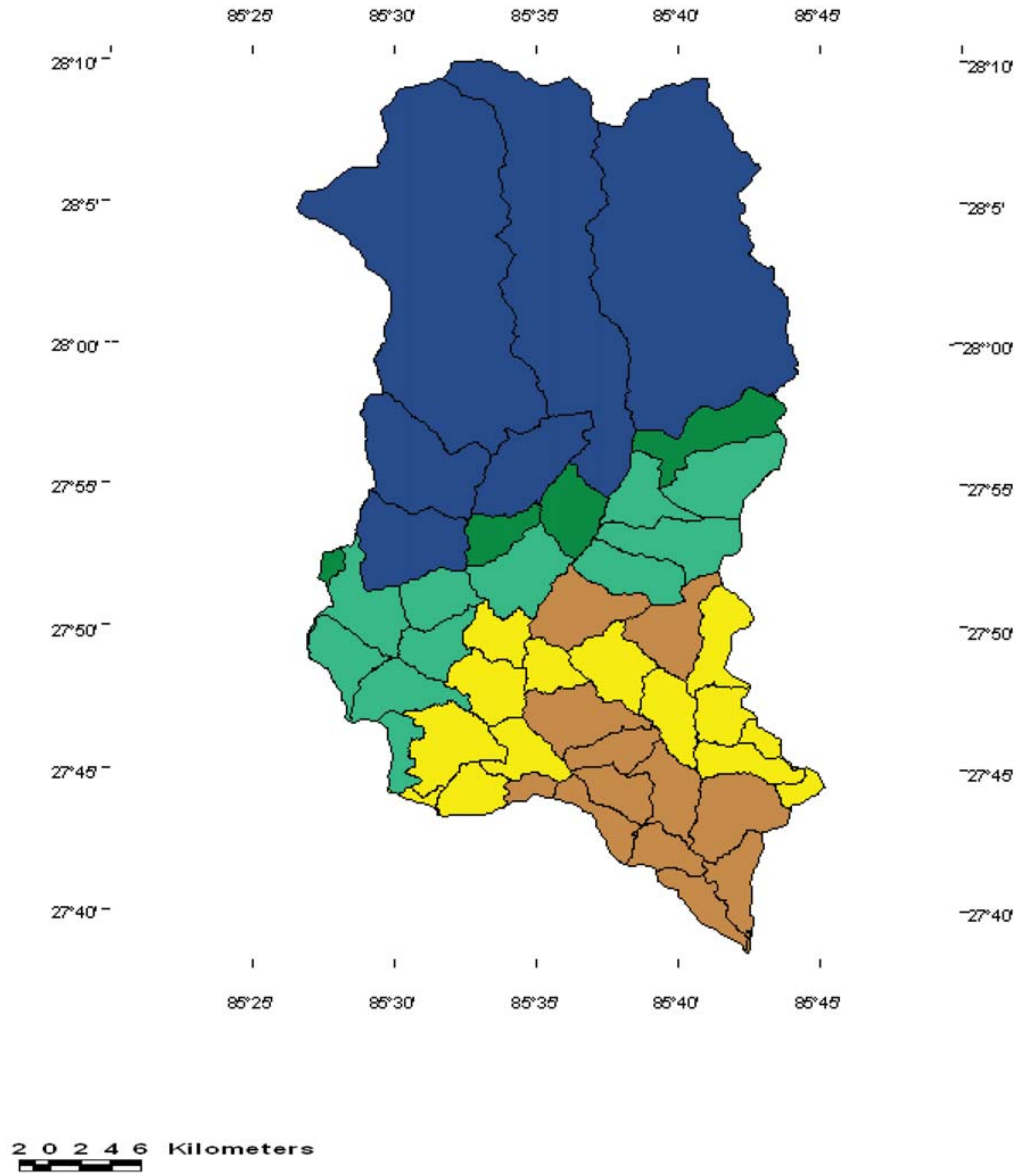
Map No 5: CAPACITY (C)


85°25'
85°30'
85°35'
85°40'
85°45'
28°10'
28°5'
28°00'
27°55'
27°50'
27°45'
27°40'
2 0 2 4 6 Kilometers
USE
Very Low
Low
Medium Low
Medium
Medium High
High
Very High

