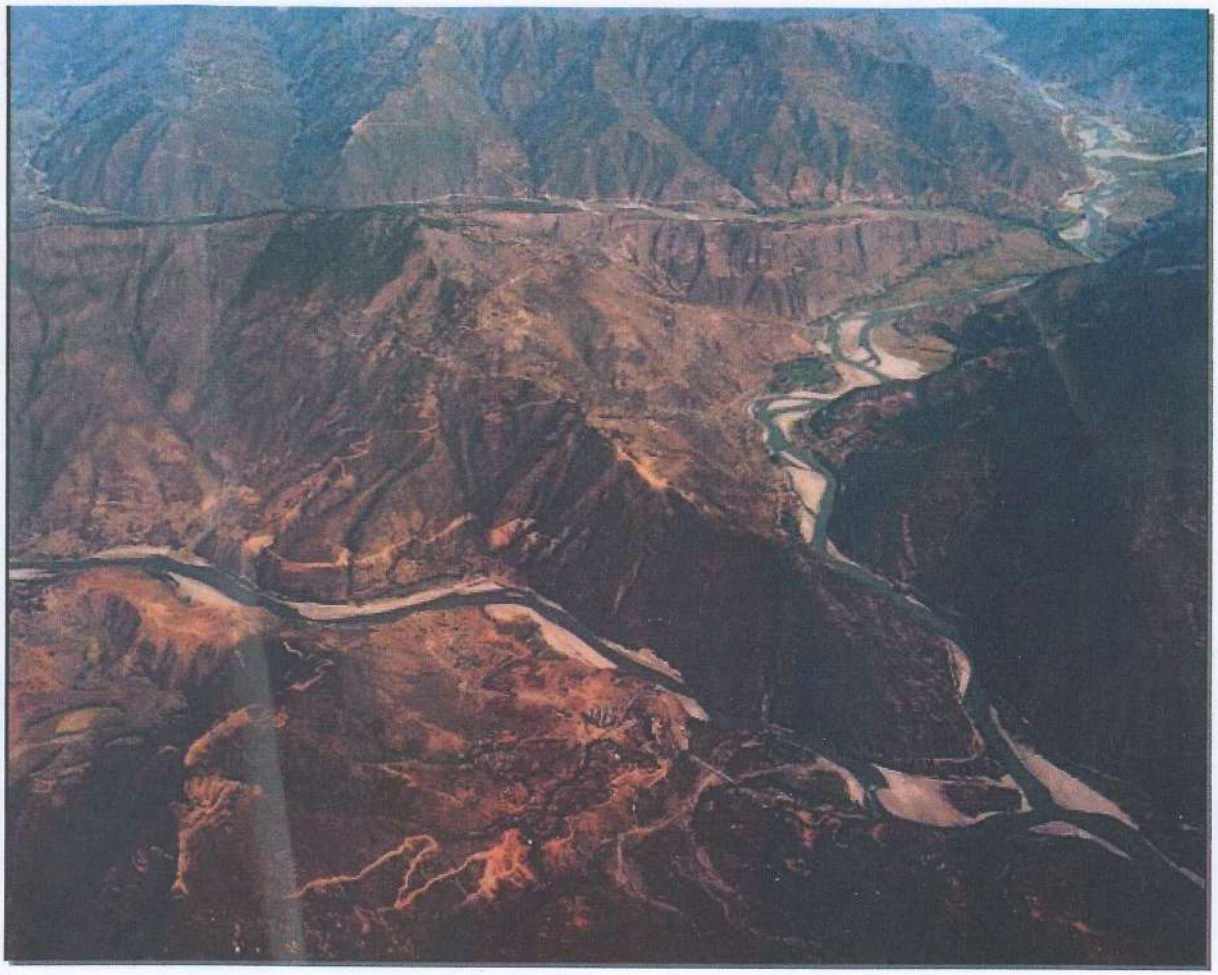
ENVIRONMENTAL IMPACT ASSESSMENT (EIA) STUDY OF

Sunkoshi Marin Diversion Multi - Purpose Project (28.62 MW)



EIA Final Report

SUBMITTED TO:
Ministry of Forests and Environment
Singh Durbar, Kathmandu

THROUGH:
Ministry of Energy, Water Resources and Irrigation
Singha Durbar, Kathmandu

Submitted by:	Prepared by:
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कार्यकारी सारांश

१. परिचय

सुनकोशी मरिन डाइभर्सन बहुउद्देश्यीय आयोजना सम्बन्धी प्रस्तावको प्रवर्द्धक जलस्रोत तथा सिंचाइ विभाग हो । यस आयोजनाको मुख्य उद्देश्य सुनकोशी नदीको पानी फर्काएर मरिन खोलामा झारी बागमती नदीको बागमती सिंचाइ मार्फत प्रदेश नं.२ को बारा, रौतहट, धनुषा, महोत्तरी, सर्लाही गरी ५ जिल्लाहरुको १२२,००० हेक्टरमा वाह्रै महिना सिंचाइ सुविधा पुऱ्याउने रहेको छ । यसको लागि सुनकोशी गाउँपालिका वडा नं ६ को सुनकोशी नदीमा १२ मि. उचाईको बाँध बाँधी ६७ क्युविक मिटर प्रति सेकेण्ड पानी १३.१ कि. मि. लामो सुरुङ्गको माध्यमबाट कमलामाई नगरपालिका बडा नं २, कुसुमटारस्थित मरिन खोलामा खसाली २८.६२ मेगावाट जलविद्युत उत्पादन गर्ने प्रस्ताव रहेको छ । मरिन खोलामा पानीको बहाव बढ्नाले कमलामाई नगरपालिकाको वडा नं १ र ४, मरिन गाउँपालिकाको वडा नं १,२,३,४,५,७ र ८, हरिहरपुर गढी गाउँपालिकाको वडा नं २,४,५,६ र ८ मा असर गर्ने छ ।

वातावरण संरक्षण नियमावली, २०५४ को नियम ३ को अनुसूची २ को ऊ(७) को अनुसार, जलाशयको पानी अन्यत्र व्यवस्थापन गर्नका लागि वातावरणीय प्रभाव मूल्याङ्कन अध्ययन गर्नु पर्ने हुन्छ । यसैगरी आयोजना क्षेत्र राष्ट्रपति चुरे तराई मधेश संरक्षण क्षेत्रमा पर्ने र आयोजनाको लागि ५ हेक्टरभन्दा बढी वन क्षेत्र आवश्यक पर्ने भएकोले नियम ३ संग सम्बन्धित अनुसूची -२ अनुसार वातावरणीय प्रभाव मूल्याङ्कन अध्ययन गर्नु पर्ने कानूनी प्रावधान रहेको छ । यी तीनै प्रावधान यस आयोजनामा लागू हुने भएकोले यो वातावरणीय प्रभाव मूल्याङ्कन प्रतिवेदन तयार गरिएको छ । यस अध्ययनले आयोजना सडकको निर्माण, निर्माण सामाग्रीहरुको सङ्कलन र भण्डारस्थलको सञ्चालन लगायत जलविद्युत निर्माणको अंश समेट्दछ । यस प्रतिवेदनले बहुउद्देश्यीय आयोजनाबाट उत्पादित विद्युतको लागि प्रशारण लाइन र सिंचाइ नहर निर्माण कार्यलाई समेटेको छैन ।

क्षेत्र निर्धारण र कार्यसूची स्वीकृति गर्ने समयमा आयोजनाको जडित क्षमता ४२.३ मे.वा. थियो । आयोजनाको सम्भाव्यता अध्ययन अनुकूल जडित क्षमता २८.६२ मे.वा. आर्थिक रुपमा किफायती र उपयुक्त पाइयो ।

