कपाडीगाँड उप-जलाधार व्यवस्थापन योजना

बडीकेदार गाउँपालिका, डोटी

(Kapadigaad Sub-watershed Management Plan

Badikedar Rural Municipality, Doti)

२०७६

उप-जलाधार व्यवस्थापन योजना तर्जुमा गर्नको लागि अमेरिकी सहयोग नियोग यूएसएड पानि कार्यक्रम अन्तर्गत वातावारण, उर्जा तथा जल अनुसन्धान केन्द्र (CREEW), काठमाडौँको प्राविधिक योगदान र सहजिकरण तथा ग्रामीण समुदाय विकास केन्द्र (RCDC), डोटीको स्थानीय स्तरमा समन्यव र सामाजिक परिचालन भई तयार गरिएको हो ।

This sub-watershed management plan was formulated under the USAID Paani Program with technical contribution and facilitation by Center of Research for Environment, Energy and Water (CREEW), Kathmandu and local level coordination and social mobilization by Rural Community Development Center (RCDC), Doti in Nepal.

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बडौली, डोटी

सुदूरपश्चिम प्रदेश, नेपाल

पत्र संख्या:०७६।०७७

च.नं.:

शुभ कामना मन्तव्य

सुदूरपश्चिम प्रदेशको डोटी जिल्लामा अवस्थित यो गाउँपालिका विकट पहाडी भेगमा अवस्थित भएता पनि प्राकृतिक र जैविक विविधताले सम्पन्न मानिन्छ । भौगोलिक बनावट र भौगर्भिक अवस्थाका कारण मनसुनी वर्षासँगै बाढी र पहिरो यस क्षेत्रका विद्यमान समस्या हुन् । यसका साथै अनियन्त्रित वन विनास, सडक विस्तार, प्राकृतिक श्रोत र जलाधारको यथोचित व्यवस्थापन नहुँदा विश्वव्यापी जलवायु परिवर्तनका प्रभावहरु भू-क्षय, पहिरो, बाढी र पानीका मुहान सुक्ने समस्याहरुले विकराल रुप लिन सक्ने छन् । फलस्वरुप कृषि योग्य जमिन नष्ट भई खाद्य समस्या उत्पन्न हुनु, स्थानीय जिविकोपार्जनमा समस्या आउँदा स्थानीयवासीको सामाजिक तथा आर्थिक अवस्थामा प्रतिकुल प्रभाव पर्ने देखिन्छ । त्यसै गरि जैविक जीव र वनस्पति तथा जल पर्यावरणमा समेत यसका नकारात्मक प्रभाव पर्ने देखिन्छ । तसर्थ, जलवायु परिवर्तनबाट उत्पन्न हुन सक्ने समस्यालाई समयाकुल नगर्नु जल, जमिन, जीवजन्तु र जनताको अन्तर सम्बन्ध पहिचान गरी जलाधार व्यवस्थापन गर्नु अपरिहार्य आवश्यकता हो ।

स्थानीय सरकार सञ्चालन ऐन २०७४ बमोजिम स्थानीय सरकारलाई स्थानियस्तरमा वन, वनजन्य सम्पदा, जैविक विविधताको संरक्षण र प्रवर्धन, वातावरण संरक्षण क्षेत्रको निर्माण र व्यवस्थापन, सामुदायिक भू तथा जलाधार संरक्षण र त्यसमा आधारित आय आर्जन कार्यक्रम, जलाधार व्यवस्थापनजन्य सामुदायिक अनुकुलन जस्ता महत्वपूर्ण कार्यको कार्यान्वयनकालागि समन्वय, सहकार्य र नियमनकारी भूमिकाको जिम्मेवारी प्रदान गरिएको छ । त्यसै अनुरुप भू-तथा जलाधार संरक्षण कार्यालय डोटी, वातावरण, उर्जा तथा जल अनुसन्धान केन्द्र (CREEW) र ग्रामीण समुदाय विकास केन्द्र (RCDC), डोटीको प्राविधिक तथा आर्थिक सहयोगमा नेपालको भू-उपयोग नीति (२०७२) मा आधारित रही र उप-जलाधार व्यवस्थापन निर्देशिका (२०७३) लाई अनुसरण गरी यस गाउँपालिको क्षेत्र अधिकार भित्र पर्ने कापडीगाड उप-जलाधार व्यवस्थापनको योजना तयार पारिएको छ । स्थानीय जनताको प्रत्यक्ष संलग्नतामा तयार पारिएको यस उप-जलाधार व्यवस्थापन योजनाले यो क्षेत्रमा विद्यमान वातावरणीय र जल-वायु प्रतिकुलतालाई न्यनीकरण र समयानुकुलन गरी स्थानिय जिविकोपार्जन र पर्यावरणलाई जोगाउन महत्वपूर्ण भूमिका खेल्ने छ ।

यस योजना तर्जुमा गर्न आर्थिक र प्राविधिक सहयोग गर्नु भएकोमा भू- तथाजलाधार संरक्षण कार्यालय डोटी र वातावरण, उर्जा तथा जल अनुसन्धान केन्द्र (CREEW) र ग्रामीण समुदाय विकास केन्द्र (RCDC), डोटीलाई कृतज्ञता व्यक्त गर्न चाहन्छु साथै अन्य सरोकारवालासँग यस योजनाको भावी कार्यान्वयनमा साथ र समर्थनको अपेक्षा गर्दछु ।

कृष्ण बहादुर चन्द

गाउँपालिका अध्यक्ष

कृष्ण बहादुर चन्द
अध्यक्ष

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प्रदेश सरकार
सुदुरपश्चिम प्रदेश
उद्योग,पर्यटन,वन तथा वातावरण मन्त्रालय
प्रदेश वन निर्देशनालय
भू तथाजलाधार व्यवस्थापन कार्यालय
डोटी

फोनः ०९४-४२०२५८

मन्तव्य

नेपालको भूगोलमा हिमाल, पहाड, तराइ, मधेससम्म आआफ्नै विशेषता छ । धेरै भिरालो जमिन रहेको र त्यसमाथि जलवायु परिवर्तनले हाम्रो भू भागमा नकरात्मक असर पारीरहेको सन्दर्भमा जलाधारहरुको दिगो व्यवश्थापन अति नै जरुरी छ । जलाधार व्यवश्थापन भनेको कुनै जलाधार क्षेत्र भित्र रहेका जल, जमिन, जंगल, जनवार, तथा जनता सहित समग्र पर्यायवरणको एकिकृत व्यवश्थापन हो, जसले प्राकृतिक स्रोत सम्पदाको दिगो व्यवश्थापन हुन सक्दछ । पानी लगायत वातावरणीय ह्रासका प्रभावहरु सुक्ष्म क्षेत्र (स्थानीय)मा सजिलै अनूभव गर्न सकिने भएकाले उपजलाधार क्षेत्रहरुको उचित व्यवश्थापन गर्नु अति नै जरुरी छ । एकिकृ जलाधार व्यवस्थापन अवधारणा अनुसार उपजलाधार क्षेत्रको व्यवश्थापन योजना तयार गरी कार्यान्वयन तथा अनुगमनको कार्य वि.सं. २०३१ देखि नेपाल सरकारले भु तथा जलाधार संरक्षण विभाग मार्फत गर्दै आएको थियो । संघियताको कार्यान्वयन संगै उक्त कार्यको कार्यान्वयन प्रदेश तथा स्थानीय तहलाइ हस्तान्तरण भएको छ । तसर्थ स्थानीयतहमा कार्यक्रम सञ्चालन गर्दा जलाधार स्रोतहरुको दिगो र बुद्धिमता पूर्वक गर्ने एक पद्धती अबलम्बन गर्नुपर्ने देखिन्छ । विकास निर्माणको काम गर्दा वातावरणीय पक्षलाइ राम्रोसंग ध्यान दिनुपर्दछ । कुनै एक जलाधार भित्र त्यहाँको भुमिको क्षमता अनुसार प्रयोग गर्ने र संरक्षण गर्ने कार्य गर्दै गएमा जलाधार क्षेत्रको संरक्षण, व्यवश्थापन तथा वातावरणीय सन्तुलन कायम भइ जलवायु परिवर्तनको नकरात्मक असरवाट समेत वच्न सकिन्छ ।

कपाडिगाड उप-जलाधार क्षेत्र धेरै भिरालो जमिन तथा कमजोर भु वनोटका कारण वाढी तथा पहिरोको जोखिममा छ । जथाभावि रुपमा वनजंगल फडानी गर्ने, अव्यवश्थित तरीकाले कच्ची सडक निर्माण गर्ने, तथा प्राकृतीक स्रोतको उचित व्यवश्थापन नहुनुले यस क्षेत्रमा जलवायु परिवर्तनको असरहरु जस्तै भु स्खलन, बाढिपहिरो, खडेरी, पानीको स्रोत सुकेर जानु जस्ता असरहरु वाट उच्च जोखिममा रहेको देखिन्छ, जसले उक्त क्षेत्रका स्थानीय जनताको जिविकोपार्जन, जैविकविविधता तथा जलचर प्राणीहरुको वासस्थानको उपलव्धतामा समेत गम्भिर असर पर्नसक्ने हुँदा उप-जलाधार क्षेत्रको उचित व्यवश्थापन गर्नु अपरिहार्य रहेको छ ।

यसै परिप्रेक्षमा USAID PAANI कार्यक्रमको आर्थिक सहयोगमा वातावरण, उर्जा तथा जल अनुसन्धान केन्द्रले यस भु तथा जलाधार व्यवश्थापन कार्यालयको प्राविधिक सहयोग तथा वडिकेदार गाउँपालिकाको समन्वयमा कपाडिगाड उपजलाधार क्षेत्र व्यवश्थापन योजना तयार पारेको छ । यस योजना भु तथा जलाधार संरक्षण विभागले तयार पारेको उप-जलाधार व्यवश्थापन योजना तर्जुमा कार्यविधी २०७३ तथा भू उपयोग निति २०७२ को अधिनमा रहि तयार पारिएको छ ।

बहुपक्षिय सहभागितामा तयार गरिएको यो योजनाको सफल कार्यान्वयनको कामना गर्दै आवश्यक प्रभावकारी कार्यान्वयनमा यस कार्यालयले प्राविधिक तथा आर्थिक सहयोग गर्न सक्ने कुरा व्यक्तगर्न चाहान्छु । अन्त्यमा यस योजना तयार पार्ने वातावरण, उर्जा तथा जल अनुसन्धान केन्दलाइ विषेश धन्यवाद दिदै योजना तर्जुमामा सहयोग गर्ने स्थानीय सामुदाय तथा सम्पुर्ण सरोकारवाला निकायमा धन्यवाद व्यक्त गर्न चाहान्छु ।

धन्यवाद ।

श्याम कुमार श्रेष्ठ
बरिष्ठ जलाधार व्यवश्थापन अधिकृत
२०७७ जेष्ठ

बरिष्ठ जलाधार व्यवस्थापन अधिकृत

Summary

Integrated watershed management plan including forest, agriculture, water and land resources plays an important role in sustaining the better health of watershed. Also, natural resources are the key resource for sustaining the rural livelihood in Nepal. Land, water and biomass management are the major component of watershed management, where basically land and water resources maintain the agriculture and livestock economy in the country. The main objectives of sub-watershed management plan is to address the diverse but inter-linked issues in the sub-watershed systematically in planned way, to protect and conserve all natural resources in a sustainable manner, to enhance climate change resilience of communities, to enhance availability of water for drinking and agriculture, to build capacity of local stakeholders from rural municipalities and communities in preparation of the sub-watershed management plan and its implementation in Kapadigaad sub-watershed of Badikedar Rural Municipality.

Natural hazard such as landslide, flooding are generally occurred within a sub-watershed region. But in present scenario, due to the human activities the frequency of landslide, flooding, increasing drought and other drying up of water resources were commonly seen within sub-watershed area. Kapadigaad sub-watershed area is no exception from these natural and human made disaster of Badikedar Rural Municipality. Increasing drought, drying up of spring water source were commonly seen in upstream of sub-watershed area while flooding was commonly occurred in downstream area. Moreover, fire hazard in forest area was common problem in all over the sub-watershed area. These problems and issues were identified based on the public participatory meeting, community survey and field survey.

The prioritization of Kapadigaad sub-watershed among the five sub-watersheds delineated in Badikedar Rural Municipality was based on participatory approach and vulnerability assessment using the indicator values. Large sub-watershed with higher number of population needed more food crops and this in turn demanded more water utilization and other natural resources. The data shows that out of 46 water sources in Kapadigaad sub-watershed, 2 water sources had already dried up and 40 water sources outlets were drying up slowly. Also, 9% respondent said that drinking water was hardly sufficient for their daily life and 40% respondent said there was no irrigation water. Within the sub-watershed area, destructive fishing activity was absent but still there was use of small size of net for fishing in Kapadigaad. In addition, about 9000 tons per year dry matter was needed for the livestock population within the sub-watershed area. Moreover, almost every household of the sub-watershed area used

firewood for cooking purpose. The major source of firewood for human and feeding for livestock was community forest. Also, this plan shows that about 6,47,464.00 litre water per day was required for human and livestock population.

With the support of local representatives from the community level, community groups and staff from the rural municipality office were facilitated in preparing community level implementation plan reflecting different conservation program and development activities as per community's needs. The activities and recommendations will be the basis for implementation of management plan in close coordination and collaboration with ward office of ward 1, 2 and 4 of Badikedar Rural Municipality and rural municipality office with the technical and financial support of Soil and Watershed Conservation Office, Silgadi Doti and Water Induced Disaster and Irrigation Division Office, Doti. Community user groups and community people will be an integral part of planning, implementation and monitoring of proposed activities including implementation agencies, ward office, rural municipality office and local representatives from the local level and local government. Altogether, the total cost for the implementation of this plan is estimated to be 114.00 million rupees (*i.e. 11 crores 40 lakhs rupees*).

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1. Introduction

1.1. Background

In a watershed, natural resources- land and soil, water, forest are the basis for sustenance and balance of various ecological systems and environment; and economic activities in Nepal also depend on them. Efforts for conservation and management of these natural resources at sub-watershed level have been made by the district level offices of the Department of Soil Conservation and Watershed Management (DSCWM), government of since decades. Sub-watershed management is important also because it contributes to increased agricultural production through better protection and conservation of fertile and productive land and soil for agricultural production and also enhances production of water sources for drinking, livestock and irrigation.

On the other hand, sustainable management of water, soil, forest and other resources in watersheds of Nepal depends on addressing climate change and environment changes, and protecting healthy and bio-diverse ecosystems. Most of the streams and tributaries are shrinking and drying due to both natural disasters such as landslides, river bank cutting, flood, drought and; human activities such as overexploitation and degradation of natural resources (forest, land, water); and unplanned settlements and infrastructure developments especially rural roads. Availability of water from water sources is getting less compared to last decades due to degradation of water sources and increasing dryness in the watershed. At rural municipality level, there is lack of legal and regulatory frameworks/instruments for conservation of aquatic biodiversity resource and plans for their sustainable management.

In these context, sub-watershed management plan is prepared for the sub-watersheds of the Thuligaad Watershed that covers areas of Jorayal Rural Municipality (419 km^2) (RM) located in in Doti district of the Sudurpachim Pradesh. Thuligaad watershed is identified as important watershed of Karnali River Basin. In the watershed, availability of water to 91% households is difficult because of drying water sources, water quality of the sources is degrading, and as rural road construction is not well regulated it has also led to landslides and destruction of aquatic habitat. Destructive fishing and overfishing in the watershed is also major issue as it has brought down fish stock population and affecting their breeding.

The Land Use Policy 2015 is a milestone for sustainable land use and its management approved by the Government of Nepal just after the big earthquake of 2015 in Nepal. The main aim of this policy is to categorize/classify entire lands of the country into various Land Use Zones

such as agricultural zone, residential zone, industrial zone, river and lake reservoir zones, forest zones, public use and open space zone. etc. Another is to ensure the use of Land and Land Resources (LLRs) on the basis of Land Use Plans (LUPs) for protection of agricultural land, hygienic, beautiful, well-facilitated settlement and sustainable urbanization, and for forests areas including natural heritages, biodiversity and historical, cultural and religious, archaeological and areas of strategic importance and to mitigate natural and human created-disastrous hazards. Moreover, Agriculture Perspective Plan (1995) and Agriculture Development Strategy (2015-2035) has been formulated by the Government of Nepal for reducing poverty and enhancing food security for all people. These plans and strategy helps for sustainable use of land and its proper management to enhance the soil quality and productivity. Besides that, DSCWM was established under the Ministry of Forests and Soil Conservation in 1980 with major role and responsibility to plan and implement soil conservation and watershed management activities through 70 district soil conservation offices in Nepal. However, after restructuring of the government into three tiers as Central Government, Province Government and Local Government in 2017; Soil and Watershed Conservation Office (SWMO) have been formed two each in the province. SWMOs are under the Ministry of Industry, Tourism, Forest and Environment of the provincial government. Soil and Watershed Management Office (SWMO) Doti office in Sudurpacchim Pradesh (province) oversees the five districts- Kailali, Doti, Accham, Bajura and Bajhang.

Integrated sub-watershed management plan for Karnasigaad sub-watershed can play crucial role to reduce natural and human pressure on the natural resources. Effective implementation of the plan can contribute to reduce soil erosion, landslide and drought in upstream of the sub-watershed; reduce flooding and inundation of agricultural land and settlements, reduce sedimentation and prevent loss of lives and property. Further it can enhance water availability for human, wildlife and aquatic species; improve water quality, revival of water sources, conservation and proper use of land and vegetation; and also improve local peoples' livelihood condition through sustainable use and management of local resources. Moreover, this plan addresses the status of aquatic biodiversity especially fish diversity and also focus on terrestrial biodiversity such as plantation of various plant species, conservation and protection of native species, protection of wildlife through information dissimilation and awareness activity.

1.2. Objectives

Overall objective is preparation and implementation of sub-watershed management plan in Kapadigaad sub-watershed is to protect and conserve available natural resources *viz*. land, soil, water, forest, fish and aquatics primarily by the joint effort of local communities and local government for maintaining ecological and environmental balance, increasing the productivity of the natural resources and making their sustainable use for economic and overall prosperity of the local people.

Specific objectives

i) To address the diverse but inter-linked issues in the sub-watershed systematically in planned way.
ii) To protect and conserve all natural resources in a sustainable manner.
iii) To enhance climate change resilience of communities.
iv) To enhance availability of water for drinking and agriculture.
v) To build capacity of local stakeholders from rural municipalities and communities in preparation of the sub-watershed management plan and its implementation.

The local stakeholders include rural municipality authorities, political representatives at the ward and municipalities, communities and CBOs.

1.3. Scope

The sub-watershed management plan emphasized various scope related to the watershed management. Few of the scope measures related with

i) Proper utilization of different land use such as agriculture land, degraded land and forest land for the sustainable resource harvesting
ii) Enhancing the water quality and accessibility for the local people as well as for the aquatic species
iii) Increasing the diversity of aquatic species (mainly fish population and diversity) as well as terrestrial diversity
iv) Enhancing the local livelihood through the adaptive practices against the climate change and other natural disaster such as drought, flood, landslide, forest fire etc.
v) Mitigation measures to reduce the erosion process and over exploitation of natural resources

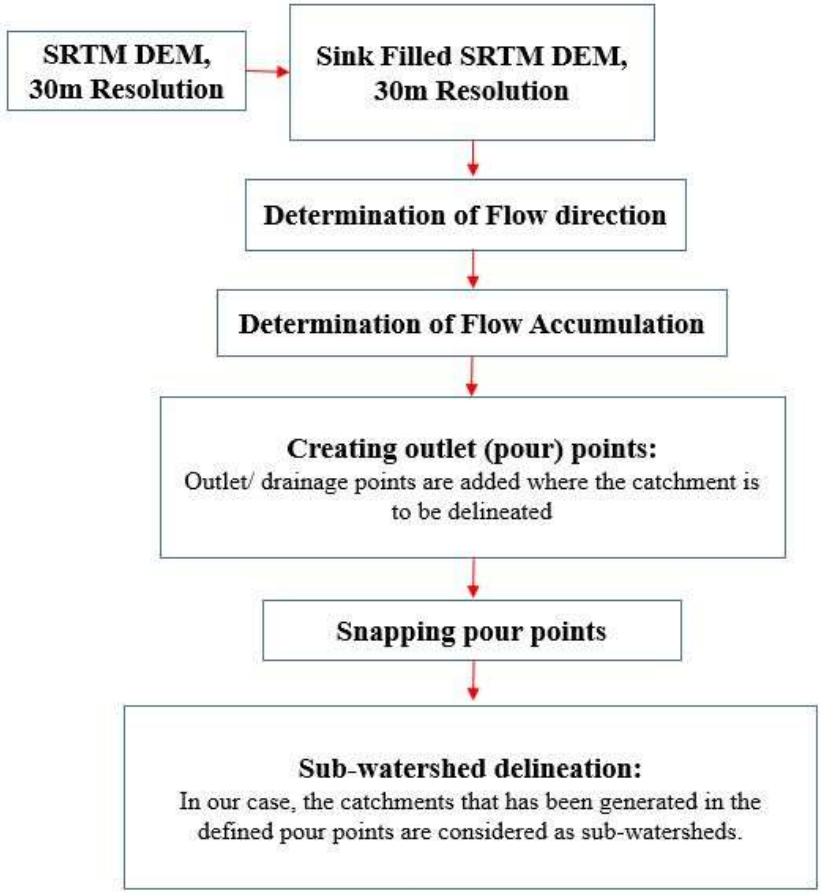
2. Selection of Sub-watershed

The selection process of sub-watersheds consists of four major components. The first one is the catchment delineation process and the second one is a number of indicators that normalizes to generate a priority value. They are described hereafter.

2.1. Catchment Delineation

i) Data and Process of Catchment Delineation

For the catchment delineation, a gap filled SRTM DEM of resolution 30m is used. The process used is shown below.



Flow chart 1: Sub-watershed delineation process chart

ii) Earlier Works

Catchment delineation is one of the most important factors for selection of a sub-watershed. A sub-watershed was earlier classified according to the size of the delineated catchment. Different literatures and conventions classify sub-watersheds differently.

Earlier, the document published by DSCWM (Department of Soil Conservation and Watershed Management) in 2016, "Sub-watershed Management Planning Guideline" and another

document published by DSCWM in 2017 inside the "Training Handouts for Sub-watershed Management Planning" where a reference of the World Bank has been taken into consideration.

The document published by DSCWM in 2016 states that a sub-watershed is of area 1500 ha (15 sq.km) to 2500 ha (25 sq.km) with an allowance of 10% less or more. Another document by DSCWM in 2017 states that a sub-watershed is of area 1-10 sq.km. There seems to be a contradiction on different official documents published by DSCWM itself. Therefore, we earlier had considered an area of 10-15 sq.km as sub-watershed.

The pictures shown below are from the DSCWM document from 2017 "Training Handouts for Sub-watershed Management Planning".

- micro-watershed: catchment of a primary channel
- sub-watershed: catchment of a secondary channel, which consists of one or more micro-watersheds
- watershed: catchment of a larger channel, stream or river which comprises of a number of micro-watersheds and sub-watersheds
- river basin: catchment of a big rivers comprises of a number of larger watersheds

Watershed Unit	**Typical area (km^2)**
Micro-watershed	0.05-0.50
Sub-watershed	1-10
Watershed	10-100
Sub-basin	100-1,000
Basin	1,000-10,000

Adopted after The World Bank 2008. Water Sector Board Discussion Paper Series. Paper No. 11. Watershed management Approaches, Policies and Operations: Lessons for Scaling Up

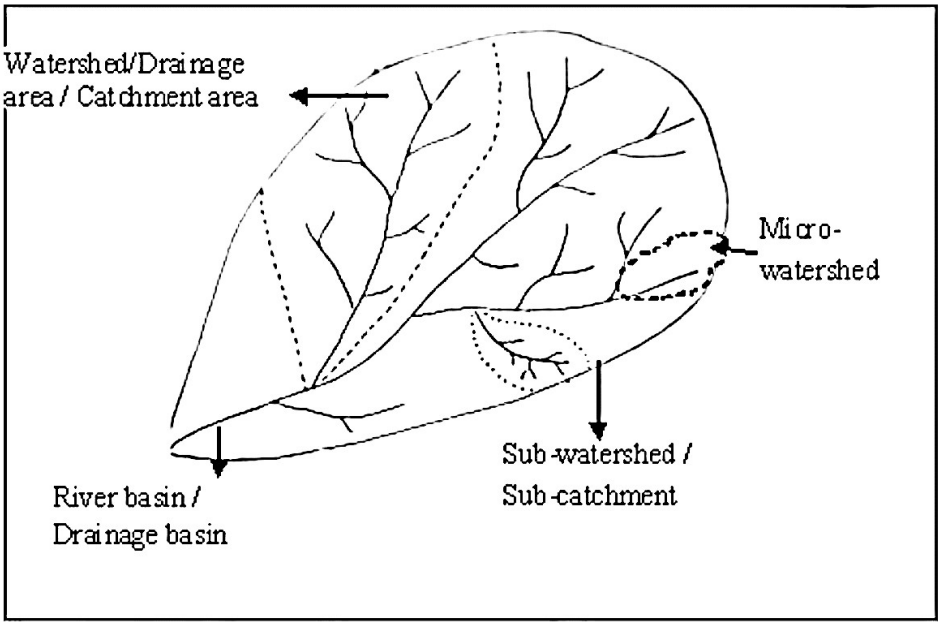


Figure 1: Schematic diagram of watershed

Similarly, the picture below is a screenshot from the document published by DSCWM in 2016, "Sub-watershed Management Planning Guideline".

- The first task is to delineate all sub-watersheds within a district.
- The size of a functional sub-watershed is presumed to be that which can be managed by users, approximately 1500 to 2500 hectares.
- For practical purposes, the area of the sub-watersheds may cross the presumed range by up to 10 %.

All the sub-watersheds that are inside the Thuligaad watershed were delineated. Among them, watersheds that are under 15 sq. Km were noted.

The pictures below shows previously delineated sub-watersheds, sub-watershed area of below 15 sq. Km, and sub-watershed area of below 10 sq. Km. Among them, a few were selected as shown in the figure 2.

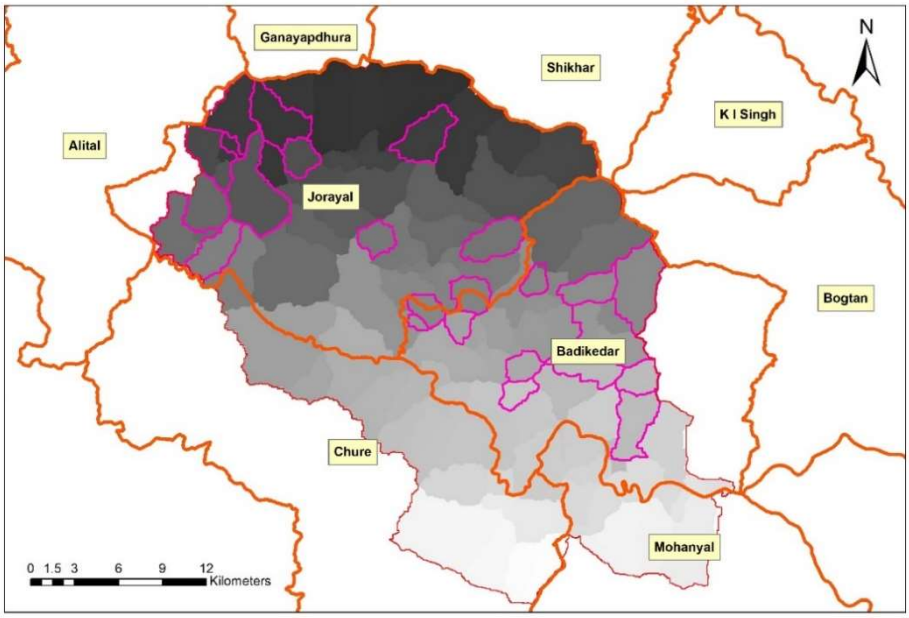


Figure 2. Sub-watershed identified within the Thuligaad watershed

iii) Revised Delineated Sub-watersheds

The process of delineating a catchment and considering it as a sub-watershed based on area has limitations. The area seemed to be too small and did not capture a water stretch where most of the population is settled. Considering the area-based approach would be inappropriate and the sub-watershed management plan developed for it would have been very limited.

On a discussion between CREEW and USAID Paani Program team at Baluwatar office, these limitations were discussed and decided not to use the process. Later it was agreed that the catchment corresponding to a water stretch should be considered as a sub-watershed. Hence, the delineation of catchments was done based on the order of the river.

As seen in the topographical map shown in figure 3, major settlement is along the water stretch.

