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Kamala Basin field trip to support the basin planning process in Nepal

A project in the Sustainable Development Investment Portfolio (SDIP)

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This work contributes to CSIRO and WECS intent to further scientific cooperation in water resource management and is undertaken under the guidance of the Nepal-Australia Joint Advisory Committee on Water Resource Management.

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Important disclaimer

Ethics

The activities reported herein have been conducted in accordance with CSIRO Social Science Human Research Ethics approval 'SDIP Phase 2 - Koshi (12/17)'.

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SDIP's goal is increased water, food and energy security in South Asia to support climate resilient livelihoods and economic growth, benefiting the poor and vulnerable, particularly women and girls

SDIP end-of-strategy (2024) objective: Improve the integrated management of water, energy and food in the major Himalayan river basins – especially addressing climate change and the interest of women and girls

SDIP end-of-investment (2020) objective: Key actors are using and sharing evidence, and facilitating private sector engagement, to improve the integrated management of water, energy and food across two or more countries – addressing gender and climate change

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Abbreviations

CMISP	Community Managed Irrigation Sector Project
CSIRO	The Commonwealth Scientific and Industrial Research Organization, Australia
DDC	District Development Committee, Nepal
DFAT	Department of Foreign Affairs and Trade, Australian Government, Australia
DHM	Department of Hydrology and Meteorology, Nepal
DOED	Department of Electricity Development, Nepal
DOI	Department of Irrigation, Nepal
DSCWM	Department of Soil Conservation and Watershed Management, Nepal
DWIDM	Department of Water Induced Disaster Management, Nepal
DWSS	Department of Water Supply and Sanitation, Nepal
GoI	Government of India
GoN	Government of Nepal
ICE WaRM	International Centre of Excellence in Water Resource Management, Australia
JAC	(Nepal-Australia) Joint Advisory Committee (on Water Resources Management)
MOE	Ministry of Energy, Nepal
MOIR	Ministry of Irrigation, Nepal
NDRI	Nepal Development Research Institute
SDIP	Sustainable Development Investment Portfolio
WECS	Water and Energy Commission Secretariat, Nepal

Executive summary

Kamala Basin in the South central region of Nepal is an important basin for irrigated agriculture but has limited water resource during the dry season. The development and implementation of a Kamala Basin plan may have a significant impact on the water resources management and provide access to water for the population in a sustainable way.

This report presents a summary of a field trip to the Kamala River basin in the South central region of Nepal during the period of 28th of February to 4th of March 2017. The aim of the field trip was to gather information to support the development of the pilot Kamala Basin plan as part of the Sustainable Development Investment Portfolio (SDIP) Phase 2 activities. Fourteen Nepalese stakeholders, eleven from Government and three from Non-Governmental organizations, and five from Australia participated in the trip. Planning for the trip included collation of bio-physical and social data.

The group visited the regional offices of the Department of Irrigation and the Department of Water Induced Disaster Management in order to establish a broader discussion of the project with regionally based senior officials. The trip included visits to irrigation areas, water canals, and erosion containment and reduction infrastructure. The group met with local farmers and communities leaders to identify and discuss water access issues and limitations especially the need for year-round water availability for multiple crop rotations and finishing of crops in the dry season.

Irrigated agriculture is an important economic, environmental and social feature of the Kamala Basin. The most common irrigation system is surface irrigation in which open canals are used as the water conveyance structures and gravity method is used to irrigate the agricultural land. However, in some parts of the downstream Terai regions, groundwater is pumped for irrigation. Larger irrigation systems consist of weirs or barrages in the river to divert water into the main canal, secondary and tertiary canals from which water is fed into the field, while smaller run-of-the-river systems are fed by small canals directly from the river. The predominant crops are rice during the wet period and wheat and maize during winter and the dry season. In most of the agricultural lands there is not enough soil water available during the entire dry season, limiting the production to maximum of two crops per year.

Main water related issues

Several issues related to water management were observed in this catchment during the field trip. Some may be improved with the development and implementation of a Basin Plan.

- The Kamala River is unstable due to a high level of erosion, sedimentation and gravels that are transported during the monsoons, damaging infrastructure, irrigation canals and altering the riverbed.
- Impact of monsoon rainfall on riverbeds remains a problem, despite a large project being undertaken by the DWIDM that built infrastructure to reduce the water velocity and reduce the damage during storms.
- Parts of the basin are susceptible to temporary floods which may cause damage to local proprieties, affecting crops and livestock in extreme events.
- A high level of drainage causes rapid water depletion. No storage structures (dams) are found to store water of the monsoon season, which could be used for dry season for various purposes.
- Simple infrastructure such as that which diverts water from the river to parallel canals, require constant maintenance and rebuilding 3-4 times per year.

- Additional issue to water limitation during the dry season is the small land size per family. This is a strong economic limiting factor, which leads to minimal income generation for families in the region.
- Groundwater is used for domestic consumption but little is used for irrigation. There are some groundwater information available, however more detail is required to better understand the potential use of groundwater resources.
- Irrigation project initiatives and resource allocation appear to be poorly integrated between departments and GoN divisions. Opportunities exist for greater coordination of water-related work by government agencies and other actors.
- Limited infrastructure exists to distribute water in most parts of the basin.
- The current irrigation systems may require efficiency improvements to reduce evaporation and retain water in the system longer.
- Low level of awareness is observed in the farming community on how to improve irrigation efficiency.
- Lack of proper policy in water allocation between upstream and downstream of the canal irrigation users is observed.
- Funding sources are a limiting factor for water infrastructure construction.

Findings

The main findings of the field trip were:

- Capacity to engage in river Basin Planning needs to promote the integration of technical officers with farmers, politicians, provincial government, and national government.
- Stakeholder engagement needs to be done in parallel with the modelling activities and capacity building.
- A common action between the GoN Ministries is required to synchronise proposals and establish new projects.
- There is limited hydrological and meteorological data available or being collected to fully support basin modelling.

Recommendations

- Improving infrastructure and managing watershed is important and needs to be pursued in a coordinated way across different relevant state and non-state actors.
- Obtain information of the existing water resources, with respective location and availability during the year as well as water consumption, crop productivity, water distribution from local offices and a better understanding of the social aspects.
- A modelling exercise may help to demonstrate priorities and critical location for infrastructure and benefits.
- Meteorology and streamflow data collection is strongly recommended in order to contribute to modelling validation and to quantify water availability.
- Explore the potential to use groundwater for irrigation.
- Establish stakeholder engagement action plan.
- Maintenance of the existing weirs and river and irrigation canals to quantify and improve flows. The canals need to be cleaned up – rubbish removed, overhanging vegetation removed and other obstacles that reduce flow capacity of these canals.

- Storage structures or diversion of water from another river is required to meet the year round irrigation and other purposes.
- Funding organisations need to focus on adoption of existing research for activities with a higher potential to promote impact for the farmers and communities and improve the sustainability of the production systems.

1 Introduction

1.1 Background

This SDIP Phase 2 project aims to support and improve regional water planning and management through existing bilateral engagements and regional initiatives. The focus of work in 2016-2017 was capacity-development, which included working with government officials to increase their capability to devise and implement effective policies for water resource management. This engagement process supports the overarching SDIP objective of key actors using and sharing evidence to improve the integrated management of water, energy and food by including local research institutes, training providers and experts in its delivery. The capacity building generated by the development of a Basin Plan for the Kamala Basin of Nepal includes practical activities in priority areas selected by the Government of Nepal (GoN).

The Kamala Basin was selected in 2016 by the Nepali representatives on the Nepal-Australia Joint Advisory Committee on Water Resource Management (the JAC) as a pilot basin for a joint exercise to develop an example of a Basin Plan for Nepal. The objective of this exercise is to identify the practical steps and actions necessary to develop and implement a plan that will provide direction for water management in the basin with a potential to be applied to other basins in Nepal.

It will also give the Nepali participants sufficient exposure to understand and evaluate products to be developed as part of the World Bank Basin Planning consultancy.

Activities include developing an understanding of the biophysical and social aspects of the basin; ability to identify the main issues and potential solutions related to basin management and develop GoN capabilities. Basin planning often has a significant modelling component to enable simulation and analyses of a range of Basin Planning scenarios. The development and implementation of Basin Plan development in Nepal requires the engagement and representation of the GoN with the participation of government agencies related to water resources as well as non-governmental stakeholders.

With this premise and with the support from NDRI, CSIRO and WECS organised a 5-day field trip to the Kamala Basin to identify the relevant aspects of water use, limitations to water use, issues and existing practices and projects being undertaken. The intent of this first visit was to provide an overview of the most important aspects and drivers related to water resources in the basin, meeting and learning from the representatives from the local departments and informal meetings with leaders from local communities. The schedule is available at Appendix A .

1.2 Representation and participation

The field trip had representatives from nine government and non-government agencies from Nepal, and CSIRO and International Centre of Excellence in Water Resource Management (ICE WaRM) from Australia with a total of 19 participants (Appendix B). The Nepali team was selected by the GoN departments. The diversity of backgrounds in the group was established in order to cover the different aspects related to water resources management. The represented government agencies were Water and Energy Commission Secretariat (WECS), Department of Hydrology and Meteorology (DHM), Ministry of Energy (MOE), Department of Electricity Development (DOED), Department of Water Induced Disaster Management (DWIDM), Ministry of Irrigation (MOIR), Department of Soil Conservation and Watershed Management (DSCWM) and Department of Water Supply and Sanitation (DWSS). CSIRO and ICE WaRM had five participants with expertise in agronomy, ecology, hydrology, social science, and water policy development.

NDRI contributed with three scientists and with trip logistics and provided interpretation support when meeting with local community people (Figure 1).

Figure 1 Participants of the field trip at Janaki Temple in Janakpur

2 Objectives and outcomes

2.1 Objectives

The objectives of the field trip were to identify the main elements of water use and resource availability in the Kamala Basin, meet with local officials related to water resources management from the GoN and interact with community level water users. An additional aim was to overview the existing and potential future issues related to water resources management in order to generate information and promote discussion on the scope and processes to develop the Kamala Basin plan.

2.2 Outcomes

- Knowledge was obtained which will enable the scoping of issues to be considered in the development of the Kamala Basin plan.
- Initial interaction with the local GoN officials was established that will promote the exchange of information and data necessary to undertake the Basin Planning process.
- A dialogue was established between the GoN participants and identified the requirements for capacity building.
- Discussion with the local officials on water resources management which enabled the development of an understanding the factors limiting water availability and quality to be considered in the Basin Plan.
- Identification of data availability and gaps in information, which are essential for the project.
- A contact network between scientists from CSIRO, ICE WaRM and GoN was established.
- An understanding of the social economic and environmental features of the basin was obtained.
- The basis on which to prioritise future actions related to the development of the Basin Plan was established.

3 Activities

3.1 Itinerary of the visit to Kamala Basin

The itinerary and route (Figure 2) were designed by WECS, NDRI and CSIRO to visit different parts of the Basin (Figure 3). The participants from the GoN were nominated by the respective agencies with the intent of representation by the main government organisations related to water management.

The group visited the regional offices of DOI, DWIDM, DDC. The local senior officials guided the group's visit of irrigation areas, water canals and erosion control infrastructure. The group discussed the issues and limitations water access throughout the year especially during the dry season.

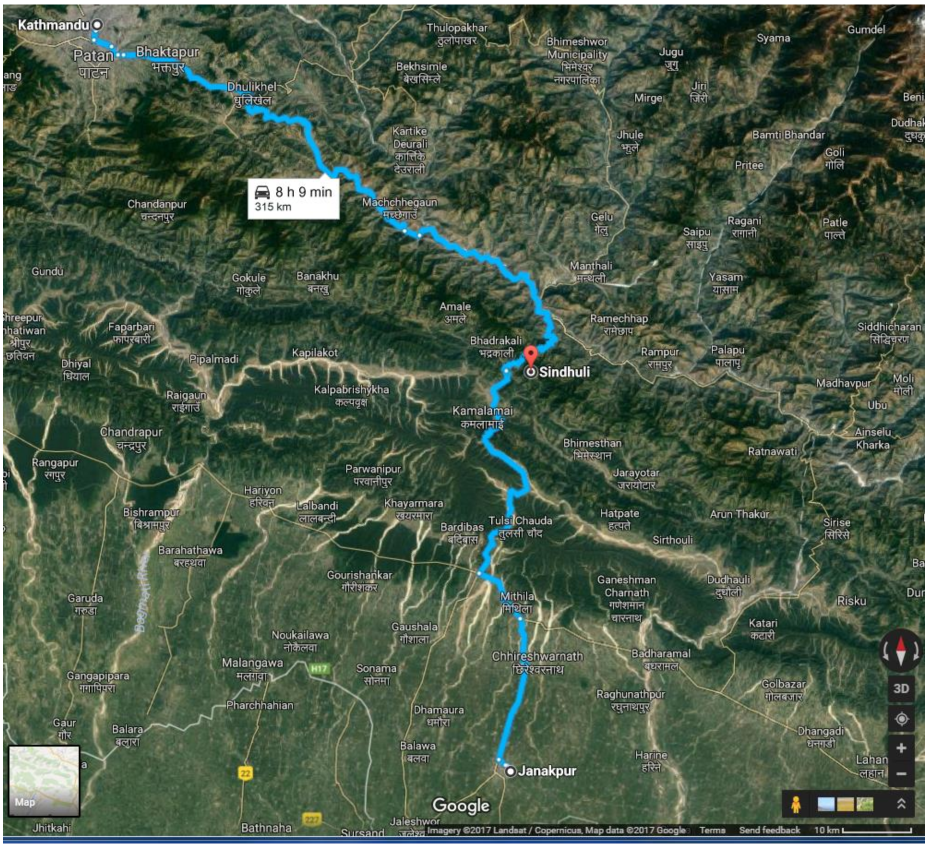

Figure 2 Map of the main itinerary from Kathmandu to Janakpur

Figure 3 Kamala Basin location (red lines show the basin boundary and sub-catchments)

Day 1, 28 February 2017

Travel from Kathmandu to Sindhuli district visiting the upper part of the Kamala Basin, which enabled discussion within the group of the characteristics of the region. The group stopped to inspect the bed of the Kamala River at the crossing point of the main road close to Sindhuli madi (

Figure 4).