२. आयोजनाको विवरण

सुनकोशी मरिन डाइभर्सन बहुउद्देश्यीय आयोजना प्रदेश नं ३ अन्तर्गत नेपालको सिन्धुली जिल्ला र रामेछाप जिल्लामा अवस्थित छ । यस आयोजनाको लक्ष्य सुनकोशी नदीको पानी बागमती नदीको एउटा सहायक मरिन नदीमा फर्काउनु हो । यसरी फर्काएको पानीबाट २८.६२ मेगावाट विद्युत उत्पादन गर्ने र विद्यमान बागमती सिंचाइ नहरको क्षमता बढाउने उद्देश्य हो । प्रस्तावित बहुउद्देश्यीय आयोजनामा विभिन्न संरचनागत पूर्वाधारहरु रहने छन् । यस आयोजना अन्तर्गत सुनकोशी गाउँपालिका वडा नं. ६, खाँडादेवी गाउँपालिका वडा नं. ४ र मन्थली नगरपालिका वडा नं. ६ क्षेत्रभित्र समुन्द्री सतह देखि ४७६ मिटरमा ३१२ हेक्टर जमिनमा एक जलाशय पोखरी बन्नेछ । यसको बाँध तथा सेडिमेन्ट पोखरी सुनकोशी गाउँपालिका वडा नं. ६ मा रहनेछ । यस आयोजनाको हेडरेस सुरुङ TBM मेशिनले निर्माण गर्ने भनी प्रस्ताव गरिएको छ ।

यस आयोजनाको मुख्य संरचनाहरुको रुपमा डाईभर्सन वियर (ब्यारेज), इन्टेक, कनेक्टिङ क्यानल, डिसेन्डिङ बेसिन, पावर कन्डुइत, हेडरेस टनेल, सर्ज टैंक, पेनस्टक, विद्युतगृह र स्विचयार्ड रहेका छन् । यस आयोजना क्षेत्र भित्र वि.पी. राजमार्गको ४२५ मिटर डुबान क्षेत्रमा र त्यस्तै प्रवेशमार्ग, डिस्यान्डर लगायत अन्य संरचनाहरु व्यवस्थापन गर्नका लागि वि.पी. राजमार्गको ४७५ मिटर प्रयोगमा आउने छ र यस्तो कारणबाट २.३ किलोमिटर राजमार्ग नयां बनाउनु पर्ने हुन्छ। उत्पादित जलविद्युत ३७.२ कि.मि. लामो डवल सर्किट प्रसारण लाइन मार्फत राष्ट्रिय ग्रीड अर्न्तगत ढल्केवर उपकेन्द्र (सव-स्टेशन) मा जोडिनेछ ।

प्रस्तावित आयोजनाको लागि कूल ३४६.८९ हेक्टर जमिन आवश्यक पर्दछ जसमध्ये ३४०.५१ हेक्टर स्थायी र ६.३९ हेक्टर अस्थायी रुपमा आवश्यक पर्दछ । स्थायी रुपमा प्रयोग हुने जमिनमध्ये ६९.४६ हेक्टर जग्गाधनी प्रमाण पुर्जा भएको निजि जमिन र १८.३७ हेक्टर जग्गाधनी प्रमाण पुर्जा नभएको जमिन प्रयोग हुनेछ । बाँ[illegible] हेक्टर सरकारी

जग्गा प्रयोग हुनेछ । जसमध्ये सरकारी वन क्षेत्र ४.४८ हेक्टर, सामुदायिक वन ३.४० हेक्टर, वुट्यान ११.५ हेक्टर, नदीले ओगटेको ५०.६८ हेक्टर र नदीको बगर १८२.६३ हेक्टर पर्दछ । आयोजनाको लागि चाहिने अस्थायी जमिनमध्ये २.०४ हेक्टर नदीको बगर क्षेत्रको जमिन र ४.३५ हेक्टर जग्गाधनी प्रमाण पुर्जा विनाको उर्वर जमिन रहेको छ ।

प्रस्तावित आयोजना निर्माण सम्पन्न हुन ५ वर्ष लाग्नेछ । प्रारम्भिक कार्यहरु जस्तै आयोजनाको टेण्डर प्रक्रिया, जग्गा प्राप्ति, क्याम्प निर्माण सुविधा र आवश्यक प्रारम्भिक पूर्वाधार निर्माणको कार्य पहिलो वर्षमा गरिने छ । ठेक्का सम्झौता भएको मितिले ४ वर्ष भित्र आयोजनाको मुख्य संरचनाहरुको निर्माण कार्य सम्पन्न हुनेछ ।

प्रस्तावित आयोजनाको लागत खर्च २०१९ को बजार भाउ अनुसार अनुमान गरिएको छ । २८.६२ मेगावाट जलविद्युत उत्पादनका लागि ने.रु. ४६,१९,३९,६५,३२१ (छयालिस अरब उन्नाइस करोड उनन्चालिस लाख पैसट्ठी हजार तीन सय एक्काइस) लाग्नेछ जस अनुसार प्रति मेगावाट मुल्य रु. १,६१,४०,४४,९१० (एक अरब एकसट्ठी करोड चालिस लाख चौवालिस हजार नौ सय दश) लाग्दछ र प्रारम्भिक अध्ययनले सिंचाइ कार्यबाट आयोजना लागतको करिव १७.०५ प्रतिशत फाइदा लिन सकिने देखाएको छ । जलविद्युत उत्पादन सम्बन्धी कार्यलाई बहुउद्देश्यीय आयोजनाको सह-उत्पादनको रुपमा लिइएको छ *र मुख्य फइदा सिंचाइ क्षेत्रबाट हुने भएकोले प्रति इकाई* विद्युत*लागत बढी देखिएको छ।*

३. अध्ययन विधि

प्रस्तुत वातावरणीय प्रभाव मूल्याङ्कन प्रतिवेदन तयार गर्दाको अवधिमा प्रकाशित एवं अप्रकाशित प्रतिवेदन र नक्शाको व्याख्याको माध्यमद्वारा सहायक सूचना सङ्कलन गरिएको थियो र आयोजना स्थलमा घरधुरी प्रश्नावली, चेकलिष्ट, नमुना सर्भेक्षण, नाँप-जाँच, प्रयोगशालामा परीक्षण, मुख्य व्यक्तिहरुको सहभागीतामा छलफल तथा अन्तरक्रिया बैठक गरी प्राथमिक तहका सूचना सामग्री सङ्कलन गरिएको थियो । उपयुक्त विधिको प्रयोग गरी प्राथमिक र सहायक सूचनाको विश्लेषण गरिएको थियो ।

विज्ञहरुको अनुभव, चेकलिष्ट, नक्शांकन जस्ता विधिको प्रयोग गरी आयोजनाका लागि लाभदायी तथा प्रतिकूल प्रभावहरुको पहिचान तथा आङ्कलन गरिएको थियो । प्रभावहरुको प्रस्तुतिकरण गर्न म्याट्रिक्सको प्रयोग गरिएको छ । प्रभावको उल्लेखनीयता मूल्याङ्कनको लागि अङ्कको प्रयोग, संरक्षण गरिएका वनस्पतिका प्रजाति सम्बन्धी सूचीको प्रयोग, अध्ययन टोलीका सदस्यहरुबीच छलफल, विज्ञहरुसँग परामर्श, राष्ट्रिय नीति, कानून तथा स्थानीय प्रचलन आदिलाई मध्यनजर गर्दै प्रभावहरुको मूल्याङ्कन गरिएको छ । ती प्रभावहरुको महत्वको बारेमा निर्णय गर्नका लागि राष्ट्रिय वातावरणीय प्रभाव मूल्याङ्कन निर्देशिकाको अवलम्बन गरिएको छ ।

विश्लेषित तथ्याङ्कको आधारमा आधारभूत वातावरणीय अवस्थालाई ध्यानमा राख्दै पहिचान गरिएका तथा आँकलन गरिएका प्रभावहरु समावेश गरी यो वातावरणीय प्रभाव मूल्याङ्कन प्रतिवेदन तयार गरिएको छ । यस प्रतिवेदनमा सकारात्मक प्रभावलाई वृद्धि गर्न र नकारात्मक प्रभावको प्रकृति हेरी न्यूनिकरण गर्ने उपायहरु वा उचित क्षतिपूर्तिको बारेमा उल्लेख गरिएको छ । साथै, वातावरण संरक्षणका उपायहरु, वातावरणीय अनुगमन तथा परीक्षणको कार्यान्वयनको लागि आवश्यक पर्ने कार्यान्वयनकारी जिम्मेवारी, व्यवस्थापन, कर्मचारी, रिपोर्टिङ्ग, बजेट तथा समन्वयको पक्ष सहितको वातावरण व्यवस्थापन योजना तयार गरिएको छ र यसलाई वातावरणीय प्रभाव मूल्याङ्कन प्रतिवेदनको अभिन्न अङ्गको रुपमा समावेश गरिएको छ ।