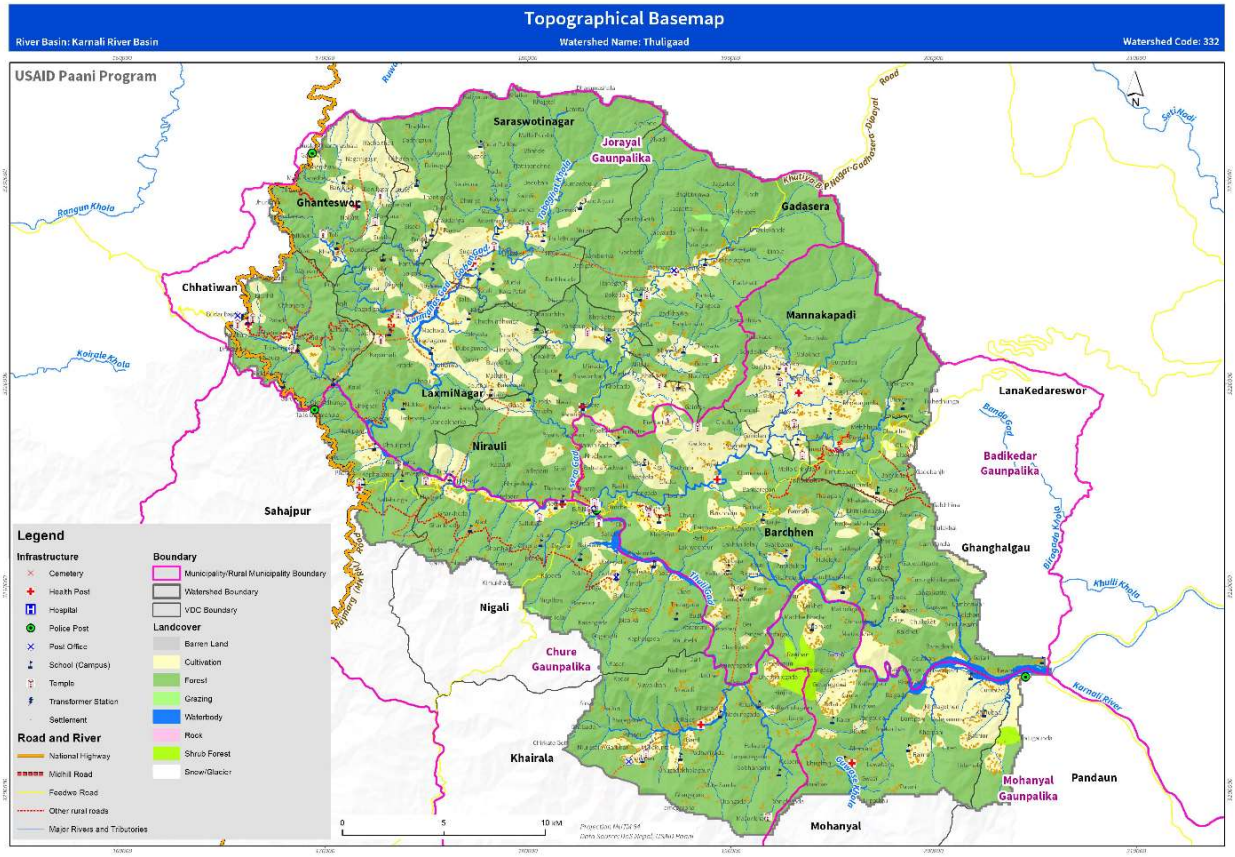


Figure 3: Sub-watershed delineation within a Thuligaad watershed in topographical base map

A schematic drawing of the order of the river and the catchments are shown in figure 4.

Considering Thuligaad watershed as the first order river, its direct tributary (second order) has been considered as the river whose catchment is considered as sub-watersheds. Using this process, Badikedar Rural Municipality has 5 sub-watersheds delineated as shown in figure 5. They are Chaud Khola (B1) 15.011 Km^2, Binsen khola (B2) 9.573 Km^2, Paneri Khola (B3) 16.916 Km^2, God Khola (B4) 11.476 Km^2 and

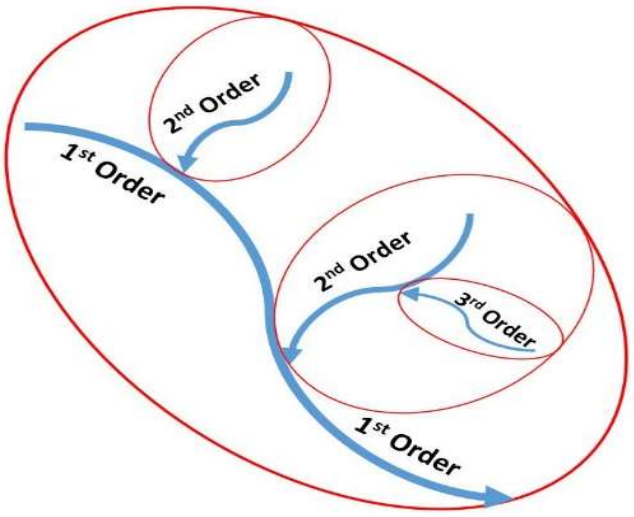


Figure 4: Schematic diagram of river order

Kapadigaad (B5) 132.48 Km^2 delineated inside the Badikedar Rural Municipality within the Thuligad watershed well depicted in figure 5.

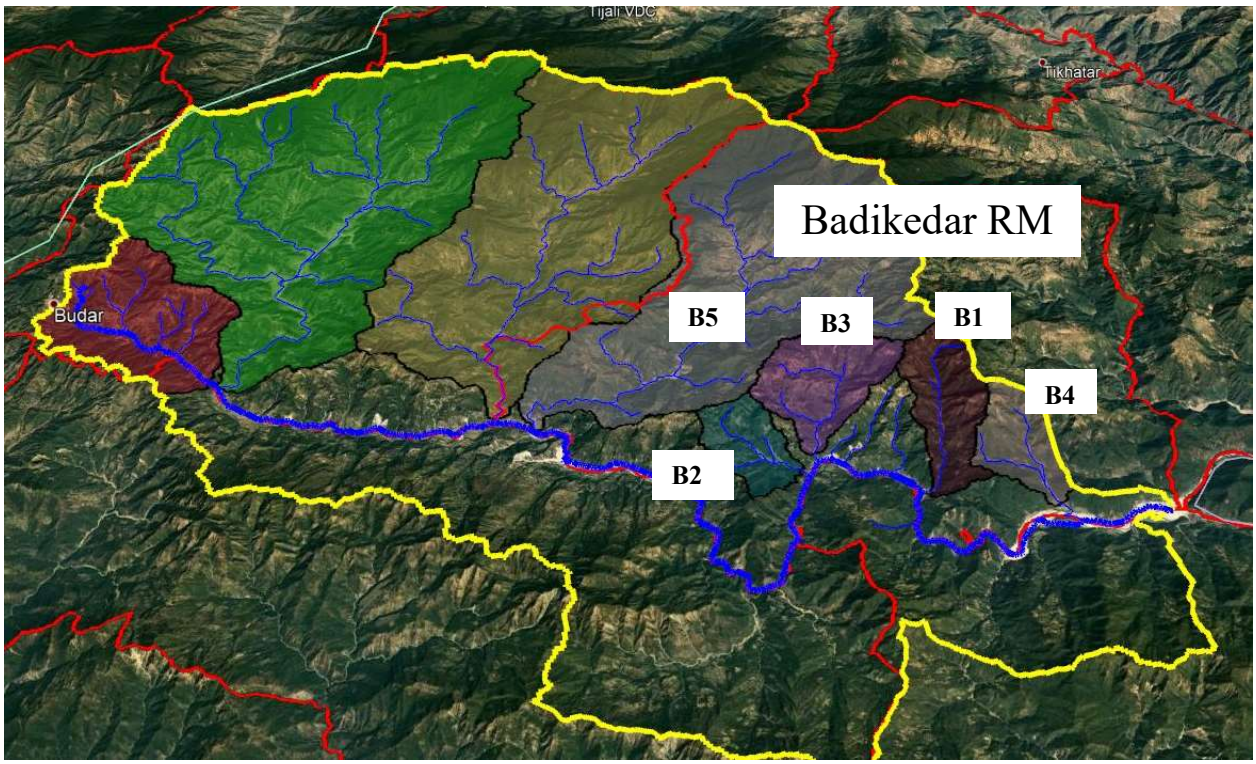


Figure 5: Sub-watershed of Badikedar Rural Municipality within the Thuligaad watershed

2.2. Indicators

After delineating sub-watersheds based on the order of the river, one of the sub-watersheds to be worked on is selected using different Indicators. These Indicators are reflections of different components that exists within a sub-watershed. Different Indicators reciprocate to different values. These values are calculated by using the answers from the form that was filled by the local stakeholders during different field visits. The questionnaire that was distributed and used to collect data.

There are 4 main components i.e. Water, Demography, Land use - Land Cover and Climatic and Biophysical Hazard inside the sub-watershed that we have considered. Various indicators reflect these components. Different components, their respective indicators, and the percentage that it contributes for prioritization a sub-watershed is shown in the table below:

Table 1. Component and indicators of sub-watershed prioritization

Components	Indicators	
Water (35%)	1) Water availability (25%)	i) Water for household; ii) Water for agriculture and livestock
	2) Water quality and ecology (10%)	i) Quality of water; ii) Source of pollutants; iii) Aquatic biodiversity
Demography (25%)	3) Population and socio-economics (25%)	i) Population and its composition; ii) Economic activities; iii) Public health
Land use and land cover (LULC) (30%)	4) Agricultural aspect (10%)	i) Types of crops; ii) Increase/decrease in productivity over the years
	5) Forest aspect (10%)	i) Forest coverage; ii) Management and its use
	6) Urban settlement/Infrastructure (10%)	i) Access to water source; ii) Use of water by health post, cottage industries etc.
Climatic and biophysical hazard (10%)	7) Disaster vulnerability (10%)	i) Slope lands; ii) Landslides area; iii) Floods events; iv) Forest fires

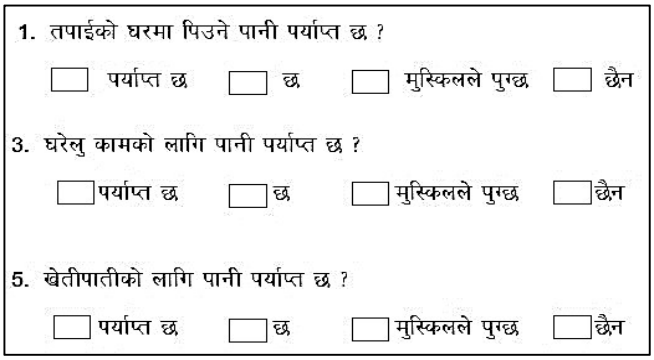
Seven indicators have been used to obtain the priority value using which the sub-watersheds are selected. These indicators are explained below.

I) Water Component

i. Water Availability (I1)

The indicator is one of the most important indicators in Thuligaad watershed. It carries high weightage (25%) along with the indicator that represents the demography aspect. This indicator incorporates issues such as availability of water for drinking, household use, livestock and agricultural purpose.

The information regarding the availability of water has been reflected by the answers provided by the stakeholders from the questionnaires. For water availability aspect, answers of question number 1, 3 and 5 are taken into consideration to calculate indicator value (*Ivalue*). However, there are more questions such as question number 6, 15, and 16 that reflect about the water availability aspect. These answers are not used for calculating the indicator value but will be used for the management plan as it is a primary source of data obtained from stakeholders. The questionnaire is shown below.


1. तपाईको घरमा पिउने पानी पर्याप्त छ ?

☐ पर्याप्त छ ☐ छ ☐ मुस्किलले पुग्छ ☐ छैन

3. घरेलु कामको लागि पानी पर्याप्त छ ?

☐ पर्याप्त छ ☐ छ ☐ मुस्किलले पुग्छ ☐ छैन

5. खेतीपातीको लागि पानी पर्याप्त छ ?

☐ पर्याप्त छ ☐ छ ☐ मुस्किलले पुग्छ ☐ छैन

Questions number 1, 3 and 5 asked about the water availability for drinking purpose, household use and irrigation purpose respectively. The answers have four options arranged from highly availability to low availability. For our study, priority is given to the least availability aspect. The least water availability option is given the highest value i.e. 87.5% (the range is 75% to 100% and its average value is 87.5%). Similarly, the highest water availability option is given the lowest value i.e. 12.5% (the range is 0% to 25% and its average value is 12.5%). Similarly, other values are 37.5% (range of 25% to 50%) and 62.5% (range of 50% to 75%) for other options.

The option that receives the highest number of answers is considered for calculation. For example, option A (option with highest water availability with value 12.5%) is selected by the majority, then the value 0.125 (12.5%) is selected for that option.

In our case, option A has received the highest number of answers (60% have selected option A) in question number 1, option B in question number 3 (60%) and 5 (40%).
Question number 1 gets the value 0.125 and question number 3 and 5 gets the value 0.375.

Questions	Options			
	A	B	C	D
1	60%	20%	20%	0%
3	20%	60%	20%	0%
5	20%	40%	20%	20%

Questions	Options			
	A	B	C	D
1	0.125	0.375	0.625	0.875
3	0.125	0.375	0.625	0.875
5	0.125	0.375	0.625	0.875

Here, if two different option gets the same number of selections, then their value is averaged. For example, option number B and C both gets selected by 30% of the people, then their value

is calculated as sum of 0.375 (value for option B) and 0.625 (value for option C) and then dividing that sum in half.

The indicator value (*Ivalue*) for Indicator that reflects the water availability (I1) contains three questions. The values obtained from these three questions are then averaged and Ivalue is generated.

$$\boldsymbol{Ivalue} = \frac{Value\ of\ A + Value\ of\ B + Value\ of\ C}{3}$$

Indicators	Q. No.	Options				Ivalue
		A	B	C	D	
Water Availability (I1)	1	0.125				0.292
	3		0.375			
	5		0.375			

This reflects the *Ivalue* for one ward. There can be more than one ward in a sub-watershed. In that case, area proportion method is used for the calculation of the Prioritization value. For example, the figure below shows a sub-watershed which consists of three wards inside it. To calculate the priority value, Ivalue of these three wards are distributed according to the area proportionate method.

In the above figure, total area of sub-watershed is about 187.20 Km^2 where ward no. 1 covers 32.47 Km^2 (17%), ward no. 3 covers 85.31 Km^2 (46%) and ward no 4 covers 69.45 Km^2 (37%). The priority value for each sub-watershed is calculated by using equation 1.

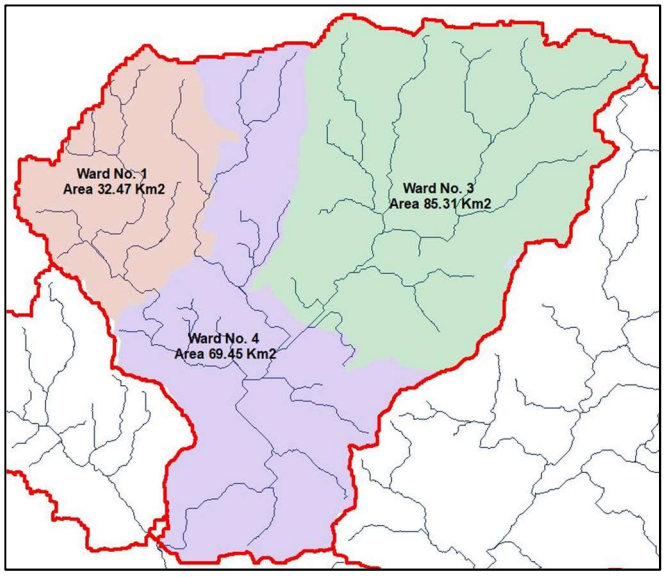


Figure 6: Ward wise map of Kapadigaad sub-watershed

$$Pv = \frac{i1 * a1 + i3 * a3 + i4 * a4}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

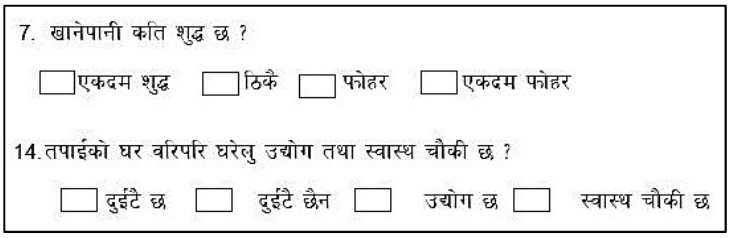
Where,

a1 = area of ward no. 1, a3 = area of ward no. 3, a4 = area of ward no. 4, A = Total area of the sub-watershed, i1 = Ivalue of ward no. 1, i3 = Ivalue of ward no. 3, i4 = Ivalue of ward no. 4.

ii. Water Quality and Ecology (I2)

This indicator carries 10% of weightage for obtaining the priority value of a sub-watershed. Information regarding water quality is reflected by question number 7 and question number 14. These two questions are taken into consideration to calculate the indicator value, as they are the primary source of data. However, there are earlier studies in Thuligaad watershed that describes the state of quality of water. Those reports and documents will be considered for developing sub-watershed management plan.

The answers received from the questionnaires are analysed. The picture below shows question number 7 and 14 that were asked to fill in the questionnaire.


7. खानेपानी कति शुद्ध छ ?

☐ एकदम शुद्ध ☐ ठिकै ☐ फोहर ☐ एकदम फोहर

14. तपाईको घर वरिपरि घरेलु उद्योग तथा स्वास्थ चौकी छ ?

☐ दुईटै छ ☐ दुईटै छैन ☐ उद्योग छ ☐ स्वास्थ चौकी छ

The process of calculating the Indicator value (*Ivalue*) and Priority value (*Pv*) is same as explained in I1. For this case, priority has been given to lower quality of water. i.e. lower the quality, higher the priority.

I. Demographic Component

i. Population and Socio-economics (I3)

This indicator is one of the most important indicators in Thuligaad watershed. It carries high weightage (25%) along with I1. This indicator incorporates the demographic aspect of a watershed.

Population is directly proportional to the socio-economic aspect in any area. The area with higher population density is bound to have higher social as well as economic activities on it. Population of different wards have been collected from the respective Rural Municipality and then used to generate the Indicator value (Ivalue) of each ward within a sub-watershed and then later used to calculate the priority value (Pv).

Similarly, the table below shows the population and area of different wards of Badikedar Rural Municipality in the table 2.

Table 2: Ward wise population of Badikedar Rural Municipality

Ward no.	Population	Population %	Area (sq.km)	Area %
1	2817	17.07%	54.92	16.42%
2	2762	16.74%	59.78	17.88%
3	3996	24.21%	80.83	24.17%
4	3535	21.42%	87.15	26.06%
5	3393	20.56%	51.71	15.46%
Total	16503	100.00%	334.39	100.00%

(Source: Village profile of Badikedar Rural Municipality, 2075)

In simpler terms, it can be said that the area that lies inside the sub-watershed is multiplied by the population density to obtain the total population.

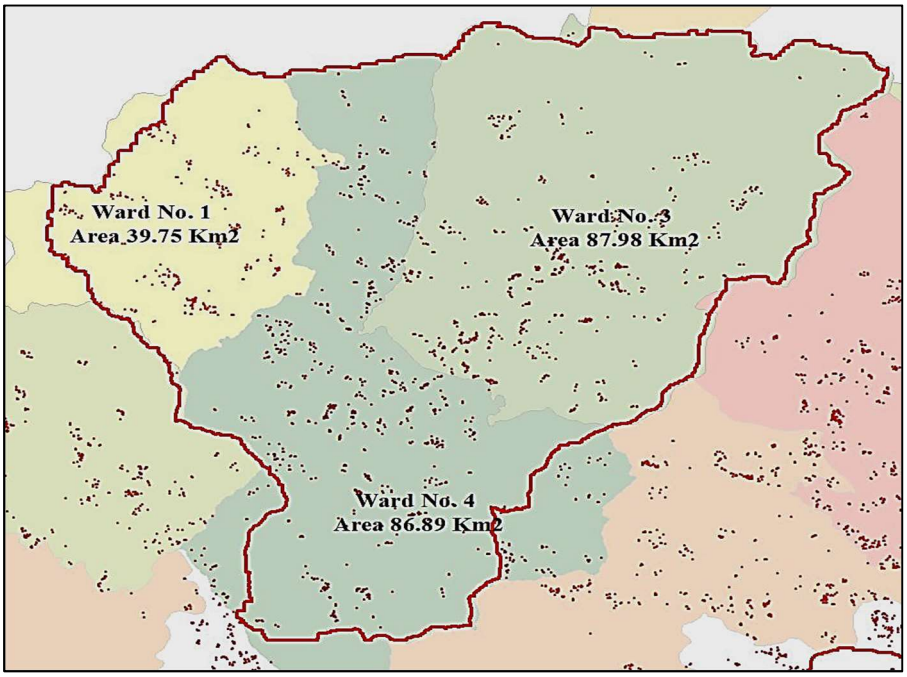


Figure 7: Population density within the sub-watershed area

In the above figure, we can see that there are different wards that is located inside a sub-watershed. The area of different wards inside the sub-watershed is calculated and then the population is distributed using the area proportion method by using equation 2.

$$\text{Population of sub wateshed} = \sum_{i=1}^{n} \left(\frac{\text{Area of the ward\_}i \text{ inside the sub watershed}}{\text{Total area of the ward}} * \text{Total population of ward\_}i \right) \quad \ldots\ldots\ldots\ldots 2$$

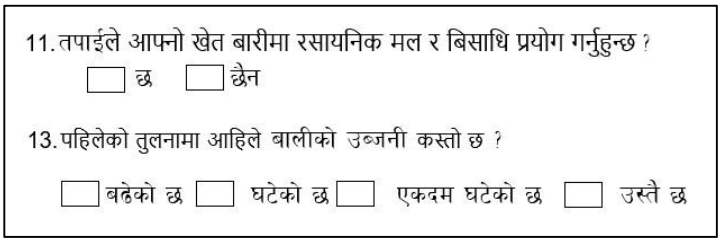
Where, n = Total number of wards inside a sub-watershed.

The sub-watershed with the highest population gets highest priority.

III. Land Use and Land Cover (LULC) Component

i. Agricultural Aspect (I4)

This indicator carries 10% of weightage for obtaining the priority value of a sub-watershed. Question number 10, 11, 12 and 13 are the ones that provide first-hand information about the agricultural aspect inside the sub-watershed. However, for generating the Ivalue, question number 11 and 13 are taken into consideration. Answer of other questions will be helpful for developing the sub-watershed management plan.


11. तपाईले आफ्नो खेत बारीमा रसायनिक मल र बिसाधि प्रयोग गर्नुहुन्छ ?
☐ छ ☐ छैन

13. पहिलेको तुलनामा आहिले बालीको उब्जनी कस्तो छ ?
☐ बढेको छ ☐ घटेको छ ☐ एकदम घटेको छ ☐ उस्तै छ

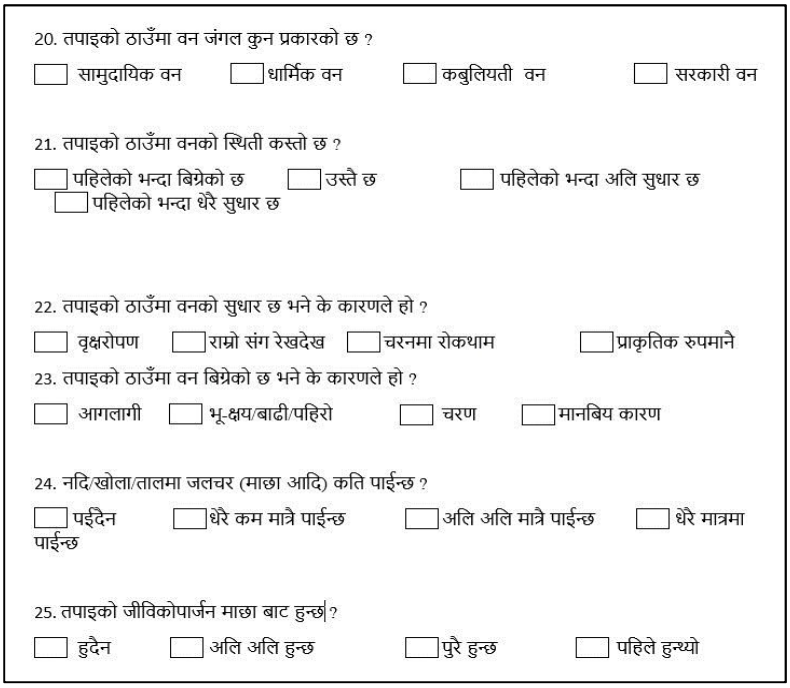
Question number 11 asks about the usage of fertilizers to increase the production of crops. This question is to know whether the people are using fertilizers as it has various long-term as well as short-term effects.

Here, higher priority is given to lower productivity. The process to obtain indicator value (Ivalue) is similar to that of I1.

ii. Forest Aspect (I5)

This indicator carries 10% of weightage for obtaining the priority value of a sub-watershed. Question number 20, 21, 22, 23, 24 and 25 are the ones that provide first-hand information about the forest aspect.

Information gathered from these questions and other documents that are available from the Rural Municipality will be used for the watershed management plan. However, forest is given equal importance in this prioritization process. Therefore, indicator value (Ivalue) for all the ward are given the same value.


20. तपाइको ठाउँमा वन जंगल कुन प्रकारको छ ?
☐ सामुदायिक वन ☐ धार्मिक वन ☐ कबुलियती वन ☐ सरकारी वन

21. तपाइको ठाउँमा वनको स्थिती कस्तो छ ?
☐ पहिलेको भन्दा बिग्रेको छ ☐ उस्तै छ ☐ पहिलेको भन्दा अलि सुधार छ
☐ पहिलेको भन्दा धेरै सुधार छ

22. तपाइको ठाउँमा वनको सुधार छ भने के कारणले हो ?
☐ वृक्षरोपण ☐ राम्रो संग रेखदेख ☐ चरनमा रोकथाम ☐ प्राकृतिक रुपमानै

23. तपाइको ठाउँमा वन बिग्रेको छ भने के कारणले हो ?
☐ आगलागी ☐ भू-क्षय/बाढी/पहिरो ☐ चरण ☐ मानबिय कारण

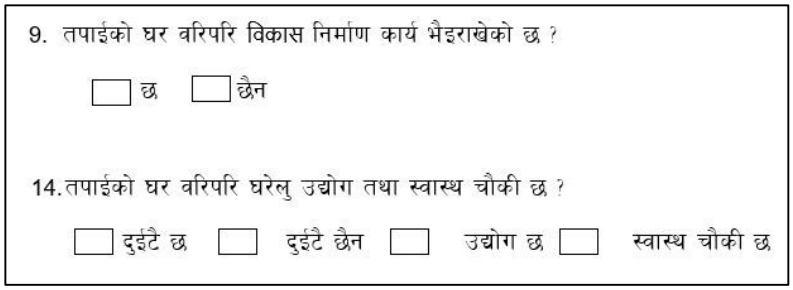
24. नदि/खोला/तालमा जलचर (माछा आदि) कति पाईन्छ ?
☐ पईदैन ☐ धेरै कम मात्रै पाईन्छ ☐ अलि अलि मात्रै पाईन्छ ☐ धेरै मात्रमा पाईन्छ

25. तपाइको जीविकोपार्जन माछा बाट हुन्छ ?
☐ हुदैन ☐ अलि अलि हुन्छ ☐ पुरै हुन्छ ☐ पहिले हुन्थ्यो

iii. Urbanization/ Infrastructure Aspect (I6)

This indicator carries 10% of weightage for obtaining the priority value of a sub-watershed. Question number 9 and 14 are the ones that provide primary information about the infrastructure development aspect in that area.

This indicator provides information related to change in different aspects within a sub-watershed due to development of various infrastructures. In addition, the access to the water source for the stakeholders is also covered by this indicator.


9. तपाईको घर वरिपरि विकास निर्माण कार्य भैइराखेको छ ?

☐ छ ☐ छैन

14. तपाईको घर वरिपरि घरेलु उद्योग तथा स्वास्थ चौकी छ ?

☐ दुईटै छ ☐ दुईटै छैन ☐ उद्योग छ ☐ स्वास्थ चौकी छ

For the calculation of Ivalue, question number 9 has only 2 options as answers. Priority is given if development works is being carried out and it gets full value of 1 (i.e. 100%). If development works has not been carried out then it gets the value of 0 (i.e. 0%). In question number 144, the priority is given if the distance to the water source is longer for the stakeholders.

For the calculation of Ivalue in a sub-watershed, area proportionate method is applied similar to I1.

IV. Climatic and Biophysical Hazard Component

i. Disaster Vulnerability (I7)

This indicator also carried 10% of weightage for obtaining the priority value of a sub-watershed. Question number 19 provides information related to the disasters that occurs in their wards and Rural Municipality.


19. मथिको प्रकोप् मध्य कुन चाहिँ कसरी देखिन्छ ?

बाढी	☐ आउदैन	☐ अचानक	☐ बर्षायाममा	☐ सधै
पहिरो	☐ जादैन	☐ अचानक	☐ बर्षायाममा	☐ सधै
भुक्षय	☐ आउदैन	☐ अचानक	☐ बर्षायाममा	☐ सधै
नदी कटान	☐ आउदैन	☐ अचानक	☐ बर्षायाममा	☐ सधै
आगलगि	☐ आउदैन	☐ अचानक	☐ बर्षायाममा	☐ सधै
सुख्खा / खडेरी	☐ आउदैन	☐ अचानक	☐ बर्षायाममा	☐ सधै

For this indicator, higher occurrence of disaster gets higher priority. If the disaster is going on throughout the year then it gets the highest priority.

For the calculation of I-value in a sub-watershed, area proportionate method is applied similar to other indicators.

Household and Community Survey

As following the section 2.1.2, community questionnaire survey was done in all wards of the Badikedar Rural Municipality with in the watershed area. Altogether, 200 households (at least 30 household in each ward) were surveyed for identifying the most vulnerable sub-watershed from the rural municipality. The questionnaire such as water viability and quality for drinking and household propose, water source status and management practice, energy source, agricultural production and pattern, climate change impacts/disaster and forest related questions were addressed and asked to the local community people. The questionnaire data were filled and analysed for the sub-watershed prioritization.

A total of 974 household survey was carried out in Kapadigaad sub-watershed to assess the socio-economic condition and availability of the resources for sustainable management and utilization of the natural resources in the sub-watershed.

2.3. Prioritization of sub-watersheds

After obtaining one priority value for each sub-watershed, sub-watershed with highest priority value will be selected. If more than one sub-watershed will have same priority value, importance will be given to indicator that is high on water availability value.

Priority Value = 35% × Water component + 25% × Demographic component + 30% × Land Use and Land Cover component+ 10% × Climatic and biophysical hazard component.

Since the components have their respective indicators, priority value is actually calculated using the following formula.

Priority Value = 25% × Water availability + 25% × Population and socio-economics + 10% × Water quality and ecology + 10% × Disaster vulnerability+ 10% × Agricultural aspect + 10% × Urban settlement/ infrastructure + 10% Forest aspect

2.4. Selection of Sub-watersheds

After all the analysis and calculation, one sub-watershed among many sub-watersheds for both Rural Municipality are selected.