Figure 4 Kamala River close to Sindhuli madi (left) and upper Kamala catchment view (right, nº1 in Fig.3)

Day 2, 1 March 2017

Visit to Irrigation Development Division Office, Sindhuli, received by Divisional Engr. Anubhav Chaudhary and Engr. Jankak Dhakal. A discussion focussed on the challenges in irrigation sector of Sindhuli District, water resources availability and challenges with river bed degradation or aggradation. The district office is responsible for working with local communities and support small scale irrigation. The irrigation office is only involved in small scale planning and support for local water user committees. Large project plans are formulated at the centre level, i.e. Department of Irrigation. However, small scale projects such as the CMISP

(Community-Managed Irrigation Sector Project) is managed by the local office, some social and ecological data has been collected.

At one site inspection, riverbed degradation of more than a metre per year is the main problem in the canal intake site. It was suggested that the cause was natural scouring of bed material by monsoon flows, which had reputedly become more variable in recent years, as well as excavation for construction material like stone, gravel and sand from the riverbed, upstream and downstream of the intake. In-channel embankments are made to raise the river water level to maintain flow into the entry canal. However they are frequently washed out or severely damaged by flood. Aggradation and degradation of the river bed is significant in most part of the Kamala River. There is limited budget for maintaining and repairing canals within the district and given the size of each enterprise (less than one acre per family).

Crop irrigation is important for the local economy and the water requirement is estimated based on the size of the irrigation command area. Small-scale projects are often implemented independently or with other Departments. However, large projects, and where projects are close together, there are discussions between the relevant districts and/or departments. Large irrigation projects are planned and managed under central level of the GoN coordination. District level coordination between different offices is made by a District Development Committee in which all the heads of the offices participate. It appears that most of the projects are carried out in isolation, and require further coordination – a process that may be facilitated by the Basin Planning process.

The group visited the Sabo dams and Ranibas Irrigation site. The Sabo dams (sediment control dams) were constructed across the tributaries of Kamala Basin in series of storages. Some are constructed from concrete, while others are constructed from gabions. Basic canals were built to divert water from the river and to be used for irrigation (Figure 5). However, the embankment has been breached by flooding three times already this year (2017). The local people have had to rebuild it four times. Generally, they fund the construction cost of the embankment. It costs about Rs 50,000 per construction, which is quite costly in terms of return from the agricultural produce given the size of each enterprise. The canal is carrying about 300 l/s of water to the field. An area of 75 ha with each land holding being irrigated on a rotational basis by the villagers of about 250 households (Figure 5).

Rice is the main crop that people grow in paddies during the monsoon and spring season. Wheat and maize are the other most common crops grown using end-of-season water and soil moisture – however the success of these crops is determined by the onset of the dry season. The cropping area is small for each household (less than an acre) which reinforces the need to obtain three crops per year and maintain irrigation throughout the year. Around the homes, small areas of vegetables are also grown. Water from the river is also used for domestic use but not for drinking, which is provided from groundwater wells. People in the area are desperately waiting to receive river training work and technical assistance. Discussion with several landholders suggested that fish are becoming less abundant every year (Figure 6).

Figure 5 Satellite image showing canal built by the community to collect water for irrigation of 75 ha

Figure 6 Kamala River (top left), channel to divert water from the river for irrigation (top right, nº2 in Fig.5), well to pump water to domestic use (bottom left) and example of river excavation (bottom right)

Day 3, 2 March 2017

Visit to the Kamala Irrigation Management Division and discussions with Engineers Arun Kumar Yadav, Birendra Prasad Karnal and Hasmat Ansari. The group visited the Kamala River weir, irrigation regulators and canals, which run from Kamala to Raghunathpur (Figure 7 and Figure 8). Local meetings were held with irrigators from local villages around the canal system that receive water from the irrigation scheme who were concerned that the availability of water from the scheme was declining particularly at the end of the growing season leading to declining yields.

The division controls the releases of water, with water flows estimated based on past measurements. There are no current continuous measurements of streamflow in the canals; there are measurements of the water height, and flow is estimated based on equations developed many years ago (the system is approximately 40 years old).

The two main issues are the sedimentation that requires continuous maintenance (funding and hence maintenance until recently was limited) and the scarcity of water from March to the beginning of the wet season.

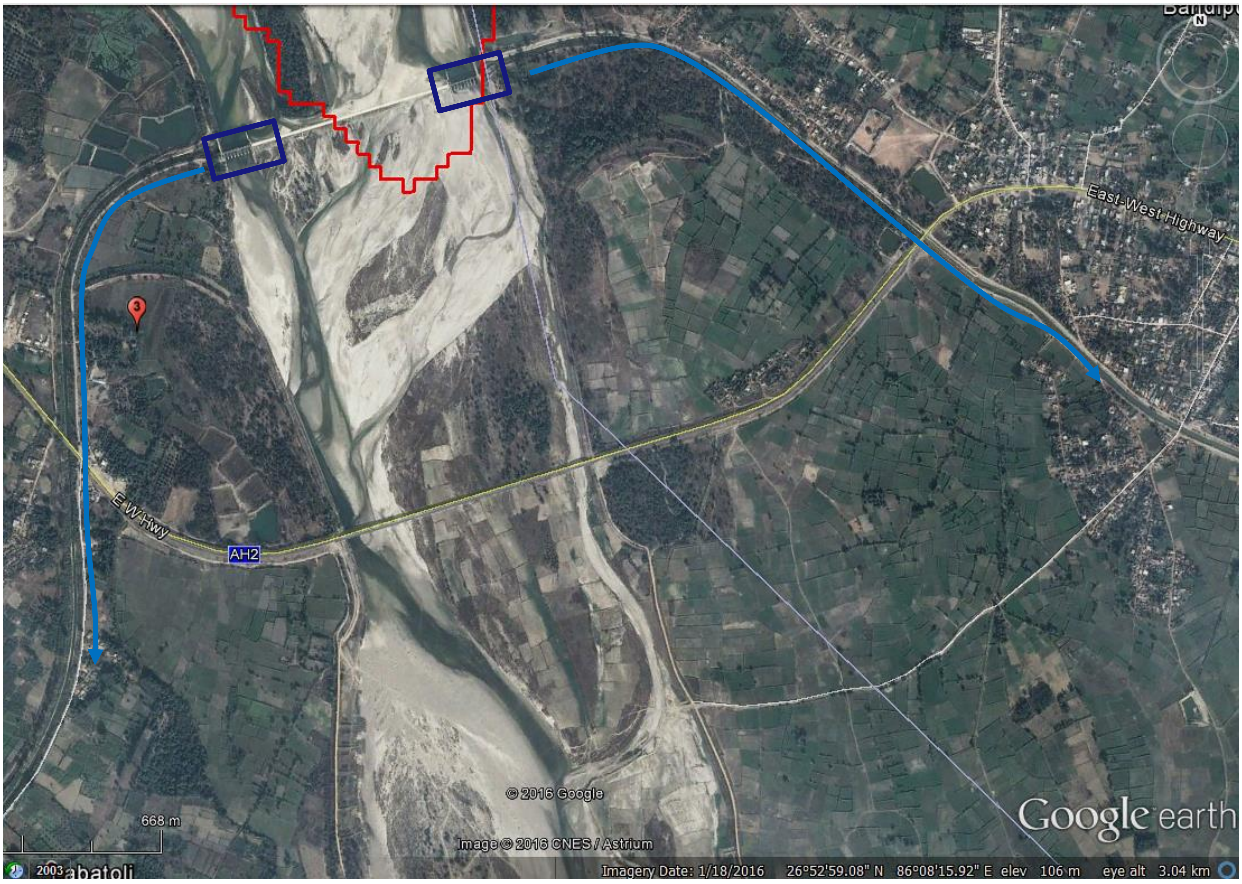

Figure 7 Satellite Image showing the two canals (blue lines) built to divert water from Kamala River for irrigation. The blue squares show the points where the water is diverted from the river

Figure 8 Infrastructure to divert water from the river to the irrigation canals. The water is mainly used for irrigation, domestic, and recreation. Discussion with the communities' leaders and the Head of the Irrigation Division on how water has been used and limitations

The group visited another irrigation scheme from one of tributaries of the Kamala River that presents similar issues of sedimentation and scarcity of water at the end of the dry season. The riverbeds have been exploited with extraction of sand and rocks for construction industry (Figure 9).

Figure 9 View of a tributary of Kamala River used for irrigation (top left); group meeting and discussing with the local communities (top right); litter in the canals (bottom left) and traffic of trucks transporting sand and rocks from the river (bottom right)

Day 4, 3 March 2017

Visit to DWIDM to discuss and visit the infrastructure installed along the Kamala River to protect the riverbank, reduce erosion and sediment movement. This is a US$42M project between GoN and GoI (Figure 10).

Figure 10 Meeting with engineer responsible for erosion control of the river bank; infrastructure (gabions) with rocks from the river (top right); concrete posts installed to reduce erosion of the riverbanks in Kamala River during the monsoon, the middle right shows the concrete post covered with sediments after two years of installation; infrastructure to divert water from flooded areas (bottom left) and irrigated paddock (bottom right)

Day 5, 4 March 2017

Return to Kathmandu from Janakpur. The limited capacity of the road system, due to a lack of maintenance, to transport products produced in the basin would appear to be an important limiting factor in the growth of the region. The region is however, relatively close to India which could be developed as an alternative market. However more information is needed to make a judgement on this.

4 Key findings

4.1 Existing environmental, economic and social aspects

- The Kamala Basin has an area of 2050 km^2 and a population of nearly half a million people, giving a density of 205 people per km^2, with most people reliant on agriculture for survival. It is understood that across the irrigation areas of the country about 85% of properties are less than one acre. Based on literature reviewed prior to the field trip, the Koshi Basin (in which the Kamala is situated) is described as having complex social stratification. People in the Terai (plains) are generally more deprived than hill or mountain groups, and that lower caste people and Muslims are more deprived than higher caste people. Approximately 50% of deprivation (based on a multidimensional poverty index) derives from lack of access to electricity, improved drinking water, and improved sanitation (Khadka et al., 2014[1]). Dalits in the Terai experience the highest levels of multidimensional poverty, with low education and social capital. Muslims and Dalits reported a difficulty in influencing even local decision making (Khadka et al., 2014).
- Agriculture is the main economic activity and source of income for most of the population in the Kamala Basin. Irrigation is essential for production since the rainfall distribution is concentrated in 6 months and most of the streamflow occurs during 4 months of the year.
- Irrigation water is delivered mainly by canals and distributed using gravity and in some limited cases by pumps and pipes. Rice cultivation uses inundation systems and is concentrated during the monsoons. Usually the household is able to obtain two crops per year but during the dry season, there is not enough water for irrigation for the potential third crop since the irrigation water lasts only until March. Farmers at the tail end of surface irrigation schemes may receive inadequate water and need to access groundwater which requires some form of pumping.
- It is suggested that there is a strong relationship between monsoon activity and groundwater. The open canal system and flood irrigation will recharge groundwater and increase soil moisture which is available until late in the dry season. Observations suggested that groundwater levels were relatively close to the soil surface (about 1.5m below the soil surface). Groundwater water extractions still rely predominantly on pumps run by diesel.
- The dominant crops of rice, wheat and maize are low value crops competing with prices from production in India. Alternative crops with higher values are rare except for some vegetables produced at a small scale.
- Much of the young agricultural workforce leave the region to work overseas (the lower caste people predominantly work in the Middle East in the construction sector) affecting the capacity of regional production. It is estimated that more than 35% of Nepal's GDP is provided by remittance from overseas workers. Male labour out-migration has been described as a defining feature of agrarian change in South Asian rural communities, including this region. It is a response to inadequate livelihoods and household food insecurity. The increasing burden on women left to farm has important implications for agricultural productivity, gender relations, and nutrition and health (Foran et al., in review[2]).