वातावरण संरक्षण नियमावली, २०५४ को नियम ७ (२) बमोजिम वातावरणीय प्रभाव मूल्याङ्कन प्रतिवेदनको मस्यौदा तयार भएपछि श्रावण १७, २०७६ मा कमलामाई नगरपालिका बडा नं २ मा अवस्थित कुसुमेटार सामुदायिक वनको भवनमा यस प्रतिवेदन सम्बन्धमा सार्वजनिक सुनुवाई भएको थियो । सार्वजनिक सुनुवाई हुने समय, मिति र स्थान बारेमा जानकारी दिदै वि.सं. २०७६/०४/०७ (राष्ट्रिय दैनिक हिमालय टाइम्समा) सार्वजनिक सूचना प्रकाशित गरिएको थियो र त्यस्तो सूचना विभिन्न संस्थाहरु, सम्बन्धित गाउँपालिका, जिल्ला कार्यालयहरु लगायतका संस्थाहरुमा पत्र टॉस गरिएको थियो । साथै तत्सम्बन्धमा मुचुल्का समेत उठाइएको थियो । सार्वजनिक सुनुवाईबाट प्राप्त सुझावको आधारमा यस प्रतिवेदनलाई अन्तिम रुप दिएपछि आयोजना कार्यान्वयन हुन विभिन्न नगरपालिका तथा गाउँपालिकाहरुबाट सिफारिस पत्र लिई यसै प्रतिवेदनमा संलग्न गरिएको छ । यसैगरी प्रभावित सामुदायिक वनबाट आयोजना कार्यान्वयनका लागि सिफारिस पत्र सहित सङ्कलन गरिएको छ ।

४. नीति, कानून र निर्देशिकाहरू

वातावरणीय प्रभाव मूल्याङ्कन अध्ययनका क्रममा यो प्रतिवेदन तयार गर्दा आवधिक योजना, विषयगत नीति तथा रणनीतिमा उल्लेख भएका वातावरण, वन, जलविद्युत विकास सम्बन्धमा विद्यमान योजना तथा नीतिहरुको विस्तृत समिक्षा गरिएको छ । यस आयोजनाको लागि जलविद्युत विकास नीति, २०५८ लाई छाता नीतिको रुपमा रहेको छ । यसका अतिरिक्त, यो प्रतिवेदन तयार गर्दा जलस्रोत रणनीति, नेपाल जैविक विविधता रणनीति एवं राष्ट्रिय जल योजनाको पनि समिक्षा गरिएको छ ।

आयोजना कार्यान्वयन गर्दा अवलम्वन गर्नुपर्ने सम्बन्धित कानूनहरुको पनि यस प्रतिवेदनमा विस्तृत समिक्षा गरिएको छ । यो आयोजना कार्यान्वयन गर्दा वातावरण संरक्षण ऐन, २०७६ वातावरण संरक्षण ऐन, २०५३ र वातावरण संरक्षण नियमावली, २०५४ जलश्रोत ऐन, २०४८ र नियमावली, २०४९ विद्युत ऐन, २०४९ र विद्युत ऐन नियमावली, २०४९ वन ऐन २०७६ तथा वन नियमावली २०५१ का विभिन्न प्रावधानहरु आकर्षित हुनेछन् र तिनको परिपालना गरिनेछ । यस्का अतिरिक्त भूमि ऐन २०२०, र अन्तर सरकारी वित्त व्यवस्थापन ऐन, २०७४, जलचर संरक्षण ऐन, २०१८ जग्गा प्राप्ती ऐन, २०३४ विस्फोटक पदार्थ ऐन, २०१८ तथा सार्वजनिक सडक ऐन, २०३४ लगायत प्रजातिको संरक्षण सम्बन्धी महासन्धिहरुको पनि समिक्षा गरिएको छ ।

यस प्रतिवेदन तयार गर्दा जलस्रोत र वन क्षेत्रसँग सम्बन्धित वातावरणीय प्रभाव मूल्याङ्कन निर्देशिका तथा दिग्दर्शनहरुको पनि विस्तृत रुपमा उपयोग गरिएको छ । यसैगरी गाउँपालिका तथा जिल्लास्तरीय तथा केन्द्रीय तहका संस्था जस्ता स्थानीय सरकार एवम् वन तथा वातावरण मन्त्रालय र ऊर्जा, जलस्रोत तथा सिंचाइ मन्त्रालय जस्ता केन्द्रीय स्तरका निकायहरुको भूमिका साथै जिम्मेवारीहरुको पनि समिक्षा गरिएको छ ।

विद्यमान नीति तथा रणनीति, वातावरणसंग सम्बन्धित कानुन, निर्देशिका तथा दिग्दर्शनहरु लगायत वातावरणीय प्रभाव मूल्याङ्कनको आधारभूत सिद्धान्त र अभ्यास बमोजिम समेत आयोजनाको कार्यान्वयन गर्दा वातावरणमा पर्न सक्ने प्रतिकूल प्रभावहरुलाई हटाउने/न्यूनिकरण गर्ने वा क्षतिपूर्ति दिने व्यवस्थाका लागि आयोजनामा वातावरण संरक्षणका उपायहरु समायोजन गर्न प्रस्तावकलाई जिम्मेवार हुने भएकोले सम्भव भएसम्म यी कुराहरुलाई ध्यानमा राखी यो प्रतिवेदन तयार गरिएको छ ।

५. विद्यमान वातावरणीय अवस्था

भौतिक वातावरण: यो आयोजना क्षेत्र नेपालको प्रदेश नं ३ अर्न्तगत रामेछाप र सिन्धुली जिल्लामा समुद्र सतहबाट ३९० देखि ४९० मिटरबीचको क्षेत्रमा पर्दछ । यस आयोजनाको न्यूनतम तह विद्युत गृह क्षेत्रको टेलरेसको ४१०.० मिटर रहेको छ, र जलाशयको पानीको तह (उच्चतम) ४७४.० मिटरमा रहेको छ । यस आयोजना क्षेत्रमा सामान्य उष्ण मौसम रहेको र अधिकतम तापमान २७.६° देखि ३७.५° सेल्सियस छ र जाडोयाममा यहाँको तापक्रम ३.४° देखि २०.७° सेल्सियस रहेको छ । यहाँ वार्षिक सरदर १५८६ मिलिमिटर पानी पर्दछ ।

सुनकोशी नदी कोशी नदीको एक महत्वपुर्ण सहायक नदी हो । वार्षिक बहाव अगष्ट महिनामा सरदर अधिकतम १७५०.५ घनमिटर प्रति सेकेन्ड रहेको छ भने न्युनतम ८५.८ घनमिटर प्रति सेकेन्ड मार्च महिनामा अनुमान गरिएको छ । यो नदीको औसत वार्षिक बहाब र यो आयोजनाभन्दा अरु आयोजनाहरुको सम्भाव्यतालाई मध्यनजर गरी यस आयोजनाको डिजाइन बहाव ६७ क्युमेकस सिफारिस भएको छ ।

यस आयोजना क्षेत्रको प्रवेशमार्ग रानीमाता बनौटसंग सम्बन्धित छ, विद्युतगृह सिवालिक चट्टानसंग जोडिएको छ । रानीमाता बनौट बाक्लोबाट पातला हुदै गएको, राम्रो उज्जाउ हुने, धुसर क्षेत्र हुदै हरियाली, कडा चट्टान र यस्को तल्लो शिवालिक बालुवा ढुंगा र माटो ढुंगाले बनेको छ ।