The Indicator values for all the indicators have been calculated. Using that indicator values of wards, area proportionate method have been used and then calculated for sub-watersheds.

After calculating the Indicator values, prioritization values are calculated and the sub-basin with highest priority value is selected.

Selected Sub-watershed at BadiKedar Rural Municipality

There are 5 sub-watersheds inside Badikedar Rural Municipality. The names are given as Chaudgaad (B1), Binesangaad (B2), Panerigaad (B3), Godgaad (B4) and Kapadigaad (B5).

The indicator values of all five sub-watersheds have been calculated. All 7 indicator values are shown in the table 3.

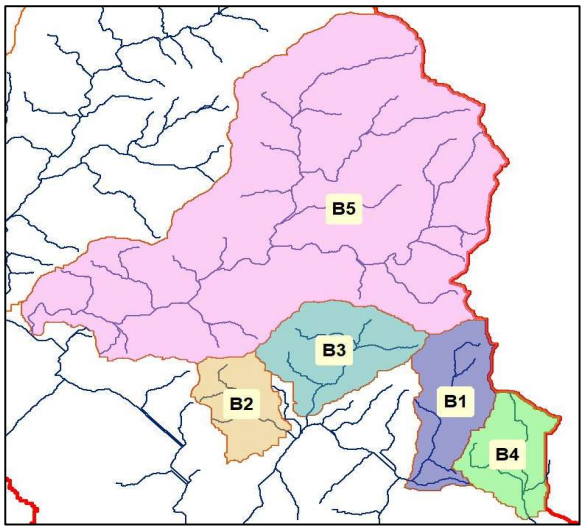


Figure 8: Delineated sub-watersheds of Badikedar Rural Municipality

Table 3. Indicators values for each sub-watershed of Jorayal RM

Indicators values							
Sub-Watersheds	I1	I2	I3	I4	I5	I6	I7
Chaudgaad (B1)	0.457	0.590	0.086	0.625	0.200	0.149	0.542
Binesangaad (B2)	0.671	0.625	0.054	0.631	0.200	0.676	0.542
Panerigaad (B3)	0.708	0.625	0.092	0.625	0.200	0.688	0.542
Godgaad (B4)	0.417	0.625	0.067	0.625	0.200	0.063	0.542
Kapadigaad (B5)	0.441	0.470	0.700	0.727	0.200	0.448	0.542

These indicator values were used to calculate the priority values of each sub-watershed. The sub-watershed with maximum priority value has been selected.

Table 4: Priority values for individual sub-watershed of Badikedar Rural Municipality

Prioritization	
Pv = 25% of I1 + 10% of I2 + 25% of I3 + 10% of I4 + 10% of I5 + 10% of I6 + 10% of I7	
Sub-watersheds	Pv
Chaudgaad (B1)	0.346
Binesangaad (B2)	0.449
Panerigaad (B3)	0.468
Godgaad (B4)	0.326
Kapadigaad (B5)	0.524

Sub-watershed Kapadigaad gets the highest priority value. Hence, it is selected for the preparation of sub-watershed management plan.

3. General Information

3.1. Physiography

Physiographic region	: Siwalik
Sub-watershed	: Kapadigaad
Area	: 13,165 Ha
Latitude	: 28º 59' 50'' N to 29º 7' 40'' N
Longitude	: 80º 44' 50'' E to 80º 54' 00'' E
Altitude variation (GPS) variation	: 750 m to 1943 m

3.2. Topography and Climate

Thuligaad watershed is located in Doti District of Sudur Pachim Pradesh in the far-western region of Nepal. Thuligaad watershed lies in the Karnali River Basin across two districts i.e. Kailali and Doti. Jorayal and Badikedar Rural Municipalities is located in Doti whereas Chure and Mohanyal Rural Municipalities are located in Kailali district. Thuligaad watershed is between latitude 28.849° - 29.213° and longitude 80.569° - 80.971°.

In Badikedar rural Municipality there are 5 wards i.e. Barchhen (ward no. 1 and 2), Ghanghalgau (ward no. 3), Mannakapadi (ward no. 4) and Lanakedareshwor (ward no. 5).

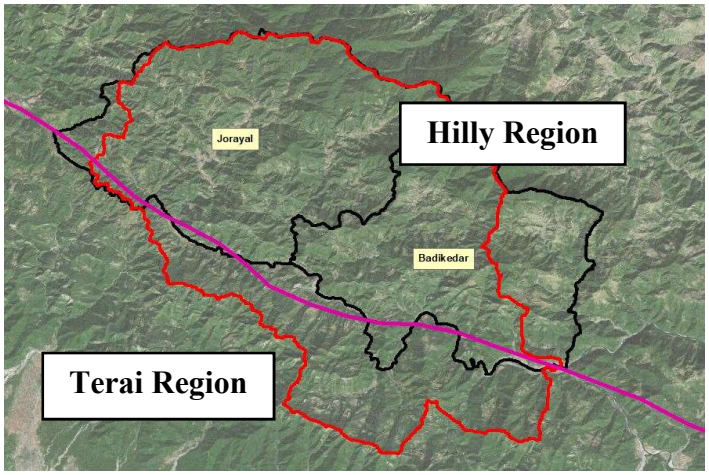


Figure 9: Physio-geographic map of Thuligaad watershed

The prioritized sub-watershed for the sub-watershed management plan preparation is located in wards 1, 2 and 4.

The minimum elevation inside Thuligaad watershed is 600m above mean sea level (asl) and the maximum elevation is 2869m asl.

Due to the variance of elevation, there is three different types of climate inside the Thuligaad watershed i.e. tropical climate up to 1200m asl, sub-tropical climate from 1200-2100m asl, and

temperate climate above 2100m. The maximum temperature recorded is 36 degree Celsius and

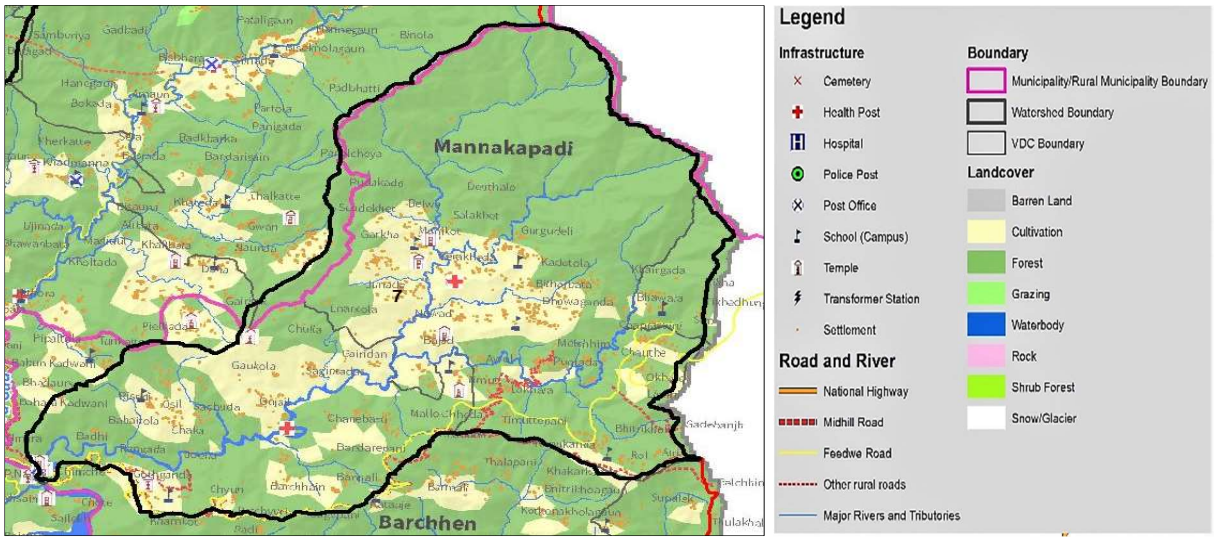


Figure 10: Topographic map of Kapadigaad sub-watershed

the minimum temperature recorded is 5 degree Celsius. The annual precipitation is 1934.33mm (as per station no. 214 at Kola Gaun) inside Thuligaad watershed where 1701.62mm is during the wet period (May - October) and 232.71mm during the dry period (November – April).

For the prioritized sub-watershed Kapadigaad, its GPS coordinates are 28º 59' 50'' N to 29º 7' 40'' N and 80º 44' 50'' E to 80º 54' 00'' E. The maximum elevation is 2869m asl and the minimum elevation is 600m asl.

The slope of the land in Kapadigaad mostly falls under the 45-degree slope as can be seen from Figure 12. Most of the land is below 30-degree slope. The variation of colour in the picture shows that the terrain is quite undulating as a result prone to disasters like landslides and erosions.

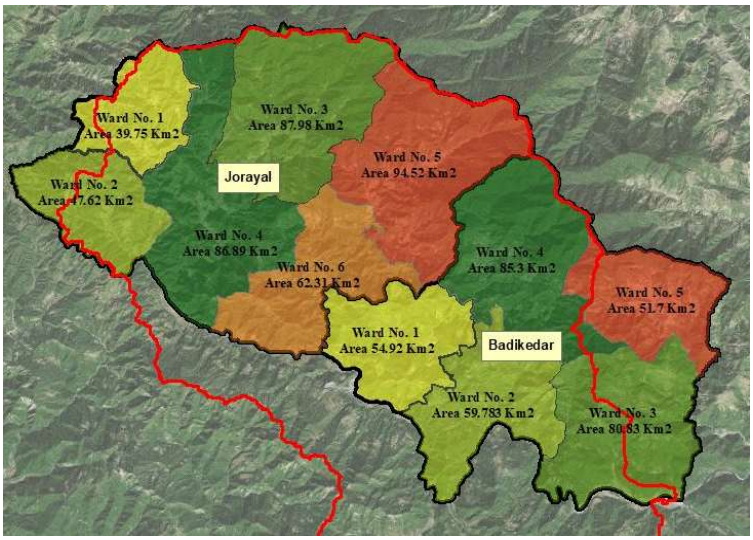


Figure 11: Ward map of Badikedar and Jorayal RM

The slope map for the selected sub-watershed is shown in the maps figure 12.

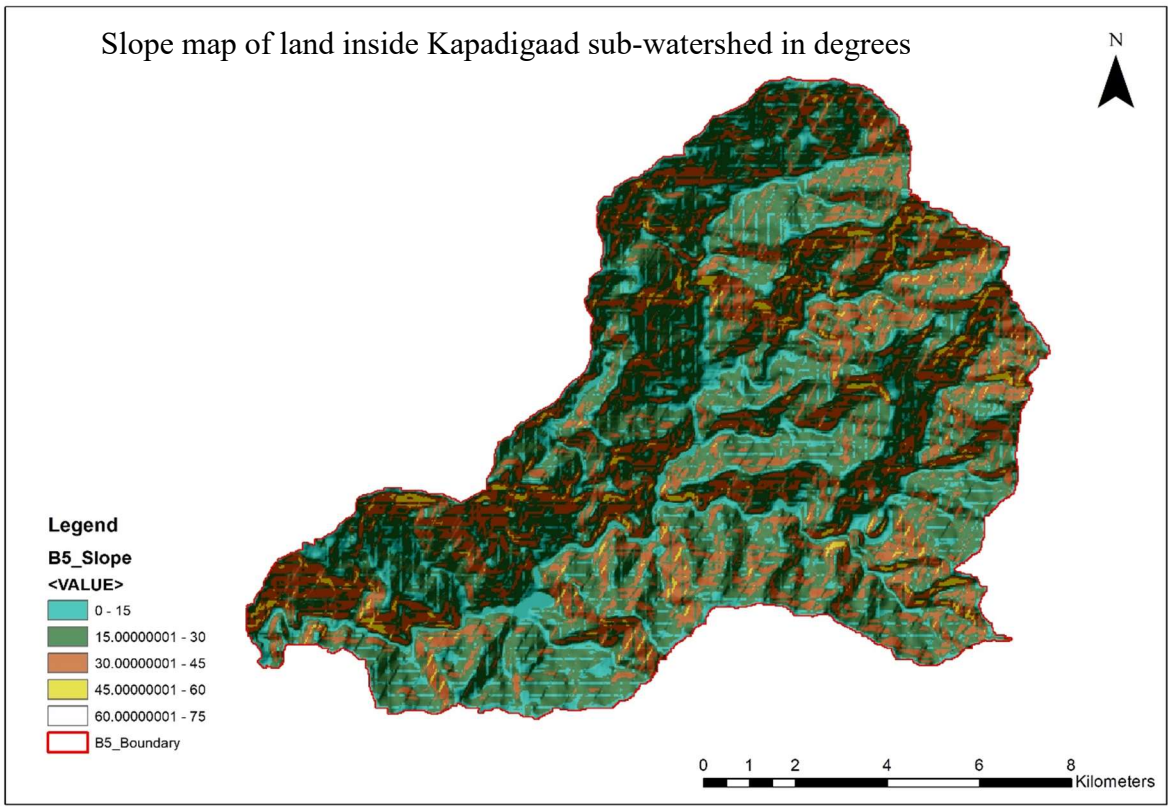


Figure 12. Slope map of Karnasigaad sub-watershed

3.3. Soil and Geology

The available geological map is in scale of 1: 50,000 with contour interval of 200 metres and showing various geological features like strike and dip of beds, faults, folds, cross sections, and geological history of the area. It can also be useful in practical applications like zoning and hazard assessment.

Dadeldhura Thrust, Sirse Thrust, Main Boundary Thrust and Rangun Khola Thrust are found in these areas. Various rock beds are found nearby Karnasigaad river and Thuligaad river of different attitude.

Regional geological setting of the study area is mainly dominated by different rock types from Precambrian to Quaternary deposits.

The geological structure lies within a country Nepal has not a very old, however, the thrust like Dadeldhura Thrust and Sirse Thrust are found in the lower section of the Kapadigaad sub-watershed and other various faults included within a sub-watershed area (Figure 13 and 14). The geological map is showing various geological features like different formations, rock types, faults and orientation of bed rocks in the study area.

Quaternary deposits of clay, silt, sand, gravel and conglomerates are seen on both banks of lower section of Kapadigaad i.e. surrounding at Deuli where mostly occurred the flood plain area. Some parts above Dadeldhura Thrust like Binoda and Nakutti, Dandaghar are rich in chlorite, biotite to garnetiferous grey schist dated Precambrian era. On the banks of Thuligaad river nearby Nakku and Umara, Tallo Sirsi are rich in quarzitic sandstone, shale and dolomites due to Ramkot formation. At Shivanagar nearby Main Boundary Thrust (MBT), grey talcosic shale and white quarzitic sandstone are found. Dubbidanda formation between Sirse Thrust and Dadeldhura Thrust, comprising areas like Basauti, Gunad, Dhankatte, Rawatkatte and Khargaun are found to be rich in phyllites, quartzes and amphibolite dating Precambrian era.Mathillo Alyadi, Alyadi, Kala Pokhara, Jagarkot, Jaspatta, Rawa,Gadigaun, Toligada , Kala Chiura, Boharagaun, Pataligaun, Thulaganda and Jasyaudo areas having maximum altitude upto

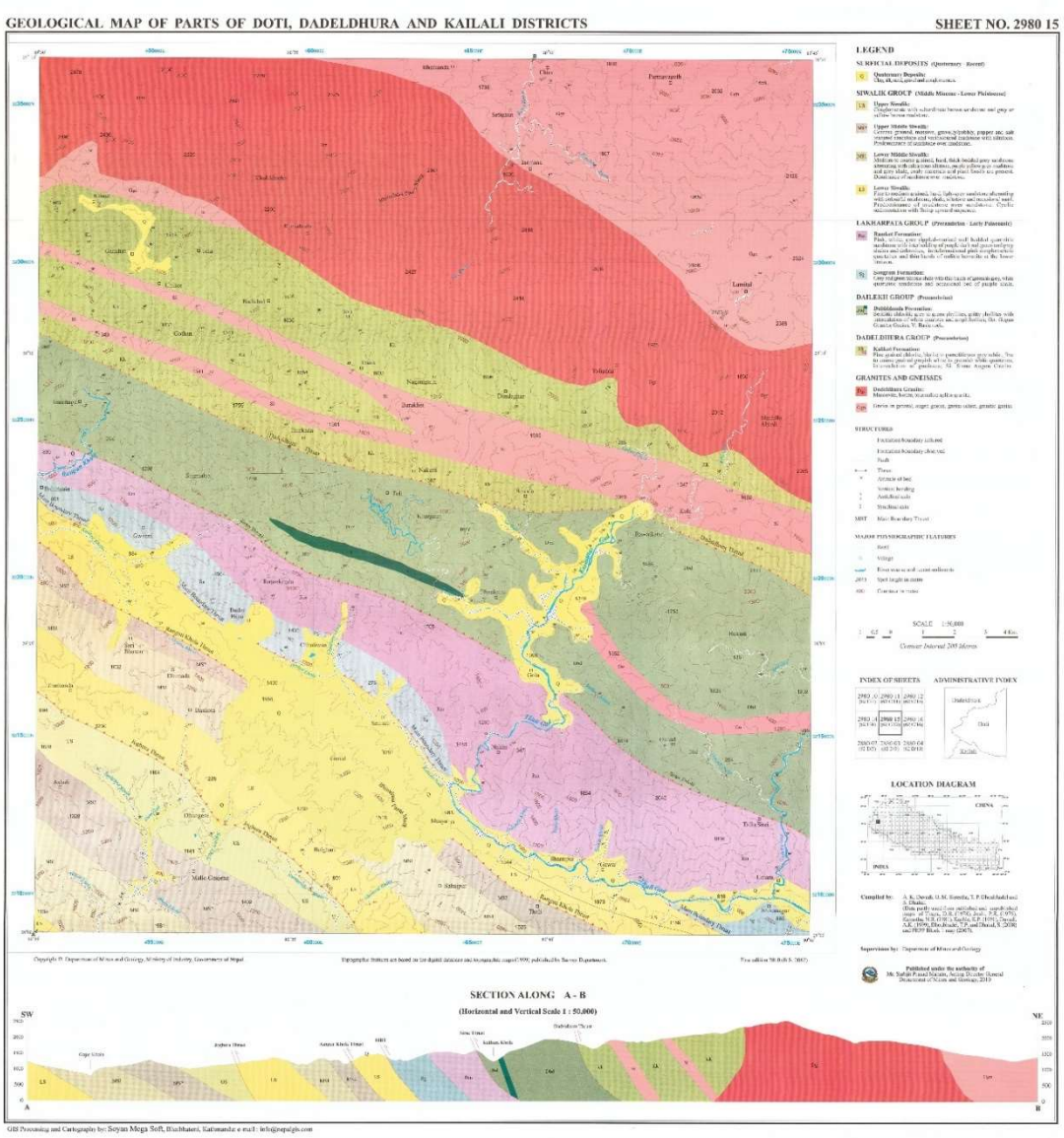


Figure 13. Geological map of Thuligaad watershed area

2505m (msl) are rich in muscovite, biotite, tourmaline aplitic granite while Kola, Barakhet, Badigadgaun , Patal, Dan and Ghattekhet areas are rich in Gneiss.

Mathillo Alyadi, Alyadi, Kala Pokhara, Jagarkot, Jaspatta, Rawa,Gadigaun, Toligada , Kala Chiura, Boharagaun, Pataligaun, Thulaganda and Jasyaudo areas having maximum altitude upto 2505m (msl) are rich in muscovite, biotite, tourmaline aplitic granite while Kola, Barakhet, Badigadgaun , Patal, Dan and Ghattekhet areas are rich in Gneiss.

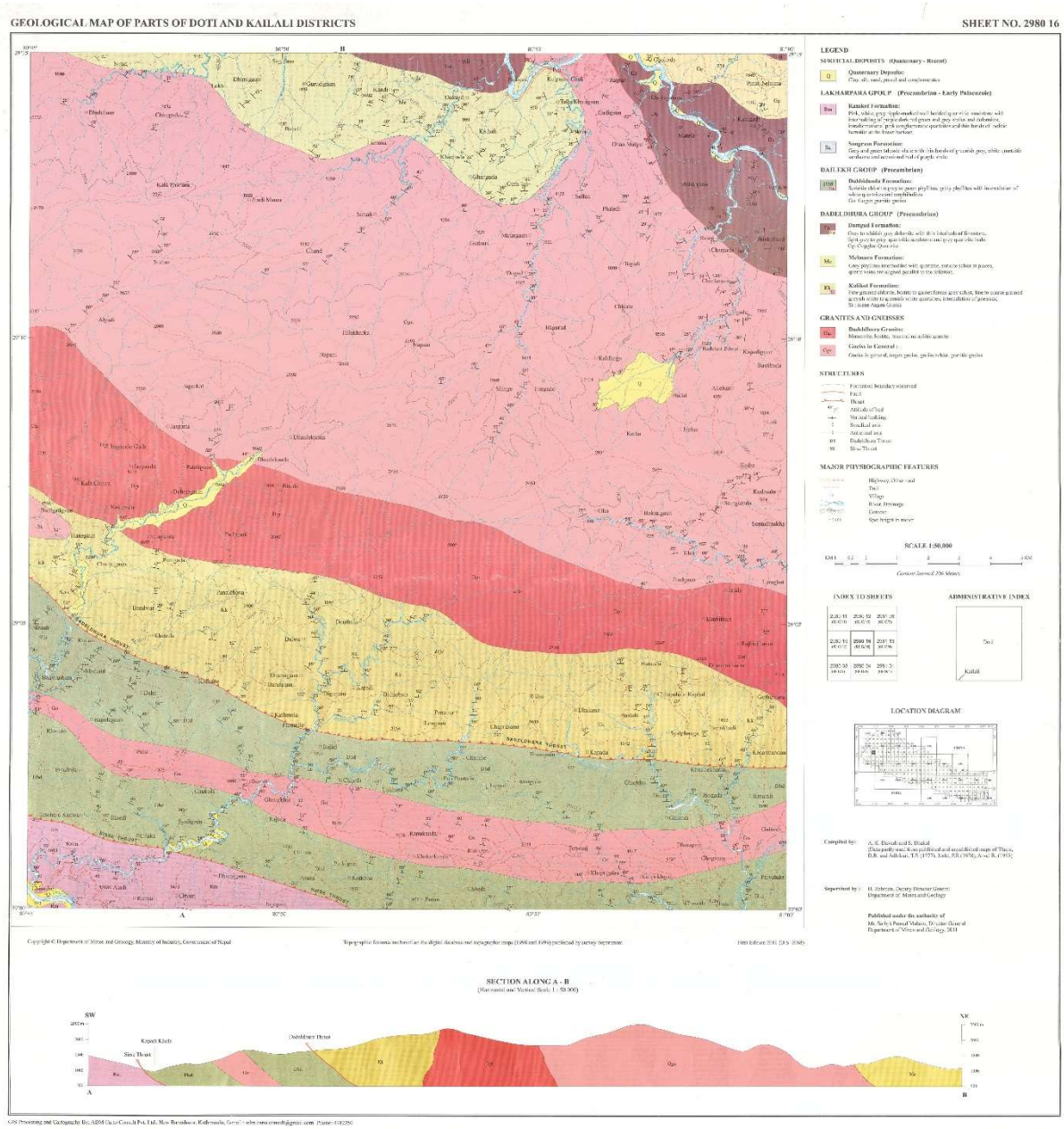


Figure 154. Geological map of Thuligaad watershed area

3.4. Hydrology

Thuligaad River is a direct tributary of the Karnali River. In our study, sub-watersheds are considered as the catchment of direct tributaries of the Thuligaad River. Hence, the river that represent our sub-watershed becomes the third order river in context of the Karnali River. Both the selected sub-watersheds are headwater (uppermost) catchments that contributes to the Thuligaad River. Hydrology informs about the water availability in a certain area. The availability of water plays an important role for various socio-economic as well as daily activities inside that area. For a management plan that focuses on watershed, hydrology plays a very important role. Hydrology of Thuligaad watershed, Badikedar Rural Municipality and the selected sub-watershed area are described hereafter.

Hydrology of Thuligaad Watershed

The hydrology of an area depends mainly on the amount of precipitation (snow + rainfall) that the area receives. Factors such as temperature, wind, solar radiation, etc. also plays an important role.

Inside the Thuligaad watershed, one precipitation station is established under Department of Hydrology and Meteorology (DHM), Government of Nepal shown by yellow doted color in figure 15. Using precipitation data provided by the government of Nepal, the rainfall of Thuligaad area has been analyzed.

The station is known as station number 214 as named by DHM. In addition, the figure shows three watersheds (58, 61 and 64). International Water Management Institute (IWMI) Nepal has considered these watersheds for developing a hydrological model of the region.

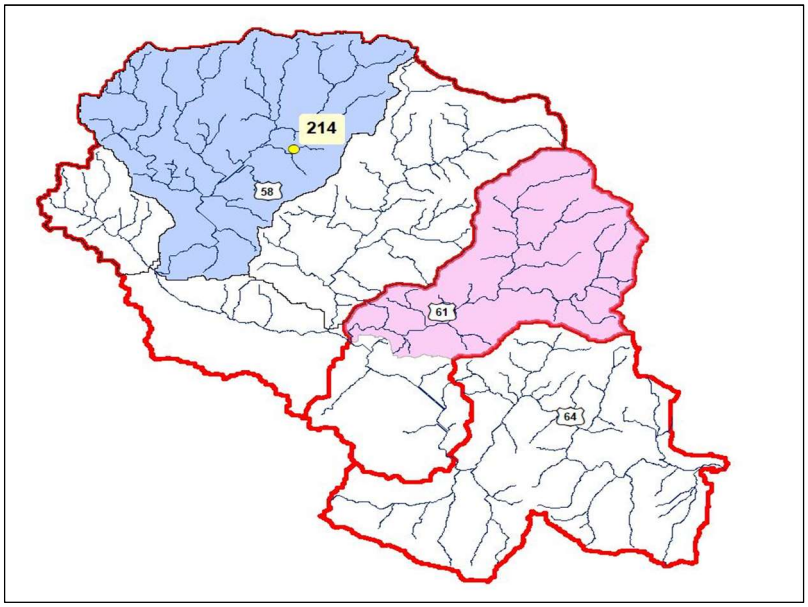


Figure 15: Hydrological station showing in map of Badikedar and Jorayal RM

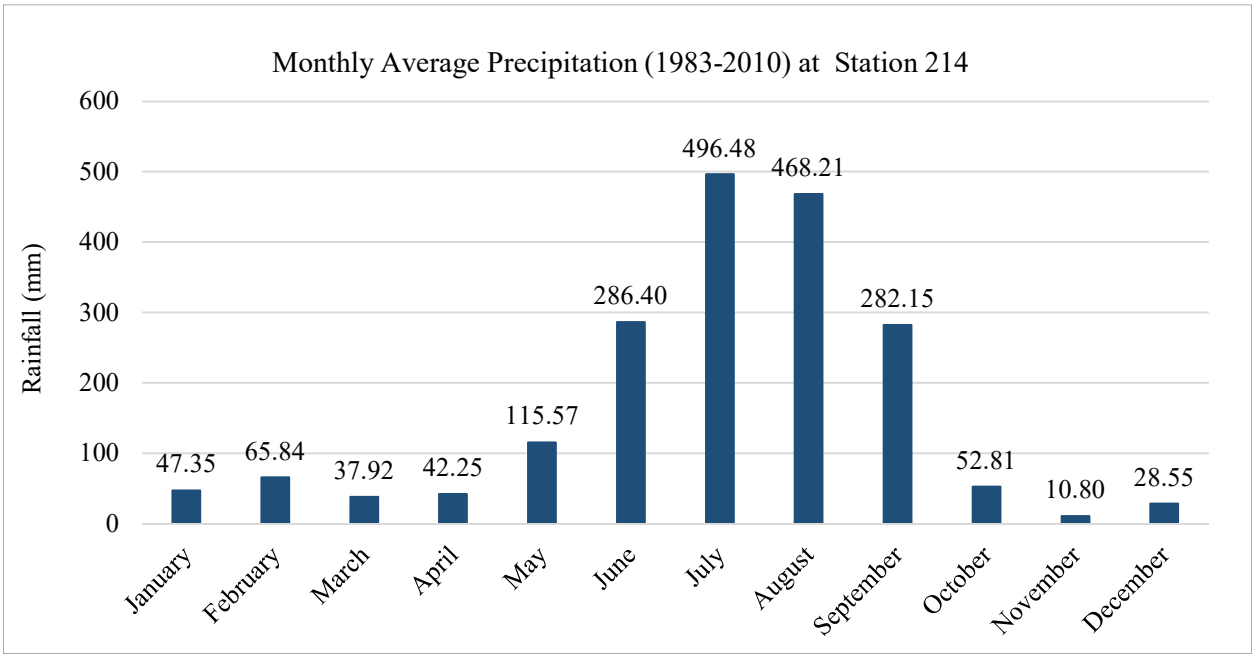


Figure 16: Monthly average precipitation of station at Kola Guan

The average monthly precipitation pattern for 28 years (1983- 2010) is shown in figure 16. This shows the monthly variability of precipitation in Thuligaad watershed. The month of November receives lowest precipitation whereas the month of July receives highest precipitation. It can be clearly seen that the precipitation is higher from May until September. This is mainly the contribution of rainfall as this is the monsoon period. Months like December, January, February and March also receives rainfall but there will also be significant contribution of snow during those months.