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[1] Khadka, M., Rasul, G., Bennett, L., Wahid, S., Gerlitz, J.-Y., 2014. Gender and Social Equity in Climate Change Adaptation in the Koshi Basin: An Analysis for Action, in: Leal Filho, W. (Ed.), Handbook of Climate Change Adaptation. Springer-Verlag, Berlin.

[2] Foran, T., Sugden, F., Lahiri-Dutt, K., Neupane, N., Siddiqui, S., Darbas, T., in review. A framework to improve argument over gender and development, applied in Asia's Koshi River Basin. Manuscript submitted to Geoforum.

- Floods during the monsoons are frequent but last only a few days due the high drainage rates and water level recession.
- Irrigation using canals appears to present low efficiency with high water loss by drainage and evaporation.
- Compared to building new surface schemes, irrigation can be provided faster by investing in tube wells or pond rehabilitation.
- The high level of sedimentation and extraction of gravel and sand create major problems to install and maintain infrastructures to distribute water across the basin. This instability of the riverbed causes alteration of the drainage and river course. Infrastructure and canals are regularly silted reducing their capacity to distribute water efficiently.
- Erosion is also common across the basin from the upstream to downstream. This is normally attributed to deforestation - however we observed that much of the upstream part of the basin is covered with dense vegetation. Consequently, it is suggested these claims need further evaluation.
- The extensive and widely distributed extraction of sand and rocks along the Kamala River appears to contribute to the instability of the river.
- The engineering infrastructure projects in place are helping to reduce erosion and protect the riverbanks, however they appear to be unsustainable and it is a continuous battle to reduce the sediment movement.
- The very small area of crop per household is a real issue that contributes to the poverty in the Kamala Basin and respective districts. More valuable alternative crops that increase productivity, reduce water loss and increase water use efficiency can contribute to poverty alleviation. These must be considered in the Basin Plan in terms of water requirements and alternatives to the existing situation. Changes in these directions need to consider the population interest, adequate training and engagement and other aspects of socio-technical feasibility associated with structural adjustment.
- The group did not have the opportunity to explore in detail issues related with water quality but it appears to be necessary to improve the quality of the water for domestic use, drinking water and sewage treatment.
- Biodiversity in the irrigation areas appears to be low. The Terai was once the most diverse area in Nepal, however due to human growth and land clearing for irrigation purposes, biodiversity is now reduced. Much of the riparian zone has been cleared which reduces habitat for many riparian species of birds, terrestrial animals and insects. It is well understood that the Kamala River has been highly overfished in the recent past and a highly sought-after food source is no longer available. This assessment must be countered by the fact that the visit occurred during the dry period when little water was available, however, given that the basin is characterised by high drainage and rapid flow dispersion, the situation is unlikely to improve during the monsoon season.
- There appears to be limited experience with strategic (i.e. long-term) participatory Basin Planning. Experience with stakeholder engagement is focussed on short-term issues. For example, in the lower basin a committee for flood-affected people exists (Kamala Pidit Sarokar).
- The social diversity and complexity of the Kamala Basin in Nepal means that a Basin Planning process will require consideration of a variety of socio-technical options, and must include affected people, as their input is needed to identify *pros* and *cons*. For example, some stakeholders (including the Department of Irrigation) regard a water diversion from the Sun Koshi Basin as a key solution to provide supplemental irrigation in the Kamala Basin. However, a trans-basin diversion requires building a water storage in the donor basin upstream of the diversion. This may require prior approval of a large-scale multipurpose

project (e.g. Sun Koshi 1) in order to realize synergies. Diversions from the Sun Koshi are described as having potential impacts on dry season flows in the Koshi downstream of Chatara (ADB, 2016[3]). However, from an IWRM perspective, whether a trans-basin diversion represents an optimal solution remains to be explored from a variety of perspectives (not assumed *a priori*).

4.2 Relevant aspects for the development of the Basin Plan

The development of the Kamala Basin Plan will need to consider the aspects described in this report with a higher level of detail and local data quantifying water use in the different districts, and water use plans, with engagement of the local population in the discussions and directions proposed. It is important to quantify the problems, where possible, and potential solutions that the plan will address in order to provide water as required to increase productivity in a sustainable way. Capacity building in modelling will contribute to guiding the GoN and decision makers to the desired outcomes but it needs to be integrated with the local demand of water resources and in line with the priorities from the communities and the local capacity of the representatives of the GoN.

The Basin Plan will need to consider the trade-offs associated with many of the issues identified in this report for example the view that the ecology of the Kamala River is declining despite the view that it is already ecologically poor. If ecological restoration works are to be considered then the consequential effect on the livelihoods of relatively large numbers of people will need to be considered and planned for in the Basin Plan. This will require significant community engagement as well as incentives to support the change by investing in more efficient practices that enable water to be applied to the environment (similar to Australia-the Australian schemes may provide some guidance for the development of schemes in Nepal).

[3] ADB (2016) Operational Research for the Dudh Koshi River System, Nepal. Draft Final Report V2: Supporting Report, Water Resources. Reta-6498. July 2016. Prepared for the Nepal Electricity Authority. Asian Development Bank

5 Recommendations for further action

The SDIP2 project work plan provided for the development of modelling capabilities through training in hydrological modelling for 12 GoN people in Kathmandu in April 2017. It also included secondment activities with the participation of three professionals from the GoN for a period of two weeks in Australia in order to develop the modelling to provide information to the Basin Plan (JAC have recommended 6 people in total). These activities will provide the group with the capabilities to create a water resource plan, describe possible scenarios and promote discussions about alternatives for water management in the Kamala Basin. This will include the benefits and dis-benefits of different decisions. Modelling also requires data for validation, since the available data is limited. This requires a plan to quantify water resources in the basin.

The group that will be trained in the modelling and Basin Plan is recommended to develop the following activities:

- Collate the existing datasets of use and demand of water including in irrigated and non-irrigated crops in the Basin, together with relevant socio-economic data.
- Obtain written reports or more information from the regional offices about the number of producers, crops types and productivities, irrigation areas, production limiting factors (i.e. infrastructure such as roads, water deficit, pest and diseases, water quality, erosion, sedimentation, water deficit to produce during the dry season, market, floods, etc), water consumption and respective distribution including surface and groundwater sources. Process the information creating a diagnostic of the water resources and priorities for the Basin.
- Identify relatively simple management actions to be undertaken and others that require more investment and time.
- Identify the geographic areas or districts of priority in the Basin as well as the target communities likely to be affected.
- Establish a plan for stakeholder engagement, one that is sensitive to social structures and processes (e.g. caste, landholdings, gender, biophysical location) that differentiate stakeholders.
- Promote discussion across government agencies and start stakeholder engagement.
- Obtain and analyse data of gender activities changes and trends.
- Analyse of the current situation compared with the proposed development options to quantify (where possible) and describe potential benefits, risks and implementation actions.

Appendix A Field visit program

DATE	TRAVEL	ACTIVITIES UNDERTAKEN
28 Feb 2017	Kath-Sindhuli Time: 8AM	• Start at 8 AM take lunch at Khurkot, • Travel to Sindhuligadi, headwaters of Kamala River • Travel along Kamala River and visit Ranibas, Dhungrebas • Learn about issues of watershed degradation, climate change impacts and water use issues • Travel to Sindhulimadi and night stay • Contact with local IDD/DWIDM/DDC • IDD Sindhuli: 047-520105; IDD Dhanusha:041-523176
01 Mar 2017	Sindhuli-Kamalamai MNP	• Visit IDD office, DWIDM office and DDC • Learn about issues of Kamala River bank erosion, watershed degradation, • Visit Triveni Ghat and learn about Tharu community, agriculture in Kamala Basin, water supply issues • Travel along Tawa Khola, Katari • Travel back to Sindhulimadi and night stay
02 Mar 2017	Sindhuli-Bandipur /Godar/ Janakpur	• Travel to Bandipur 8 AM via Mirchaiya (E-W highway) • Visit Chisapani the gorge from where Kamala River enters into Terai • Visit Kamala Irrigation Management Division (Telephone: 041-650196), see Kamala weir and irrigation regulators • Travel along right main canal of Kamala IP up to Raghunathpur, see irrigation command area, flood embankment bunds • Travel to Janakpur via Dhanusha Dham and night stay at Janakpur • Visit Janaki Temple in the evening
03 Mar 2017	Janakpur-Dhanusha	• Travel to eastern part of Dhanusha (Phulbaria) via Mahinathpur • See embankment bunds at Malhania, Phulbaria, • Travel to Siraha via Mirchaiya, see command area of Kamala IP eastern canal • Visit right embankment bunds at Chikana, Bheria • Return back to Janakpur and night stay
04 Mar 2017	Janakpur-Kathmandu	• Travel back Kathmandu via Sindhuli

Appendix B List of participants and institutions

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Appendix C Kamala Basin information

The contents of this Appendix have been reproduced from the Kamala Basin Information report, prepared by the Nepal Development Research Institute (NDRI), as part of trip preparation.

Abbreviations

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CSIRO	Commonwealth Scientific and Industrial Research Organization
DoED	Department of Electricity Development
DoI	Department of Irrigation
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DWIDM	Department of Water Induced Disaster Management
GNI	Gross National Income
HDI	Human Development Index
HPI	Human Poverty Index
IWRM	Integrated Water Resource Management
ICIMOD	International Centre for Integrated Mountain Development
JAC	Joint Advisory Committee
MODIS	Moderate Resolution Imaging Spectroradiometer
MoE	Ministry of Energy
NDRI	Nepal Development Research Institute
NGO	Non-Governmental Organization
NWP	National Water Plan
PPP	Purchasing Power Parity
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat

C.1 Background

Nepal is striving to graduate into the status of developing country in 2022 and achieving the sustainable development goals set for 2030. Proper utilization of the country's natural and human resources in an efficient way can only make it possible realizing these targeted goals. Water resources, being one of the principle natural resources, can play a major role in enhancing the pace of overall development of the nation. Recognizing the wider economic, socio-cultural, environmental importance of water resources in this context, National Water Plan of Nepal has put forward Integrated Water Resources Management (IWRM) as a policy principle for the development and management of water resources (NWP, 2005). Major Institutions working in water field such as Water and Energy Commission Secretariat (WECS), Ministry of Energy (MoE), Department of Electricity Development (DOED), Department of Irrigation (DoI), Department of Water Induced Disaster Management (DWIDM), Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) has opinioned the need on the application of IWRM approach to deal with water resources of the country for its optimum utilization (Suhardiman et al., 2015)4. National Water Resources Policy (2016) also recognized IWRM from the holistic perspective for the sustainable development of water resources in the country. With support of WWF Nepal, WECS implemented IWRM in two pilot projects at sub-basin level viz. Dudh Koshi and Indrawati sub basins under the framework of Koshi River Basin Management Strategy (WECS, 2011). Joint Advisory Committee (JAC) has proposed to implement IWRM principle in Kamala Basin with the financial and technical supports from CSIRO - the Commonwealth Scientific and Industrial Research Organisation, an Australia's largest scientific research organisation and one of the largest and most diverse scientific organisations in the World.

C.2 Major River Basins of Nepal

Based on the nature of the origins, Nepalese rivers are classified into three categories: i) Himalayan Rivers which originates from Himalaya and carry snow-fed flows with significant discharge even in the dry season, Mahabharat Rivers which originates from Mid-Hills are fed by rainfall, springs and groundwater and Terai (Southern) Rivers which originates from Churia Hills are characterize by almost no flow in the dry season and flash floods during the monsoon period (June to September). Koshi, Narayani, Karnali and Mahakali are Himalyan Rivers, Mechi, Kankai, Kamala, Bagmati, West Rapti and Babai are mid-hill Rivers. A river basin map of Nepal delineated by NDRI using ASTER DEM is shown in Figure 11.

[4] Diana Shardiman Diana, Clement Floriane and Bharati Luna (2015) Integrated water resources management in Nepal: Key stakeholder's perceptions and lessons learned. *International Journal of Water Resources Development.* Vol. 3, Iss. 2, 2015.