आयोजना क्षेत्रले जमिन भिरालो हुने कुनै सम्भाव्य जोखिम निम्त्याउदैन । सडक करिडोर लगायत आयोजना क्षेत्रको विभिन्न संरचना रहने क्षेत्रमा अस्थिर रुपमा जमिन भिरालो हुने सम्भावना रहने छैन । भिरालो भाग खासगरी मध्यमस्तरको छ र भौगर्भिक अवस्थाले समेत आयोजनाको सरंचनाको लागि राम्रो आधार स्थापना गर्नका लागि सतहको गहिराइ कम

र जमिनको अवस्था अग्लो होचो रहेको पाइन्छ। यस नदीमा बार्षिक थिग्रो (थिग्रिने पदार्थ) को भार अन्दाजी १८,९७६,०५६ घनमिटर रहेको छ जसमध्ये करिब ८७ प्रतिशत पानीसंग घुलमलिएको (Suspended sediment) आंकलन गरिएको छ।

आयोजना क्षेत्रमा कुनै औद्योगिक गतिविधिहरु सञ्चालन भएका छैनन र ग्रामिण प्रकृतिको छ। स्थलगत निरीक्षणको आधारमा त्यहाँ पानीको गुणस्तर बिगार्ने खालको कुनै पनि क्रियाकलाप देखिदैन। साथै ध्वनिको उच्च तह र वायु प्रदूषण समेतको समस्या देखिदैंन।

हिमनदी र हिमतालको लगत अध्ययन अनुसार, अन्तरराष्ट्रिय एकीकृत पर्वतीय विकास केन्द्र (ICIMOD) ले सन् २०१५ मा प्रकाशन गरेको हिमताल अकस्मात फुटेर तल्लो तटीय क्षेत्रमा आउने बाढी सम्बन्धी अध्ययन प्रतिवेदन अनुसार सुनकोशी नदी र तामाकोशी नदीमा विभिन्न हिमतालहरु मिसिएका छन्। सुनकोशी नदीमा च्छो रोल्पा जस्ता केहि हिमतालको आकार (क्षेत्रफल) असामान्य बृद्धि भएको तथा केही हिमतालको विष्फोटन भैसकेको सन्दर्भमा यो नदीको जलाधारमा रहेका हिमतालहरुको बारेमा सामयिक जानकारी राख्नु अनिवार्य भएको छ। च्छो रोल्पा तालमा ३ मिटर घटाईएको तथा तालको आउटलेटमा च्यानल निर्माण गरिए तापनि अझैपनि खतरनाक अवस्थामा रहेको छ। ICIMOD को मोडलिङ नतिजा अनुसार तालको तल्लो क्षेत्रमा flood routing फरक फरक भएको पाईएको छ।

बिभिन्न श्रोतहरु (USGS) बाट हाल अद्यावधिक गरिएको भूकम्पीय नक्साकंनले यो आयोजना सामान्य सम्भाव्य जोखिम सहित ६ देखि ७ क्षेत्रको बीचमा अवस्थित छ। सिफारिस गरिएको PGA बाँधस्थलको लागी ०.२७ g रहेको छ भने विद्युतगृहको लागि ०.२५ g देखि ०.२७ g रहेको छ।

जैविक वातावरण: आयोजना क्षेत्रका वन क्षेत्रमा साल, खैर, सिसौ, कर्मा लगायत अन्य मिश्रित खालका रुख विरुवा पाइन्छ। यो आयोजना कार्यान्वयन हुने क्षेत्र विशेष गरि सुनकोशी वा तामाकोशी नदीले डुवान गरेको क्षेत्र पर्दछ हेडवर्क्स, सर्ज टैंक, विद्युतगृह, पेनस्टक पाइप, काम गर्ने शिविर, फोहोर संकलन केन्द्र जस्ता आयोजनका संरचनाहरु वन क्षेत्रमा रहने छन्। यी संरचना रहने क्षेत्रमा खासगरी खैर, सिसौ, सिमलको संख्या अत्यधिक रहेको छ। डुवान क्षेत्र यस्को मुख्य अध्ययनको क्षेत्र हो। यस क्षेत्रको खासगरी नदी किनारमा र निजी खेतमा त्यत्तिकै उम्रिएका स-साना वा बाढी पश्चात उम्रिएका वनस्पति पाइन्छन। विद्युतगृह क्षेत्र उष्ण प्रदेशिय क्षेत्र देखि मध्य उष्ण प्रदेशिय क्षेत्र भित्र रहेको साल जङ्गल भित्र रहने छ।

वनक्षेत्र चरण स्थलका रुपमा साथै घाँस दाउरा, काठ र मुढा संकलनमा प्रयोग गरिएको छ। सो वन क्षेत्रमा विभिन्न प्रजातिका गैह्रकाष्ठ वन पैदावार (NTFP) पाइन्छन्। हाल यी गैह्रकाष्ठ वन पैदावार (NTFP) कुनै पनि व्यापारिक प्रयोजनमा आएका छैनन् तर व्यापारिक हिसावले उत्पादनको सम्भावना रहेको भने छ।

स्थानीय मानिसले बताए अनुसार यी वन क्षेत्रमा चितुवा र स्याल बारम्बार देखा पर्दछन्। स्थलगत अध्ययन (सर्भेक्षण) का आधारमा यहाँ ११ प्रजातिका स्तनधारी र त्यति नै सङ्ख्याका चराका प्रजातिहरु, ८ प्रकारका घस्ने जन्तु र सुनकोशी नदीमा ४३ प्रजातिका माछाहरु पाइन्छन्।

सामाजिक-आर्थिक तथा साँस्कृतिक वातावरण: यस आयोजनाको आयोजनाका क्षेत्र भन्नाले आयोजनाको संरचनाहरु रहने गाउँपालिका तथा नगरपालिकाहरुको वडाहरुलाई जनाउँदछ। आयोजना क्षेत्रमा कुल जनसङ्ख्या १५,८७२ र घरधुरी सङ्ख्या ३,०२६ रहेको छ तथा एक घरमा सरदर ५.२५ जना मानिस बस्दछन्। कुल जनसङ्ख्याको ५३.५० प्रतिशत मानिसहरु आर्थिकरुपले सक्रिय छन्। यी मध्ये ७३ प्रतिशत मानिस आफ्नो पूरा समय खेती किसानीमा संलग्न छन्। यहाँ तामाङ र क्षेत्री जातिको बाहुल्यता छ कूल जनसङ्ख्याको क्रमशः २२.२६ र २०.६३ प्रतिशत हुन आउँछ। त्यसपछि मगर तथा ब्राम्हणको जनसङ्ख्या रहेको छ। आयोजना क्षेत्रका ९६ प्रतिशत घर माटो, ढुङ्गा तथा काठबाट बनेको छ र टिनको छानो रहेको छ। प्रायः सबैजसोको घरधुरीको आकार सानो भए तापनि बस्नको लागि आफ्नै घर छ, गाइवस्तुको लागि तथा दाउरा, सुख्खा घाँस वा पराल राख्नको लागि छुट्टै छाप्रो छ।

यहाँ ६ वर्ष र सो भन्दा माथि उमेरको साक्षर सङ्ख्या ६५.५ प्रतिशत देखिन्छ जुन जिल्लाको सरदर ६७ प्रतिशत भन्दा कम हो। सामान्य ज्वरो, रुघाखोकी, झाडापखाला, पेटमा जुगा पर्ने तथा पेट सम्बन्धी सामान्य रोग यस क्षेत्रमा हाल देखिएका रोगहरु हुन्। आयोजना क्षेत्रका करिब ६८.८ प्रतिशत घरधुरीले वितरित खानेपानी पाएका छन्। सरसफाईको अवस्था सन्तोषजनक छ र जम्मा ४९ प्रतिशत घरधुरीले मात्र चर्पी प्रयोग गरेको पाइयो।

यस क्षेत्रमा कृषि र पशुपालन मुख्य पेशाको रुपमा रहेको छ । करिब ९२.५ प्रतिशल मानिसले अहिले पनि खाना पकाउन दाउरा प्रयोग गरेको पाइयो ।