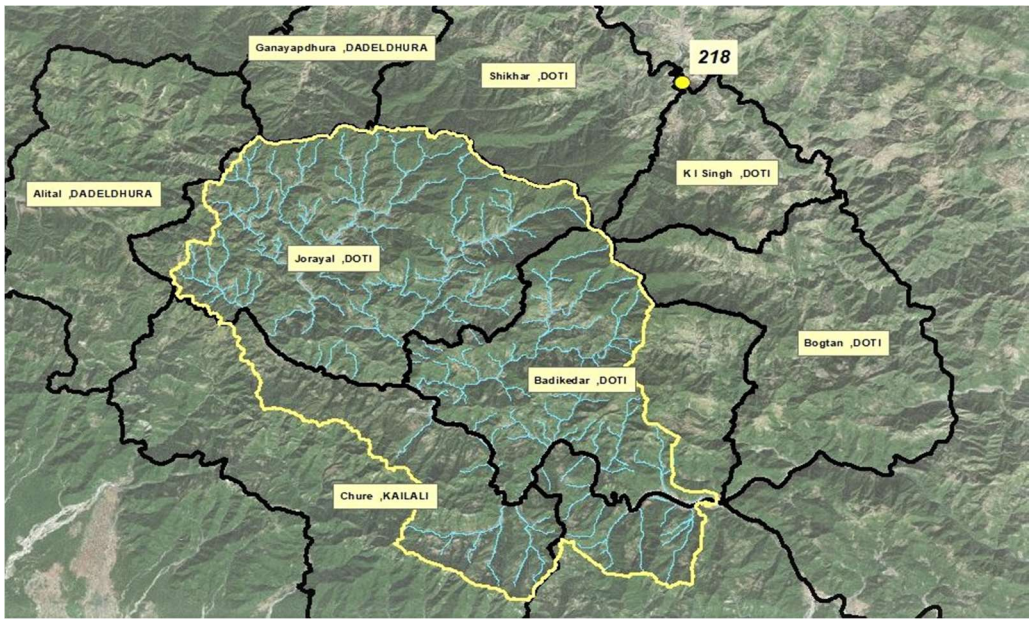


Figure 17: Tributaries of Thuligaad River within the watershed area

In the above figure 17, temperature station is indicated by no. 218. For the analysis of temperature data, this station is considered as it is inside Doti district and is the nearest one to the Thuligaad watershed.

The above chart shows the monthly variation in temperature based on station no. 218. Data from 1983 till 2017 has been taken for the analysis. The average monthly temperature shows June and July are among the hottest and the month of December and January are among the coldest.

The red line shows the maximum temperature recorded for each month and the blue line shows the minimum temperature recorded for the same period. This correlates with the precipitation in Thuligaad watershed as the months where the major contribution to the precipitation is snow has the lowest values.

For the discharge of the Thuligaad watershed, results of hydrological model developed by International Water Management Institute (IWMI) Nepal was used and then analyzed. The monthly variation in average discharge is shown in figure 18.

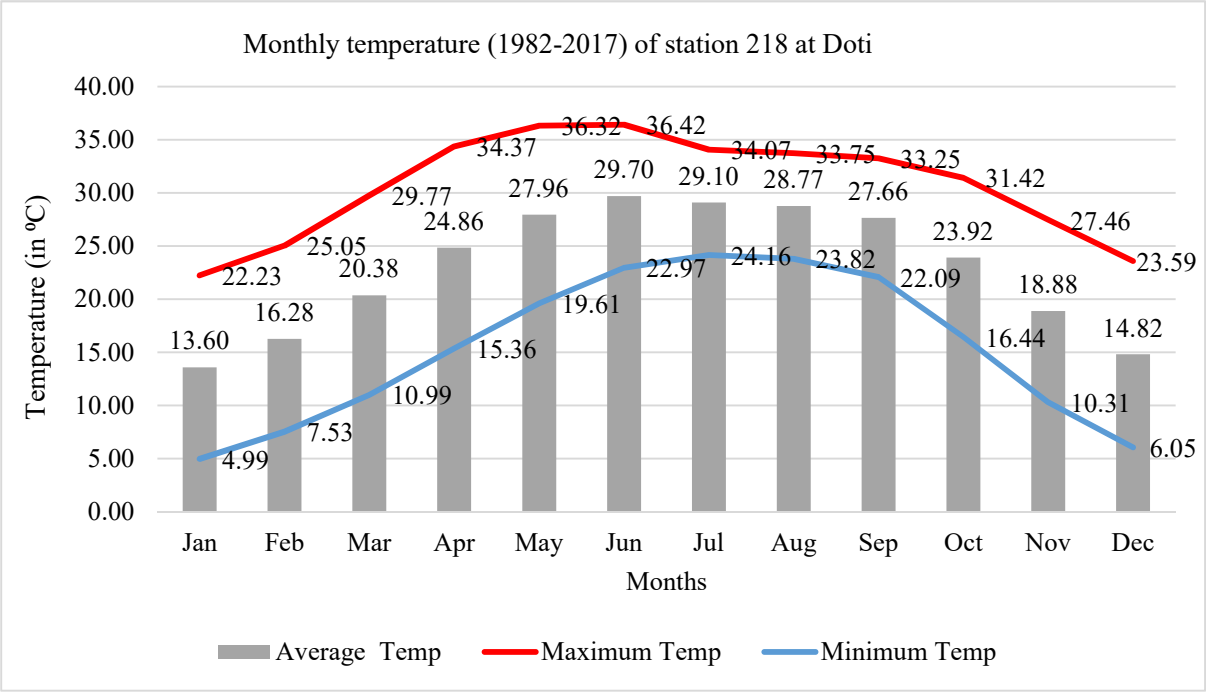


Figure 18. Minimum, Maximum and average temperature of station 218

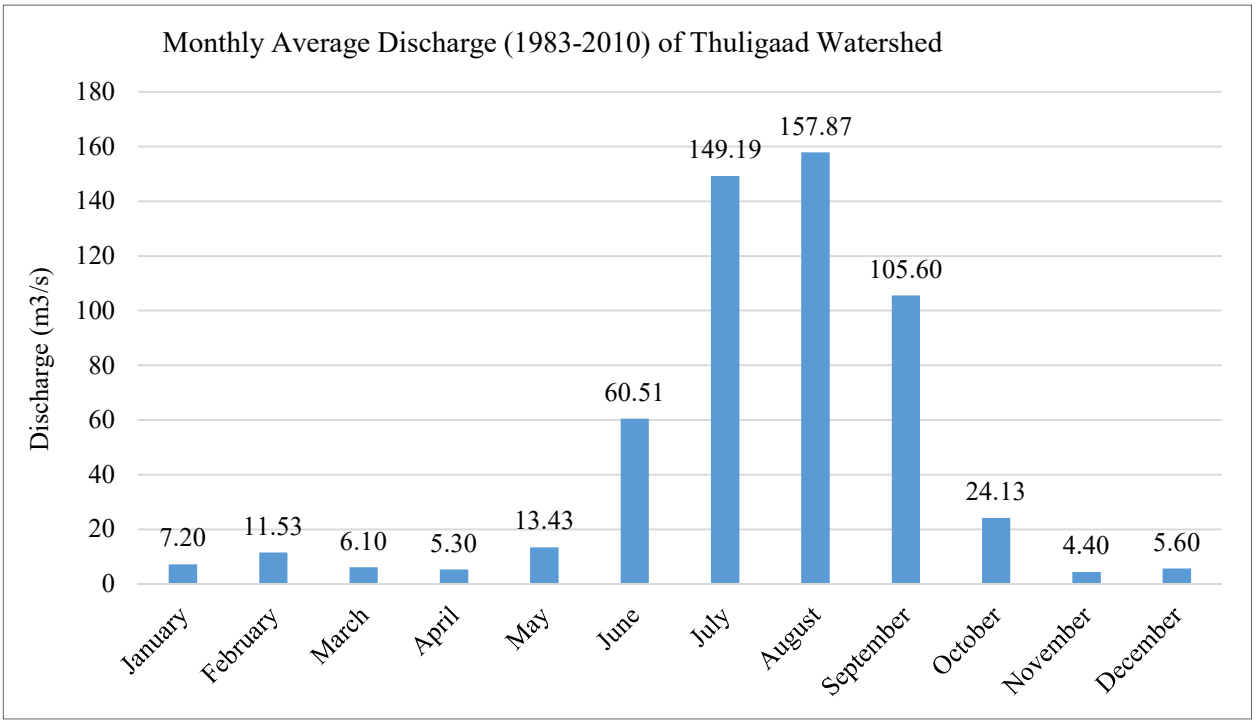


Figure19. Monthly average discharge of Thuligaad watershed

Similar to precipitation, the period from June to September has higher discharge values and months from November to April has lower discharge values. Almost, 86% of the total volume of water is discharged from the river during the monsoon season only. The high volume of water into the river section caused flood impact on the surrounding of the river bank.

The positive relationship between the monthly precipitation and monthly discharge from the Thuligaad watershed region shown in figure 19. Highest discharge (i.e. >250 m^3/s) in Thuligaad river was occurred in July 1990 while at the precipitation occurred in July 2009 (i.e. about 1200 mm). Although low rainfall and discharge occurred in driest period i.e. November to April.

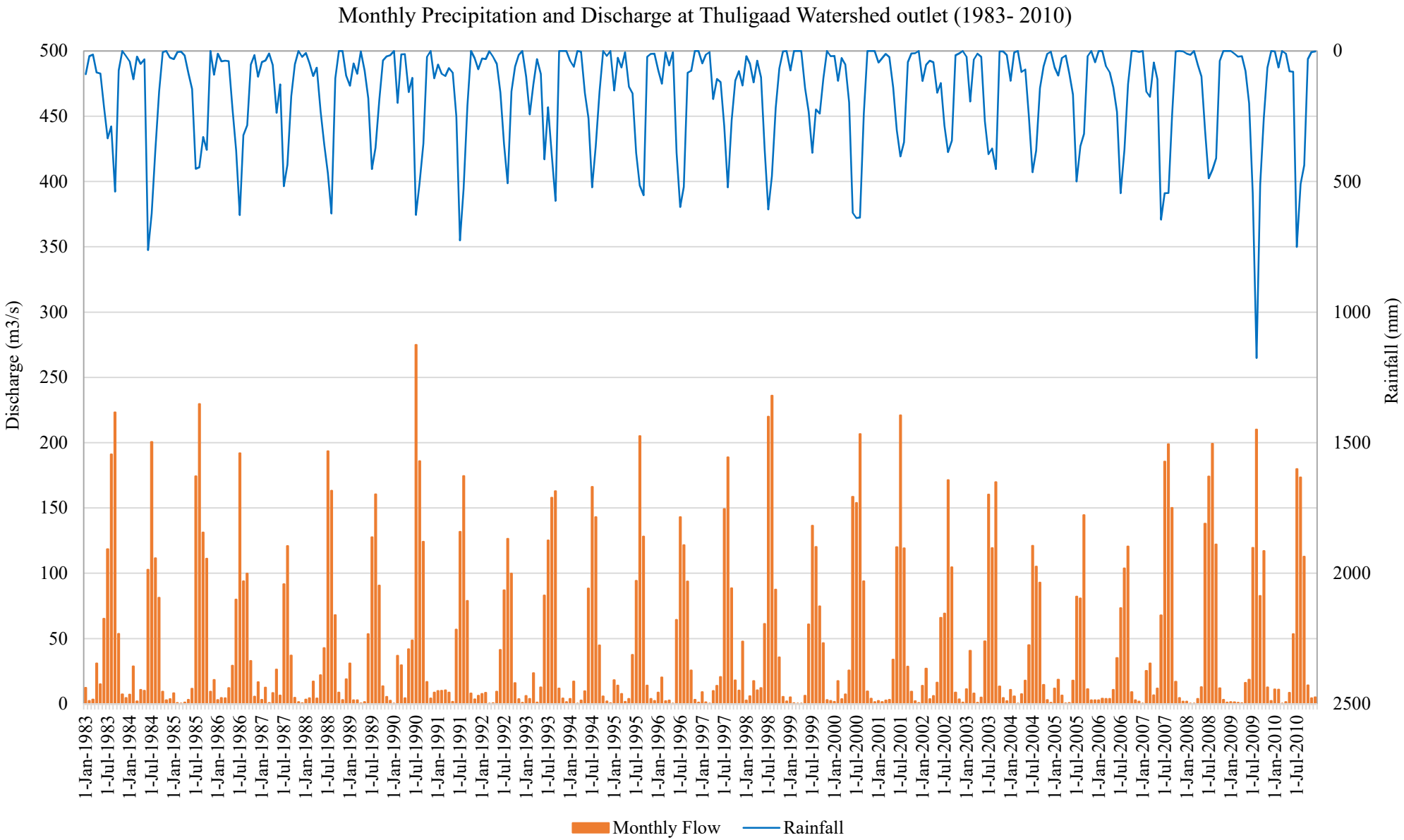


Figure 20. : Monthly average discharge and rainfall graph of Thuligaad watershed

Hydrology of Badikedar Rural Municipality

The discharge of the Badikedar Watershed is also calculated using the same model developed by IWMI. Catchment correlation method has been used to calculate the contribution of Badikedar watershed in the Thuligaad watershed.

Discharge from the Badikedar Rural Municipality is much more in wettest month likewise July, August and September while driest period was November to January.

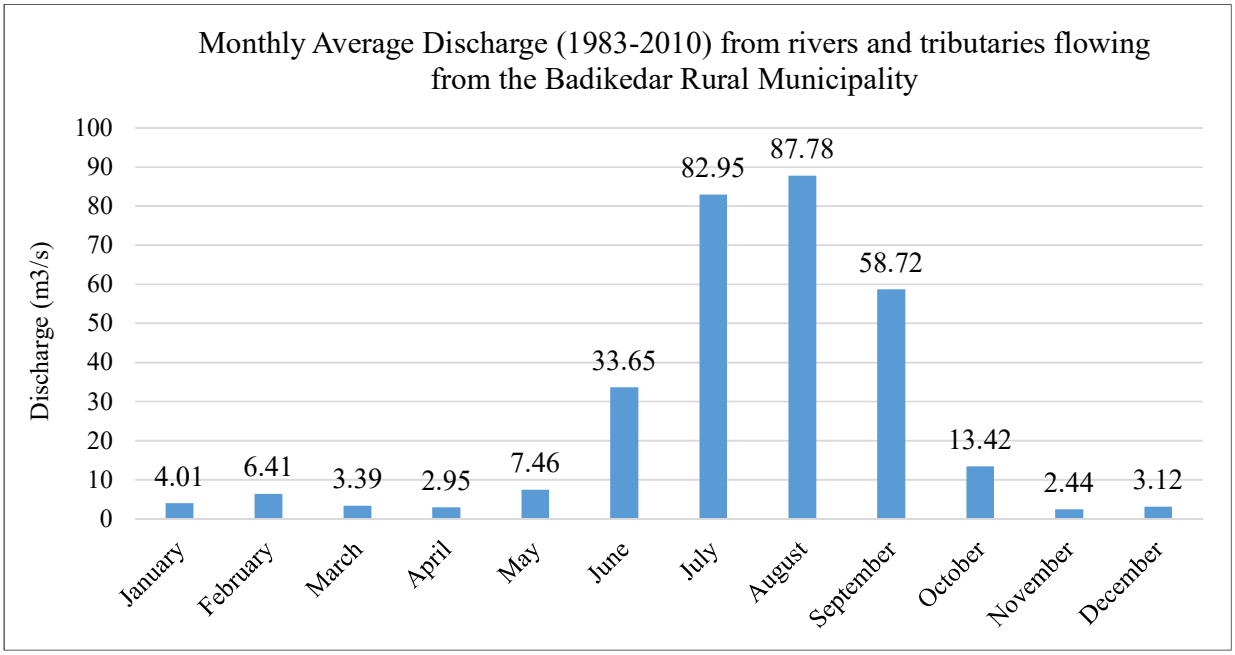


Figure 21. Monthly average discharge of Badikedar Rural Municipality

Hydrology of Kapadigaad sub-watershed

Similar hydrological model is used to calculate the monthly average discharge of the Kapadigaad sub-watershed region. Also, Catchment correlation method is used for discharge calculation. The graph of average monthly discharge is shown in figure 21.

The month in which the maximum water is available in Kapadigaad is August and the driest month is April. As can be seen from the graph, November to April is the driest period and the monsoon period i.e. June to September is the period with high availability of water.

Flood return period analysis has been done at intervals of 2, 5, 10, 20, 50 and 100 years have to check the extent of flood that this Kapadigaad sub-watershed is likely to experience at the

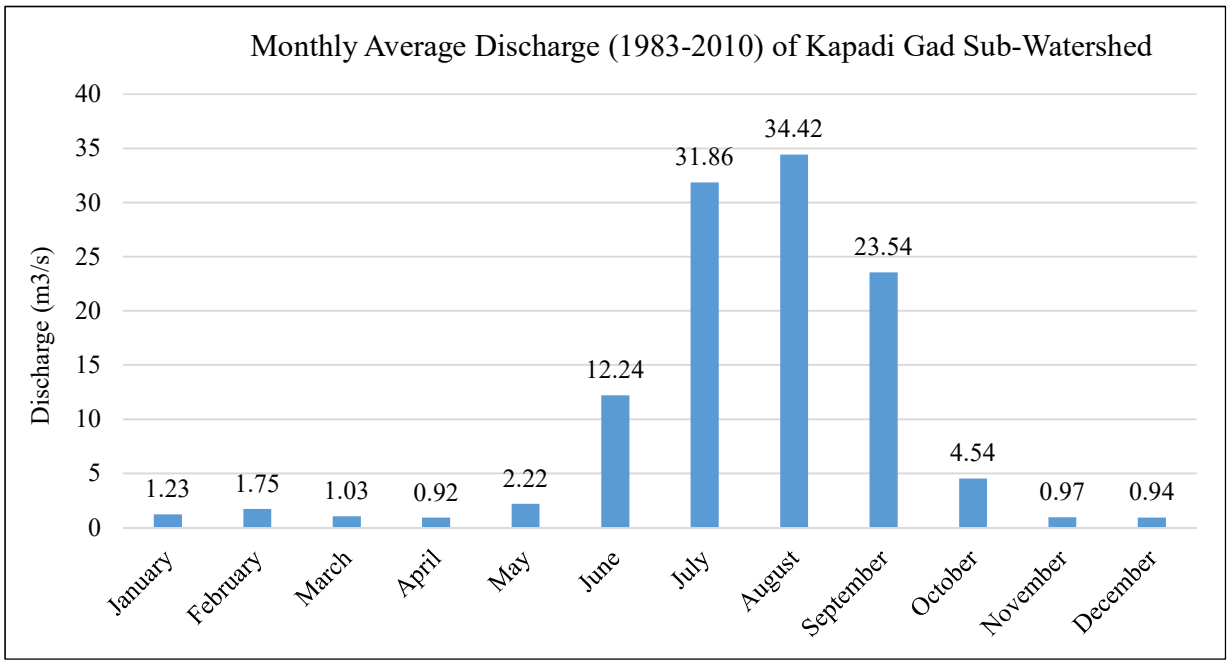


Figure 22: Monthly average discharge of Kapadigaad sub-watershed

confluence of its major tributaries and its outlet at Thuligaad River. The values obtained are calculated by using the WECS-HYDEST method by the Government of Nepal.

About 58 m^3/s water discharge if the flood return after 2 year at the confluence point while at the same time about 86 m^3/s water will discharge to the Thuligaad River. In addition, if the flood return period is increased (for example flood return period from 5 to 100), the quantity of water in the stream will be increased (i.e. 128 to 258 m^3/s in daily basis at outlet). Thus, the short duration of flood return period will effect minimally impact and/or less hazardous in the surrounding of the stream/river bank. Also, an instantaneous flood was calculated for each return period. The instantaneous flood shows high water discharge than daily basis because of the quick measurement of flood discharge in the stream/river just after rainfall within the sub-watershed area for instantaneous flood discharge. Thus, local government should be prepared to tackle the flood occurred in the river/stream. Regular discharge measurements in downstream upstream,

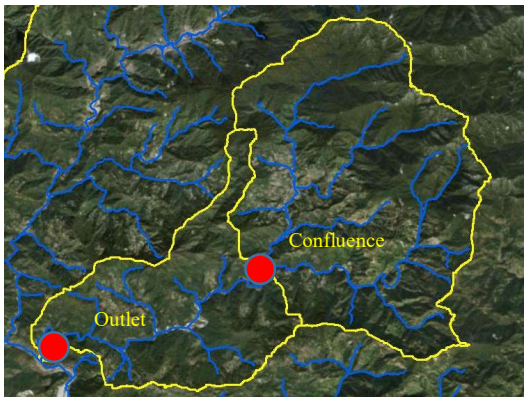


Figure 23: Flood discharge calculated at confluence and outlet point of Kapadigaad sub-watershed

measurements of rain gauge station, establishment of early warning system, construction of flood wall, gabion wall etc. might be the best ways to minimize the loss of life and other resources from the high flood impact. The details of the return period and flood discharge from the Kapadigaad is shown in table 5.

Table 5: Flood discharge in different point of Kapadigaad sub-watershed

Return Period (years)	Flood Discharge (m3/s) at confluence		Flood Discharge (m3/s) at Outlet	
	Daily	Instantaneous	Daily	Instantaneous
2	58.69	96.73	86.05	137.65
5	88.72	160.95	128.05	224.30
10	110.10	210.03	157.62	289.50
20	131.56	261.59	187.08	357.33
50	160.80	335.00	226.93	452.97
100	183.77	394.90	258.02	530.37

3.5. Water Resources and Aquatic biodiversity

Water Resources in Thuligaad watershed

Thuligaad watershed, in general has less than 2% of the area covered with water bodies. This is comparatively low to the population density inside the watershed. Recently, water resources mapping was conducted by YAE/PAANI Program. The data discussed hereafter is based on that survey.

In total 433 sources of water resources outlets have been noted inside the Thuligaad watershed. Among 433, 281 are open springs, 53 are ponds, 34 are stone spouts and 2 are wells. Most of these water resources are of perennial type and some are seasonal.

Seventeen of these sources are already dried up while flow in 264 water resources points are decreasing. There has been no change in the flow of 151 resources whereas 1 resource has its flow increasing. The flow in these water resources points have been measured up to 20lps.

Water Resources in Kapadigaad

Water sources are drying up rapidly in the present scenario due to the overused of natural resources and development of infrastructure without any environment protection measurement. The similar

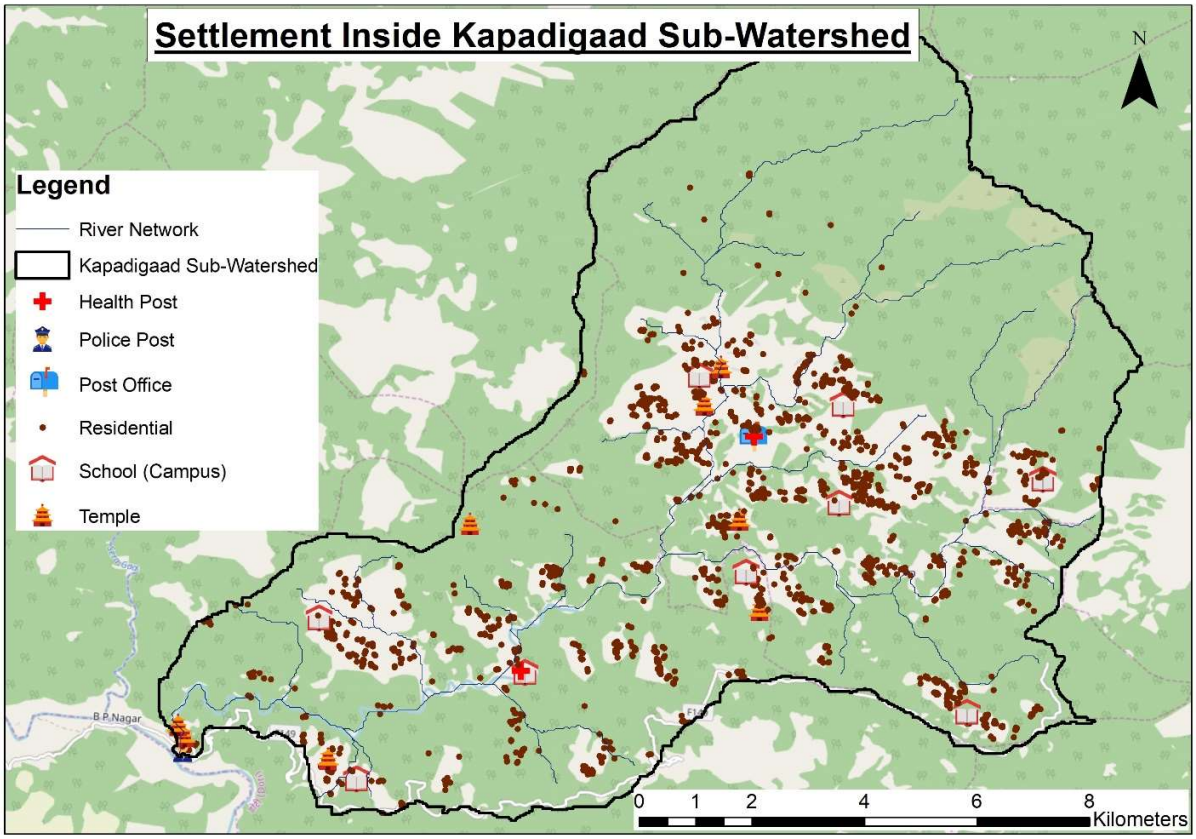


Figure 24: Water resource map of Kapadigaad sub-watershed

case of drying up of water sources can be seen in Kapadigaad sub-watershed area too. There are 46 water resources outlets inside the Kapadigaad sub-watershed in Badikedar. Out of the 46 water resources outlets, 23 are open springs, 6 are concrete tanks, 12 are ponds and 5 are stone spout. 41 are of Perennial type and the remaining 5 are seasonal. 2 outlets, one at Khamakota and the other at Ketali has dried up and 40 water resources outlets are drying up slowly. In the remaining 4, no change has been noticed yet. The details of the spring water source status is shown in annex IV.

To avoid the water source drying up, local people of Thuligaad watershed have been initiating the conservation practices of local water body. For example box 1 shows wetland and spring source conservation practices by the lake committee of Chattiwan village of Jorayal Rural Municipality.

Box No. 1: Wetland and spring water source conservation: A case of Chattiwan Lake

Wetland is the key source of surface water as well as significant amount of water recharge into ground water. Lake water bodies are aesthetically as well as ecologically very important sources which provides the home for many species and recreation to the human.

Chhatiwan Lake is located in Jorayal-2, Chhatiwan, Doti which is about 3 km far from the Budar from Bhidatta highway. The lake conservation committee named as Chattiwan lake conservation committee are actively participate to the lake conservation activities likewise removing invasive plant species from the lake, gabion wall construction surrounding the lake area, plantation and forest conservation of surrounded lake watershed area etc. According to the Mr. Sunil Ayar (member of Chhatiwan Lake conservation committee), due to the rainfall, the flash flood deposited the silt, mud and stone in the lake which reduces the depth of lake and make polluted. The north-western side of the lake is covered by the forest area but low biomass and steep slope cause high surface erosion. The lake conservation committee has planned to tree plantation in the open land and open grazing are strictly prohibited. In addition, the lake conservation committee are initiated to construct the stone filled in galvanized iron net for reducing silt, stone and organic matter to reach the lake. District soil conservation office and Jorayal rural municipality has allocate fifteen lakh budget for the lake conservation in this fiscal year. Chhatiwan Lake is also important for fish diversity. According to the Mr. Ayar, verities of fish such as *Gode, Gerodi, Balaain* etc. can be seen in rainy season but people are not killed any fish from the pond. However, fishes are killed during the rainy season, while fishes are moved to the upstream from lake. The lake conservation committee has planned to make a tourism place and enhance the local livelihood through the tourism activity.

Although 71% of the total area of sub-watershed is covered by the forest land, trees and vegetation coverage is very less inside the forest area of Kapadigaad sub-watershed area. The common trees are Saal (*Shoria robusta*), Sallo (*Pinus roxburghii*), Katus (*Catanopsis indica*), Chiuri (*Diploknema butyracca*), Tej patta (*Cinnamomum tamala*), Rutha (*Sapindus mukorossi*), Utis (*Alnus nepalensis*), Banj oak (*Quercus leucotrichophoro*), Kafal (*Myrica esculenta*) etc. Thus, within the sub-watershed area, board leaf forest, middle leaf and mixed types of forest are found. Others, animals such as Wild boar (*Sus scrofa*) and Monkey are common species found in Kapadigaad sub-watershed area.

Presence of lakes acts as an important habitat for migratory birds and fishes. According to various surveys, 17 wild animal species of national and global importance live in the watershed, as well as nine reptile species, 20 types of birds, 27 species of fish and 16 species of aquatic vegetation.

The fish stock has decreased. This is due to the deposition of construction materials from the excavation works that is on-going for road access. Over-fishing and poisoning also have contributed to it in some extent. This also has reduced the food supply of fish-eating birds significantly. Most of these bird species have declined in numbers from Nepal's wetlands and many of them are now included on the national threatened species list.

In terms of fisheries, there is a strong relationship between fish stocks and fish-dependent livelihoods. According to the Thuligaad Watershed Health Report (draft) PAANI Program, in lakes, rivers, and streams of the watershed, 27 species of fish and 16 species of aquatic vegetation were report. Of those species, *Sahar*, *Zebra machha*, *Buche asala*, *Asala soal*, *Chuche asala*, and *Rajabam* are commercially valuable native fish species. Surveys reveal that 69% of households perceive that native fish species are declining.

(i) Badikedar Rural Municipality has banned fishing using gear named *Chimti* around BP Nagar area since 2018

(ii) Badikedar Rural Municipality has also banned fishing gear named *Chauthi* which is imported from India via Gaurifanta adjoined to Dhangadhi, Kailai. For this, other 3 RMs in Thuligaad watershed should also support this initiative.

(iii) Debris from the rural road construction work has reached the adjoining river and stream and disrupted the habitat of fish and other aquatic lives.

(iv) USAID Paani Program has already initiated consultation with local communities and rural municipalities for formulation of aquatic biodiversity conservation act.

(v) In Badikedar Rural Municipality, *Kuri* named weed plant has been observed as invasive plant which is widely seen in Silgadhi; also *Banmara* is also widely found as invasive plant in Badikedar Rural Municipality.

Fish diversity of Thuligaad and Bogatan Lagam Karnali Watersheds

Thuligaad and Bogatan Lagam Karnali watersheds are rich in fish and aquatic diversity. There are 27 species of fish belonging to 10 different families.