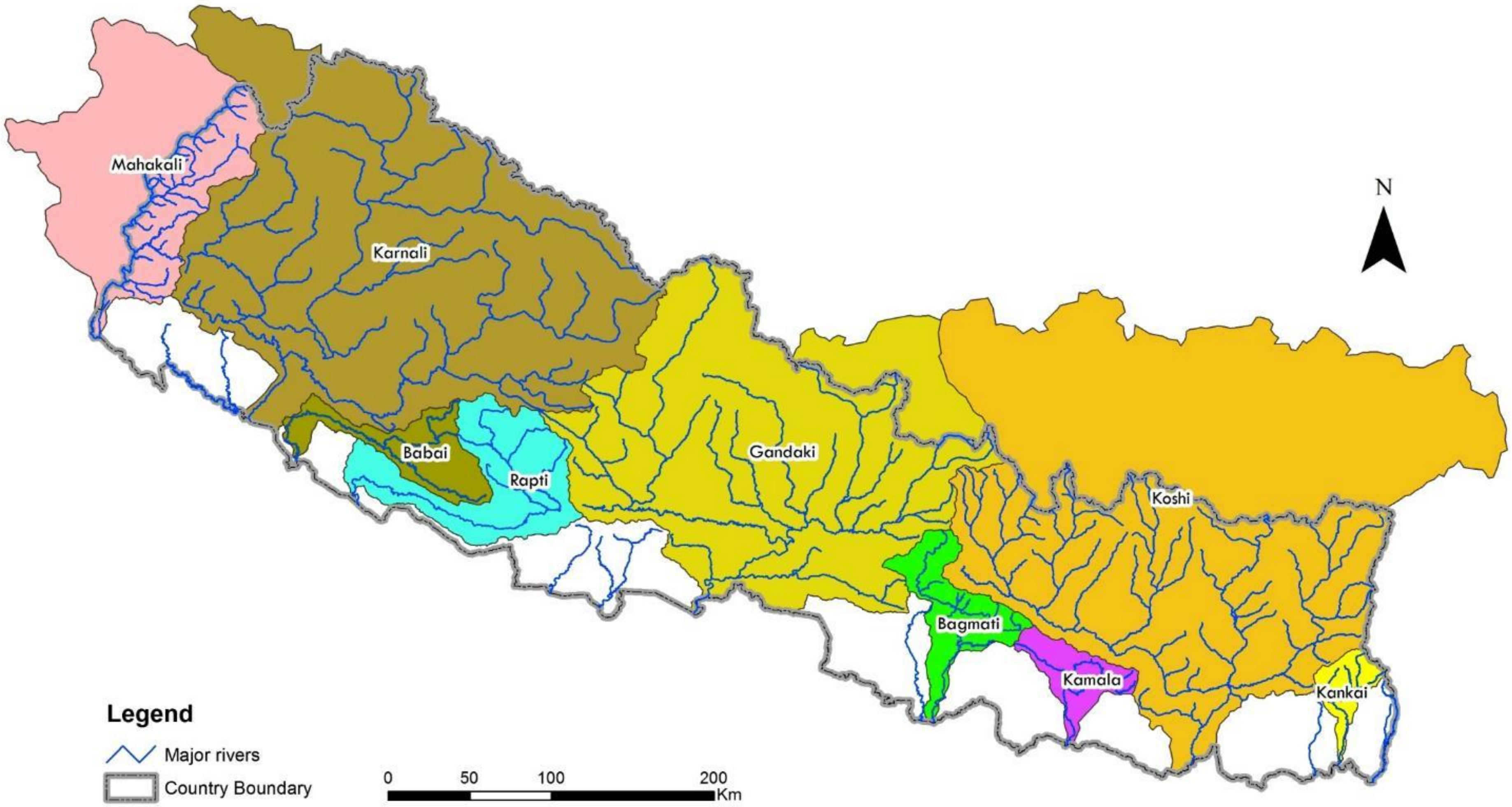


Figure 11 Major rivers and river basins of Nepal

C.3 Kamala Basin

Kamala basin has a drainage area of about 2,050 km^2 at the Nepal-India border. The maximum elevation of the basin is 2107 m and minimum elevation is 50 m above mean sea level (amsl). More than 60% of the catchment area lies below 500 m and about 30% lies in between 500 - 1000 m while the rest 10% lies above 1000 m.

The basin mainly lies in Siraha, Sinduli, Dhanusa and Udayapur districts. The total number of Village Development Committees (VDCs) in the basin is 104. The distributions of district boundaries are provided in Table 1. It shows that half of the Kamala basin lies in Sindhuli district, while a quarter of basin lies in Udayapur district. The number of VDCs of each district with its area within Kamala basin is provided in **Annex 1.**

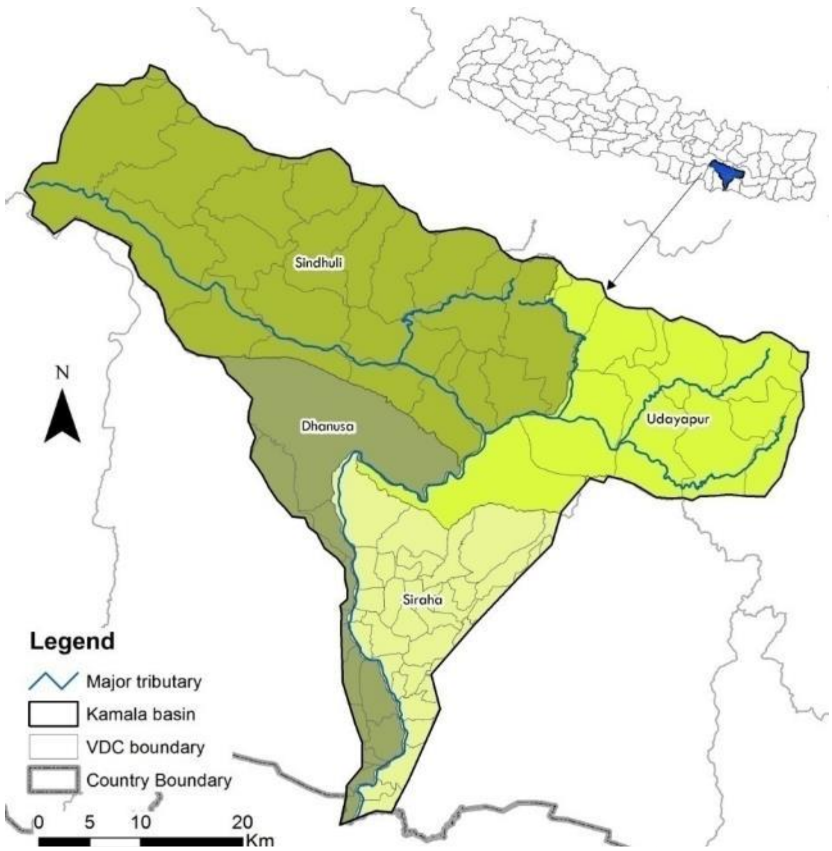


Figure 12 Kamala River Basin

Figure 13 Upstream and downstream of Kamala River from Kamla Bridge at East-West highway

Table 1 District coverage in Kamala basin with no. of VDCs

SN	DISTRICTS	AREA OF BASIN WITHIN THE DISTRICT (KM^2)	% OF AREA	NO. OF VDCS	AREA OF VDCS (KM^2)	% AREA OF VDC LYING IN KAMALA BASIN
1	Dhanusa	271.9	13.31	21	517.1	52.6
2	Sindhuli	970.7	47.5	26	1202.3	80.7
3	Siraha	305.7	14.96	39	483.1	63.3
4	Udayapur	495.2	24.23	18	787.4	62.9
Total		**2043.5**	**100**	**104**	**2989.9**	**68.3**

Source: CBS, 2011, GoN and Cotour Map of Nepal

C.4 Land use

Land use data of Kamala Basin is extracted based on processed MODIS satellite data (250 m x250 m) by ICIMOD. Land use pattern of the Kamala Basin is given in Figure 14 and Table 2. It shows that 60% of the land is covered by forest, mainly by broad leaved forest and one-third of the total land area is practised for agriculture. The coverage of built up area, shrub land and grass land is very small, which accounts about 1% of the total basin area. Built up is less than half percent. The percentage of land use distribution according to district and is provided in Annex 2.

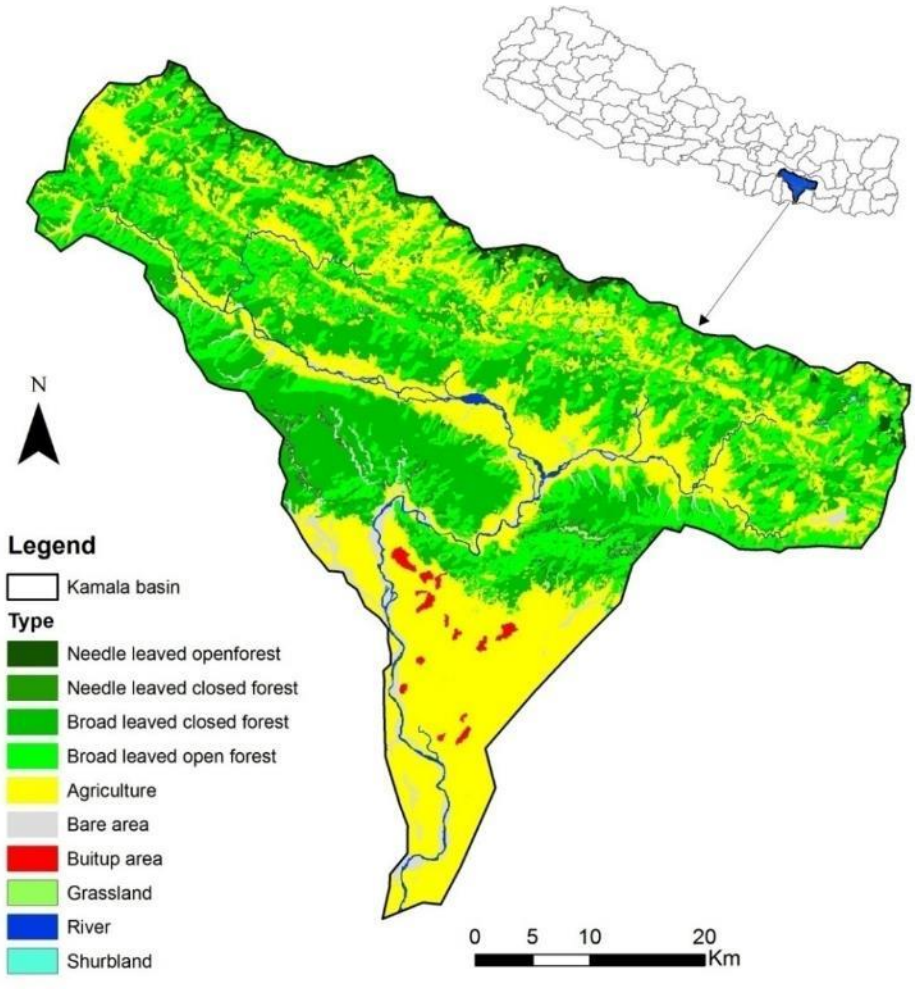


Figure 14 Land Use Map of the Kamala Basin

Table 2 Land use of Kamala Basin

LAND USE TYPE	AREA IN SQ.KM	%
Needle leaved forest	63.43	3.104
Broad leaved forest	1170.20	57.260
Shrub land	9.40	0.460
Grassland	18.55	0.908
Agriculture	711.37	34.809
Bare area	46.96	2.298
Built up area	8.31	0.407
River	15.45	0.756
Total area	**2043.67**	**100**

C.5 Hydro-meteorology

There are three meteorological stations at Sindhuli Gadi, Janakpur airport and Udayaur Gadhi measuring air temperature. The mean annual temperatures in each station are respectively 23, 25 and 24˚C. The meteorological stations within and close to the basin are shown in Table 3 and Figure 15. The average annual rainfall in the basin is about 1681 mm. The seasonal variation of rainfall in the basin is very high, where 80% of the rainfall occurs during monsoon season (JJAS) as shown in Figure 16. As shown in Figure 17, the upper North-Western side of the basin is wetter compared to North-Eastern side which is bit drier.