आयोजनाबाट प्रभाव पर्ने परिवारको सामाजिक-आर्थिक स्थिति: ५३२ घरधुरीका ४,२३४ व्यक्तिहरुलाई आयोजनाबाट प्रभावित हुने परिवारको रुपमा वर्गीकरण गरिएको छ । ती परिवारहरु जग्गा अधिग्रहण भएको कारणले मात्रै आयोजना सम्बन्धी गतिविधिहरुबाट प्रत्यक्ष रूपमा प्रभावित हुनेछन् । आयोजनाले खासगरी ४४ घर (डुवान क्षेत्रमा २४ तथा विद्युत गृह क्षेत्रमा २०), ३७ टहरा (डुवान क्षेत्रमा १९ तथा विद्युत गृह क्षेत्रमा १८), ३० गोठ, ३ जेनेरेटर गृह, १५ भुमिगत इनार, २ सोलार प्यानल र यसबाट सञ्चालित १ खानेपानी आपुर्ति प्रणाली, वि.पि. राजमार्गको ९०० मिटरमा प्रत्यक्ष प्रभाव पार्नेछ । आयोजनाबाट प्रभावित परिवारको करिव ५२ प्रतिशत जनता आर्थिक दृष्टिले क्रियाशिल रहेको देखिन्छ । डुबान क्षेत्रमा बसोवास गर्ने मध्ये करिब ९० प्रतिशत मानिसहरु माझी समुदायका छन् । कुल जनसङ्ख्याको करिव ७३ प्रतिशत साक्षर छन् र २० प्रतिशतले SEE (प्रवेशिका बराबर) वा सो भन्दा माथिको शिक्षा हासिल गरेका छन् । यसैगरी आयोजनाबाट असर पर्न सक्ने करिव ७३ प्रतिशत जनता कृषि उत्पादन र पशुपालनमा पूर्ण रुपमा संलग्न भएका छन् । प्रभावित बहुसङ्ख्यक परिवारको आफ्नै घर छ ।

आयोजनाबाट प्रभावित परिवारसंग ५ रोपनी भन्दा कम जमिन रहेको छ । धान, मकै, गहुँ, फापर र कोदो यहाँको मुख्य खाद्यान्न वाली हुन् त्यसैगरी दाल, तोरि, फलफुल र सागपात नगदे वाली हुन् । प्रभावित मध्ये करिव २१ प्रतिशत परिवारले आफुलाई १ वर्षभन्दा बढी आवश्यक पर्ने खाद्यान्न आफै उत्पादन गर्दछन् । पशुपालन व्यवसायले परिवारको आयस्रोत बढाउन मुख्य योगदान दिएको छ ।

आयोजनाबाट प्रभावित परिवारको सरदर वार्षिक आम्दानी र खर्च क्रमशः ने.रु. तीन लाख नौ सय तेह्र र ने.रु. तीन लाख त्रिचालिस हजार दुई सय सोह्र रहेको देखिन्छ । आम्दानीको मुख्य श्रोत कृषि, नोकरी (जागिर), पशुपालन, बिप्रेषण तथा अन्य रहेका छन् । त्यस्ता प्रभावित परिवारले अखाद्य वस्तुमा भन्दा खानपिनको लागि बढी रकम खर्च गर्ने गरेका छन् ।

बत्ति बाल्ने ऊर्जाको मुख्य श्रोत बिजुली रहेको छ । करिब ८६.८१ प्रतिशत आयोजनाबाट प्रभावित परिवारलाई पाईप मार्फत खानेपानीको पहुँच रहेको छ भने सरसफाईको स्थीति राम्रै रहेको छ ।

आयोजनाबाट प्रभावित सबै परिवारले आयोजनाले सम्पत्ति अधिग्रहण गरे वापत क्षतिपूर्ति स्वरुप नगद क्षतिपूर्तिको आशा गरेका छन् । प्रभावित कुल परिवारहरुमध्ये ५०.९१ र ४२.५९ प्रतिशत परिवारले आयोजनाको कार्यहरुमा क्रमशः अदक्ष र दक्ष कामदारको रुपमा काम गर्न इच्छा व्यक्त गरेका छन् । सम्पुर्ण प्रभावित परिवारले अधिग्रहण गरिने सम्पत्ति बापत उचित मूआब्जालाई पहिलो प्राथमिकतामा राखेका छन्, तत्पश्चात् क्रमशः रोजगारीको अवसर, आयोजना क्षेत्रको विकास र विद्युत शक्तिको उपलब्धीमा जोड दिएका छन् ।

६. वातावरणीय प्रभावहरु

सकारात्मक प्रभावहरु

निर्माणका क्रममा आयोजनाले लगभग ८४० जना दक्ष, अर्ध-दक्ष तथा अदक्ष व्यक्तिहरुलाई रोजगारी दिनेछ । स्थानीय जनतालाई पहिलो प्राथमिकता दिइनेछ । उपलब्धताको आधारमा अदक्ष कामदार स्थानीय क्षेत्रबाटै लिने आयोजनको मनसाय रहेको छ । आयोजना अवधिमा यस क्षेत्रमा धेरै खर्च हुने हुनाले स्थानीय अर्थतन्त्रमा त्यसको अनुकूल प्रभाव पर्ने कुरा पनि प्रष्टै छ । यस आयोजनाले निर्माण सम्बन्धी सीप, आय आर्जन बढाउने सम्बन्धी तालिम तथा ज्ञान दिने एवम् प्राविधिक दक्षता बढाउन प्रभावित परिवार र स्थानीय जनतालाई प्राथमिकता दिई तालिम दिनेछ । यसैगरी यस आयोजनाले कार्यान्वयन गर्ने सामुदायिक सहयोग कार्यक्रमबाट आयोजना स्थल लाभदायी हुनेछ । ३१२ हे. जमिनमा बन्ने जलाशयमा नौका विहार लगायत अन्य पर्यटनका कायक्रम विकास गर्न सकिनेछ । माझी समुदायको परम्परागत पेशा लाई पुनर्जिवित गर्न जलाशयमा माछाका भुराहरु छोडिनेछ ।

आयोजना सञ्चालनको समयमा आयोजनाले वार्षिक २५०.५९४ गिगावाट घण्टा विद्युत उत्पादन गर्नेछ । विद्युत उत्पादन पश्चातको पानी बागमती सिंचाइ आयोजना मार्फत प्रदेश नं.२ को बारा, रौतहट, धनुषा, महोत्तरी, सर्लाही गरी ५

जिल्लाहरुको थप १२२,००० हेक्टर जमिनमा सिंचाइ सुविधा पुऱ्याउने लक्ष्य राखेको छ र खाद्यान्न उत्पादनमा व्यापक बृद्धि हुने अपेक्षा गरिएको छ । यस आयोजनाको प्रस्तावक नेपाल सरकारले नेपाल विद्युत प्राधिकरणलाई बिजुली बिक्री गर्नेछ । त्यसरी निश्चित बिजुली बिक्रीबाट प्राप्त रकम आयोजनाबाट प्रभावित प्रदेश र स्थानीय निकायका लागि छुट्याइनेछ । विद्यमान नियमानुसार जलविद्युत उत्पादनबाट प्राप्त हुने राजश्व मध्ये स्थानीय सरकारले २५ प्रतिशत, प्रदेश सरकारले २५ प्रतिशत र बाँकी ५० प्रतिशत संघिय सरकारले पाउनेछ । साथै आयोजना प्रभावित क्षेत्रमा सामुदायिक सहायता कार्यक्रम संचालन गर्नको निम्ति आयोजना लागतको ०.७५ प्रतिशत अर्थात रु. ३४.५४ करोडको व्यवस्था आयोजनाले गर्नुपर्ने हुन्छ । क्षेत्र निर्धारण र सार्वजनिक सुनूवाइको समयमा स्थानीय व्यक्ति तथा संस्थाले आयोजनामा शेयर लगानीमा ठूलो उत्साह देखाएका छन् । सर्वसाधारणको शेयर लगानी गर्न यो आयोजनालाई कम्पनी मोडलमा लग्नु पर्नेहुन्छ । आयोजनाको ३१२ हेक्टर जलाशय क्षेत्रमा आयोजनाको आवश्यक सहयोगमा नौका विहारको प्रवर्द्धन गर्न र जलाशय क्षेत्रको वरिपरी हरियाली तथा पार्कहरु बनाई पर्यटकिय स्थलको रुपमा विकास गरिने छ ।