Table 6: Fish diversity of Thuligaad and Bogatan Lagam Karnali Watershed

SN	Class/Family	Number of species
1	Anguillidae	1
2	Bagridae	1
3	Claridae	1
4	Cobitidae	*2*
5	Cyprinidae	17
6	Mugilidae	1
7	Nemacheilinae	1
8	Saccobranchidae	1
9	Schilbeidae	1
10	Siluriformes	1
	Total number of species	27

(Source: Fish vulnerability assessment report of Karnali Basin 2019)

The keystone species are: Mahsheer (*Tor putitora*), Asala (*Schizothorax richardsonii*) and Bajelo (*Gardi, Labeo dero*). In Thuligaad watershed, the destructive fishing locations are 4 and spawning locations are 7.

Table 7: Threats to keystone fish species in Karnali Basin

SN	Threat	Fish species
1	Breeding time	Gardi
2	Decreased water level	Gardi, Sahar
3	Decreased food source of fish	Gardi, Sahar
4	Destructive fishing (gillnet, current, poison, etc.)	Asala, Gardi, Sahar
5	First flooding, poisonous weeds	Asala, Gardi, Sahar
6	Flood and landslides	Asala, Gardi
7	Gravel mining	Asala, Gardi, Sahar
8	High market price and high demand	Gardi, Sahar

9	Increased waste	Asala, Gardi
10	Invasive non-native fish	Gardi
11	Lack of awareness	Asala, Gardi, Sahar
12	Lack of legal framework	Asala, Sahar
13	Loss of natural habitats and decrease in prey spp.	Asala, Gardi
14	Over-fishing	Asala, Gardi
15	Road construction along river side	Asala, Gardi, Sahar
16	Use of pesticides	Gardi, Sahar

(Source: Fish vulnerability assessment report of Karnali Basin 2019)

Table 8: Participatory ranking in Thuligaad and Bogatan Lagam Karnali Watershed

SN	Threats	Ranking
1	Destructive fishing (gillnet, current, poison, etc.)	Very high
2	Flood and landslides	Very high
3	Increased waste	High
4	Lack of legal framework	High
5	Loss of natural habitats and decrease in prey spp.	Low
6	Road construction along river side	Low
7	Use of pesticides	Low

(Source: Fish vulnerability assessment report of Karnali Basin 2019)

Table 9: Fish spawning, nurturing and fishing sites in Badikedar Rural Municipality

Municipality	Nearby settlement	Nursing site	Spawning site	Over fishing site
Badikedar RM, Doti	Ghangal Khola, Kharka			X
	Biregada		X	

	Gaukhola		X	
	Syaltadi	X		
	Ghaganru	X		

(Source: Fish vulnerability assessment report of Karnali Basin 2019)

3.6. Land Resources

Thuligaad Watershed is an area where the majority of land is covered by the forest. About 85% of the watershed is covered by forest, 14% agricultural land and 1% shrub-forest mix land.

The map below shows the land-use distribution inside the Thuligaad watershed area.

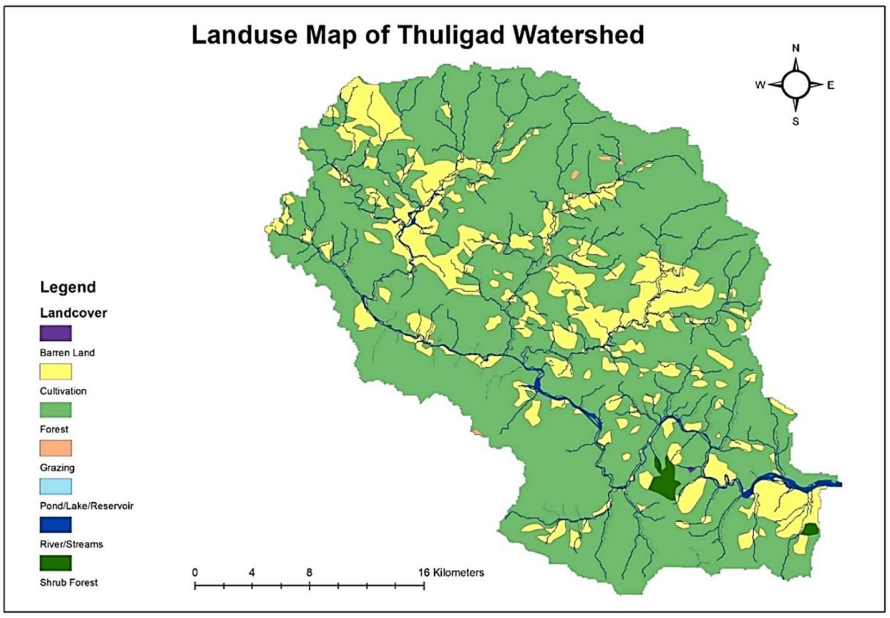


Figure 16: Land use map of Thuligaad watershed

As can be seen on the map, water bodies such as lakes, ponds, reservoirs and rivers/ streams cover very less area. The total area covered by the water bodies is less than 2% inside the Thuligaad watershed.

According to Thuligaad Watershed Health Report (draft) by PAANI Program, Thuligaad watershed contains diverse habitat for both terrestrial and aquatic species. This is because of the variance in forests, wetlands and rangelands from the lower mid hills to higher elevations. The forest are dominated by Chir pine (*Pinus roxburgii*) and mixed broad-leaf trees at lower altitudes and Quercus forest at higher elevation.

Land Cover of Kapadigaad Sub-watersheds

Different land use pattern such as forest, cultivation and surface water body of Kapadigaad sub-watershed has identified in Badikedar Rural Municipality. The forest area is covered by 71%

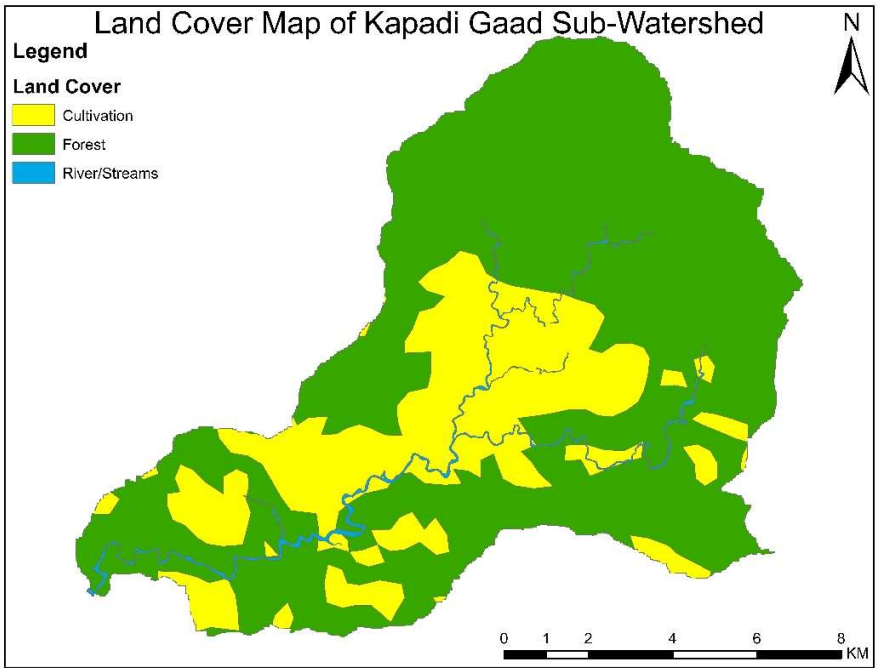


Figure 17: Land use map of Kapadigaad sub-watershed

following the 27% land is agriculture land. Although, degraded land and landslide area are very less, so these lands are not able to show in the land use map. The high contribution of forest land within the sub-watershed area caused minimize an impact of soil erosion and landslide. The table 10 and figure 26 show the distribution of land in Kapadigaad sub-watershed.

Table 10: Land use distribution in Kapadigaad sub-watershed

SN	Land cover type	Area
1	Cultivation	27.32%
2	Forest	71.36%
3	River/Streams	1.32%

3.7 Hydropower

There are no large hydropower in Kapadigaad sub-watershed of Badikedar Rural Municipality, however, small hydropower and micro-hydro are constructed and proposed. An operation phase of hydropower such as Kapadigaad hydropower which has 3.3 Mega Watt capacity and micro-

hydro likewise Sere Gad micro-hydropower which has 12 KW total capacity located in ward number 4 of Badikedar Rural Municipality. Moreover, another micro-hydro Chheda hydro-power (8 KW capacity) is under construction phase in Kapadigaad sub-watershed of Badikedar Rural Municipality. Furthermore, such types of small hydropower and micro-hydro shall be installed in the tributaries and main stream of Kapadigaad after the detail field survey.

3.8. Population

Status of the Household

The total number of household in Kapadigaad sub-watershed is 973. The household is shown in table 11.

Table 11. Number of household in Kapadigaad sub-watershed

SN	Household number	Percentage
1	973	100

(Source: Social survey, 2076)

Population Status

The total number of population in Kapadigaad Sub-watershed is 7043. The number of male population is less than female population by about 2%. The total population of male female population is in table 12.

Table 12. Number of population in Kapadigaad sub-watershed

	<5 Years	5-19 Years	20-59 Years	>60 Years	Total	In percentage
Female	278	1019	1577	269	3143	47.91
Male	364	1220	1658	175	3417	52.09
Total	642	2239	3235	444	6560	100

(Source: Social survey, 2076)

Table 13. Number of household based on religion

SN	household based on religion				
	Hindu	Buddhism	Christian	Muslim	Others
1	972	--------	1	--------	---------

(Source: Social survey, 2076)

Table 14: Number of household based on caste

SN	Household based on ethnicity		
	BCTS	Janajati	Dalit
1	790	78	105

(Source: Social survey, 2076)

Livestock Population

Livestock is the second major income generation activities in the watershed area after agriculture farming. Livestock farming provides the compost manure to maintain the soil productivity and crop growth. Farmers of the Badikedar Municipality do not have practice of using chemical fertilizer. The survey shows that cattle (cow/ox) and goat are common livestock, however few households have buffalo, chicken, rabbit and pig also. Therefore, cattle, goat and buffalo are considered key forest resource user for their feeding. The table 15 shows the livestock population in Kapadigaad sub-watershed.

Table 15: Livestock population status

Sub-watershed	Cattle	Buffalo	Goat	Rabbit	Chicken
Kapadigaad	5158	195	11199	164	1828

(Source: Social survey, 2076)

4. Analysis of Problem

This chapter addresses the problems that the selected sub-watersheds are facing. As the Thuligaad watershed itself has a major issue with the availability of water, its sub-watersheds also have similar problems.

Kapadigaad sub-watershed is prone to various vulnerable disasters like landslide, soil erosion, and flood and fire hazard. It also has problem regarding the availability of water for daily use, particularly for the households that are located in the higher altitudes. The problems are discussed hereafter.

4.1. Water Availability, Accessibility and Quality

During the process of collecting information from the sub-watersheds inside the Thuligaad watershed, our team had distributed questionnaires to the local stakeholders in Badikedar Rural Municipality. Question number 1 until 7 were about the water availability and water quality in the area the respective stakeholders reside in. As these were the primary data obtained directly from the watershed, they were of high importance and hence taken into consideration for the sub-watershed selection process and as well as for the management plan.

4.1.1. Water Availability

Kapadigaad is also a headwater catchment (catchment where there is no contribution from upstream and the runoff available is solely based on the catchment itself). The water resources outlets are very limited because of this. The water contributing to runoff as well as groundwater sources will eventually come out of an outlet at the surface, which normally is at the lower elevations. Being a headwater catchment, the availability of such spring outlets is comparatively lesser than to a downstream catchment.

The social survey shows that about, 60% of the respondent answered the water for drinking is sufficient while about 9% of the total respondent said it is very hardly sufficient drinking water now a days. Moreover, about 22% said that the water for daily household use is hardly enough and also 40% respondents said that there have no irrigation water due to the lacking the irrigation facilities.

4.1.2. Water Quality

The settlement at the lower altitudes, near to the river, face a different problem altogether. It's not the quantity of water that is the problem there, it's the quality of water that needs to be managed. According to the report "Thuligaad Watershed Health Report" by the USAID PAANI Program, the water is not suitable for drinking for 57% of the households. According to that report, tests were conducted for the quality of water indicating normal levels of pH, ammonium, phosphate and nitrate. The concentration of solid waste management was also low which threatens the quality of water in the long run.

The social survey data shows that about 85% of the total respondent said that the water quality might be good which is used for the drinking purpose while 5.5% said water quality is bad and 0.5% respondent said the water quality is very bad, can't be used for drinking purpose and they have trouble of water for household purpose.

4.1.3 Water Accessibility

There are many households near to the ridge. These households have to bring water from the spring sources/ rivers, which are at lower altitudes regularly for their daily chores. This is the reason why sub-watershed Kapadigaad is in requirement of water management, mostly at the settlement near to the ridge.

According to the local people, the major source of water for drinking and other household purposes are spring source, piped water, tap water and small water rivulet. About, 18% of the total respondent said that the water source is far from house. They took more than 30 minutes time for water brings to home. Similarly 20% people took within 30 minutes and 15% people took within 20 minutes time. The data shows that the water are not easy to transport from the source to home and people from the Kapadigaad sub-watershed spending more time for water collection for the various purpose in their home.

To9 enhance the water accessibility of the rural mountain people, rain water harvesting is one of the best practices. Rain water collection during the monsoon season as well as other time period can make easy people's daily life. Rainwater harvesting into the cemented pot is common practice in mountain areas. One of the best example of rainwater harvesting in hill and mountain areas in given in box 1.

Box No. 2: Rainwater harvesting: Water security for rural livelihood

Access of water availability in rural areas of hills and mountain regions are very difficult. Women and children are spending more than an hour to collect the drinking water in most of the mid-hill to mountain region. Due to avoiding these problem, rain water harvesting technologies are developed. One of example of the success of rain water collection is in Kerabari, Jorayal-2, Doti district. According to the Krishna B. Kadal, the water collection tank was established before 18 years by the supporting of HELVETAS-Nepal. Till the date, the function of water collection tank system is good. The capacity of tank is 7000 litters, if the tank is full during the rainy season, it can support for nearly 6 month for 3-4 members of a family for only drinking water. In Kerabari area, these has 9 household in this community and all of them have water collection tank. People are much happier after the construction of water collection tank. Also, they faced water scarcity for cattle drinking and other household purpose, so they give willingness to construct other tank too.

4.2. Demography

4.2.1 Population

The population of Kapadigaad sub-watershed is calculated considering the population density of ward number 1, ward number 2, and ward number 4. 36.06% of ward number 1 contributes 1849 number of people, 6.16% of ward number 2 contributes 285 number of people, 84.02% of ward number 4 contributes to 3408 number of people and 5.18% of ward number 5 contributes to 341 number of people inside Kapadigaad sub-watershed. Consequently, the total population of people inside Kapadigaad, using the population density approach is 5883. Inside Kapadigaad sub-watershed, 98.70% of the settlement is for residential purpose.

During the process of data collection and workshops, by interacting with the local stakeholders, we came to know that the daily use of one household is about 200-250 liters of water per day in current scenario for different purpose in household (*Social survey, 2076*).

Previously when toilets were not in use, the water required for a family would be about 20 liters per day. According to the village profile prepared by the Badikedar Rural Municipality, the average family in Badikedar consists of 6 people. This indicates that the average water that a person consumes is about 16 liters per day for drinking and household use.

As can be seen in the map, the settlement distribution is denser near to the banks of the river inside

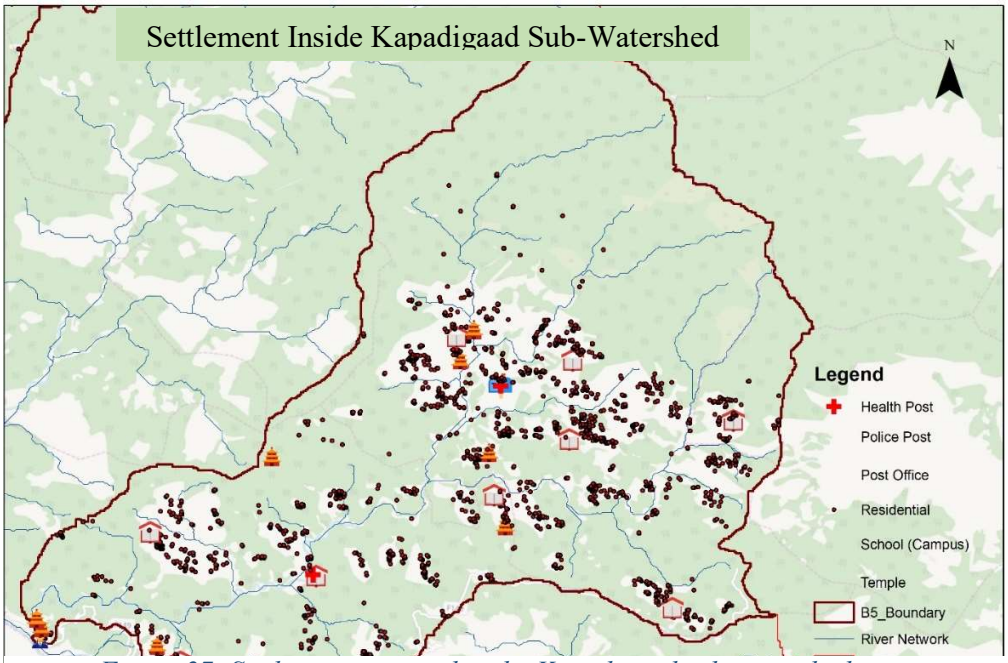


Figure 27: Settlement area within the Kapadigaad sub-watershed area

Kapadigaad at different altitudes. The main problem at such areas would be the seasonal floods that will inundate agricultural as well as residential areas. Also, there are people residing near to the ridge lines at higher altitude. For them the availability of water is lower as the accessibility of water is more difficult.

4.2.2 Socio-economic Aspect

Kapadigaad sub-watershed has a diversified social structure. The gender balance is also almost the same (48.60% female and 51.40% male). Among 5 wards inside the Badikedar Rural Municipality, ward number 3 has the highest number of population i.e. 24.21%. Ward number 4 contributes 21.42% of the total population, ward number 5 contributes 20.55%, ward number 1 contributes 17% and ward number 2 contributes 16.73% of the total population in Badikedar Rural Municipality. Ward number 1 and 4 have large areas located inside Kapadigaad sub-watershed.

Population distribution according to the religion is heavily dominated by the people that follow Hinduism (96.83%). However, there are people who follow Buddhism (2.97%) and Christianity (0.19%). Similarly, people of Brahmins/Kshatriyas cast highest in number (59.54%), Dalits are 19.48% and Janajatis are 20.97% of the total population (Badikedar Village Profile).

54.46% of the total working population are farmers as agriculture. 3.50% hold regular jobs, 1.45% are involved in business and about 8% do not have any work and are jobless. About 22.23% of the population have migrated abroad, mainly India in search of work and a better lifestyle.

According to the data provided in the village profile, the food security of Badikedar Rural Municipality is not encouraging. Only 20.44% of the family have access to food for all year around. Remaining 79.56% of the people are not secured in terms of food and do not have enough food for all year long even though they do their own farming.

The income inside Badikedar Rural Municipality is on an average Rupees 12,851. According to village profile developed by Badikedar Rural Municipality, one of the major sources of income in the Rural Municipality is remittance. About 48% of total income is generated from people of Badikedar Rural Municipality working in India.

Major economic activity in Kapadigaad sub-watershed is agriculture. This shows how important is the availability of water for agriculture. Proper management of water for irrigation can boost up the economic aspect of the sub-watershed rapidly as it has a good market for the agricultural products, mainly Turmeric and Ginger.

There are 9 educational institutes in Kapadigaad sub-watershed. According to the village profile, among the enrolled students, 50.95% are female students and 49.04% are male students. There is 1 campus in ward number 1 where there are 59 male students and 42 female students.

There are 2 health posts inside the Kapadigaad sub-watershed, one at each ward 1, and 4. The major disease/ illness that people are facing inside the Kapadigaad sub-watershed is diarrhea and dysentery. This is due to the lack of public awareness and drinking water direct from the source without boiling it. Gastric and ulcers are also common. This is also due to consuming food and water without properly treating them. Pneumonia is also common. This is primarily in the high altitude areas as it gets very cold in the winters and most of the houses are not properly built. In

addition, the living conditions for most of the people are not very good, especially the ones at higher altitude, which further contributes to the disease.

99% of the people use firewood as their primary source of fuel and the remaining 1% use biogas and LPG gas. For lighting purpose, only 37.43% of the households have access to electricity generated from solar energy. 8.37% use electricity generated from hydropower and have been connected from the grid.

Analyzing all the socio-economic aspects that have been discussed above, it is clear that the selected sub-watershed needs proper management of its resources. Water can be used primarily to enhance the living standards and uplift the economic aspect of the stakeholders, as agriculture is the primary source of income and food. That is why proper management of water resources will be the primary focus.

4.3. Land Use and Land Cover

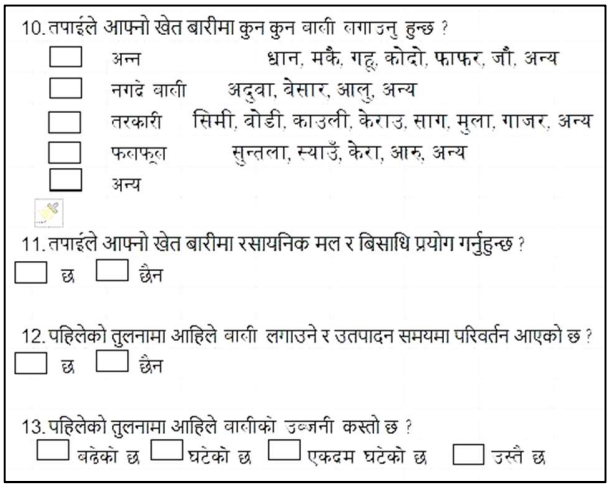
4.3.1 Agricultural Aspect

Agriculture is the one of main source of food and income for Kapadigaad sub-watershed. About 95% of the total people are involved in agriculture and remaining likewise teachers, government and non-government/private job, foreign employer and other jobs are 2.0%, 0.72%,. 1.85% and 1.84% respectively. About, 27.32% of the land is occupied by cultivation land in Kapadigaad sub-watershed.

Farming of ginger and turmeric is well organized while groundnut farming is cultivated at lower elevation along the Thuligaad River. Cultivation of traditional crop buckwheat has almost lost. The details of the cropping pattern is shown in annex VI. Agroforestry has not been practiced prominently. Farmers apply farm yard manure (FYM) and compost in traditional manner even though number of training have been provided. Use of chemical fertilizers is less and is in decreasing trend. Pesticide use have recently started mainly by vegetable grower farmers in dry months, and this trend of use of pesticide is in increasing trend.

The questionnaires that was distributed to obtain primary data from the stakeholders asks about the type of crops, the change in cropping period and pattern over the years and the use of insecticides and fertilizers.

Responses related to question number 10 from all the wards are similar. All of them have chosen all four options regarding the type of crops that they plant on their farm.


10. तपाईले आफ्नो खेत बारीमा कुन कुन वाली लगाउनु हुन्छ ?
☐ अन्न धान, मकै, गहू, कोदो, फाफर, जौ, अन्य
☐ नगदे वाली अदुवा, बेसार, आलु, अन्य
☐ तरकारी सिमी, बोडी, काउली, केराउ, साग, मुला, गाजर, अन्य
☐ फलफूल सुन्तला, स्याउँ, केरा, आरु, अन्य
☐ अन्य
11. तपाईले आफ्नो खेत बारीमा रसायनिक मल र बिसाधि प्रयोग गर्नुहुन्छ ?
☐ छ ☐ छैन
12. पहिलेको तुलनामा आहिले वाली लगाउने र उतपादन समयमा परिवर्तन आएको छ ?
☐ छ ☐ छैन
13. पहिलेको तुलनामा आहिले वालीको उब्जनी कस्तो छ ?
☐ बढेको छ ☐ घटेको छ ☐ एकदम घटेको छ ☐ उस्तै छ

Responses to question number 11 are mostly negative i.e. about 88% respondent said no use of chemical fertilizer and pesticides but remaining 12% respondent said there use of chemical fertilizer and pesticides to grow the vegetable farming. Although, few of farmers used organic farming system as commercial agro farm. Box number 1 shows best practices against the climate change in agriculture farming using the organic fertilizer as business purpose.

Similarly, about 75% respondent said that the cropping times have changed as compared to the past time. Also, about 56% respondent said that the production of crops have been reduced than the past years.

Land management is major issue in Badikedar RM. There is need of improvements in terrace farming (*Gara sudhar*). Soil erosion is more from bigger terrace than smaller ones. Bamboo production is abundant and it can be used in bioengineering works as control measures for landslides and gully erosion. At household level, bamboos are used for checking minor landslides or slope land stabilization. Training on bamboo furniture is needed to increase income of local communities.

4.3.2 Rural Settlement/ Infrastructure

The rural settlement and development of infrastructure plays an important role in the land use change inside the sub-watershed. The number of settlement increases and becomes denser in a specific area, more will the resources be used; hence, more resources will be needed of management.

Rural settlement is better in most cases, especially keeping the socio-economic aspect in context. However, it also has various negative aspects attached. For our case inside Kapadigaad sub-

watershed, the main problem is the depletion of quality and quantity of water due to road construction.

Box No. 3: Climate smart best management practices of agriculture farming

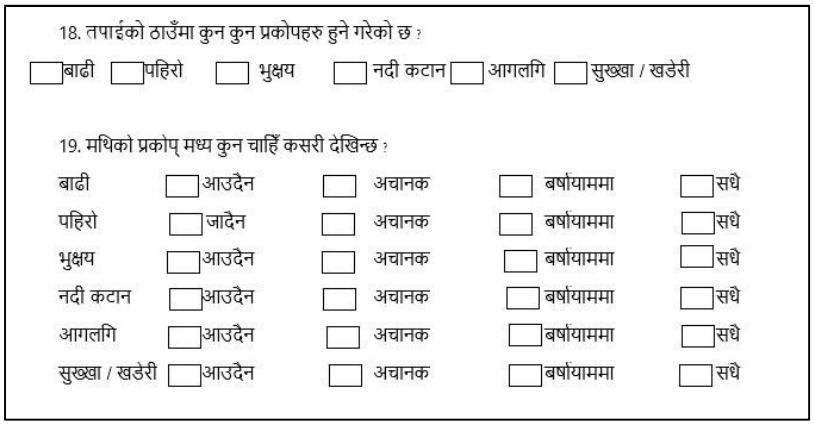
Agriculture farming practice inside the plastic house as a business purpose is one of the costly method for the local farmer of the rural area people. Plastic house also called poly house, where plants can grow rapidly due to optimum temperature for plants growth and can protect from the other natural disasters likewise hailstorm, speedy wind etc. Manshing Mahata, as a lead farmer of Ghanteshwor, Jorayal-1, Doti district. He has a total of 5087 square meter land but only 763 square meter has been used for poly house farming. MAD Nepal was providing a training before five years ago for poly house and drip irrigation farming system. Then, Mr. Mahata has been started a commercial farming and his local market is Ghanteshwor bazar along the Bhim Dhatta highway, also vegetable wholesaler are come to his farm and ordered. As a fertilizer, he used only an organic fertilizer and prepared himself by using the ginger, onions, chilly, nettle etc. In addition, Mr. Mahata used drip irrigation system in his tunnel house farm. The irrigation water source is nearly 1 km far from his farm and plastic pipe was used for water collection. Now, the verities of seed are grown by himself for his farm as well as sell to the other farmers too in reliable price. Mr. Mahata is fully satisfied from his business but sometime due to fall of reliable price of vegetables in the market, he blamed to his job.

Road has been the ever in demand development project inside the Thuligaad watershed itself for generations, and rightly so. It opens access to a variety of socio-economic options. In addition, the road connects to the Badikedar Temple, which is a very sacred place for the people following Hinduism. As a result, tourism is also a big part. However, the quality of water and land has not been kept in consideration. The excavated material has been directly deposited into the rivers and lands haphazardly.

There have been rapid decline in fishes found in the rivers. The decline started after the construction of the roads started. Similarly, at different locations, agricultural lands were seen covered in the excavated material from the road. This has a negative impacted on the growth of crops and affected livelihood of farmers.

4.4. Climate and Bio-physical Hazard

Question number 18 and 19 on the questionnaires represented the climate and biophysical hazard inside the Badikedar Rural Municipality.


18. तपाईको ठाउँमा कुन कुन प्रकोपहरु हुने गरेको छ ?

☐बाढी ☐पहिरो ☐ भुक्षय ☐ नदी कटान ☐ आगलगि ☐ सुख्खा / खडेरी

19. मथिको प्रकोप् मध्य कुन चाहिँ कसरी देखिन्छ ?

बाढी	☐आउदैन	☐ अचानक	☐ बर्षायाममा	☐सधै
पहिरो	☐ जादैन	☐ अचानक	☐ बर्षायाममा	☐सधै
भुक्षय	☐आउदैन	☐ अचानक	☐ बर्षायाममा	☐सधै
नदी कटान	☐आउदैन	☐ अचानक	☐ बर्षायाममा	☐सधै
आगलगि	☐आउदैन	☐ अचानक	☐ बर्षायाममा	☐सधै
सुख्खा / खडेरी	☐आउदैन	☐ अचानक	☐ बर्षायाममा	☐सधै

From all the wards, the stakeholders have answered that all the disasters asked in the questionnaires occur. This shows that disasters like flood, landslides, soil erosion, riverbank cutting, forest wildfire and droughts are occurred in prioritized sub-watershed in Thuligaad watershed. According to the filled questionnaires, 27% respondent said floods, 66% said landslides, 10% said soil erosion, 22% said riverbank cutting, 82% said wild fire and 83% said drought occurs all over the watershed. Flood, landslide and river bank cutting mostly occurred during the monsoon season while other disasters like drought and erosion problem are frequently occurred during all over the year. However, there are no community or village scale (or large scale) practices for the local and watershed level disaster management activities. Disasters like forest wildfire is instantaneous in nature and occur all of a sudden.