Table 3 Meteorological stations in Kamala basin

STN_NAME	INDEX	TYPE	LAT.	LONG.	ELEVATION (M)	ANNUAL AVERAGE	DATA AVAILABLE**
Sindhuli Gadhi	1107	C* & P*	27.28	85.97	1463m	2624.06 mm/22.90 °C	1955-2016
Bahun Tilpung	1108	P	27.18	86.17	1417m	1982.38 mm	1958-2016
Tulsi	1110	P	27.03	85.92	457m	1650.42 mm	1956-2016
Janakpur Airport	1111	C	26.72	85.97	90m	1423.29 mm/24.86 °C	1969-2016
Chisapani Bazar	1112	P	26.92	86.17	165m	1581.12 mm	1955-2016
Kurule Ghat	1210	P	27.13	86.43	497m	961.24 mm	1948-2016
Udayapur Gadhi	1213	C	26.93	86.52	1175m	1865.14 mm/24.78 °C	1947-2016
Siraha	1216	P	26.65	86.22	102m	1412.98 mm	1947-2016

*Source: DHM, GoN, Nepal (P=Precipitation station; C=Climatological Station; **Data available period for rainfall stations)*

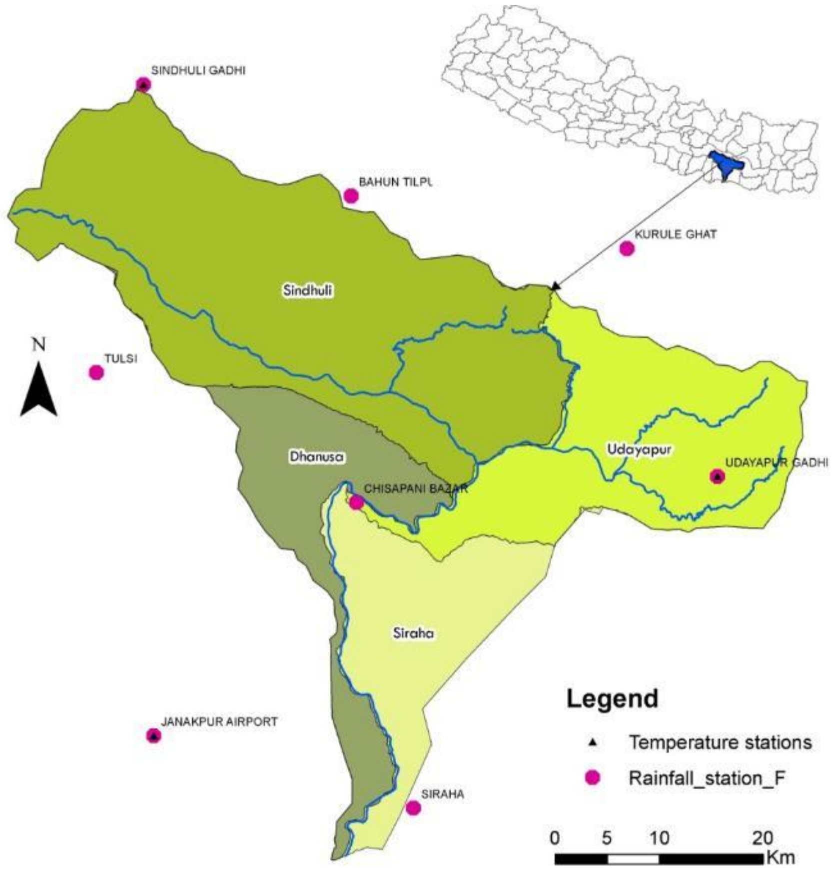
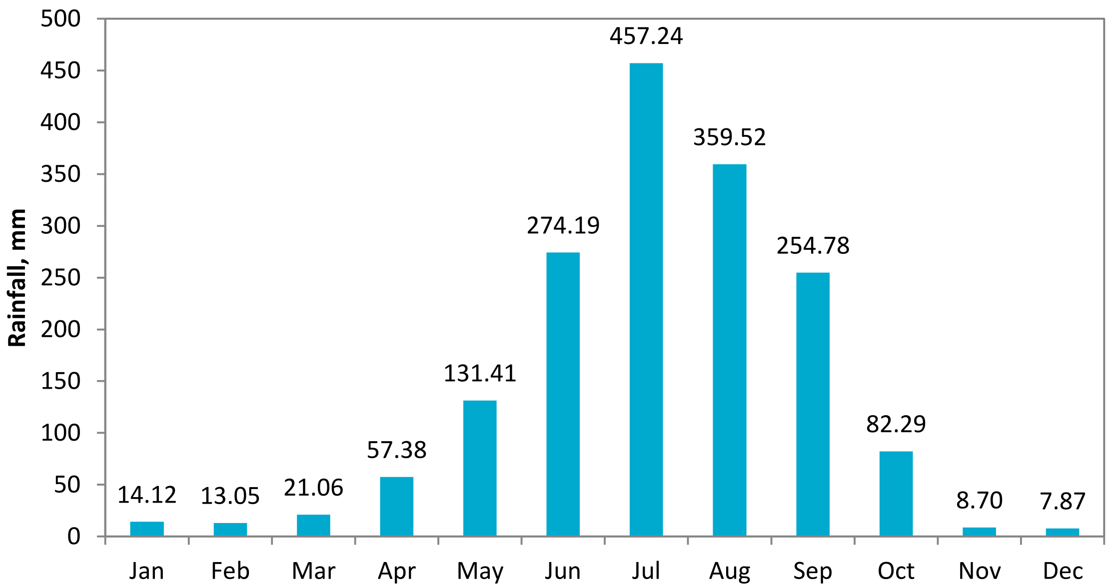


Figure 15 Meteorological stations in Kamala basin



Source: DHM, GoN, Nepal

Figure 16 Monthly distribution of rainfall in Kamala basin

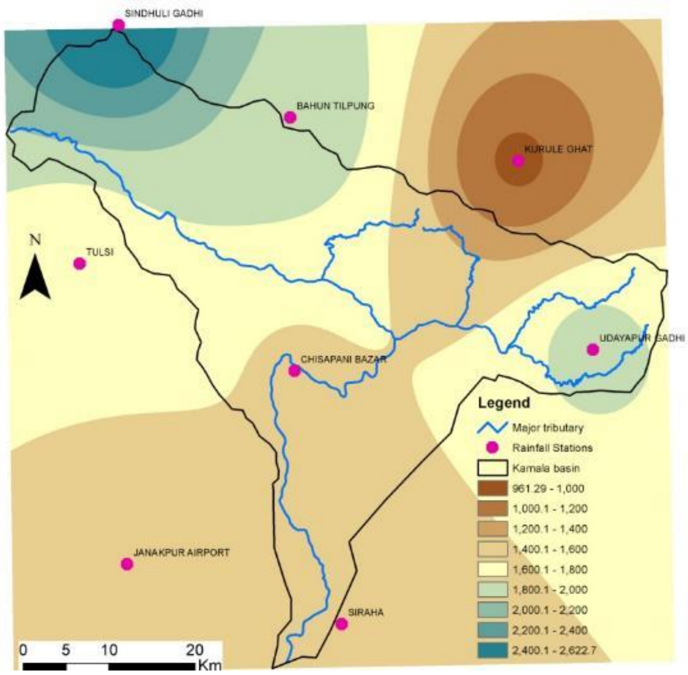
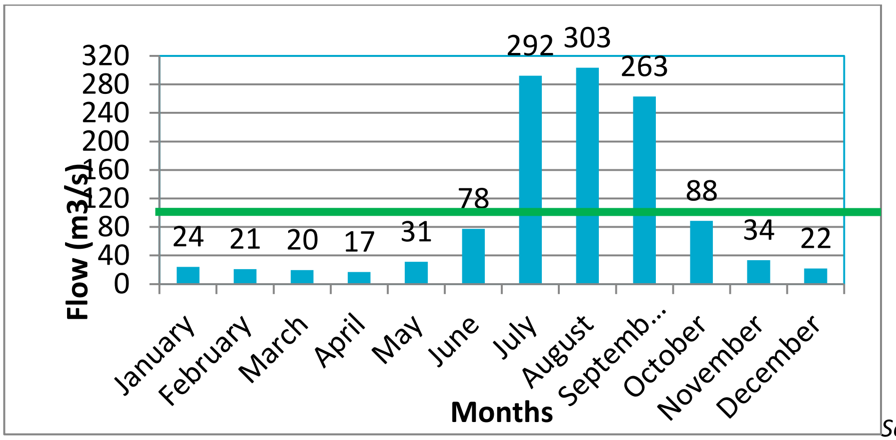


Figure 17 Isohyetal map of Kamala basin

The mean monthly stream flow in Kamala River at Nepali Boarder is shown Figure 18. The annual average stream flow of the basin is 99 m^3/s, where almost 80% of discharge occurs in four monsoon months (JJAS)[5]. The minimum and maximum flows generally occur in April and August respectively. The seasonal variation of flow is very high with 303 m^3/s in August and 17 m^3/s in April (Figure 18). The ratio of maximum to average monthly flow is about 3.5 while average to minimum is 6. It gives the ratio of maximum to minimum flow of 18. This indicates that there is a need of proper water resources management for water security. The hydraulic analysis has shown that in almost every stretch of the study area, the Kamala River cannot contain its extreme flood discharge within the defined banks and as a result, overbank flow and branching are common phenomena (Shrestha, 2017)[6].



Source: Joshi et al. (2008)

Figure 18 Monthly distribution of flow in Kamala Basin at Nepalese Boarder

[5] Joshi, N.M. and Shrestha P.M., (2008). Jalasrot Vikas Sasntha`/Nepal Water Partnership Anamnagar, Kathmandu, NEPAL (http://www.jvs-nwp.org.np/sites/default/files/Number%20%2046.pdf)

[6] Shrestha, M. (2016). Kamala Basin: Water and Energy Commission Secretariat, Kathmandu, Nepal (Unpublished Report)

C.6 Groundwater resources

Terai districts of Nepal have good amount of groundwater. Dhanusa and Siraha are, thus, the two districts where there is potential of groundwater availability for various uses (Sharma, 1995)[7].

Siraha District

About 400 km^2 of area in Kamala Basin especially in the south of east-west highway is suitable for shallow tube-well. The discharge varies from 3 to 5 liter per second. The transmissivity varies between 100 and 10,000 m^2/day. The recharge is about 274 million cubic meters per annum. Deep tube-well in the area is of poor quality in terms of dischrage.

Dhanusha

Shallow tubewells are possible in the north and middle part. The discharge ranges from 3 to 10 l/s. The transmissivity varies between 100 and 10,000 m^2/day as in Dhanusha district. Recharge is estimated to be 311 million cubic meter. Deep tube-well in the area is also of poor quality in terms of discharge.

C.7 Floods and sediment

After the floods of 1987, 4 km and 1.5 km long sections of the embankment with riverside protection were constructed at Bheria as a solution to the inundation and erosion problems; however, the measures have been quite inadequate. The villages Malhaniya and Inerwa are badly affected from erosion and inundation. Similarly villages Kiratpur, Paterwa, Lakar, Phulbaria, Sarsar, Tariya and Chatari still have flood problems and they are under serious threat of either being washed away or being inundated **(Shrestha, 2016).** At several locations, severe bank erosion occurred and as a result of which Bheria, Chikna-Bhokraha, Nirdhana, Sarswar, Basbhitta, etc. on the left bank and Barmajhiya, Kiratpur, Hathmunda, Sakhwa-Madan, Lakkad, Phulbaria, Malhaniya, etc., on the right bank are now at the verge of being washed out. About 1.5 km of existing embankment in total has been completely washed out at different locations. Inundation in the flood plains occurred for about a week due to overbank flow and also due to branching of river at quite a few locations on both sides **(Shrestha, 2016).**

Sedimentation affects all types of water resources development works viz: irrigation, water supply and hydropower development etc. The fragile geological nature of the Siwalik Hills in the watershed produces high loads of sediment. The annual sediment load estimated for Kamala Basin is about 7 million tons **(Thapa and Pradhan, 1997)**[8].

C.8 Geology

The geology of the basin can be divided into three parts: Mahabharat range, Siwalik range and Terai plains.

Mahabharat Range

The upper catchment lies in the broad zone of much folded Jurassic strata composed of black shales and argillaceous sandstones, probably the eastern continuation of spite shales. The whole group is very soft and friable and has received a great amount of crushing and compression.

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[7] Sharma, C.K. (1997). Shallow Aquifers of Nepal, Mass Printing Press, Kathmandu

[8] B. B. Thapa and B. B. Pradhan (1997). Water Resources Development: Nepalese Perspectives. Institute for Integrated Development Studies, Kathmandu Nepal

Siwalik Range

The composition of the Siwalik deposit shows that these are nothing other than the alluvial detritus derived from the sub-aerial waste of the mountains, swept down by their numerous rivers and streams and deposited at their feet. Weathering of the Siwalik rocks has been proceeding at an extraordinarily rapid rate since their deposition and strikingly abrupt forms of topography have been evolved. The terraces comprise clay, sand and gravels. By and large, the geology of the Kamala catchment shows unstable nature, which is susceptible to heavy erosion, and thereby yielding high sediment loads.

The Plains

The area is underlain by alluvium of recent to sub-recent age extending down to a depth of 130 m to 140 m. The alluvium comprises of a succession of sand beds of varying texture mixed with silt and clay with occasional gravels.