प्रतिकूल प्रभावहरु

भौतिक वातावरण - आयोजनाबाट भौतिक वातावरणमा पर्ने प्रमुख प्रभाव ३१२ हेक्टर क्षेत्रको डुबान क्षेत्र हो । यस डुबान क्षेत्रमा पर्ने (१) २४ वटा घर , (२) १९ वटा टहरा, (३) ३ वटा पानि तान्ने घर, (४) २३०० मि. वि.पि. राजमार्ग, (५)१.५९ कि.मि. स्थानिय सडक, ७) १५ वटा ट्युववेल, ८) दुईटा सानो सोलार प्यानेल, (९) खाडाँदेवि गाउँपालिकाको बृहत खानेपानी आयोजनाको ट्युववेल, विद्युतगृह तथा सोलार प्यानेल, (१०) १६०० मि. विद्युत प्रसारण लाईन र १६ वटा पोलहरु, (११) करिब ७९४ मि. लामो सिंचाइ कुलो, (१२) ३ वटा झोलुङ्गे पुल र (१३) १ वटा समाधि स्थल लाई यस आयोजनाले प्रत्यक्ष प्रतिकूल प्रभाव पार्नेछ । साथै यस आयोजनाको विद्युत गृह निर्माण हुने क्षेत्रमा १२.३८ हेक्टर जमिन, ८०० मिटर धरान चतरा सडक र २० वटा घर र १८ टहराहरुलाई प्रतिकूल प्रभाव पर्दछ । यी संरचना बाहेक अन्य निर्माणसँग सम्बन्धित प्रभावहरु जस्तै जमिनको भू-उपयोग परिवर्तन, वायू प्रदुषण, उच्च ध्वनी प्रदुषण, निजी जग्गामा निर्माण सामाग्रीहरु थुपार्ने, Quarry सञ्चालन गर्ने, पहिरो जाने, माटो बग्ने, कामदार शिविर सञ्चालन गर्दा हुन सक्ने प्रभाव र आयोजना सञ्चालनको समयमा सुनकोशी नदीमा पानीको बहाव कम हुने र मरिन खोलामा बहाब बढ्ने जस्ता भौतिक वातावरणमा सम्भाव्य प्रतिकूल प्रभाव पर्नेछन् ।

आयोजनाको इन्टेकदेखि विद्युतगृहसम्मको सडकमा सवारी साधनको आवत-जावत एवम् निर्माण सामग्रीको ओसार-पसार गर्दा कार्वन मोनोअक्साइड, सल्फर डाइअक्साइड एवम् धुलोको मात्रा स्थानीय वायुमण्डलमा थपिने छ । आयोजना क्षेत्रमा हाल अन्य ग्याँस निष्काशन गर्ने स्रोत नभएकोले यो प्रभावको परिमाण सामान्य, स्थानीय तहसम्म र छोटो अवधिको लागि हुने आङ्कलन गरिएको छ ।

आयोजनाको वाँध निर्माण गर्दा नदीको पानी हिउँद र गृष्म महिनाको करिव ४ महिना धमिलो हुनेछ । निर्माण कार्यमा संलग्न कामदारहरुका कारण स्थानीय जनताको खानेपानी प्रणालीमा थप चाप पर्न सक्नेछ र फोहोरमैलाको निष्कासनको समस्या बढ्न सक्नेछ । फोहोरमैलाबाट नजिकै रहेको पानीको स्रोत थप प्रदूषित हुन सक्दछ ।

सुनकोशी नदीले सुन्दर प्राकृतिक दृश्यमा प्रतिकूल प्रभाव पार्न सक्दछ र नदीको रुपमा परिवर्तन गर्न सक्दछ । यसैगरी क्रसिङ्ग प्लान्टको सञ्चालनबाट धुलोको मात्रा बढ्ने छ ।

हलुका र ठूला मालवाहक सवारी साधनले प्रयोग गर्ने डिजेल र पेट्रोल, इन्जिन, गियर तथा ब्रेकबाट चुहिएको तेल तथा ग्रिज लगायत अन्य तरल पदार्थबाट जमिनमा रहेको पानी प्रदूषित हुन सक्नेछ र अक्सिजनको मात्रा घट्न गई जलीय जीवमा प्रतिकूल प्रभाव पर्नेछ ।

सुनकोशी नदीको हेडवर्क्सबाट पानी फर्काउँदा नोभेम्बरदेखि मे महिनासम्म ७ महिना पानीको मात्रा कम हुँदा तापक्रम बढ्नेछ । मरिन खोलामा पानी बढ्ने हुँदा खोलाको तापक्रम मे महिनामा ०.०९° देखि ४.३५° सेल्सियसले घट्ने आङ्कलन गरिएको छ ।

जैविक वातावरण: यस आयोजनालाई कुल सरकारी जमिन २५२.६८ हेक्टर आवश्यक पर्ने छ । जस मध्ये ४.४८ हेक्टर वन क्षेत्र, सामुदायिक वन ३.४ हेक्टर उपयोग हुनेछ र ११.५ हेक्टर बुट्यान र बाँकी २३३.३ हेक्टर नदी र बगर क्षेत्र पर्दछ

। साथै आयोजनालाई ६.३९ हेक्टर सरकारी जमिन निश्कासित फोहोर व्यवस्थापन गर्न (Disposal) को लागि आवश्यक पर्न सक्छ । निश्कासित फोहोर व्यवस्थापन गर्ने ३ वटा Disposal Site मध्ये एक(३.४६ हे.) Tail race नजिक पर्दछ भने अन्य दुई मरिन खोलाको हालको पुल भन्दा माथिल्लो क्षेत्रमा पर्दछन् । यी जमिनमा रहेका बोटविरुवामा पर्न सक्ने प्रभावको आङ्कलन गर्न सम्पुर्ण रुख तथा पोल आकारको विरुवाको गणना गरी विवरण लिइएको छ । आयोजनाले ४१६ वटा विभिन्न प्रजातिका रुखहरु र १९३९ वटा पोल आकारको विरुवालाई प्रभाव पार्नेछ । यी प्रभाव पर्ने विभिन्न प्रजातिका वनस्पतिहरु सुनकोशी नदी, तामाकोशी र मरिन खोला वरिपरि पाइन्छन् । यिनमा सिरिश र खयरका रुखलाई मुख्य क्षति पुग्नेछ ।

हेडवर्क्सको लागी ठोस बाँध बाँधी पानी लैजादा हेडवक्स देखि तल अर्को खोला नमिसिए सम्म सुनकोशी नदी क्षेत्रमा पानीको बहाव कम हुने देखिन्छ । यसले गर्दा जलीय जीवलाई नकारात्मक प्रभाव पर्ने देखिन्छ । साथै सुनकोशीको पानी मरिन खोला पठाउँदा मरिन खोलामा पानीको वहाव उल्लेख्य रुपमा बढ्ने र पानीको तापक्रम घट्ने सम्भावना देखिन्छ । जस्ले गर्दा मरिन खोलामा पाइने माछा लगायत अन्य जलिय जीवलाई सकारात्मक प्रभाव पर्ने देखिन्छ ।

आयोजना क्षेत्रमा जङ्गली जनावर, विभिन्न चरा चुरुङ्गी र सर्प, छेपारो आदी घस्ने प्राणी पाइए तापनि ती प्राणी अन्य वासस्थानमा जान सक्ने भएकाले तिनमा उलेख्य वातावरणीय प्रभाव नपर्ने आङ्कलन गरिएको छ ।

सामाजिक-आर्थिक तथा सांस्कृतिक वातावरण: आयोजना कार्यान्वयनका लागी कुल ६९.४६ हेक्टर निजी जमीन र १८.३७ हेक्टर जग्गाधनी प्रमाण पुर्जा विनाको जमिन स्थायीरुपमा प्रयोग हुने भएकोले स्थायी प्रभाव पर्दछ । खेतीयोग्य जमिनमा क्षति पुग्न जादा धान, गँहु, मकै जस्ता उत्पादन समेत घट्ने र माटोको मात्रा समेत घट्न जान्छ । यो आयोजनाबाट ४४ वटा घर (डुवान क्षेत्रमा २४ तथा विद्युत गृह क्षेत्रमा २०), ३७ वटा टहरा (डुवान क्षेत्रमा १९ तथा विद्युत गृह क्षेत्रमा १८) मा समेत प्रत्यक्ष प्रतिकूल प्रभाव पर्दछ ।