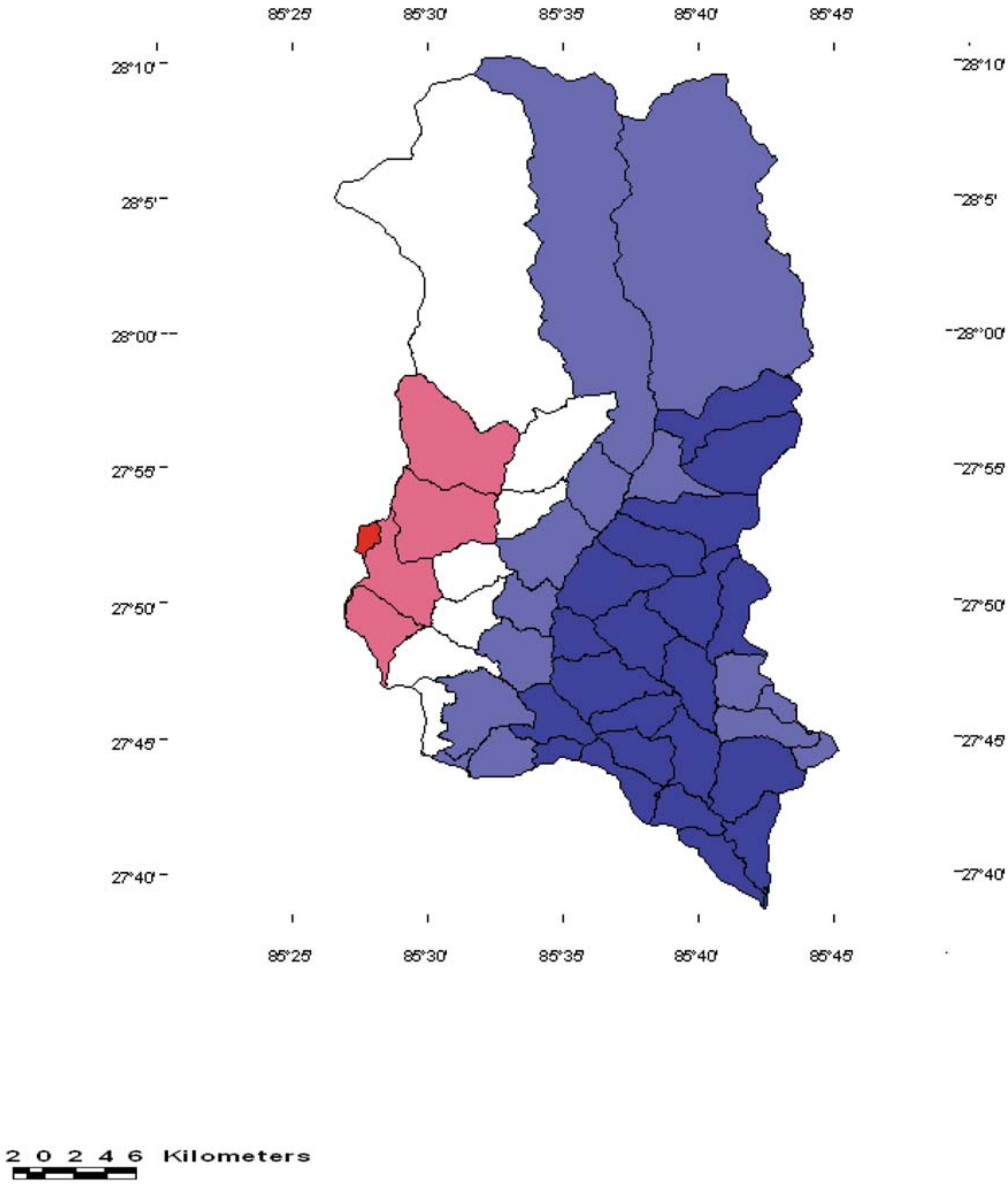
Map No 6: USE (U)



Map No 7: ENVIRONMENT (E)



Map No 8: MONSOON RAINFALL



Non-Monsoon rainfall, mm

- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

Map No 9: NON MONSOON RAINFALL

WWF in Numbers

1961

WWF was founded in 1961

+ 100

WWF is in over 100 countries, on 5 continents

+ 5M

WWF has over 5 million supporters

+ 5,000

WWF has over 5,000 staff worldwide

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.wwfnepal.org

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