C.9 Socio-cultural and economic conditions

C.9.1 Households and population

Based on 2011 census data the total population in 2011 within the basin is estimated using normalized method (use of ratio of % Area of VDCs lying in Kamala Basin to Area of Basin within the District of Table), which is about just less than a half million in 85,000 households (Table 4). This gives the household size of about 5 persons. The population density of the basin is 206/Km^2. Since Terai districts (Dhanusa and Sarlahi) has more population than those of the hilly districts (Sindhuli and Udayapur), the population density is more in Terai settlement. The data in the table also shows that female population is higher than the male ones. It also shows that about 95% of the people are having their own house to live. The literate percentage of the people of Dhanusa, Sindhuli, Siraha and Udayapur districts are 50.4, 60.5, 50.2 and 68.8 percentages respectively. However, female literacy rate is lower than that of male one[9].

Table 4 Population distribution in the basin

SN	BASIN DISTRICTS	BASIN HOUSEHOLDS	BASIN POPULATION	HOUSEHOLD SIZE	SEX RATIO (F/M)	OWN HOUSE %
1	Dhanusa	13981	74336	5.32	1.05	98.5
2	Sindhuli	28672	139782	4.88	1.10	89.3
3	Siraha	29646	140907	4.75	1.09	96.5
4	Udayapur	13547	66426	4.90	1.12	94.6
Total		**85847**	**421451**	**4.96**	**1.09**	**94.71**

Source: CBS, 2011, GoN, Nepal

C.9.2 Religion

The main religion of the people of study districts are Hindu, Buddhism, Islam, Kirat, Christianity, Prakriti, Bon, Jainism, Bahai and Sikhism. The percentage of Hindu, Buddhism, Islam, Christianity and others are given in Table 5. In all districts Hindu population out weight other. Buddhist is comparatively more in Hilly districts while Islam in Terai districts. The composition of the people living in the basin is assumed to follow the same proportion to that of respective districts.

[9] http://unesdoc.unesco.org/images/0022/002276/227683e.pdf

Table 5 Main religions in study districts in percentage[10]

SN	BASIN DISTRICTS	HINDU	BUDDHISM	ISLAM	CHRISTIANITY	OTHERS
1	Dhanusa	89.35	1.49	8.36	0.09	0.71
2	Sindhuli	64.47	30.43	0.06	0.98	4.06
3	Siraha	90.19	1.73	7.46	0.06	0.56
4	Udayapur	72.57	12.12	0.68	2.39	12.24
Total		**79.15**	**11.44**	**4.14**	**0.88**	**4.39**

Main caste and ethnic group of people in the study districts are as follows[11]:

1. Hill Brahman/Chhetri (HBC)
2. Hill Dalits (HD)
3. Newar(N)
4. Disadvantaged Hill Janajati (DHJ)
5. Non-Disadvantaged Hill Janajati (NDHJ)
6. Madhesi/Terai Brahman/Chhetri (MTBC)
7. Madhesi/Terai Dalits (MTD)
8. Non-Disadvantaged Terai Janajati (NDTJ)
9. Disadvantaged Terai Janajati (DTJ)
10. Non-Disadvantaged Other Madhesi/Terai (NDOMT)
11. Disadvantaged Other Madhesi/Terai (DOMT)
12. Muslims (M).

C.9.3 Drinking water

The main source of drinking water used by the people living in the basin is calculated by normalized method and given in Table 6. About 34% use the tap water while other 62% water use from tube well or other form of wells. Still some people are using river water as drinking water.

Table 6 Main source of drinking water

DISTICT	PIPED WATER	TUBE WELL/ HAND PUMP	COVERED WELL	UNCOVERED WELL	SPOUT WATER	RIVER/STREAM	OTHERS	NOT STATED
Dhanusa	13	61	3	19	0	1	1	1
Sindhuli	60	8	3	23	2	2	0	0
Siraha	7	81	0	8	0	1	1	1
Udayapur	55	16	2	21	1	4	1	0
Average	**34**	**42**	**2**	**18**	**1**	**2**	**1**	**1**

Source: CBS, 2011, GoN, Nepal

[10] *Village Development Committee and Demographic Profile of Nepal 1013, Megha Publication and Research Center, Kathmandu, Nepal.*

[11] http://un.info.np/Net/NepDocs/View/

C.9.4 Fuel

Different fuel used in different locality is given in Table 7 as calculated using normalized method. Low quality fuel (firewood and cow dung) constitutes more than 90%. Use of LP gas and bio gas merely accounts 4% showing the lower level of economic conditions in general.

Table 7 Fuel usually used for cooking

DISTRICT	FIREWOOD	KEROSENE	LP GAS	COW DUNG	BIO GAS	ELECTRICITY	OTHERS	NOT STATED
Dhanusa	54.7	1.2	0.9	41.3	0.3	0.0	0.1	1.4
Sindhuli	85.0	0.5	7.5	0.2	3.0	0.0	0.2	0.4
Siraha	51.2	1.3	1.8	42.8	0.2	0.1	0.4	0.9
Udayapur	94.1	0.5	3.3	0.9	0.5	0.0	0.1	0.5
Average	**71**	**1**	**3**	**21**	**1**	**0**	**0**	**1**

Source: CBS, 2011, GoN, Nepal

C.9.5 Household facilities

The percentage of people using various modern facilities is estimated using normalized method and shown in Table 8. Only one third of the population is having television set, almost no house is having computer and internet and motor. However, mobile has become popular within the people of the basin. Only about 55% of the household have access for electricity for lighting. In general, it can be surmised that the people of the area are not well off economically.

Table 8 Percentage of households by types of household facilities

DISTRICT	RADIO	TELEVISION	CABLE TELEVISION	COMPUTER	INTERNET	MOBILE PHONE	MOTOR	MOTOR CYCLE	BICYCLE
Dhanusa	41	31	5	1	0	92	1	7	51
Sindhuli	51	25	13	2	1	49	0	3	5
Siraha	37	43	6	2	0	60	2	8	51
Udayapur	46	13	7	1	0	50	0	2	8
Average	**44**	**28**	**8**	**1**	**0**	**63**	**1**	**5**	**29**

Source: CBS, 2011, GoN, Nepal

C.9.6 Agriculture

The main cereal crops are paddy, maize, millet, wheat and barley; Cash crops are oil seed, potato, tobacco, sugarcane; Pulses are lentil, chick pea, black gram, grass pea; livestock are cattle, buffalos, sheep, goat, pigs, fowl, duck; citrus are mandarins, sweet orange, lime, Lemon; winter fruits are apple, pear, walnut, peach, plum and summer fruits are mango, Banana, guava, papaya, jack fruit.

C.9.7 Forest and Herbs

Forest of the study basin accounts almost two third of the basin area lying in Churia Range and Mahabhart Range. Main herbs available in the area *are Kurilo, Gurjo, Chiraito, Timur, Tejbokra, Tejpat, Ban lasun, Ritha, Satabari Jhyau (DoF, 2006)*[12].

C.9.8 Income status and Well Being

Per capita income provides individual wealth. Human Development Index (HDI) is calculated based on the long and healthy life, measured by life expectancy at birth; knowledge, measured by adult literacy and mean years of schooling; and a decent standard of living, measured by Gross National Income (GNI) per capita in purchasing power parity (PPP$). Based on percentage of people not expected to survive to age 40, adult illiteracy rate, percentage without safe water, percentage of children under age five who are malnourished and deprivation in economic provisioning, Human Poverty Index (HPI) is calculated. If the HDI reflects the expansion of opportunities and choices, the HPI captures the denial as a result of income and capability deprivation. Table 9 presents these values in the study four districts. As detail breakdown is only available in district level, it is assumed that it holds true to the people of the basin. The performance in terms of economic status and well being of all districts are less than the national average.

Table 9 Per-capita income, HDI and HPI[13]

DISTRICT	PER CAPITA INCOME, $	HDI	HPI
Dhanusa	580	0.487	41.72
Sindhuli	509	0.504	37.95
Siraha	426	0.474	42.62
Udayapur	569	0.533	29.74
Average	521	0.500	38.01
Nepal	**718**	**0.541**	**31.12**

C.9.9 Birds

In Kamala Basin 65 species of birds of 10 orders and 31 families were recorded. Out of them, *Passeridae* and *Corvidae* family birds are more with 12% for each. The highest number of birds falls to order *Passeriforme*s with 34 species (52%) followed by *Ciconiformes* 14 (22%), Coraciformes (8%), *Falconiforme*s (6%), *Columbiforme*s (5%), *Gruiformes* and *Piciformes* are 2% each and *Psitaciformes*, *Cuculiforme*s and *Ansariforme*s are represented by 1% for each (Parajuli, 2013)[14] . Some pictures of the birds available in the Kamala Basin are shown in Figure 19.

[12] Department of Forest (2006), Kathmandu, Nepal.

[13] *Source: http://hdr.undp.org/sites/default/files/nepal_nhdr_2014-final.pdf*

[14] Parajuli, Kanchan (2013). Survey Bird Species Richness in Kamala River Basin, Lowland, Nepal, Central Department of Zoology, Tribhuan University, Nepal

Source: Parajuli (2013)

Figure 19 Bird species in Kamala Basin

C.9.10 Main cultural and religious sites

Table 10provides information about main cultural, historical, religious and natural spots in located within or close to Kamala Basin.

Table 10 Places of cultural and religious importance

DISTRICT	SN	IMPORTANT SITE	IMPORTANCE	LOCATION
Siraha	1	Sahles Phoolbari	Historical, natural resource	Siswani, Padriya
	2	Manikdaha	Natural resource, religious	Malhaniya,Govindpur
	3	Salhes Gahwar	Historical, religious	Siraha Municipality
	4	Saraswor Mahadev	Historical, religious	Saraswor
	5	Hariharnagar Pataal Pond	Historical, religious , Natural resource	Laxmipur, Pattari
	6	Parasnath Mahadev	Historical, religious	Itari Prasai
	7	Balasundari Bhagwati	Historical, religious	Bhagwanpur
	8	Hanumandhoka daha	Natural resource, religious	Maheshpur Pattari
	9	Kamaldaha	Natural resource, religious	Phulbariya
	10	Nandababa temple	Historical, religious	Badharamaal
	11	Budhangarha	Historical Brahman	Gorchhari
	12	Akashganga	Natural resource, religious, Social	Muksar
	13	Dhamiyain Maain	Religious	Asanpur

DISTRICT	SN	IMPORTANT SITE	IMPORTANCE	LOCATION
	14	Dinabhadri	Religious, Social	Pipra Pradha
	15	Kabhre Mahadev Temple	Historical, religious	Taregana
	16	Pakdiyagarha	Historical	Bhadaiyy
Danusha	1	Janaki Temple	Historical, religious	Janakpurdham
	2	Shivas bow , broken by Ram	Historical, religious	Dhanusadham
	3	Vivah Mandap	Historical, religious	Janakpurdham
	4	200 sacred ponds	Historical , Religious and Ritual baths	Janakpurdham
	5	Mithila Women's Art Center	Mithila Art and Craft	Janakpurdham
Sindhuli	1	Sindhuli Gadhi palace	Ancient palace ,Junar orange farming	Sindhuli Gadhi
	2	Siddha Baba Temple	Historical, religious	Sindhulimadi valley
	3	Kaalimaai Temple	Historical, religious	Kamalamai municipality 4
	4	Hariharpurgadi	Historical	
	5	Kusheshwor Mahadeve Templ	Religious	Dumja VDC
Udayapur	1	Indreshwor Mahadev	Temple	Gaighat
	2	Trivenidham	Meeting point of three River	Gaighat
	3	Rautaha Pokhari	Natural resource, Religious significance	Gaighat
	4	Chaudandigadhi	Historical	
	5	Remains of Belka palace	Historical	
	6	Tapti Bokhara	Natural resource	
	7	Udayapurgadhi	Historical	
	8	Giddhagaya	Historical	
	9	Rajdaha	Natural resource	
	10	Chikretham	Natural resource	
	11	Falls (Manedanda waterfall, Chatang waterfall, Batase fall, Runche waterfall)	Natural resource	
	12	Basaha Than	Religious significance	
	13	Mainarani Temle	Religious significance	
	14	Mahadkali Temple	Religious significance	
	15	Bow of Bhimsen	Religious significance	
	16	Khat Temple	Religious significance	
	17	Kakani Mai	Religious significance	
	18	Cave (Tankela, Batpati, Jhak)	Religious significance	

C.10 Existing main projects

C.10.1 Kamala Irrigation Project

Kamala Basin has agricultural land area of 711.37 km^2. To address the irrigation project, Kamala Irrigation Project was envisioned and constructed in 1984 with Irrigation Command Area = 25,000 ha. There are a number of Farmers Managed Irrigations Schemes too. The irrigation water demand of the Kamal Basin was estimated based on the following assumptions (WECS, Kamala Basin)

Assumptions

- Irrigation System Efficiency = 57%

Cropping Pattern as follows

- Early Paddy-Main Paddy-Wheat = 20%
- Main Paddy-Wheat -Fallow = 40%
- Early Paddy-Sugarcane-Fallow = 15%
- Sugarcane- Fallow = 5%
- Main Paddy-Pulses-Fallow = 10%
- Main Paddy - Oilseeds- Fallow = 10%

Based on the above assumptions water requirement (m^3/s) was estimated to be

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dev
12.27	26.19	33.77	36.99	23.88	66.51	20.08	19.55	12.65	34.21	52.85	8.12

The flow in the Kamala basin with seasonal variation demands the proper water management to fulfill the irrigation requirement of the basin.