विभिन्न सामाजिक र साँस्कृतिक पृष्ठभूमि भएका मानिसहरुको कारण आयोजना स्थलमा विद्यमान स्वास्थ्य, सरसफाइ, र नीति र कानुनी समस्या आउन सक्ने आङ्कलन गरिएको छ ।

आयोजनालाई चाहिने जग्गा जमिनको संक्षिप्त विवरण

क.स.	विवरण	सरकारी जमिन	निजी जमिन	जम्मा
१	स्थायी जमिन	२५२.६८ हेक्टर	८७.८३ हेक्टर	३४०.५१ हेक्टर
२	अस्थायी जमिन	६.३९ हेक्टर	-	६.३९ हेक्टर
	कुल जम्मा			**३४६.८९ हेक्टर**

७. विकल्प विश्लेषण

विभिन्न क्षमताका विद्युत उत्पादनको विकल्प विश्लेषण गरिएको छ । आयोजना हुँदा र नहुँदाको अवस्थाको बीचमा तुलना गरिएको छ । प्रस्तावित आयोजना कार्यान्वयनको लागि वन क्षेत्र बाहेक अन्य वैकल्पिक स्थान नभएकोले वन क्षेत्रको विकल्पको विश्लेषण गर्न सकिएन । लघु विद्युत, सोलार पावर र थर्मल पावर जस्ता जलविद्युतका लागि सम्भाव्य विकल्पहरुका बारेमा समेत विचार गरिएको थियो तर यो बहुउद्देश्यीय आयोजना भएकोले ती विकल्पहरु स्वत: अनुपयुक्त देखिए ।

८. प्रभाव अभिबृद्धि र न्यूनीकरण गर्ने उपायहरु

सकारात्मक प्रभाव अधिकतम गर्ने उपायहरु

आयोजना निर्माण अवधिमा, आयोजनाबाट प्रभावित हुने परिवार तथा स्थानीय जनतालाई तोकिएको योग्यता पुगेको अवस्थामा प्राथमिकताको आधारमा रोजगारी दिइने छ। यो रोजगारीबाट आयोजनामा काम पाउने परिवारको आम्दानी बढ्ने छ। आयोजनाले ठेकेदारसँग सम्झौता गर्दा आयोजनाबाट प्रभाव पर्ने परिवार तथा स्थानीय जनतालाई प्राथमिकताको आधारमा दक्ष तथा अर्ध-दक्ष दुवै प्रकारका कामदारलाई रोजगारी दिनु पर्ने र उचित ज्याला वा तलब दिनु पर्ने र जिल्लाबाट स्वीकृत दर भन्दा नघट्ने गरी ज्याला वा तलब दिनु पर्ने कुरालाई वाध्यकारी दफाको रुपमा समावेश गरिनेछ ।

आयोजनाले, आयोजना क्षेत्र भित्र उचित स्थानहरु तोकेर उद्यमीहरुले नै फोहोर मैला व्यवस्थापन गर्ने गरी चिया पसल तथा स्थानीय उत्पादन समेत वेच्न पसल राख्न दिने व्यवस्था मिलाउने छ। आयोजनाले आयोजनाबाट प्रभाव पर्ने परिवार एवम् स्थानीय गरी ५३२ जनालाई नगदेवाली, पशुपालन तथा उद्यम विकासका सम्बन्धमा दक्षता बढाउनको लागि प्राविधिक ज्ञान र सीपमूलक तालिम प्रदान गर्नेछ।

नेपाल सरकारले स्थानीय निकायहरुको विकास कार्यक्रमको लागि निर्माण लागतको ०.७५% सामुदायिक सहयोग कार्यक्रमको लागि व्यवस्था गर्नुपर्ने प्रावधान राखेको हुँदा, प्रभावित गाउँपालिकाहरु र नगरपालिकाले भौतिक पूर्वाधार विकास, स्वास्थ्य र शिक्षाका लागि यस आयोजनाबाट रु. ३४ करोड ६५ लाख थप रकम प्रदान हुनेछ। प्राप्त रोयल्टी र सामुदायिक सहयोग कार्यक्रम अन्तर्गत प्राप्त हुने सहयोग मध्ये निर्माण समयको ५ बर्ष अवधिभरमा आयोजनाले वार्षिक रु १ करोड गरी रु ५ करोड सहयोग गर्नेछ। उक्त सहयोग प्राथमिकताको आधारमा शिक्षा, स्वास्थ्य र खानेपानी, कृषि विकास, स्थानीय वनको संरक्षण, जैविक विविधता र स्थानीय विकास सम्वन्धी गतिविधिमा प्रयोग हुनेछ। बाँकी रकम आयोजना सञ्चालन अवधिमा खर्च हुनेछ। प्रभावित गाउँपालिकाका प्रत्येक वडाको प्रतिनिधित्व हुने गरी एक समन्वय समितिको गठन गरिने छ। यो समितिले प्रभावित गाउँपालिकाको आवश्यकताहरु प्राथमिकिकरण गर्नेछ। आयोजनाबाट पर्न सक्ने र परेका अनुकूल तथा प्रतिकूल प्रभावलाई समेत विचार गरी सञ्चालन अवधिका लागि सन्तुलित रकम छुट्याइनेछ।

प्रतिकूल प्रभाव न्यूनीकरण गर्ने उपायहरु

भौतिक वातावरण: वायुको गुणस्तरमा आउने सम्भाव्य परिवर्तनलाई विचार गरी ग्राभेल तथा धुले सडकमा आयोजनाले वर्षको ४ सुख्खा महिना (फेब्रुअरी देखि मे महिनासम्म) दैनिक १ पटक पानी छर्किनेछ। आयोजनाका ३ हजार किलोमिटर गुडेका सबै सवारी साधनहरुको नियमित (मासिक) मर्मत-सम्भार हुनेछ र तिनले प्रदूषण सम्बन्धी राष्ट्रिय मापदण्डको पालना गर्नु पर्नेछ। धुलोमा काम गर्ने कामदारको लागि मास्कको व्यवस्था गरिने छ। कामदारहरुलाई आवश्यक सुरक्षित उपायहरु उपलब्ध गराइनेछ र तिनीहरुको दुर्घटना बीमा गरिनेछ। यसैगरी आयोजनामा काम गर्दा बिरामी परेमा आयोजनाले आफ्नै खर्चमा औषधोपचार गरि दिनेछ।

आयोजनाका कर्मचारी एवं कामदारको लागि राष्ट्रिय खानेपानीको मापदण्ड र विश्व स्वास्थ्य संघको निर्देशिकाको पालना हुने गरी सफा खानेपानी उपलब्ध गराइने छ। आयोजनाको क्रियाकलापबाट निस्कने सबै ठोस तथा तरल फोहोरमैलालाई सुरक्षित प्रकारले निष्कासन गरिने छ।

ध्वनीको तह कम गर्न विस्फोटक पदार्थको प्रयोगलाई न्यून गरिने छ। निर्माण क्षेत्र वाक्लो प्लाईउडले घेरिने छ। निर्माण कार्यमा संलग्न कामदारलाई कानमा लगाउने प्लग दिइने छ। कम्प्रेसर जस्ता ध्वनी बढाउने मेसिनमा ध्वनी न्यून गर्ने उपकरणको जडान गरिने छ। निर्माण क्षेत्रमा गुड्ने सवारी साधनलाई उत्पादक संस्थाको सुझाव बमोजिम नियमित रुपमा मर्मत-सम्भार गरिने छ र हर्न बजाउन समेत निषेध गरिने छ।