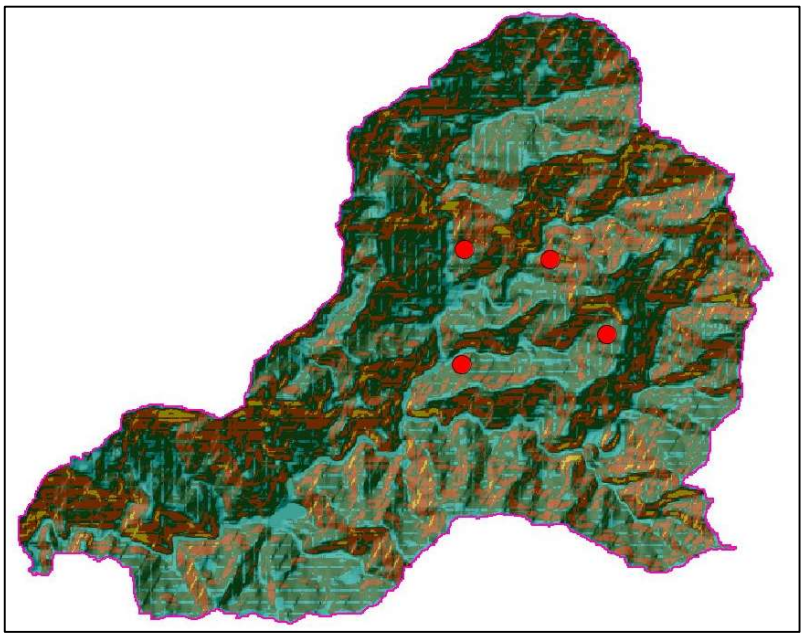


Figure 28: Flood and landslide hazard map of Kapadi Gad sub-watershed

The red dots in figure 26 shows the locations of natural disaster (flood and landslides) inside Kapadigaad sub-watershed.

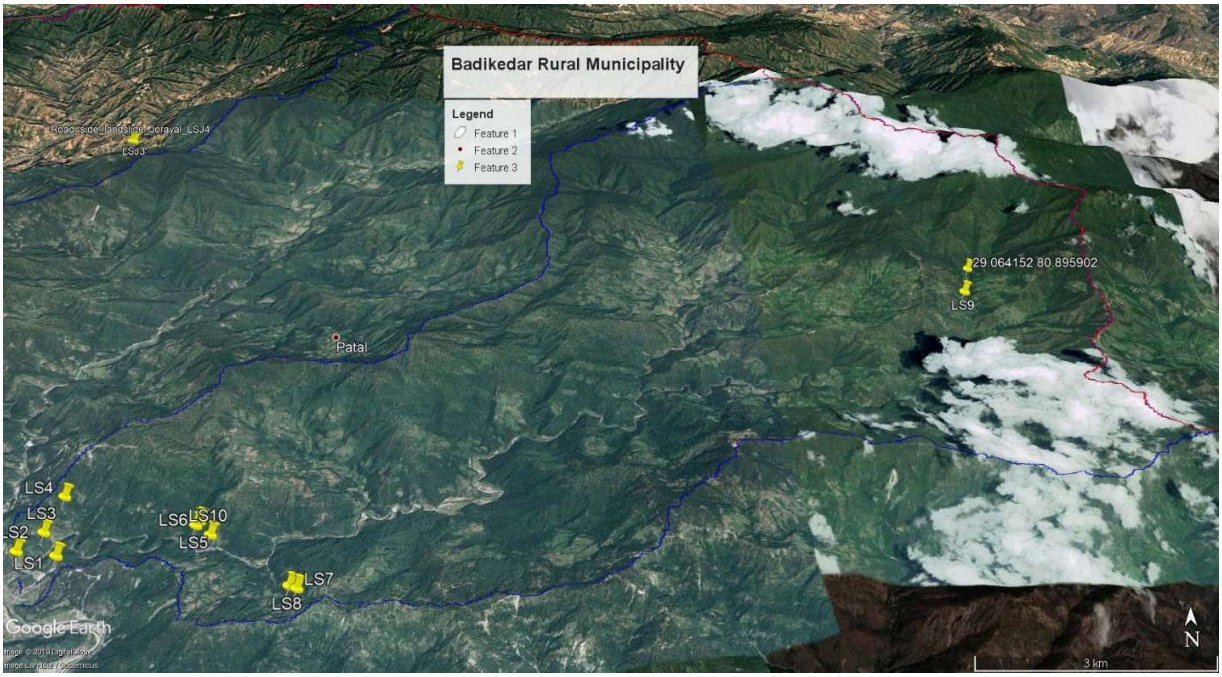


Figure 29: Landslide prone area within a sub-watershed area

The yellow point shows that the landslide occurred in prioritized sub-watershed area of Thuligaad watershed (Figure 29).

Landslide occurred due to the toe cutting and without proper management planning during the tunnel construction for hydropower

Agricultural lands are changed into the flood plain due to the high flood occurred in Kapadigaad at Deuli

Fragile lands are highly vulnerable during the rainy season caused high erosion and landslide

Naked Mountain are one of the cause for high surface soil erosion and speedup of surface water runoff

Low sapling biomass in the forest area is caused of open grazing and no implementation of forest management plan

Migration of local people to the terai region cause lots of mountain agricultural are degraded

Rockfall and debris slide are other major watershed degradation problems along the steep slopes of the catchment.

The below figure 32 shows that the flood susceptibility map over the sub-watershed area. Flood susceptibility map was assessed with using the GIS considering the low-laying area around the mainstream and major tributaries of Kapadigaad as the area vulnerable to the sedimentation, debris flow and inundation area.

4.5. Resource use problem

Land, water and forest are the key resource use for producing people's basic needs such as food, fodder, fuel wood and timber. An optimum use of natural resource can maintaining the natural environment and sustainable food producing from the resource. Therefore, proper designing program and strategies can fulfilling the basic needs without degrading the natural resources, it is important to analyse the production/supply and demand status of basic needs.

4.5.1. Food status

Wheat, paddy and maize are the common cereal crops cultivated in *Khet* (irrigated) and *Bari* (non-irrigated) land areas of the sub-watershed area. Paddy is common crops in *Khet* land and maize is

common in *Bari* lands. Although, wheat is common in both types of lands. Moreover, potato, groundnut, mustard, and other vegetables are commonly cultivated in both types of land. The food production and food requirements in terms of cereal value, the sub-watershed has deficit of about 207 tons of cereal.

Table 16: Cereal production

Cereal production in tons						
Paddy	Rice equivalent (0.65)	Wheat	Maize	Potato	Cereal equivalent for potato	Total cereal equivalent
A	b = 0.65*a	c	d	e	f = 0.25*e	g = b + c + d + f
385.632	233.110	517.860	509.861	67.260	16.815	1,344.906

(Source: Social survey, 2076)

Table 17: Cereal Requirement

Population	Per capita annual cereal requirements (in Kgs)	Total cereals requirements in tons	Cereals balance in tons
X	y	z = x*y/1000	g-z
6560	160	1,049.600	1,344.906 - 1049.6 = (+) 295.306

Note: Cereal value of paddy is considered to be 0.65, cereal value of potato is considered to be 0.25 and rest of the cereals is considered as 1.

Per capita annual cereal requirement vary with the age, weight, and their activeness. However, cereal consumption depends on economic status as well. Therefore, depending upon the situation, appropriate figure need to be chosen ranging from 160-200 Kgs.

4.5.2 Fodder need assessment

Livestock is an integral part of the rural economy and in the lack of fodder production, overgrazing became one of the key processes resulting land degradation. Livestock such as cattle, buffalo and goats are key animals that use much more fodder from forest resource. Therefore proper programs

and plan need to implement for the forest resource management. According to the household survey, cattle, buffalo and goat are grazed in the open places such as degraded land, riverside and open forest grazing land. Fodder species plantation is less exercise in this community and could be a potential activity under the on-farm conservation intervention in the sloping agriculture lands to reduce the pressure on surrounds forest. Free grazing is common practiced in the sub-watershed area and to reduce the dependency on forest fodder, trees/grass plantation at private land and degraded land could be the potential activities.

Table 18: Fodder need status

Livestock	Number of livestock	Average weight of livestock	Total weight of livestock in Kgs	Dry matter in Tons/Year
	a	b	c = a*b	d = c/100*2.25*364/1000
Cattle	5158	150	773,700	6336.603
Buffalo	195	230	44,850	367.32
Goat	11199	25	279,975	2292.99

(Source: Social survey, 2076)

4.5.3 Soil Nutrient Status

Assessment of soil quality of agricultural land is an important for the sustainable soil properties management. The soil quality is found varied among the different altitude of the agriculture land. The pH of the soil was found acidic nature which is varied from 4.8 to 7 with an average value 5.75 ± 0.64 shown in table 10. The pH of all soil sample are below 7 (i.e. neutral pH) which indicated that soil pH degrading in the present scenario. The maintenance of soil pH can help to main the other soil nutrients such as NPK and other soil micronutrients such as Zn, Mg B, Cu, No and Fe. Also, acidic soil have low density of soil pores which might affect surface water recharge into the ground water.

Similarly, the organic matter was medium quality, total nitrogen and available phosphorus were high and exchangeable potassium was very high nutrients soil. Soil organic matter is an important parameter for the physical properties of the soil, which influence on the water holding capacity in surface soil. In addition, mostly loamy sand and sandy soil classification texture were found in Kapadigaad sub-watershed area. This types of soil help to the groundwater recharge but it is

equally vulnerable from the soil erosion possibility. The details of the soil nutrients status is shown in table 19 and annex VI.

Table 19: Soil nutrient status in Kapadigaad sub-watershed

pH		Organic matter (%)		Total Nitrogen (%)		Available Phosphorus (Kg/ha)		Exchangeable Potassium (Kg/ha)	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
5.75	0.64	4.55	1.71	0.23	0.09	80.29	85.37	639.73	343.53

(Source: Soil fertility map of Doti district, 2075)

4.5.4 Fuel Wood Status

About 85% of the total area is covered by the forest land in Kapadigaad sub-watershed area. According to the household survey, the major source of fuel wood for cooking and heating space and water is community forest. About 100% firewood, is used for cooking purpose. The heavy load of use of firewood by the communities can be reduced by the construction of biogas because most of the household have their cattle and/or buffalo. Also, the favourable temperature could be found in the lower region of the Kapadigaad sub-watershed area. The table 20 and table 21 below illustrate the energy needs and fulfilment status.

Table 20: Energy need status

Population	Per capita annual fuel wood need (Kgs)	Total fuel wood required in Tons
A	b	c = a*b/1000
6560	600	3936

Table 21: Energy fulfillment status

Proportion of energy consumption of HHs from different sources (%)						
	Fuel wood from FC	Solar	Electricity	*Diyalo*	Kerosene	Others
Cooking	100					
Lighting		79.93	17.61	1.76	4.23	0.35

(Source: Social survey, 2076)

4.5.5 Water Need Status

Water for drinking (human and livestock) and irrigation is the major needs of the rural community. The major water source in rural areas are spring water source and river water for fulfilment the water requirements. During the field visit, local community using the many other practices for water collection except the spring and river water collection. For example rain water harvesting in cemented pot and tank, overflow water collection tank and gravity flow water tank, plastic pond construction etc. According to the field survey of Youth Alliance for Environment (YAE)/Paani Program, 2019), 46 water source outlet are inside the Kapadigaad sub-watershed area. Out of the total sources there have 2 sources have completely dried up and 40 other sources are going to drying up slowly and in remaining 4 sources no changes have been observed. This data shows that the water source might be going to drying in the near future. Therefore, the possible activities such as water source protection, plantation in the surrounding environment, construction of recharge pit, recharge pong in the upper site of spring source can be done as soon as possible.

Table 22: Drinking water need status

	Population	Water requirement (lit/day)	Total water requirement (lit/day)
Human			
Population	6560	45	295,200
Livestock			
Cattle	5158	45	232,110
Buffalo	195	40	7,800
Goat	11199	10	111,990
Chicken	1828	0.15	274.2
Rabbit	164	0.55	90.2
Sub-total drinking water need for livestock			352,264.4
Total drinking water need			647,464.4

(Source: Social survey, 2076)

Recently Water Users Masters Plan (WUMP) have been prepared by the Badikedar Rural Municipality under the technical support of Rural Village Water Resource Master Plan (RVWRMP). Quality of drinking water supply from water sources to reservoir is not good; and at household level also drinking water storage is not well managed. Most of the water supply project schemes have not been successfully implemented, and no plans have been made for monsoon water storage.

4.6. Socioeconomic and Other Problems

4.6.1 Status of House Ownership

According to the household survey, 97.83% of the population have their own house, while 0.41% population have rented household and 0.82% population have others.

Table 23: Land tenure

	Total household	Ownership of house/housing unit		
	Owned	Rented	Institutional	Others
Household number	950	4		8
Percent	97.83	0.41		0.82

(Source: Social survey, 2076)

4.6.2 Status of Literacy Rate

In Kapadigaad sub-watershed, about 78% of the total population can read and write and about 20% can't read and write. This shows that, the literacy rate in the Kapadigaad sub-watershed is good, therefore, if conservation awareness program can be conducted, people of the sub-watershed easily understand the problems/issues and they may cooperate for the solution through the published information and communication materials.

Table 24: Educational Status

	People who			
	Can read and Write	Can read only	Can't read and write	Total
Female	2230	32	791	3053
Literacy in % (F)	73.04	1.05	25.91	100
Male	2713	37	512	3262
Literacy in % (M)	83.17	1.13	15.7	100

(Source: Social survey, 2076)

4.6.3 Road Network Status

There have no black topped gravel road network within a Kapadigaad sub-watershed however, muddy/newly constructed road network are connected to the rural municipality office. Bogatan road is the main road of Badikedar Rural Municipality, the road network extend from Sahajpur, Chure Rural Municipality which was initiated from 2038 BS. Due to the muddy road, people cannot travel by bus during the monsoon season. During the rainy season, mud and other derbies from the newly constructed road are swept and reach to the small and large river. The fine particles of the sand and mud are deposited into the river bed which might be the cause of loss habitat of aquatic animals. Another, due to the high slope and fragile landscape, the water flow makes gully channel which can cause of landslides in mountain areas. The road network within a sub-watershed area is shown in table 17.

Table 25: Status of road network

Ward no.	Name of Road	Road network connected village	Length of road (km)	Types (Black topped/gravel/muddy road)	Benefited household
1	Bogatan Road	BP Nagar to Gadsera	52	Muddy road	
1	Suwakhaan Mannakapadi Road	BP Nagar to Dewali	25	Muddy road	
2	Puraan Road	Puraan to Barchhen	5	Muddy road	150
4	Khadeuli Mannakapadi agri Road	Khadeuli to Dikeban	15	Muddy road	3500

(Source: Village profile of Badikedar Rural Municipality, 2075)

5. Climate Change and Vulnerability

Global climate change has attracted much scientist and public community in the recent years. Human activities are leading to an excessive amount of greenhouse gases (GHGs) emission and concentration, which result rise in global earth's temperature due to the radiative properties of gases. There are many evidences of climate change that are being experienced by many people especially the poor and excluded around the world in different forms. Among these, Nepal is one of the popularise country and it ranks in fourth position of climate change around the globe. Nepal has good reason to be concerned about climate change as more than two million Nepalese depend on Climate-sensitive sectors like agriculture, water resources, fisheries and forestry for their livelihood (Devkota et al., 2011) [Devkota, R. P., Bajracharya, B., Maraseni, T. N., Cockfield, G., & Upadhyay, B. P. (2011). The perception of Nepal's Tharu community in regard to climate change and its impacts on their livelihoods. *International Journal of Environmental Studies*, *68*(6), 937-946].

Climate change has been universally accepted fact that the changing is rapidly at present than any time period of the past. It has greatly impact on the human social well beings and the as well as the earth system. To know the changing pattern of the climate, we assessed the temperature and precipitation data as scientifically proven, however, it is not sufficient data for climate change. Therefore, we surveyed questionnaire as well as community discussion during the field visit. The participatory approach of the climate change vulnerability was discussed at the local community and dissemination of climate change information/impact in local level.

The data of rainfall shows that rainfall trend at the station 214 (Kolagaun) has been decreasing order from 1980 to 2017. Similarly, about 87% respondent said that the trend of rainfall has been decreased at the present context. However, the trend of temperature has increased from the year 1982 to 2017. In addition, 94.5% of the total respondent said that the temperature has increase as compared with the past period. The trend line of rainfall/precipitation is shown in figure 31.

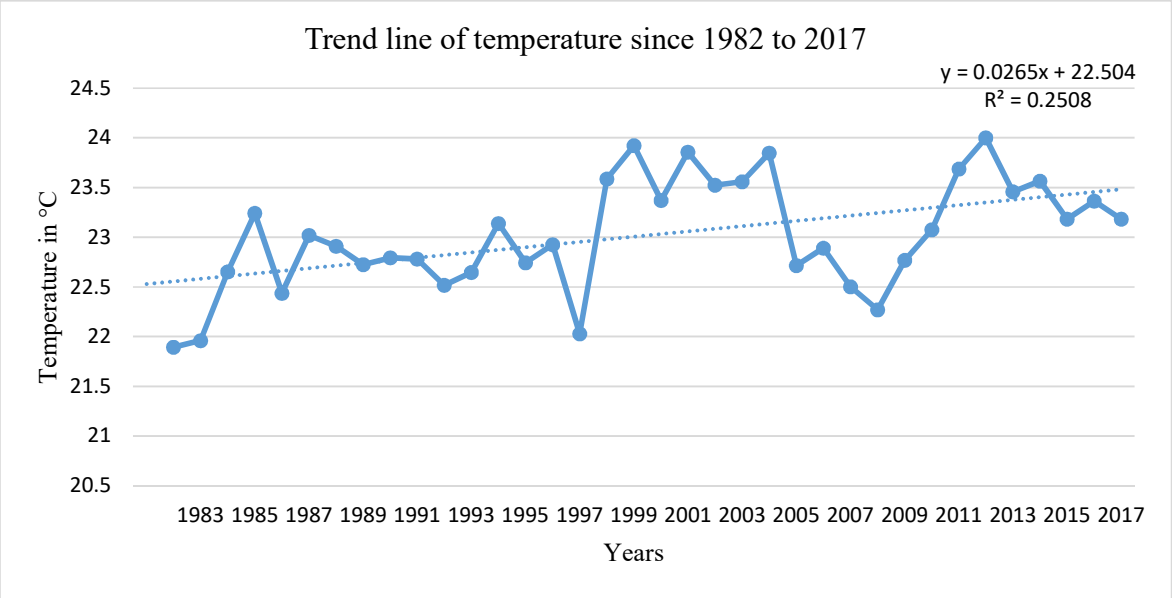


Figure 30: Temperature trend line over the Kapadigaad sub-watershed

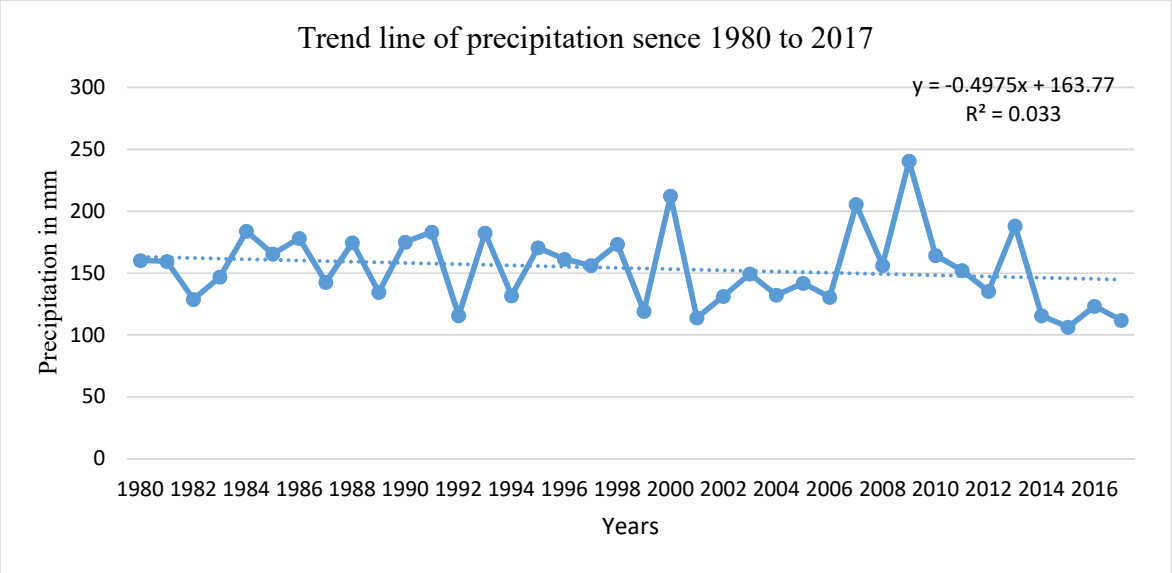


Figure 31: Precipitation trend line over the Kapadigaad sub-watershed

The information of rainfall and temperature trend was shared with the local communities during the draft sharing workshop. About 70% of the total rainfall was occurred during monsoon season only. Due to the high rainfall in monsoon season and high slope topography of this sub-watershed caused landslide and flash flood are common in the upstream and downstream of the catchment

area. The landslide and flood triggering the settlement and agricultural land of the sub-watershed area (Figure 29 and 32).

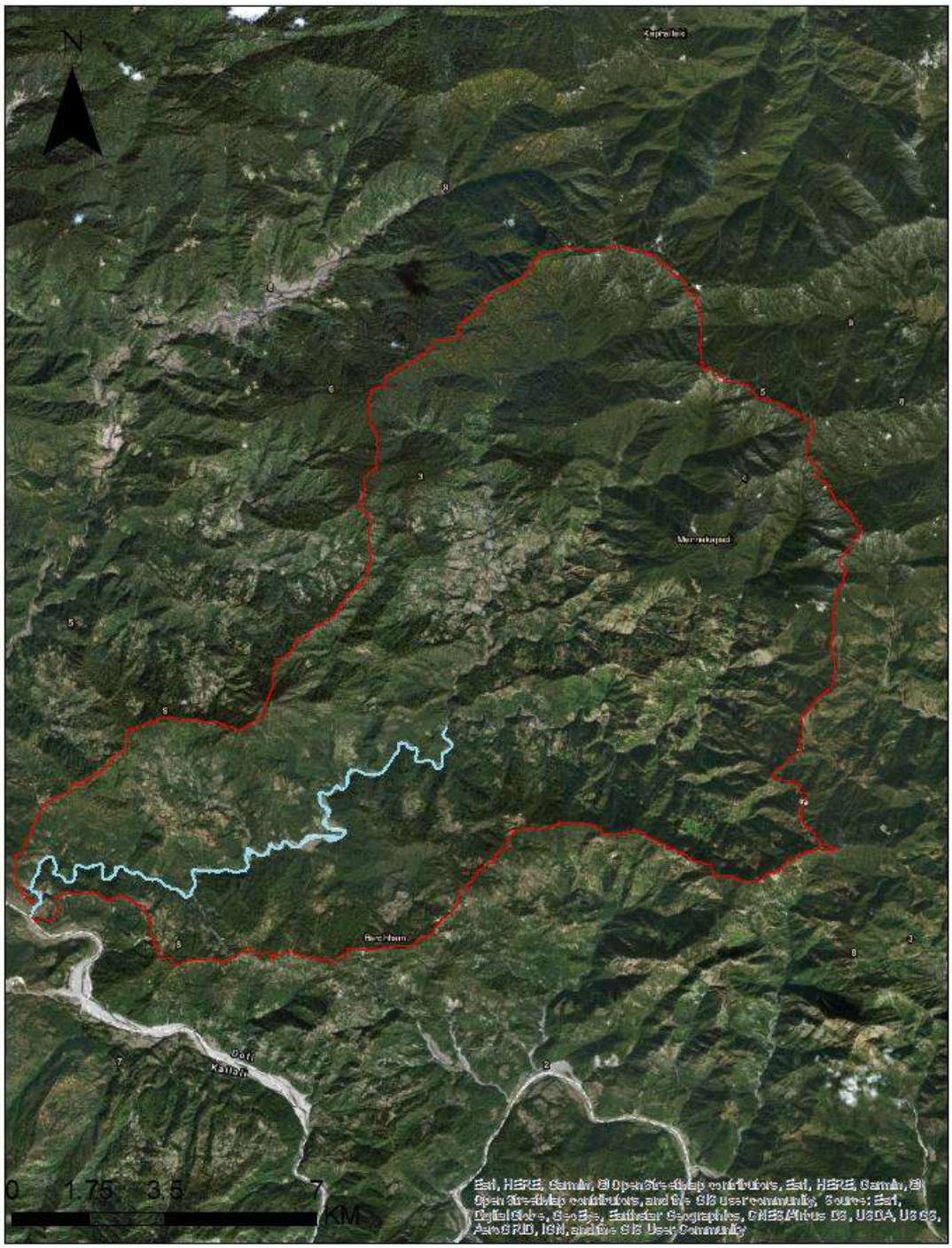


Figure 32: Flood prone areas in Kapadigaaad Sub-watershed

The positive trend of temperature with negative trend of precipitation in Kapadigaaad puts this district in high drought risk exposure and vulnerability with moderate landslide and flood risk exposure (Ministry of Environment, 2010) [Ministry of Environment (2010), Climate change vulnerability mapping for Nepal, Kathmandu, Nepal]. Limited water available for drinking and irrigation facilities caused increasing the migration of people in the lower region and decreasing the food security in the given sub-watershed. About, 22% respondent said that people from the sub-watershed area have very hardly get drinking water and other purposes such as sanitation, cooking and bathing water in the present scenario. While, about 40% of the total respondents said, there have no irrigation water due to the low precipitation within the Kapadigaad sub-watershed area. Similarly,

Photo 1: Toe cutting by river bank cutting at Deuli

more than 27% said, irrigation water get very hardly for the crop grown. Furthermore, the research of Youth Alliance for Environment (YAE) shows that the about 4% of the total spring water sources are totally drying up and about 87% sources are seasonal changed (Annex IV). The upstream community from ward four are much vulnerable from the water drying up while lower community such as Deuli (Ward 1) to the BP Nagar are much vulnerable and risk form the flood. About 35 hectare of agricultural land at Deuli have destroyed by the flood and every year, river toe cutting happening by the Kapadi Gaad (Shown in photo 1).

Furthermore, according to the local consultation and the questionnaire survey, fire hazard and increasing draught are common in all over the sub-watershed level. About 82% respondent said fire was frequently occurred every year during the drying season, while about 81% of the total respondent said drought is common in the present scenario. Moreover, there were only 28% respondent said that flood is occurred during monsoon season only. Similarly, 67% respondent

said that landslide occurred during the similar time as flood occurred. Due to the heavy rainfall during the monsoon season, the land mass are swept and also the fragile landscape and sloppy land topography caused erosion of top soil. Some sectorial impact related to climate change are listed in table 26.

Table 26: Sectorial impact related to climate change

Sectorial area	Major impact listed by the local community
Agriculture and Food security	Loos of crops due to the flood inundated and debris Less water availability for irrigation and low precipitation Introduction of new pesticides Change in rainfall timing and pattern Damaging the irrigation cannel due to the flood and landslides Increasing drought during the cropping time
Biodiversity	Increasing drought cause increase risk of fire Loss of fish habitat due to sedimentation of eroded earthen material Loss of aquatic species diversity due to the dryness of small stream/tributaries Introduction of invasive species
Water resources	Drying up of spring water sources Changing rainfall pattern cause seasonal fluctuation of spring water discharge Damaging the water supply distribution
Rural settlement and infrastructure	Damaging the rural road due to heavy rainfall and landslide Risk of rural settlement due to the landslide

Source: Field interaction

The local consultations carried out Deuli, ward one of Kapadigaad sub-watershed is mostly vulnerable from the flood, river bank cutting and landslides. Since 2040 B.S. the large flooding happened and as following 2060, 2064, and 2072 B.S. was occurred large flooding. Due to the river bank cutting, about 32 household of that area was risked from landslide. Moreover, due to the flooding in river caused inundating the agricultural lands every year and degrading the soil quality and decreasing the agricultural productivity also. Similarly, incidences of forest fire are

also on the rise though they are man-made but extended dry spells are a key contributing factor which are also on the rise mainly due to limited winter rainfall and incessant rainfall in short spells followed by dry periods (Table 27).

Table 27: Major Climate change related hazards within sub-watershed and their ranking

SN	Hazard	Ranking
1	Fire hazard	1
2	Increase drought	2
3	Landslide	3
4	Flood	4
5	Drying up of water sources	5

6. Proposed Plan for Sub-watershed Management

6.1. Land Use Recommendation

The distribution of agricultural land over the sub-watershed area according to the slope classification is much more important parameter for the conservation of watershed. The agricultural land in between the slope 30-60% occurs over large area i.e. 2114 ha but with less than 3% slope only has 5 ha. Interestingly, more than 700 ha lands in Kapadigaad sub-watershed are cultivated in >60% slope. This shows that the lands are most vulnerable from the human activity such as cultivation of crops that triggers soil erosion and landslides. Therefore these slopy agricultural lands are not suitable for the traditional crop farming as well as any cereal cropping activity. However, fodder and fruits trees plantation activity can prevent soil erosion and landslide. The moderate slope between 30-60% are cultivated with intensive soil erosion measures such as terrace management and proper channelization of drainage water. Areas below 30% slope cultivating land need moderate soil conservation measures for the crop production.

Forest coverage within a sub-watershed area is an important factor for a healthy sub-watershed. High forest coverage area helps to reduce soil erosion and prevent landslide in sloppy land too. The moderate slope between 30-60% occurs over large area i.e. 5176 ha of the sub-watershed. Overuse of forest resources cause increased surface soil erosion, landslide, reduced groundwater recharge rate as well as drying up of spring water source. Therefore, forest conservation activities and reforestation are needed. The details of the land treatments is shown in table 28.