Groundwater Irrigations [15]

Siraha

- Shallow Tube well: 13163 ha by 3096 number of Tube well
- Deep Tube well: 620 ha with 19 Tube well

Dhanusha

- Shallow Tube well: 11442 ha by 2652 number of Tube well
- Deep Tube well: 2790 ha with 62 Tube well

C.11 Proposed major projects

C.11.1 Sun Koshi Storage-cum-Diversion Scheme

This is planned for year round irrigation of the Kamala Basin and other area with Net Command Area of 138,000 ha by diverting water from Sunkoshi River to Kamala River.

Salient features of the project:

Diversion Dam: at Sunkoshi River at Sorungtar (Kurkule) which is 10 km downstream of confluence with Dudh koshi River.

- Dam Height: 48.9m
- Tunnel: 16.6 km

[15] Development of Database for Irrigation Development in Nepal (2007). Department of Irrigation, Government of Nepal.

- Diversion discharge: 72 m^3/s
- Power: 61.4 MW
- Annual Energy: 511 GWh
- Proposed Irrigation Command Area: 1,38,000 ha[16]

Kamala Dam

Kamala basin is water deficit basin. Irrigation Master Plan 1990, had identified Kamala Project as Multi Purpose Project intending to irrigate 33,000 ha of irrigable land and generating 30 MW hydropower.

- Dam height: 51 m
- High Water Level: EL 178 m
- Low Water Level: EL 163 m
- Gross Storage: 713 million m^3
- Live Storage: 493 million m^3
- Reservoir Area: 44 km^2
- Power: 30 MW
- Annual Energy: 75 GWh

C.12 Institutional mechanism

Water resources development and management is a multi-sectoral and interdisciplinary one, institutional mechanism is critical aspect for successful planning and implementation of water resources works. Various stakeholder institutions in addition to Governmental ones are involved for this purpose. Main stakeholders are:

- Water Users' organization: Mainly involved in Irrigation and Drinking Water Supply. They may be Water User Association, Water Users' Group or Water Users' Committee. They may me in the local (village or VDC level or district) or central level. Women group are also becoming popular in Nepal.
- Private sector entrepreneurs
  - Non-governmental organization (NGO)
  - Academic institutions
  - Professional societies

In the governmental level, the following organizations are involved in coordination, policy making and implementation:

- Councils/Commissions:
  - National Development Council
  - National Planning Commission
  - National Water Resources Development Council
  - Water and Energy Commission
  - Environment Protection Council

[16] Department of Irrigation. Proceedings of National Irrigation Seminar Micro to Mega: Irrigation for Prosperous Nepal, Kathmandu, Nepal, 13-14 July 2011.

- Ministries
  - Ministry of Energy
  - Ministry of Irrigation
  - Ministry of Drinking Water
  - Ministry of Agricultural Development
  - Ministry of Federal Affairs and Local Development
  - Ministry of Population and Environment
  - Ministry of Physical Planning
  - Ministry of Forest
- Departments:
  - Department of Electricity Development
  - Department of Irrigation
  - Department of Water Induced Disaster Management
  - Department of Water Supply and Sanitation
  - Department of Agriculture
  - Department of Hydrology and Meteorology
  - Department of Local Infrastructural Development and Agricultural Roads
  - Department of Soil Conservation and Watershed Management
  - Department of National Park and Wildlife Conservation
  - Department of Forests

In addition to above organizations, Nepal Electricity Authority, Hydropower Development Committees, Hydropower Generation Companies, Nepal Water Supply Corporation, Kathmandu Valley Water Supply Limited, Groundwater Resources Development Board, are some of the other organizations related to water resources development and management. Local government bodies like District Development Committees, Village Development Committees and municipalities are also involved in water resources development.

The constitution of Nepal has given the rights and use of water resources in three levels and concurrent:

- Federal Level
- Provincial Level
- Local level and
- Concurrent

List of concurrent Powers/Jurisdiction for Federation, Province and Local Level and relevant to this study are listed below

- Federal
  - Policies and criteria related protection and multi-dimensional use of water resources
  - Central level mega projects for electricity, irrigation and other projects
  - Land use policy, housing development policy, tourism policy, environment adaptation
- Provincial Level
  - Provincial level electricity, irrigation projects, drinking water, transport
  - Protection and use of language, culture, script, fine arts and religion
  - Management of national forest, water resources and ecology within the province

- Agriculture and livestock development, factories, industrialization, business, transportation
- Guthi (community trust/endowment) management

- List of Concurrent (federal and provincial)
  - Province border rivers, waterways, environment protection, biodiversity
  - Industries and minerals and infrastructures
  - Natural and man-made disaster preparedness, rescue, relief and rehabilitation
  - Tourism, drinking water and sanitation
  - Inter-provincial forest, wildlife, birds, mountains, national parks and water uses
  - Land policy and related legal provisions
- Local Level
  - Management of local markets, environment conservation and biological diversity
  - Local roads, rural roads, agriculture roads, irrigation
  - Farming and livestock, agriculture production management, livestock health, cooperative
  - Drinking water, small electricity projects, alternative energy
  - Disaster management
  - Conservation of Watershed, wetland, wildlife, mines and minerals
  - Preservation and development of language, culture and fine arts
- List of concurrent for Federation, Province and Local Level
  - Agriculture
  - Services like electricity, drinking water, irrigation
  - Forest, wildlife, birds, water use, environment, ecology and biodiversity
  - Disaster management
  - Archaeology, ancient monuments and museums

C.13 Water Resources Management of Kamala Basin

In order to provide people with access of safe and adequate quantity of drinking water and water for sanitation, to increase agricultural production and productivity, to generate hydropower, to protect the environment and conserve the bio-diversity of natural habitat and to prevent and mitigate water induced disaster or loss, the following activities are to be carried out under the framework of IWRM.

- Flood control
- Erosion control
- Optimum allocation of water resource for drinking water and sanitation, irrigation, industrial uses and hydropower development as well as environmental requirement.
- Establishment of water related information system, appropriate institutional mechanism and legal framework for coordinated management of water resources.

कमला नदी बेसिनः संक्षिप्त जानकारी

1. भूमिका

नेपाल सन् २०२२ मा अल्पविकसित मुलुकको सूचीबाट विकासशील मुलुकको रुपमा रूपान्तरण हुने प्रकृयामा छ भने सन् २०३० मा दिगो विकासका लक्ष्यहरू प्राप्त गर्ने कोशिशमाछ। यसका लागि मुलुकमा उपलब्ध जल, जमिन, जंगल, जडिबुटी, जलवयु तगायतका प्राकृतिक एवं मानवीय संसाधनको सही तरीकाबाट भरपूर विकास गर्नुपर्दछ। आर्थिक विकास, सामाजिक आवश्यकता, सास्कृतिक उपयोग, वातावरणीय संरक्षण जस्ता पक्षहरूमा जलस्रोतको सम्बन्ध रहकाले यसको बहुआयामिक महत्व छ। साथै बाढी तथा खडेरी, भूक्षय र गेग्रानीकरणबाट हुने आर्थिक-सामाजिक क्षति कम गर्नु पनि उत्तिकै जरूरी हुन्छ। यी कार्य कुशलतापूर्वक सम्पन्न गर्न सम्वन्धित निकायहरू एवं सरोकारवाला संस्था र व्यक्तिहरूको समन्वयको खाचो पर्दछ। यसर्थ यी विषयहरूको सही तवरले सम्वोधन गर्न नेपालको राष्ट्रिय जल योजना (२००५) ले एकिकृत जलस्रोत व्यवस्थापनको विधि अवलम्वन गर्नुपर्ने नीति आवश्यक ठानेको हो।

माथि उल्लेखित कारणहरूले जल तथा उर्जा आयोग, उर्जा मन्त्रालय, जलविद्युत विकास विभाग, सिंचाइ मन्त्रालय एवं विभाग, जल उत्पन्न प्रकोप व्यवस्थापन विभाग, स्थानीय पूर्वाधार विकास तथा कृषि सडक विभाग जस्ता जलस्रोतसंग सम्बन्धित सरकारी संस्थाहरु, जुन नीतिगत तहमा होस वा कार्यान्वयन तहमा काम गर्ने, जलस्रोतको विकासबाट अधिकतम लाभ लिन एकिकृत जलस्रोत व्यवस्थापनको नीति अंगिकार गर्नु पर्दछ भन्ने निष्कर्षमा पुगेका हुन्। यो कुरालाई नेपालको भखरै तयार पारिएको जलस्रोत नीतिमा पनि उल्लेख गरिएकोछ। नमूना कार्यक्रमहरुको रुपमा विश्व वन्यजन्तु कोषको सहयोगमा जल तथा उर्जा आयोगले यो विधिको प्रयोग दुधकोशी र इन्द्रावती जलाधार क्षेत्रमा लागु गरिसकेकोछ। अष्ट्रेलियाको सबैभन्दा ठूलो राष्ट्रमन्डलीय विज्ञान तथा औद्योगिक अनुसन्धान प्रतिष्ठानको आर्थिक तथा प्राविधिक सहयोगमा कमला नदीको जलाधार क्षेत्रमा एकिकृत जलस्रोत व्यवस्थापनको विधिको कार्यान्वयन गर्ने तयारी गरिरहेकोछ।

2. नेपालका प्रमुख नदी बेसिनहरू र कमला नदी बेसिन

नदीहरुको उत्पत्तिका हिसाबले नेपालका नदीहरु र तिनका जलाधार क्षेत्रहरु (नदी बेसिनहरु)लाई ३ भागमा बाड्ने गरिन्छ। कोशी, नारायणी, कर्णाली र महाकाली हिमाली; मेची, कन्काई, कमला, बाग्मती, पश्चिम राप्ती, बबईलाई पहाडी र चुरेपहाडबाट उत्पत्ति भएका नदी बेसिनलाई तराई बेसिन भनिन्छ।

कमला नदी पहाडी भूभाग (सिन्धुलीगढी) बाट शुरू हुने हुंदा यो पहाडी नदी बेसिनमा पर्दछ। यसको जलाधार क्षेत्र २,०५० बर्ग कि.मी. रहेको छ। यो बेसिन भित्र सिराह, सिन्धुली, धनुषा र उदयपुर जिल्लाका १०४ गाविस वा नगरपालिकाका केही भाग पर्दछन्। सिन्धुली जिल्लाको झन्डै आधाभाग, उदयपुरको एक चौथोइ र बांकी एक चौथाइ धनुषा र सिराहा जिल्लामा पर्ने यो नदी बेसिनमा जंगलले करीब दुईतिडाई भाग ओगटेकोछ । कृषियोग्य जमीन एक तिहाई जतिछ ।

3. जलबायु तथा जलस्रोत

यस नदी बेसिनको वार्षिक औसत तापक्रम २४ डिग्री सेन्टिग्रेड रहेको पाईन्छ भने वार्षिक रूपमा १५०० मिमि जति पानी पर्ने देखिन्छ। बर्षातको ४ महिना अर्थात असार, श्रावण, भाद्र र आश्विनका ४ महिनामा ८० प्रतिशत जति पानी पर्दछ भने बाकीं ८ महिना प्राय शुख्खा रहन्छ। आकाशबाट पर्ने पानीमा भर पर्ने भएकाले कमला नदीमा बहने पानीको मात्रा पनि वर्षातमा एकदम बढी र अन्य महिनामा एकदम कम हुन्छ। यस नदी बेसिनको वार्षिक औसत जलवहाव ९९ घनमी प्रतिसेकेण्ड रहेको छ। धनुषा र सिराह जिल्लामा भने स्यालो र डिप ट्युबवेलको प्रयोग गरी भूमिगत जलको प्रयोग गर्ने गरेको पाईन्छ।

4. बाढी र गेग्रानीकरण

सन् १९८७ को बाढीले यस बेसिनमा धैरै क्षति पुर्‍याएपछि नदीको देबै किनारमा बाँध बधियो तर पनि त्यसले त्यहाँको भूक्षय र डुवान रोक्न सकेन। पछिपछि पनि बाढीको समस्या दोहोरिरह्यो। चुरे क्षेत्रको कमलो माटो र वर्षायाममा हुने सघन वर्षाले गर्दा यो नदी बेसिनमा भूक्षय ठूलो मात्रामा हुने गर्दछ। यसको कारणले यो नदीले प्रसस्त गेग्रान (सेडिमेण्ट) ल्याउँदछ। यसरी आउने गेग्रानको मात्रा ७० लाख टन प्रतिवर्ष रहेको अनुमान छ।