Table 28: Land use recommendation as per slope classification

Code	Slope Class	Area (ha)	Recommendations
U	All Slopes	0	Protection of natural environment
Agriculture Land	<3%	5	Intensively cultivable land with some needs for soil conservation. In the river valley flood control and drainage may be needed.

	3-15%	155	Intensively cultivated land, with moderate needs for soil conservation such as maintenance of drainage and terraces. Moisture conservation measures such as shelter belt, mulching would be beneficial for better production.
	15-30%	629	Intensively cultivable land, with moderate needs for soil conservation such as maintenance of drainage and terraces. Terracing if not terraced.
	30-60%	2,114	Cultivable land, with intensive soil conservation measures needed including terracing. Terrace maintenance and proper disposal of drainage water must be undertaken. Mostly these land type will not be found.
	>60%	690	Land not suitable for cereal crop cultivation. Fruit or fodder tree plantation is recommended and should be taken under protection. Horticulture must be emphasized if terraces.
Total Agriculture Land		**3,593**	
	<30%	1,645	Production forests. Intensive forest

Forest			management for optimal use with some conservation measures is needed
	30-60%	5,176	Limited use forests. Moderate forest management with moderate conservation measures (such as selection felling system etc.) with limited use by the local population.
	>60%	2,540	Protection forests. Permanent forest protection with very little use (such as removal of old dead, dying trees) to protect water source and to prevent soil erosion is needed.
Total Forest Land		**9,361**	
Plantation		0	Managed the forest as per the objective of the plantation.
W	All Slopes	0	Protection of natural environment
WL	All Slopes	0	Protection of natural environment. Drainage improvement is essential for reclamation.
Barren Land	All Slopes	0	Protection of natural environment
Bad Lands	All Slopes	0	Conservation measures to rehabilitate the area
Landslide	All Slopes	0	Landslide treatment on the shallow seated landslide with bio-engineering techniques.
Perpetual Snow and	All Slopes	0	Protection of natural environment

Ice			
Others	All Slopes	0	Protection of natural environment
Total Area		**12,954**	

6.2. Proposed Activity and Estimated Budget

Proposed programs for on-farm soil conservation						
SN	Ward No.	Name and location	Type of work	Beneficiary (HHs)	Affected area (ha)	Estimated Budget (NRs)
1	1	BP Nagar, Thalapaani, Chimchey, Narayan khet, Syaltadi khet. Problems is that every year river bank cutting taking away the agricultural land.	Embankment, plantation	100	102	5,000,000
2	1	Possible areas of river bank cutting of agricultural lands are: Chamarikhet, Salikhet, Odatarikhet, Bagargadakhet, Kainkeht, Jogenakhet, Sakintalakhet	Embankment, plantation and bio-engineering	80	76	2,000,000
3	1	Kolagaon. Problem is landslide.	Gabion wall, plantation	32	0.50	1,000,000
4	1	Bhakunde. Problem is landslide	Plantation and bio-engineering		0.2	500,000
5	1	Rumayalkhola. Problem is landslide and land-subsidence of agricultural land	Gabion wall, plantation	30	0.5	1,500,000

6	2	Chhedakhet. Problem is river bank cutting by Kapadigaad	Embankment, plantation	15	1	300,000
7	2	Barchhain gaonkeht (upland. Babandev khola affecting the agricultural land.	Gabion wall, plantation	40	2	500,000
8	4	Mauri. Flood and landslide affecting agricultural land	Gabion wall, plantation	12	4	1,000,000
9	4	Dwalakhet. River bank cutting.	Gabion wall, plantation	20	2	400,000
10	4	Simkhet. River bank cutting.	Gabion wall, plantation	22	5	500,000
11	4	Kapadigaon. River bank cutting	Gabion wall, plantation	13	3	300,000
12	4	Dulokeht	Gabion wall, plantation	25	3	300,000
13	4	Salakhet	Gabion wall, plantation	50	2	200,000
14	4	Gataudakeht	Gabion wall, plantation	25	6	700,000
15	4	Kanerigaonkhet	Gabion wall, plantation	5	4	400,000
16	4	Chadikeht	Gabion wall, plantation	13	2	200,000
17	4	Dudhilapuntada. Landslide	Plantation and bio-engineering	22	10	150,000
18	4	Beluwakhet. Improved terrace.	Plantation, bio-engineering, dry wall	25	25	600,000
	Total Budget					**1,55,50,000**

Proposed programs for fruit tree plantation, fodder tree plantation						
SN	Ward No.	Name and location	Fruit tree plantation	Beneficiary (HHs)	Area (ha)	Estimated Budget (NRs)
1	2	Khadeuli at Gaonpalika	Walnut	25	10	500,000
2	2	Barchhaindada	Citrus variety	120	9	500,000
3	2	Rajedamuda	Orange and other citrus variety	80	3	500,000
4	1	Dang, Kola, Deuli, BP Nagar	Orange, lemon, and mausami and other citrus variety	85	3	1,000,000
5	4	Aaliwata, Bhawara	Apple, Walnut, Fodder trees	35	1	150,000
6	4	Puntada, Dudila, Maisher	Orange, mausami, lemon, other citrus, fodder trees	30	2	250,000
7	4	Rol, Ranukanda	Walnut, Timur	50	0.5	50,000
8	4	Bhujali school	Fodder trees, Timur	120	5	40,000
9	4	Dhungatikhet	Fodder trees, lemon and other citrus	10	2	150,000
10	4	Timuta	Nursery of citrus (Chukjanya)	20	5	100,000
11	4	Kumanpani muhan	Uttis, Alichi, Bayas	20	4	150,000
12	4	Bajpata school	Lemon, Mausami, Banana	150	5	300,000
13	4	Baralgaon school	Lemon, Mausami, Banana	200	4	200,000
	Total Budget					**38,90,000**

Proposed programs for forest tree plantation						
SN	Ward No.	Name and location	Type of work	Beneficiary (HHs)	Area (ha)	Estimated Budget (NRs)
1	1	BP Nagar, Deuli, Risadi, Kola, Dang, Aladi	Fodder plants, Tejpatta, Siso, Bamboos, Apil, Kimbu, Simal, Koiral, Sanan	300	10	1,000,000
2	2	Khadeuli, Chheda	Uttis, Dhupi Salla, Rai Salla, Tejpatta	50	5	800,000
3	4	Aaliwata, Bhawara, Puntuda, Timutta, Rol, Dudila, Maisher, Kumanpani muhan, Baralgaon school, Manna, Kailpaal community forest, Dhami gaun	Uttis, Kafal, Rittha, Dhupi, Tejpat, Koiralo, Bamboo, Sisau, Fodder plants, Kimbu	500	25	1,500,000
	Total Budget					**33,00,000**

Proposed programs for gully and landslide treatment						
SN	Ward No.	Name and location of landslides	Type of work	Beneficiary (HHs)	Area (ha)	Estimated Budget (NRs)
1	1	Risadi, Kola, BP Nagar	Check-dam, bio-engineering and plantation	50	1	3,500,000

2	2	Barchhaingaon, Cheda	Check-dam, bio-engineering and plantation	20	0.5	2,000,000
3	4	Khola Baralgaon	Gabion wall and plantation	50	0.5	2,500,000
4	4	Kalaruwa Community Forest Users Community	Dry wall and plantation	30	0.5	1,500,000
	Total Budget					**95,00,000**

Proposed programs for degraded land treatment						
SN	Ward No.	Name and location of landslides	Type of work	Beneficiary (HHs)	Area (ha)	Estimated Budget (NRs)
1	1	Risadi, Aladi, Deuli, Suwakhan, BP Nagar	Banning of opening grazing and control of wild fire in all the Community Forest Users Community Forests	428	214	1,500,000
2	2	Cheda, Chinne, Barchhain	Banning of opening grazing and control of wild fire in all the Community Forest Users Community Forests	53	12	1,200,000

3	4	Bajaunkot Danda	Banning of opening grazing and then plantation of fodder plants and Amriso	20	0.5	150,000
4	4	Dhamigaon Danda	Banning of opening grazing and then plantation of fodder plants and Amriso	20	1	200,000
	Total Budget					**30,50,000**

Proposed programs for irrigation channel								
SN	Ward No.	Name and location	Type of work	Types of construction	Beneficiary (HHs)	Length of Irrigation Channel	Irrigation area (ha)	Estimated Budget (NRs)
1	1	Salkhet, Syaladi, Maunodakhet, Risediko Ghatti Khet		New	80	3.5 km	26	6,000,000
2	2	Ghatte Khola		New	13	800m	2	1,472,000
3	4	Lama gada; Si Ku; Siradi	Bamboo check dam	Repair	50	2000	12	1,000,000
4	4	Aaul khet (Nuwakot)	Bamboo check dam	Repair	20	500	3	200,000

5	4	Chhadi khet irrigation channel	Check dam & Gabion wall	Repair	20	800	3	500,000
6	4	Dhane basti irrigation channel	check dam	Repair	15	800	5	300,000
7	4	Matela irrigation channel	check dam	Repair	50	1000	8	500,000
8	4	Beluwa irrigation channel	Pipe line	Repair	100	3000	1	1,000,000
9	4	Kaneri Gad irrigation channel	check dam	Repair	12	400	2	300,000
10	4	Bhujunge khet (Nuwakot)	check dam	Repair	10	500	3	250,000
	Total Budget							**1,15,22,000**

Proposed programs for water source protection					
SN	Ward No.	Name and location of landslides	Type of work	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	BP Nagar Dhungebazzar Khanepani, BP Nagar Chincharcha Sujimul Khanepani, Rumayal Khanepani, Aladi Mallagada Khanepani, Chakuda Khanepani, Risedi Galti KholaKhanepani, Budakhola Khanepani, Kola Sisne Khanepani, Saurya Urja Khanepani Kagadwin	Recharge ponds, Eye-brow Recharge pits, plantations and fencing	250	2,000,000
2	2	Chirna Khola Khanepani, Khadeuli Khola Khanepani, Cheda Khola Khanepani	Recharge ponds, Eye-brow Recharge pits, plantations and fencing	53	1,500,000
3	4	Galdikhola (Baralgaon)	Plantation, wire-mesh fencing	15	200,000
4	4	Tudekhola	Plantation, wire-mesh fencing	40	300,000
5	4	Sogada khola	Plantation, wire-mesh fencing and intake tank	20	50,000
6	4	Gudgudeli	Plantation, wire-mesh fencing and intake tank	65	300,000
7	4	Juni Khanepani Yojana	Plantation, wire-mesh fencing and intake tank	150	500,000

8	4	Ballegudi	Plantation, wire-mesh fencing and intake tank	23	250,000
	Total Budget				**51,00,000**

Proposed programs for foot trails construction						
SN	Ward No.	Name and location	Type of work	Length (m)	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	BP Nagar - Dewali - Mannakapadi	Drywall, plantation	20	428	400,000
2	2	Barau - Radi - Sairnari - Tadigada - Sirshi	Drywall, plantation	18	400	300,000
3	4	Suwakhan Deuli to Manakapadi foot trail	Dry wall and plantations	17000m	400	500,000
4	4	Simalkot to Bajpata	Expansion of foodt trail, dry wall and plantation	3000m	200	300,000
5	4	Aliwata to Bhamara and Baneti foot trail	Expansion of foodt trail, dry wall and plantation	3000m	50	300,000
	Total Budget					**18,00,000**

Proposed programs for road slope construction						
SN	Ward No.	Name and location	Length of proposed work (m)	Type of work	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	Subarkhan Devali road at Rumayal Khola in front of Bhogewan	200	Gabion wall, Drainage work and bio-engineering	250	2,000,000
2	1	BP Nagar to Ward Office Risedi	500	Drainage	178	1,500,000
3	2	Chedda to Khadeuli	300	Gabion wall, Drainage work and bio-engineering	25	500,000
4	4	Khadeuli to Timuta	100	Gabion wall, Drainage work, plantations	20	300,000
5	4	Timuta to Lamagada	300	Dry wall, Drainage, Gabion wall, plantations	60	500,000
6	4	Juni to Bajpata	500	Dry wall, Drainage, Gabion wall, plantations	100	1,000,000
7	4	Bajpata to ward office	300	Dry wall, Drainage, plantations	50	300,000
8	4	Sdigeban to Badikhet	100	Dry wall, Drainage, plantations	100	300,000

9	4	Badikhet to Garkha school	150	Dry wall, Drainage, Gabion wall, plantations	150	250,000
	Total Budget					**66,50,000**

Proposed programs for conservation pond construction						
SN	Ward No.	Name and location	Type of work	Beneficiary (HHs)	Area (ha)	Estimated Budget (NRs)
1	1	BP Nagar, Dhungebazzar, Chimche, Suzimul, Rumayalkhola, Alladi,Malaagada, Chankuda, Risedigaltikhola, Budhakhola, Kola, Sisne Khane Saurya Urja	Irrigation Ponds around households, Recharge Ponds, plantations around water sources and their wire-mesh fencing	250	40	2,000,000
2	1	Upper Risedi, Kolagaon, Rumayalgaon, Dang, Kadwani, Aladi	Irrigation ponds (new)	28	15	4,000,000
3	1	Upper Risedi, Kolagaon, Rumayalgaon, Dang, Kadwani, Aladi	Recharge ponds	28	5	2,400,000
4	2	Chinne Khola, Khadeuli Khola, Cheda Khola	Irrigation Ponds around households, Recharge Ponds, plantations around	53	20	1,500,000

			water sources and their wire-mesh fencing			
5	2	Khadeuli, Barchhain, Sishni, Barau	Irrigation ponds	200	10	2,000,000
6	3	Khadeuli, Barchhain, Sishni, Barau	Recharge ponds	200	8	1,500,000
7	4	Lekagaon Burause: Burause	Irrigation pond	13	2	500,000
8	4	Bajad	Irrigation pond	14	1	500,000
9	4	Aagida	Irrigation pond	18	2	500,000
10	4	Juni Chautara	Irrigation pond	25	3	500,000
11	4	ChaukaDanda	Irrigation pond	12	2	500,000
12	4	Timut	Irrigation pond	15	3	500,000
13	4	Garkha, Khaldanda, Rola, Kaule Kharka, Timute Paani, Khetali, Aagida, Kadetola, Deuthala	Recharge Pond	250	8	3,000,000
	Total Budget					**1,94,00,000**

Proposed programs for stream-bank protection							
SN	Ward No.	Name of location near to intervention work	Type of work	Beneficiary (HHs)	Area affected (ha)	Length of Intervention work (m)	Estimated Budget (NRs)
1	1	BP Nagar, Deuli, Runyal,	Embankment	150	700	10,000	500,000
2	4	Chheda, Timutta	Embankment	50	150	2,000	1,500,000

	Total Budget	**20,00,000**

Proposed programs for bio-diversity conservation					
SN	Ward No.	Name and location	Type of work	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	BP Nagar,	Conservation of fish, frog, crab, snake, duck, Ood, Satta maacha, Paani Ood. Conservation area declaration from Triveni to Gadseri Gad.	150	500,000
2	1	Rungel Deuli	Wild animals like wild boar, monkey feeding and destroying agricultural crops. Destroying of Kuri (wild weed plant) and use of chemicals for repelling wild animals	50	500,000
3	2	Barchhain Khanaya Tal to Kharahar	Conservation of fish, frog, crab, snake, duck, Ood, Satta maacha, Paani Ood. Conservation area declaration from Barchhain Khanaya Tal to Kharahar,	50	500,000
4	4	Khutkuli	Conservation of fish, frog, crab, tec. Conservation awareness program. Conservation area declaration.	50	500,000
	Total Budget				**20,00,000**

Proposed programs for income-generation					
SN	Ward No.	Name and location	Type of work	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	Dewali, Kola, Dang, Risedil	Livestock farming, Goat Keeping, Local Poultry farming	85	2,000,000
2	2	Khadeuli, Chheda, Barchhen	Goat Keeping, Poultry farming	30	700,000
3	4	Ranukada	Ginger and Timur	45	1,500,000
4	4	Timuta	Ginger, orange and citrus group	22	600,000
5	4	Gurgudeli, Ballejudi	Goat, Poultry, Groundnut, Soybean	100	3,000,000
6	4	Belwa, Garkha, Simalkot, Agida	Beekeeping, Goat farming, Poultry	150	3,500,000
	Total Budget				**1,13,00,000**

Proposed programs for capacity development				
SN	Ward No.	Type of work	Beneficiary (HHs)	Estimated Budget (NRs)
1	1	Discussion on environment conservation	Schools	500,000
2	1	Awareness campaign on environment and biodiversity conservation at school level	Schools	500,000

3	1	Nursery leader and nursery raising skill development training	Community	4,000,000
4	1	Commercial agriculture training	Community	1,500,000
5	2	Soil conservation training at ward and village level	Community	2,500,000
6	4	Capacity development training	Community	1,000,000
7	4	Awareness on environment conservation	Community	500,000
8	4	Awareness campaign on environment and biodiversity conservation at school level	Schools	500,000
9	4	Skill development training	Community	5,000,000
10	4	Nursery leader training (5 people)	Community	1,000,000
11	4	Commercial agriculture training	Community	1,500,000
12	4	Climate change adaptation training	Community	1,000,000
	Total Budget			**1,95,00,000**

6.2 Management Plans for Identified Problems

There were several problems identified in the sub-watershed. The core problems identified in the sub-watershed were similar to the problems generally reported in other watersheds of Nepal. There are similar problems at different altitudes such as those in lower altitudes near the rivers and those at settlements in higher altitudes near to the ridge. Similar is the problem and issues relating to the socio-economics, such as the sub-watersheds are mainly focused in agriculture as a source of income as well as for food. Therefore, reference for solution of these problems in the sub-watersheds can be considered as those already proven and practices in other similar watersheds of Nepal.

Management of problems according to specific headings i.e. water availability, water quality, water accessibility, socio-economic aspects, agricultural aspect, forest management, urbanization and various climatic and bio-physical hazards that exists inside the sub-watershed are discussed in detail. Cost estimation of most of the management activities are also calculated and discussed hereafter.

6.2.1 Water availability, accessibility and quality

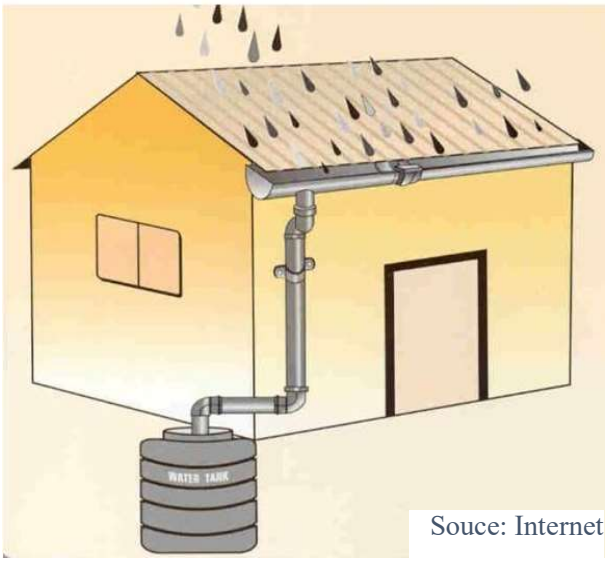
The status of water inside a sub-watershed is depicted by the availability, quality and the access. The management plans for these aspects are described hereafter.

Water Availability

Methods that will ensure water availability is discussed below:

i) Rain Water Harvesting

- Rainwater harvesting is one of the most effective methods used around the world for collection of water, mainly at places where surface water sources are limited.
- Collection of rainwater can be done in different ways and for different purposes. Placing a water tank in an open space in a convenient space will automatically collect water into it when there is precipitation.
- For household use, collecting from the rooftop of a house by directing the water through a gutter into a water tank is one of the most efficient ways.



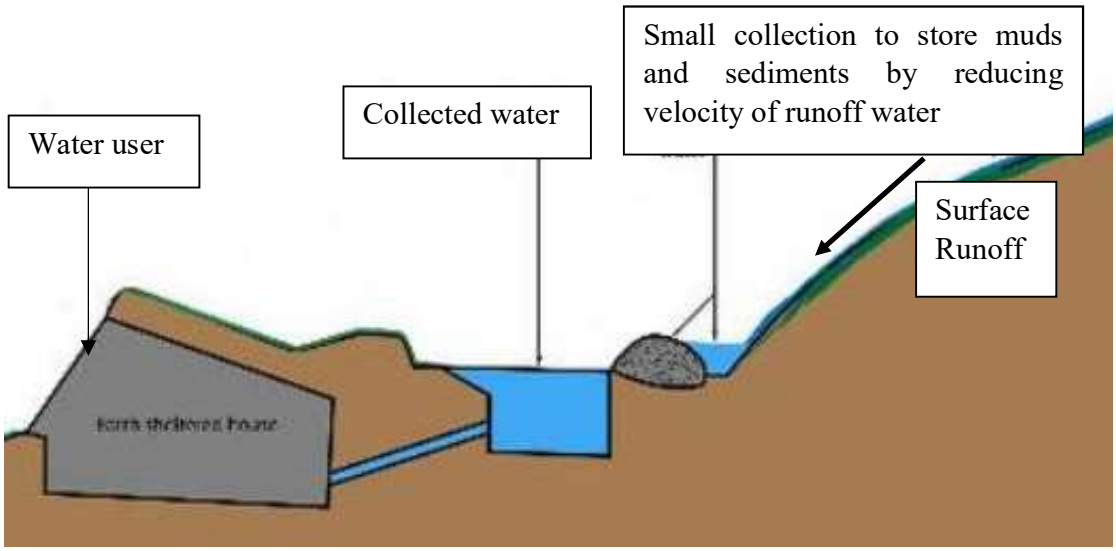
Souce: Internet

ii) Snow Water Harvesting

- The sub-watershed receives of Jorayal Rural Municipality receives snow during the winters at high altitude.
- Along with rainwater harvesting, snow water harvesting will also be very useful at Thuligaad watershed itself.
- The volume of water is roughly one third of the volume of snow when it melts. That means if a contained like the figure shown contains 3 meter of snow, when it melts, that will be equivalent to approximately 1 meter of water.
- For an area where water availability is scarce but receives snow and rain as a precipitation, these methods will be extremely efficient.

iii) Surface Runoff Harvesting

- This process is not highly in use.
- Areas that receives significant amount of rainfall during the monsoon period and snow during the winter period, there will be significant surface runoff generated.



- In the sub-watershed of Jorayal Rural Municipality, most the terrain is steep and precipitation is seasonal. Significant surface runoff will be generated which can be collected.
- Collected water can be used for irrigation purpose. As the water will have significant amount of soil in it, drinking and other household use might not be the right choice. Use of collected runoff water for Irrigation purpose will be best suitable.

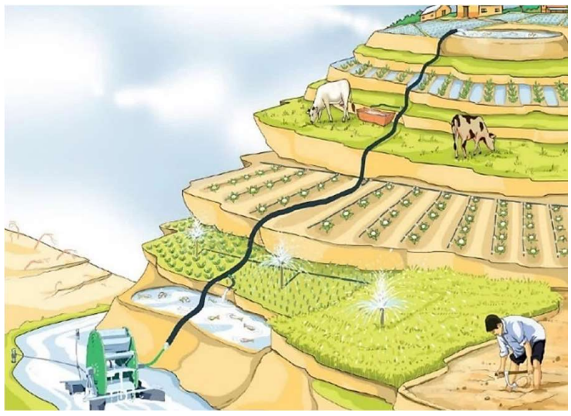
  Pumping is the most common method used at places where water is difficult to reach. Different options of pumping that should be used in the sub-watershed of Jorayal Rural Municipality is discussed hereafter.

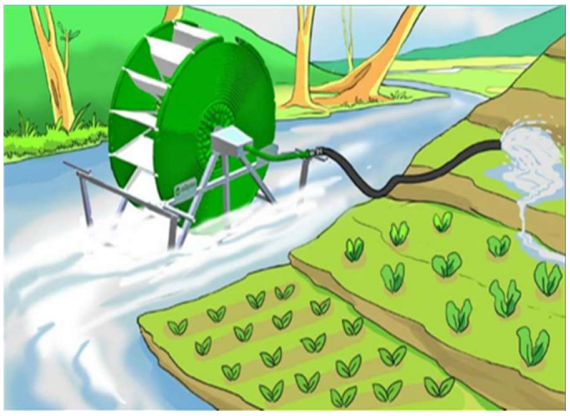
(a) Barsha Pump

- Barsha pump is the first type of hydro-powered pump developed by a Nepali company called aQysta.
- It is a water wheel propelled pump utilizes the energy from the flow of rivers and canals to pump water without requiring any fuel or electricity to be operated.
- In areas of the sub-watershed of Jorayal Rural Municipality where electricity is not accessible and using diesel pump is expensive, Barsha Pump is a very good choice.
- Depending upon the soil, crop, climatic conditions and irrigation technique, one Barsha Pump can irrigate up to 2 hectares of land. Although optional, it is recommended to use the Barsha Pump in integration with the storage system and efficient water distribution techniques such as sprinkler system, drip system, mister etc. as it helps irrigate larger area with one Barsha Pump.

- This pump is 100% environmentally friendly, as it does not produce any form of pollution
- This pump can be run 24 hours a day continuously. This makes it extremely efficient.
- Barsha pump can be used for several purpose. In appropriate places of the sub-watershed of Jorayal Rural Municipality where pollution of Rivers is affecting aquatic life, Barsha Pump can be used to fill up tanks up to 40,000 liters/day where fish farming can be done.
- Depending on the capacity, the cost of Barsha pump is about NPR 160,000 – 280,000 (*https://www.nepalitimes.com/banner/lifting-livelihoods-by-lifting-water/*). This cost is to purchase the pump. The operation cost of this pump is zero.
- According to the Barsha Pump Brochure, to irrigate 1Ha (20 Ropani) land, the operational cost of Barsha pump is Zero. The cost of electric pump is NPR 30,000 and the cost of diesel pump is NPR 73,000.

The technical aspect of Barsha pump, as provided by the manufactures themselves, is shown in figure below. More details is available in their websites *https://www.aqysta.com/products/barsha-pump/.*





		Narrow	Wide
Output [Pipe size: - 1.5 inches(40mm) for distance greater than 200 meters - 1.25 inch (32mm) otherwise]	Max. Height*	20 meters	20 meters
	Max. Distance*	2 kilometers	2 kilometers
	Max. Flow Rate*	0.5 liters/second 40,000 liters per day	0.5 liters/second 40,000 liters per day
Input Conditions Required	Min. width required	150 cm	170 cm
	Depth required	20-50 cm	20-50 cm
	Min. speed required	1 m/s	0.8 m/s
	Min. Flow rate required	300 liter/second	300 liter/second
Dimension	Width	144 cm	164 cm
	Length	179 cm	179 cm
	Height	159 cm	159 cm
	Weight	80 kg	85 kg

(b) Solar Pump

- Solar pump is a good option for places where groundwater is the source of water.
- It is a very good alternate source of energy which is completely environment friendly.
- Similar to hydro-powered pumps such as Barsha Pump, solar pumps are also highly efficient.
- According to an article writen by Sudeep Ghimire and Zulker Naeen, on average, Nepal has 6.8 sunshine hours per day with the intensity of solar radiation ranging from 3.9 to 5.1 kWh per meter square, with a commercial potential of solar power for grid connection estimated to be 2,100 MW. This means that solar can be used as a reliable sourcee of energy for pumping of water from deep aquifers as well.
- Solar water pumping technology ensures sustainable and effective access to water for irrigation, livestock watering and drinking water supply for smallholder farmers in Nepal.

- According to " Socio-Economic Assessment of Solar Irrigation System in Saptari, Nepal" by Balram Raut, Amrit Man Nakarmi and Sangeeta Singh, considering 20 years period, the lifecycle cost of solar , diesel and electric water pump are NPR 463,878, NPR 1,248,864 and NPR 181,189 respectively. Among these three systems, life cycle cost of electric is least followed by solar and lastly diesel.

- In the sub-watershed of Jorayal Rural Municipality, where electricity is not a reliable option, solar pump will be a good source instead of diesel pumps.

(c) Diesel Pump

- Diesel pump is one of the most used pumps around the world, specially at areas where groundwater is abundant in deep aquifers.
- To pump water from deep surfaces, diesel pumps are used.
- Diesel pumps are not environmentally friendly and are more costly over the period.
- In settlements at higher altitudes of the sub-watershed of Jorayal Rural Municipality, a diesel pump is in operation to pump water from sources deep inside the ground. This will be costly over a long period and will pollute the environment.

(d) Spring Water Collection

Spring water collection is one of the best ways to manage water in the sub-watershed of Jorayal Rural Municipality. As discussed under the section 4.5, there are large number of perennial spring water sources

These spring sources can be collected by various methods. One of the methods would be to use stone lined tanks at those sources. Another more practical ways would be to use the plastic water tanks that are easily available in the market and is cheaper. In addition, they are lighter in weight and can be moved when required.

Water Quality

Methods that will help improve the quality of water is described hereafter.

i) Managed deposition of excavated material

Infrastructure development works inside Thuligaad watershed and its sub-watersheds has been a priority lately. Road is one of the primary components that have been focused on. Excavation of roads have been going on for a couple of years now. Deposition of the excavated materials have not been managed. It has been dumped directly into the rivers and lands damaging the quality of water and land.

Instead of deposition of excavated soil directly into the river and land, areas can be allocated at certain intervals for deposition. Those deposited materials can be reused for other construction purpose. In this way, environment would be less polluted and the quality of water and land can be preserved.

ii) Lake water management

The water in the lakes can be polluted by various sources. Eutrophication is one of the main processes that is the result of incorporation of pollutants in the lake water.

The major reasons of Lake Water pollution are the use of fertilizers and pesticides for agricultural purpose. These chemicals contribute to the accumulation of nutrients in the Lakes. Another major reason is direct disposal of effluent discharges into the lake water. These polluting sources should be controlled to manage the water health of a Lake.

Few methods can be implemented to purify water in Lakes. They are described hereafter.