5. अर्थिक-समाजिक अवस्था

5.1 जनसंख्याको बनोट

१९६८ सालको जनगणना अनुसार यो बेसिनमा ८५ हजार घरधुरी रहेको र ५ लाखको हाराहारीमा जनसंख्या रहेकोछ। जनघनत्व औसतमा २०६ जना प्रति ब. किमी भएपनि तराईका जिल्लाहरू धनुषा र सिराहको जनघनत्व पहाडि जिल्लाको भन्दा निकै बढी रहेको पाइन्छ। यहाँको ९५% जनताको आफ्नै घर रहेको, साक्षरता ६०% को हाराहारीमा रहेको देखिन्छ।

5.2 जात जाति तथा धर्मिक समुदाय

हिन्दु, बौद्ध, इस्लाम, किरात, क्रिश्चियन, प्रकृति, बोन, जैन, सिख जस्ता धार्मिक आस्था भएका मानिसहरु यस बेसिनमा रहेका छन्। पहाडिया बाहुन, क्षेत्री, दलित; नेवार, उत्पिडित जनजाति; मधेशी-तराई बाहुन, क्षेत्री, दलित, उत्पिडित जनजाति तथा मुस्लिम लगायतका जात जातिहरु यहाँ बसोबास गर्ने गरेकोपाईन्छ।

5.3 खानेपानी, उर्जा अन्य सरसुविधा

यहा बसोबास गर्ने जनताले पाइपबाट ल्याइएको धाराको पानी, कुवा, इनार र नदीको पानी खनेपानीको रुपमा प्रयोग गर्ने गरेको देखिन्छ । दाउरा र गुईठा नै उर्जाको प्रमुख स्रोत रहेको तथ्यांकले देखाउँदछ । ग्याँस प्रयोग गर्ने जनसंख्य केवल ३% जति मात्र रहेको पाइन्छ । रेडियो, टिभि जस्ता आधुनिक उपभोग्यका सामानहरूको प्रयोग गर्ने जनसंख्य पनि कम (३०-४०% जति मात्र) रहेका छन् भने इन्टरनेट, कम्पुटर, यातायातका साधन प्रयोग गर्ने जनसंख्या त नगन्य रहेको देखिन्छ । तर दुइतिहाइ मानिससंग मोबाइल फोन भने रहेकोछ

5.4 कृषि

कमला नदी बेसिन भित्र धान, मकै, गहुं, कोदो जस्ता खाद्यन्न बाली, तेलहन, आलु, उखु जस्ता नगदे वालीहरुको खेती, गाई, भैसी, भेडा बाख्रा, संगुर, कुखुरा जस्ता पशुपक्षीं पालन, स्याउ, आँप, केरा, अंबा, मेवा, कटहरजस्ता फलफूलहरु उत्पादन हुने गरेकोछ ।

5.5 बन तथा जडीबेटी

चुरे र मध्य पहाडि क्षेत्रभित्रका बनहरू कमला नदी बेसिको बन सम्पदा हुन् । कुरिलो, गुर्जो, चिराइतो, टिमुर, तेजपात जस्ता जडिबुटीहरु यस क्षेत्रका अन्य प्राकृतिक स्रोतहरु हुन् ।

5.6 आम्दानी तथा समृद्धि

यस बेसिनको प्रति ब्यक्ति आम्दानी औसतमा ५२१ डलर रहेको छ । मानव विकास सूचकांक ०.५०० र मानव गरिविको सूचक ३८ रहेकोछ । यी सबै सूचकांक नेपालको औसत भन्दा कम रहेबाट यो बेसिनका जनताको जीवनस्तर र आम्दानी आम नेपालीकोभन्दा कम रहेको स्पष्ट बुझ्न सकिन्छ ।

6. धार्मिक तथा सास्कृतिक महत्वका ठाउँहरू

यो नदी बेसिन भित्र र नजिकमा थुप्रै सांस्कृतिक, धार्मिक, ऐतिहासिक स्थलहरू रहेका छन । उदाहरणका लागि, सिराहको कमला दह, बालसुन्दरी भगवती माईको थान, धनुषाको जानकी मन्दिर, विवाह मण्डप, सिन्धुलीको सिद्धबाबा मन्दिर, सिन्दुली गढी दरवार, उदयपुरको त्रिवेणीधाम, ईन्द्रेश्वर महादेवको मन्दिर आदि ।

7. मूख्य मूख्य पूर्वाधारहरू

कमला बेसिनको ७११ ब.कि.मी को कृषियोग्य जमिनमा सिंचाई गर्न १९८४ मा कमला सिंचाइ आयोजना निर्माण गरिएको हो । यसको सिंचाई क्षमता २५ हजार हेक्टर रहेकोछ । कमला बेसिनमा यस नदीबाट उपलब्ध हुने पानीले सिंचाई गर्न नपुग्ने भएकाले सुनकोशी नदीबाट पानी डाइभर्सन गरेर कमला नदीमा ल्याउने योजना रहेकोछ । त्यसैगरी ३३,००० हेक्टरमा सिंचाइ गर्ने उद्देश्यले कमला ड्याम निर्माण गर्ने योजना बनाइएको पाईन्छ ।

8. संस्थागत संरचना

जलस्रोतको विकास तथा व्यवस्थापन बहुआयमिक भएकाले यसको नीति निर्माण देखि कार्यन्वयन सम्मका कार्यहरु सम्पन्न गर्नका लागि सरकारी, अर्ध सरकारी, निजी, शैक्षिक एवं पेशागत संघसंगठनहरूको सहभागिता जरुरी हुन्छ । यसमा सरकारी निकायको प्रमुख भूमिका रहन्छ । नेपालको संविधानले जलस्रोत लगायतका प्राकृतिक संसाधनको उपयोगको अधिकार संघीय सरकार, प्रादेशिक सरकार र स्थानीय निकायमा राखेकाले एकिकृत जलस्रोतको व्यवस्थापन सही तवरले गर्न र उच्च प्रतिफलका लागि यी निकायहरूबीच समन्वयको जरुरी पनि उत्तकै महत्व हुन्छ ।

9. कमला बेसिनमा जलस्रोतको ब्यवस्थापन

कमला बेसिनमा बसोबास गर्ने सम्पूर्ण जनतामा आवश्यक मात्रामा गुणस्तरीय खानेपानी पुऱ्याउन, सरसफाइका लागि चाहिने पानी व्यवस्था गर्न, सिंचाइ सुविधा कृषियोग्य जमिनमा पऱ्याई कृषि उत्पादन बढाउन, जलविद्युत उत्पादन गर्ने, वातवरणीय पानी उपलब्ध गराउन र जैविक विविधताको संरक्षण गर्न एवं बाढी-खडेरी जस्ता जल उत्पन्न प्रकोपको असर कम गर्न एकिकृत जलस्रोत व्यवस्थापनको फ्रेमवर्क भित्र रहेर निम्न क्रियाकलापहरु गर्नु पर्ने देखिन्छ ।

- बाढी नियन्त्रण ।
- भूक्षय न्युनीकरण ।
- खानेपानी, सिंचाइ, उद्यौगिक क्षेत्र, जलविद्युत उत्पादन तथा वातावरणीय संरक्षणका लागि समन्यायिक जलबितरण ।
- समन्वयात्मक तरिकाले जलस्रोतको विकास र व्यवस्थापन गर्न चुस्त जलस्रोत सूचना केन्द्र, कामकाजी संस्थागत संरचना र आवश्यक कानूनी प्रावधानको व्यवस्था

C.14 Annex

Annex 1: List of VDCs within Kamala Basin

DISTRICT	DISTRICT AREA (KM²)	VDC	AREA (KM²)	DISTRICT	DISTRICT AREA (KM²)	VDC	AREA (KM²)
Dhanusha	271.94	Balabakhar	3.35	Siraha	305.72	Bishnupurkatti	0.95
		BalahaKathal	4.09			BishnupurPra.Ra	11.00
		BalahaSadhara	2.74			ChandraAyodhyapur	5.46
		Ballagoth	0.50			Chandralalpur	2.21
		Baramajhiya	2.42			Chandrodayapur	15.41
		Bharatpur	21.38			Chatari	3.33
		Bisarbhora	0.00			Chikana	5.74
		DubarikotHathalekha	4.02			Dumari	6.11
		Godar	173.78			Fulbariya	39.28
		Harine	8.41			Gautari	4.95
		Inarwa	3.38			Hanumannagar	0.29
		Labatoli	11.56			ItariParsahi	5.59
		Lakkad	12.59			Jamadaha	1.40
		Nakatajhijh	0.00			KalyanpurJabadi	13.57
		Patanuka	0.58			Kalyanpurkalabanzar	9.46
		Paterwa	0.99			Karjanha	23.41
		Puspalpur	0.23			Khirauna	0.10
		Raghunathpur	4.48			Madar	6.07
		SingyahiMaidan	15.47			MaheshpurPatari	6.16
		TulsiChauda	0.58			Majhauliya	8.44
		Yagyabhumi	1.39			Malhaniya Gamharia	5.12
Sindhuli	970.67	Arunthakur	48.10			MalhaniyaKhori	3.43
		Bahuntilpung	0.60			Media	6.54
		Balajor	33.97			NarahaBalkawa	0.11
		Belghari	39.07			Radhopur	7.23
		Bhadrakali	7.12			Rajpur	1.13
		Bhimsthan	46.15			RamnagarMirchaiya	13.96
		Dudbhanjyang	0.24			Rampur Birta	7.13
		Dudhouli	22.48			Sarswar	6.72
		Harsahi	23.34			Sikron	7.98
		Hatpate	52.75			SirahaN.P.	10.59
		Jarayotar	48.47			SitapurPra.Da.	6.64
		Jinakhu	41.51			Sukhachina	0.01

DISTRICT	DISTRICT AREA (KM²)	VDC	AREA (KM²)	DISTRICT	DISTRICT AREA (KM²)	VDC	AREA (KM²)
		KakurThakur	67.41			ThalahaKataha	3.43
		KamalamiN.P.	190.14	Udayapur	495.22	Barai	39.48
		Ladabhir(Mahendra)	29.97			Bhuttar	0.00
		Lampantar	33.46			Dumre	22.09
		Mahadevdada	0.31			Hardeni	19.21
		Nipane	18.95			Iname	0.10
		Ranibas	50.19			Katari	76.67
		Ranichuri	81.19			Lekhgau	0.57
		Ratanchura	2.31			Limpatar	9.36
		Sirthouli	47.99			Nametar	3.47
		Tandi	36.46			Okhale	0.08
		Tinkanya	5.79			Pachchawati	57.21
		Tosramkhola	0.63			Risku	68.82
		TribhuvanAmbote	42.10			ShorungChabise	0.01
Siraha	305.72	Arnamarampur	5.65			Sirise	37.93
		Badharamal	38.90			Tawashree	41.47
		Barchhawa	2.12			Tribeni	89.67
		Belaha	8.27			Valayadanda	25.15
		Bhokraha	1.82			Yayankhu	3.93
Total							**1299.37**

Annex 2: Land use distribution in Kamala Basin by districts

DISTRICT	AREA WITHIN KAMALA_KM²	TYPE OF LAND USE	AREA (KM2)	%
Sindhuli	970.7	Needle leaved forest	53.8	5.5
		Broad leaved forest	621.6	64.0
		Shrubland	5.0	0.5
		Grassland	4.8	0.5
		Agriculture	267.6	27.6
		Bare area	10.6	1.1
		River	7.2	0.7
Udayapur	495.2	Needle leaved forest	9.6	1.9
		Broad leaved forest	349.8	70.6
		Shrubland	2.2	0.4
		Grassland	6.8	1.4
		Agriculture	117.7	23.8
		Bare area	6.3	1.3
		River	2.7	0.5

DISTRICT	AREA WITHIN KAMALA_KM^2	TYPE OF LAND USE	AREA (KM2)	%
Dhanusa	271.9	Broad leaved forest	150.7	55.4
		Shrubland	0.9	0.3
		Grassland	5.2	1.9
		Agriculture	90.2	33.2
		Bare area	21.4	7.9
		Built-up area	0.0	0.0
		River	3.6	1.3
Siraha	305.7	Broad leaved forest	47.9	15.7
		Shrubland	1.4	0.5
		Grassland	1.6	0.5
		Agriculture	235.8	77.1
		Bare area	8.6	2.8
		Buitup area	8.3	2.7
		River	2.0	0.7
Total	2043.6		2043.1	

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