- Implementation of effective filter ecosystems to remove nitrogen and phosphorus present in the run-off water (such as phyto-purification plants).
- Reduction of phosphorous in detergents.
- Rationalization of agricultural techniques through proper planning of fertilization and use of slow release fertilizers.
- Use of alternative practices in animal husbandry to limit the production of wastewater.

In cases where water quality is already so compromised as to render any preventive initiative ineffective, curative procedures can be implemented, such as:

- Removal and treatment of hypo-limnetic water (deep-water in contact with the sediments) rich in nutrients since in direct contact with the release source.
- Oxygenation of water for restore the ecological conditions, reducing the negative effects of the eutrophic process, such as scarcity of oxygen and formation of toxic compounds deriving from the anaerobic metabolism.
- Chemical precipitation of phosphorous by the addition of iron or aluminum salts or calcium carbonate to the water, which give rise to the precipitation of the respective iron, aluminum or calcium orthophosphates, thereby reducing the negative effects related to the excessive presence of phosphorus in the sediments.

iv) Pumped water storage for aquatic life

The aquatic life in the rivers and lakes have been heavily damaged. There are people who depend on fish for their food as well as their livelihood. In order to revive this, pumping of water can be done using hydro-powered pump or solar pump and then stored into a large volume tank. These tanks can be constructed by excavating soil and then lining it with impermeable material so that it can hold the water without any loss. Fish farming can be done in these artificially created tanks. Pictures below shows such artificially created water tank for fish farming at ICIMOD Knowledge Park at Godavari, Kathmandu.

Water Accessibility

- Multiple storage tanks

Concrete tanks, plastic water tanks at more frequent places accounting certain households fulfilling their daily water use can be used for more access.

Underground water tanks can also be constructed at different locations that caters the distributed settlement inside the targeted area.

- More water outlet points

Construction of more taps well spread across an area will help people access water more efficiently.

6.2.2 Demography

Socio-economic aspect

Socio-economic aspect of a place is highly affected by the availability and quality of water. Having sufficient water of drinkable quality will make people focus more on other aspects rather than managing water for drinking as well as for daily chores. For higher altitude areas inside the sub-watershed of Jorayal Rural Municipality, water scarcity and health issues induced by water is a primary concern.

i) Management of Resources

Management of water is necessary at water scarce area. Reuse of water will help manage water in an efficient manner. Water used for household use such as washing can be used later to flush the toilet. This would reduce amount of water consumption significantly. Similarly, water collected from rain water harvesting, spring water harvesting, snow harvesting and surface runoff water collection can also be used for flushing the toilet.

ii) Public Health

Public health is a major issue the sub-watershed. Majority of the people are suffering from water induced diseases like Diarrhea. Proper measures need to be taken to reduce water borne diseases.

People need to be educated regarding the diseases caused by water and the process of purification of water so that they can minimize those diseases. The most effective way to control water borne diseases is boiling of water properly before drinking it. Another method of purifying water is chlorination of drinking water. Different chlorine-based water purifiers can be made available to the people by Rural Municipality so that it will not be financially stressful to the local stakeholders.

6.2.3 Land use and Land cover

i) Agricultural Aspect

As most of the farmers during workshop interaction and questionnaire survey have responded that there is problem of incidence of insects and pest and farmers are increasingly using chemical pesticides. In this context it is important to promote the application of locally made organic pesticides and integrated pest management approach. These are very commonly practiced in many parts of Nepal and is promoted by the government of Nepal.

Another issue in the sub-watershed is of the local water management. For this, it is important to promote protection of the water sources and plantation in the area. As water supply system is not yet developed, it is important to use available water using climate smart technologies to efficiently use the available water. Commonly practiced technologies are sprinkler irrigation, drip irrigation, development of conservation ponds, and irrigation ponds.

ii) Forest

About 85% percentage of Karnasigaad sub-watershed is covered with forests. Forest is a very important aspect for the well-being of sub-watersheds. Hence, management of forests is very important. A few methods that can be used for management of forests is discussed below.

- *Controlled Grazing*: According to the data collected from Jorayal Rural Municipality and interactions with the local people, it was clear that controlled grazing is not in practice in both the selected sub-watersheds, because of which soil erosion and deforestation were on a rise in both the sub-watersheds. There are many benefits of controlled grazing. Reduced soil erosion, improved air and water quality, better plant diversity, vigor and production, and improved wildlife and aquatic habitat.
- *Community forests*: Community forest is one of the best way to manage a forest. Planned activities like grazing, afforestation programs, planned agriculture system, planned seasonal plantation programs will keep forest managed. In addition, it enhances the socio-economic aspect of that place and reduces the chances of different hazards such as erosion, fire hazards, landslide and flood.
- *Bio Engineering*: Bioengineering is the most environmentally friendly methods to stabilize the soil. On doing so, different plants can be used to create a forest (densely afforested) area. Plants like Jute and Bamboo should be used to create a dense plantation area to regenerate or create new forest areas.

6.2.4 Urban settlement/ Infrastructure

Infrastructure development has been the main priority at the selected sub-watersheds in lifestyle and denser settlement, solid wastes will be generated proportionally. Proper disposal of these wastes must be done. Instead of deposition of wastes directly into the river, which causes water pollution, the wastes of all the household in the community could be collected at an area and then can be dumped underground. This will pollute the soil where the wastes are dumped. However, it will prevent the water resources and aquatic life, which may be beyond repair.

- Planned Settlement

Planned settlement is one of the most important aspects for developing communities. It is difficult to manage water, wastes, fossil fuel in an unplanned settlement. The denser settlement areas will

have limited access to water as well as other sources. Hence if settlements are planned and resources are managed properly, sustainably will be achieved.

- Sustainable/ Eco-friendly Infrastructures

To tackle the increasing temperature and unpredictable weather patterns, eco-friendly infrastructures is needed. More environmentally friendly infrastructure will help contribute in controlling climate change by generation of lesser pollution sources.

6.2.5 Climate and bio-physical hazard

In the selected sub-watersheds inside Jorayal Rural Municipality, there are climatic and biophysical hazards that takes place. These hazards needs to be managed properly. Management ideas of these hazards inside the selected sub-watersheds are described hereafter.

i) Landslide

Landslide is one of the recurring hazards in sub-watersheds. Thuligaad watershed receives significant amount of rainfall in the monsoon season. This induces different hazards, mainly landslide and flood. Management methods of landslide, which are suitable inside Thuligaad watershed is discussed hereafter.

a) Prevention from toe cutting by the rivers

The discharge of the river is high on the monsoon period. As the discharge is high, velocity of the river is also high. Higher velocity erodes the soil in the river banks. This causes the upper mass of the hills to be unstable and as a result the soil mass falls in the form of landslide.

This can be prevented by different river training techniques. The first step is to identify the stretch of river bank that is more likely to erode. Then different preventive measures on those identified areas can be implemented.

One of the cheapest, efficient and environmentally friendly methods would be to sculpt the river banks in a gentle slope and then cover it with boulders and stones. This would reduce the velocity of river and kill its kinetic energy responsible for erodes the soil. Picture of a river bank before and after stone lining can be seen below.

In areas where boulder lining is not possible, gabion walls and stone masonry walls can be constructed. Construction of gabion and stone masonry walls will be more expensive than that of boulder lining.

b) Stabilization by Bio-engineering

This is one of the most environmentally friendly methods to stabilize soil. Afforestation of different plants such as Jutes and Bamboos along with a good drainage network will help stabilize the soil.

This method can be used on both gentler (0-30 degrees) and steep sloped (greater than 30 degree) hills. For steep sloped hills, a retaining wall on the toe would have to be constructed and then bio-engineered on the upper side. For gentler sloped hills, proper drainage network with plantation of different plants and grass should be enough.

The figures below shows the stabilization of slopes using bioengineering techniques.

c) Terrace Farming

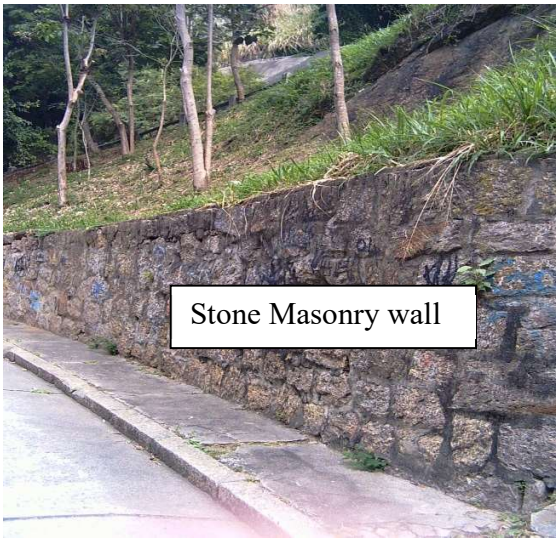
Terrace farming is one of the oldest ways that farmers have been using to manage land for agricultural purpose. This method is very efficient.

This method not only generates more agricultural lands on a steep terrain, but also stabilizes the hills from disasters like landslides and soil erosion. This method can be used in steep as well as gentler slopes. The picture below shows a typical terrace farming practise on a hill whose slope is about 45 degrees.

d) Retaining walls

Construction of retaining walls is one of the most expensive method to manage landslide. In Jorayal Rural Municipality where road excavation works is currently in progress. There are many open exposed areas near excavated roads. These areas must be stabilized using retaining walls, as

damage will be more in case of landslide. The pictures below shows different type of retaining walls constructed to stabilize soil at roadsides.

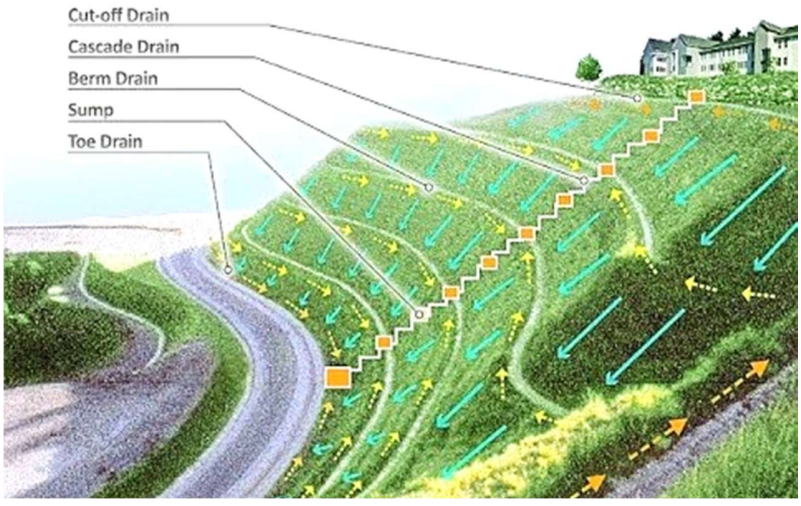


ii) Soil Erosion

Management techniques to control soil erosion inside selected sub-watersheds in Jorayal is discussed hereafter.

a) Surface drainage system

The major cause of soil erosion and landslide is unmanaged drainage system in steep as well as gentle terrains. Proper drainage network to keep the soil dry will help reduce soil erosion and the damages caused by it. The pictures shows different network of drains that should be built to keep the soil dry.



b) Sub-surface drainage system

Along with surface drainage network, sub-surface drainage network will keep the soil dry. This will reduce the chances of instability in soil mass, which will reduce soil erosion as well as landslides.

In the figures below, a typical subsurface drainage can be seen. This type of drainage system will be highly effective in Jorayal Rural Municipality as surface runoff generated is high during the monsoon period. The terrains in selected sub-watersheds are steep. A good drainage network of surface and sub-surface drainage system

Flood

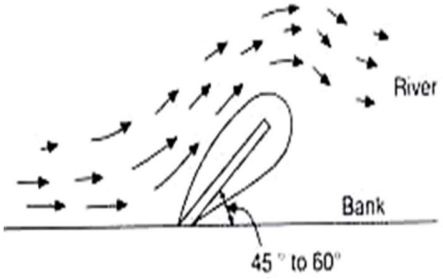
iii) River Training

Different river training structures can be constructed to manage the threat of flood. Some of the structures suitable for Jorayal Rural Municipality is discussed hereafter.

a) Dikes and Gyrones

- Construction of Dikes and Gyrones is expensive
- Dikes and Gyrones is constructed to reduce the velocity of the river and dissipate excess energy that cause high casualties.

- This will reduce the effects of floods



b) Check dams

- Construction of check dams along the length of the river helps reduce the energy of the river and control flood.
- Check dams must be constructed upstream of the area which needs prevention from flood.
- Locally available stones, boulders and gabion boxes can be used to construct check dams.
- Its construction cost is much lower than that of constructing Dikes and Gyrones.

c) Flood Wall

- This is a very effective way to prevent an area from flood.
- Floodwall should be constructed at the Riverbanks in front of any existing settlement that is likely to cause huge loss if flooded.
- Floodwall can be constructed from gabion boxes, stone masonry and concrete. In Jorayal, stone masonry walls and gabion walls are more practical instead of concrete walls.

d) Early Warning System

This is a system based on information dissemination and timely communication. Highly sophisticated system have been developed around the world for flood early warning systems that prevents heavy loss during floods.

For Jorayal, this sophisticated system is a far-fetched dream. For now, a member of the community upstream of the river should immediately inform the people living downstream as soon as the river level crossed the danger level. By doing this, severe casualties could be prevented.

Fire hazard

Fire hazard is one of the major hazards in both Jorayal Rural Municipality. On interaction with the locals and from the filled questionnaires, it can be seen that fire hazard occurs frequently in forests. The measures that can minimise fire hazards is discussed hereafter.

- *Plantation:* Plants that area perennial and have high moisture content needs to be planted more often. This will reduce the risk of dryness and possibility of catching fire significantly. Cactus will be one of the plants that grows all-round the year and contains moisture in it.
- *Public awareness:* People should be well aware that any activities related to fire should be handled carefully to avoid accidents.
- *Controlled grazing:* Over grazing inside forests, make the area dry and more likely to catch fire. So grazing needs to be controlled.

6.2.6 Others

Energy/ Hydropower

Besides the above discussed management plans, there are a few other aspects inside Karnasigaad sub-watersheds that needs to be highlighted. Those aspects are discussed hereafter.

- Renewable Energy Source: Few areas of Karnasigaad sub-watershed of Jorayal Rural Municipality have no access of electricity. Solar panels have been in use in an individual household level. Setting up a bigger solar energy system to provide electricity to all the stakeholders must be done. This will enhance the living conditions exponentially. Solar energy generated can also be connected to the national grid.

- Connection to the National Energy Grid: Currently Micro-Hydropower plants are being constructed that will be joined in the national grid and will provide electricity within sub-watershed area.

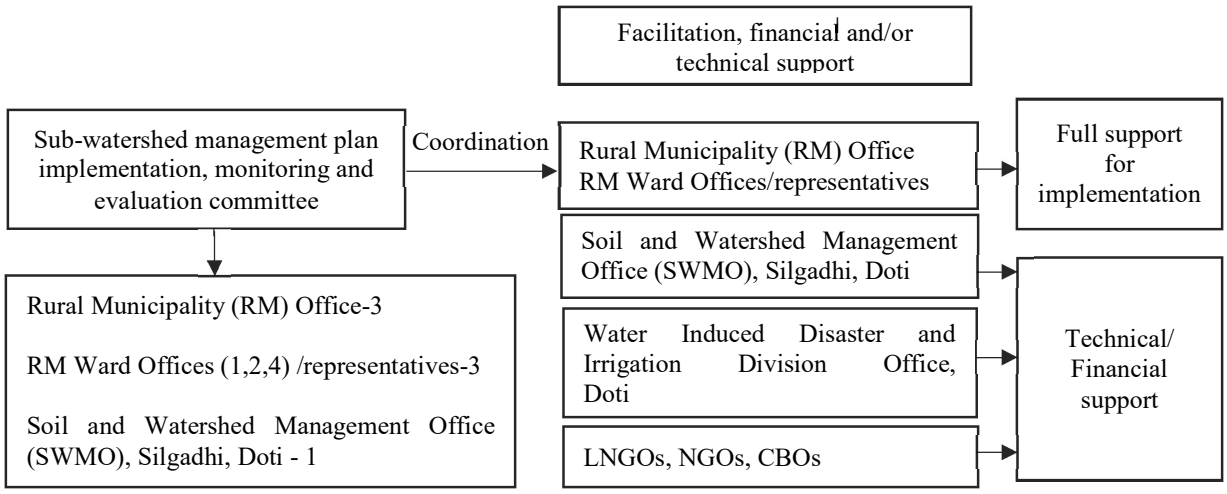
7. Implementation, Monitoring and Evaluation Mechanism

7.1. Organizational Structure

The government of Nepal established the Department of Soil and Water Conservation in 1974 under the Ministry of Forest. But later it was renamed as Department of Soil Conservation and Watershed Management (DSCWM) in 1980. The aim of this department is to engage in the implementation of the soil conservation and watershed management in all district through 61 District Soil Conservation Office. The department has been engaged actively in the planning and implementation process for soil conservation and watershed management activities. Later with restructuring of the governments in three tiers, the District Soil Conservation Office Silgadhi, Doti has been changed to Soil and Watershed Management Office (SWMO), Silgadhi, Doti in 2018 under Ministry of Industry, Tourism, Forest and Environment. Likewise, Soil and Watershed Management Office (SWMO), Silgadi, Doti, is one of the department for the soil and watershed management of five district such as Kailali, Doti, Achham, Bajura and Bajhang of Sudurpachim Province. The SWMO focused on watershed management activities such as plantation, water source protection and revival, recharge pond construction, landslide management activities, stone filled galvanized wire (*Tatbandhan*) and other integrated conservation management program. Therefore, SWMO, Silgadi, Doti will provide technical as well as financial support in planning, implementation and monitoring the sub-watershed management plan.

7.2. Implementation Mechanism

The sub-watershed management plan will be implemented with the following the principles and norms of Department of Forest and Soil Conservation (DFSC) [Former Department of Soil Conservation and Watershed Management]. Field activities will be carried out with the



Flow chart 2: Contribution agency for sub-watershed management plan

participation of local community group and youth clubs formed at the local level for the implementation. Community mobilization by the social organization and technical guidance of SWMO, will prepare an implementation plan based on existing priorities and resource available within the sub-watershed area. The implementation of the plan are based on the community capacity and resource available within the sub-watershed area. Joint contribution of community based organization, private organization and government organization following the norm, rules, management guidelines and implementation modalities of government can be more sustainable for sub-watershed management. Government offices such as ward offices, community based organizations such as forest user groups, farmer groups and water user groups are more responsible to maintain an ecological integrity and sub-watershed health.

7.3. Monitoring and Evaluation

While implementation of integrated sub-watershed management plan, monitoring and evaluation is an important tools for the measurement of success. The monitoring will be participatory approach for example participants will include from the community based organization, coordination committee, municipality and rural municipality and beneficiaries from the local stakeholders. The monitoring activity will be done in the management plan implementation site at least once for each sub-project. At the end of the project, auditing will be mandatory to maintain good understanding and trust between the local stakeholders and coordination committee and other beneficiaries.

The team of monitoring will participate in the monitoring and progress review of micro level or sub-watershed level project implementation. The focus of the monitoring and progress review will be functioning of coordination mechanism, constant fund flow and maintaining the quality and standard. At each every year, the project progress review will sharing with the monitoring committee and other local stakeholder. Sharing will help for further improve project implementation and to recommend the priorities for the next year. A monitoring plan is given in below table 29.

Table 29: Monitoring Plan

Level of monitoring	Why?	Who?	When?	How?
Micro-catchment level (Activities monitoring)	Focus on specific problem, regulating the implementation schedule, accountability	CBOs, local beneficiary and stakeholders	During the pre and ongoing progress	Public sharing and reporting and minting
Sub-watershed level (process and output level)	Maintain the work quality, continuous fund raising, progress the work quality	CBOs, representatives from the local government and government staff of local level	At least once in a year	Field visit, photograph, public hearing and presenting and quarterly report
Rural Municipality level (output and outcome)	Achievement of progress impact of project	Soil and watershed management office, representative from the local government, representative from the district and other stakeholder from the district level	At least once in a year	Field visit, photograph, joint monitoring, presenting the progress report quarterly and final report

ANNEX

I. Co-operative Limited

SN	Ward No.	Name	Address
1	1	Sunaulo Bihani Multi-Purpose Co-operative Ltd.	Dewali, Badikedar
2	1	Laxmi- Sharaswoti Multi- Co-operative Ltd.	Bipi Nagar, Badikedar
3	2	Sangalo Krishi Co-operative Ltd.	Khadeuli, Badikedar
4	2	Pragatisil Mahila Multi-purpose Co-operative Ltd.	Barchhen, Badikedar
5	2	Shree Navajagaran Mahila Krishak Co-operative Ltd.	Barchhen, Badikedar
6	4	Shree Malakapadi Multi-Purpose Co-operative Ltd.	Sukada, Badkedar

(Source: Community Survey, 2019)

II. Schools

SN	Ward No.	Name	Address
1	1	Durga Adharbhut School	Dewali, Badikedar
2	1	Janapriya Adharbhut School	Muda, Badikedar
3	1	Mohannyaleshwor Adharbhut School	Aladi, Badikedar
4	1	Laxmi Adharbhut School	Risadi, Badikedar
5	1	Shree Duna Adharbhut School	Kaibari, Badikedar
6	1	Shree Malika Adharbhut School	Patal, Badkedar
7	1	Shree Mangaleshwor Adharbhut School	Tuddkatte, Badikedar
8	2	Shree Barchhen Secondary School	Barchhen, Badikedar
9	2	Shree Kalika Adharbhut school	Chheda Badikedar
10	2	Shree Janata Adharbhut school	Bhittrikhola, Badikedar
11	2	Shree Shisu Darpan Adharbhut school	Barau, Badikedar
12	2	Shree Deveshwor Adharbhut School	Jarbuja, Badikedar

13	2	Shree Janata Adharbhut School	Sadekhaan, Badikedar
14	2	Shree Sharaswoti Adharbhut School	Shirsi, Badikedar
15	4	Melhaari Adharbhut School	Puntada, Badikedar
16	4	Shiva-Ji Adharbhut School	Bhujpali, Badikedar
17	4	Kedashwor Adharbhut School	Bajbara, Badikedar
18	4	Bishnu Adharbhut School	Baral Gad, Badikedar
19	4	Janapremi Adharbhut School	Baneti, Badikedar

(Source: Community Survey, 2019)

III. Farmer's Group

SN	Ward No.	Name	Address
1	1	Sigari farmers' Group	Alaadi, Badikedar
2	1	Pragatishil Farmers' Group	Charmchhe, Badikedar
3	2	Kalika Farmers Group	Khadyuli, Badikedar
4	2	Deaali Farmers Group	Putbesari, Badikedar
5	2	Mohannyal Farmers Group	Barmaji, Badikedar
6	2	Kasturi Farmers Group	Barchhen Dada, Badikedar
7	2	Mangaleshwor Farmers group	Garbuja, Badikedar
8	2	Laligurash Farmers Group	Puran, Badikedar
9	2	Dune Farmers Group	Chheda, Badikedar
10	2	Gangari Farmers Group	Garbuja, Badikedar
11	4	Sunaulo Kiran Farmers Group	Sukada, Badikedar
12	4	Nawagegari Farmers Group	Salakhet, Badikedar

(Source: Community Survey, 2019)

IV. Spring Source Data						
SN	Water Resources	Location	Status	Type	HHs Benefited	Discharge (lps)
1	Ponds	Chheda	No Change	Perennial	9	0.714
2	Open Spring	Chheda	Decreasing	Seasonal	12	0.625
3	Concrete Tank	Chheda	Decreasing	Perennial	13	0.625
4	Open Spring	Chheda	Decreasing	Perennial	13	0.500
5	Ponds	Gunakota	Decreasing	Seasonal	10	0.556
6	Stone Spout	Chheda	Decreasing	Perennial	9	1.000
7	Stone Spout	Chinea	No Change	Perennial	14	0.417
8	Stone Spout	Chheda	No Change	Perennial	12	0.500
9	Concrete Tank	Chimche	Decreasing	Perennial	50	0.500
10	Concrete Tank	Aladi	Decreasing	Perennial	15	5.000
11	Ponds	Aladi	Decreasing	Perennial	15	4.000
12	Open Spring	Aladi	Decreasing	Perennial	35	1.333
13	Open Spring	Khamakota	Dried Up	Seasonal	6	0.000
14	Ponds	Rumayl	Decreasing	Seasonal	3	1.000
15	Concrete Tank	Bchhain	Decreasing	Perennial	30	2.000
16	Open Spring	Bachhain	Decreasing	Perennial	4	0.417
17	Open Spring	Bachhain	Decreasing	Perennial	4	0.556
18	Stone Spout	Chine	Decreasing	Perennial	15	0.556
19	Ponds	Rumayl	Decreasing	Perennial	4	0.714
20	Open Spring	Panuta	Decreasing	Perennial	15	2.500
21	Open Spring	Legagau	Decreasing	Perennial	10	2.500
22	Open Spring	Panuta	Decreasing	Perennial	5	2.000
23	Open Spring	Burause	Decreasing	Perennial	16	3.333
24	Open Spring	Burause	Decreasing	Perennial	6	4.000
25	Open Spring	Puntada	Decreasing	Perennial	12	2.857
26	Open Spring	Melchhim	Decreasing	Perennial	4	3.333
27	Open Spring	Puntada	Decreasing	Perennial	19	2.857

28	Open Spring	Parpuntada	Decreasing	Perennial	7	0.833
29	Open Spring	Nuwakota	Decreasing	Perennial	3	0.833
30	Open Spring	Junibajar	Decreasing	Perennial	25	2.500
31	Open Spring	Ketali	Decreasing	Perennial	13	0.037
32	Ponds	Ketali	Dried Up	Seasonal	12	0.000
33	Ponds	Chaebata	Decreasing	Perennial	3	0.048
34	Open Spring	Sachhuda	Decreasing	Perennial	15	0.014
35	Open Spring	Risadi	Decreasing	Perennial	50	0.004
36	Ponds	Risadi	Decreasing	Perennial	35	0.042
37	Concrete Tank	Risadi	Decreasing	Perennial	52	0.033
38	Concrete Tank	Risadi	Decreasing	Perennial	53	0.033
39	Open Spring	Risadi	Decreasing	Perennial	12	0.048
40	Ponds	Risadi	Decreasing	Perennial	25	0.014
41	Open Spring	Timuta	Decreasing	Perennial	12	0.625
42	Open Spring	Mathemada	Decreasing	Perennial	3	0.048
43	Ponds	Budesogada	No Change	Perennial	2	0.056
44	Ponds	Bajada	Decreasing	Perennial	15	0.033
45	Stone Spout	Sogada	Decreasing	Perennial	6	0.556
46	Ponds	Khadeuli	Decreasing	Perennial	25	0.417

(Source: YAE/Paani Program, 2019)

V. Cropping Pattern

Khet (Irrigated land)												
Crops/time	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Paddy												
Wheat												
Vegetables												
Soybean												
Bari (Non-irrigated land)												
Vegetables												
Groundnut												
Ginger												
Maize												
Wheat												
Soybean												
Potato												
Mustard /lentil												

(Source: Community Survey, 2019)

VI. Soil Quality Status

SN	Ward No.	Lat (N)	Long (E)	Alt (m)	pH		Organic Matter		Total Nitrogen		Phosphorous		Potash		Texture
					Value	Class	Value (%)	Class	Value (%)	Class	Value (Kg/Ha)	Class	Value (Kg/Ha)	Class	
1	1	29.007003	80.751415	751	6.6	NN	6.395	H	0.32	H	58.45	H	259.2	M	S
2	1	29.006908	80.750299	741	7	NN	3.502	M	0.175	M	235.78	VH	160.8	M	
3	2	29.022518	80.850479	1860	5.5	SA	2.741	M	0.127	M	4.05	VH	252	M	
4	2	29.91089	80.87784	1266	6.6	NN	5.959	H	0.297	M	129.7	VH	487.2	H	
5	2	29.005921	80.833669	1549	6.1	SA	6.091	H	0.305	H	157.5	VH	926.4	VH	LS
6	2	29.023223	80.851213	1837	6	SA	0.305	VL	0.015	VL	161.4	VH	434.4	H	
7	2	29.023589	80.850622	1867	5.9	SA	6.395	H	0.32	H	120.8	L	1020	VH	
8	2	29.021659	80.848843	1922	4.8	A	6.091	H	0.305	H	17.89	VH	924	VH	LS
9	2	29.020889	80.847899	1939	5.4	A	6.395	H	0.32	H	231.81	VH	818.4	VH	
10	4	29.043497	80.865876	1246	6	SA	4.873	M	0.244	H	3.96	VL	1269.6	VH	S

11	4	29.052345	80.879353	1539	5.6	SA	3.35	M	0.168	M	5.94	VL	573.6	VH	
12	4	29.060847	80.86606	1436	5.8	SA	4.264	M	0.213	H	28.73	L	885.6	VH	
13	4	29.062022	80.850414	1350	5.4	A	3.655	M	0.183	M	4.95	VL	441.6	H	LS
14	4	29.069465	80.845124	1223	4.8	A	2.893	M	0.145	M	201.1	VH	285.6	H	
15	4	29.063735	80.855041	1421	6.4	SA	4.72	M	0.236	H	20.8	L	1250.4	VH	
16	4	29.049778	80.896335	1555	5	A	5.634	H	0.282	H	52.5	M	496.8	H	
17	4	29.049039	80.900633	1685	5	A	2.893	M	0.145	M	3.96	VL	400.8	H	
18	4	29.033843	80.859878	1441	5.6	SA	5.786	H	0.289	H	5.94	VL	628.8	VH	S

NN: Near Neutral; SA: Slightly Acidic; A: Acidic; VH: Very High; H: High; M: Medium; VL: Very Low; L: Low; S: Sandy; LS: Loamy Sandy

(Source: Soil Fertility Mapping of Doti District, 2075 by Soil Testing Laboratory, Sundarpur, Kanchanpur)