आवश्यक निर्माण सामग्री थन्क्याउनको लागि जग्गा भाडामा लिइने छ। निर्माण कार्यबाट निस्केका फोहोरलाई तोकिएको स्थानमा निष्कासन गरिने छ। ढलहरूको निर्माणलाई स्थायी रूपमा पानी वग्ने स्थानसम्म पुऱ्याइनेछ। काम सकिएपछि भाडामा लिएको जग्गालाई राम्ररी सम्याई पुनः प्रयोगमा ल्याउन योग्य बनाइ जग्गा धनीलाई दिइनेछ। प्रभावित खेतीयोग्य जमिनको संरक्षण गरि पुनः प्रयोगमा ल्याइनेछ।

आयोजनाको सञ्चालन तथा मर्मत-सम्भारको समयमा भिरालोपाखा भत्किएमा जैविक-इन्जिनियरिङ्ग विधिमार्फत पुनरुत्थान गरिनेछ । यसको लागि आयोजनाले आवश्यकता अनुसार बजेटको व्यवस्था गर्नेछ ।

आयोजनाले बाढी सरंक्षण योजना तयार पारेको छ । मरिन खोलाको तटबन्ध छेउछाउ देखि प्राथमिकतामा परेका दुबै साइडको ३४ किलोमिटर *तटबन्ध* आयोजनाबाट प्रभाव पर्ने खेतीयोग्य जमिनको सरंक्षण गरिनेछ । सरंचनाहरुको संरक्षण र भू-क्षय रोक्नका लागि कुल १८ वटा स्परहरु प्रस्ताव गरिएको छ । नयाँ बन्ने प्रस्तावित तटबन्धमा सुरक्षित तबरले नदीसम्म पानी बग्न सक्ने गरी जम्मा १६ वटा बाहिरी ड्रेन प्रस्ताव गरिएको छ । वाढी संरक्षण कार्यका लागि भैपरि आउने र मूल्य अभिवृद्धि कर सहित रु. एकासी करोड पाचँ लाख चौरासी हजार एक सय एकानब्बे रकम अनुमान गरिएको छ ।

सबै प्रभावित संरचनाहरु पुनर्निर्माण वा स्थानान्तरण गरिनेछ । स्थानान्तरणको लागि जम्मा अनुमानित रकम रु. बाह्र करोड उनन्तिस लाख साठी हजार लाग्ने अनुमान गरिएको छ ।

जैविक वातावरण: आयोजना सञ्चालन गर्दा वन क्षेत्रलाई पर्ने प्रभाव क्षतिपूर्ति स्वरुप रुख विरुवा नष्ट भएवापत सोधभर्ना उपलब्ध गराउनेछ । जग्गा क्षतिपूर्तिको लागि राष्ट्रिय प्राथमिकता प्राप्त योजनाको लागि राष्ट्रिय वन क्षेत्र प्रयोग सहितको मापदण्ड सहितको कार्यविधि २०७६ मूल्याङ्कन अनुसार जम्मा २५२.६८ हेक्टर जमिनका लागि रु. पच्चिस करोड उनन्साठी लाख एकासी हजार लाग्नेछ । पोल आकारका र ठूला रुख विरुवा गरी जम्मा २३५५ नष्ट हुने अनुमान गरिएको छ । क्षति पुग्ने रुख विरुवालाई १:१० का दरले वृक्षारोपण गर्नका लागि २३५५० विरुवा वृक्षारोपण गर्नु पर्ने हुन आउछ । एक हेक्टरमा १,६०० विरुवा रोप्ने गरी क्षतिपूर्ति वृक्षारोपणका लागि जम्मा १४.६८ हेक्टर जमिन आवश्यक पर्दछ । अस्थायी रुपमा लिइएको जमिन वरिपरि वृक्षारोपण गरिनेछ । यद्यपि, जम्मा १६.७६ हेक्टर जमिनमा मात्रै वृक्षारोपण गरिनेछ । वृक्षारोपणका लागि रु. एक करोड पाँच सय अन्ठाउन्न हजार आठ सय लाग्नेछ । आयोजनाले यो वृक्षारोपण गर्न डिभिजन वन कार्यालयको सहयोग लिनेछ । व्यारेज निर्माण भए पश्चात: सुनकोशी नदीले डुवान गरेको क्षेत्र वरिपरिबाट करिब १००,००० जति स्थानीय प्रजातिका माछाहरु ५ वर्षका लागि अन्यत्र सारिनेछ । यसका लागि वार्षिक स्टक बापत प्रतिवर्ष रु. एक करोड लाग्नेछ । वार्षिक रकम रु. पाँच करोड लाग्नेछ ।

तत्पश्चात् सुनकोशी नदीमा माछाको पुनरुत्थान हुने आकलन गरिएको छ । यस व्यवस्थाले लोपोन्मुख अवस्थामा पुगेका माझिहरुको व्यवसाय पुनरुत्थान हुनुका साथमा माझि समुदायको आर्थिक अवस्थामा सुधार आउनेछ ।

सामाजिक-आर्थिक तथा साँस्कृतिक वातावरण: आयोजनाबाट प्रभाव पर्ने घर परिवारहरु तथा सार्वजनिक सुनुवाइको समयमा चलन चल्तीको बजार मूल्यमा नगद क्षतिपूर्ती तर्फ जोड दिएका थिए । यो क्षतिपूर्तीको दर मुल्य नेपाल सरकारको जग्गा अधिग्रहण नियम अनुसार गठन गरिएको क्षतिपूर्ती निर्धारण समितिले निर्धारण गरे बमोजिम हुनेछ । हालको बजार मुल्य र सरकारी मूल्याङ्कनको आधारमा प्रति रोपनी रु. पाँच लाख देखि दश लाख मानी क्षतिपूर्ति रकम अनुमान गरिएको छ । विभिन्न स्थानहरुमा रहेका जम्मा ८७.८२ हेक्टर निजी जमिनका लागि क्षतिपूर्ति स्वरुप जम्मा रु. एक अरब बाइस करोड उनन्तिस लाख तेह्र हजार रकम छुट्टयाइएको छ । जग्गा प्राप्ति ऐन बमोजिम जग्गा प्राप्त गर्दा जग्गाको क्षतिपूर्ति र एक वर्षमा उत्पादन हुने अन्नवाली बराबरको रकम उपलब्ध गराउन प्रस्तावक जिम्मेवार हुन्छ । विभिन्न अन्नबालीको हालको बजार मूल्य अनुसार अन्नवाली वापत जम्मा रु. एकहत्तर लाख तेइस हजार क्षतिपूर्ति रकम पर्न आउछ ।

यस आयोजनाले डुवान क्षेत्रबाट प्रत्यक्ष प्रभाव पर्ने २४ वटा घर, १९ वटा टहरा, रामेछाप जिल्लाको २ वटा जेनेरेटर गृह र सिन्धुली जिल्लामा रहेको ४ वटा टहरा र १ वटा जेनेरेटरमा पुग्न जाने क्षति वापत क्षतिपूर्ति दिनेछ । प्रस्तावित विद्युत गृह र काम गर्न बनाइने शिविरले कमलामाई नगरपालिका स्थित कुसुमेटार क्षेत्रको २० वटा घर र १८ वटा टहरा गरी जम्मा ४४ वटा घर (डुवान क्षेत्रमा २४ तथा विद्युत गृह क्षेत्रमा २०), ३७ वटा टहरा (डुवान क्षेत्रमा १९ तथा विद्युत गृह क्षेत्रमा १८) मा प्रभाव पर्दछ । बजार मूल्यका आधारमा आयोजनाले प्रभाव पार्ने सम्पुर्ण संरचनाहरुको लागि क्षतिपुर्ती वापत रकम दिइनेछ । भवन संरचनाहरुको क्षतिपुर्ती वापत अनुमानित रकम रु. दश करोड पैसट्ठी लाख एक हजार एक सय लाग्नेछ । क्षतिपुर्तीका अतिरिक्त, घरधनीहरुले त्यसरी भत्काइएको घरबाट पुन: प्रयोगमा आउने सामाग्रीहरु नि:शुल्क लिएर जान पाउनेछन् । संक्रमणकालीन सुविधा स्वरुप एक तल्ले घरका लागि रु. बिस हजार र दुई तल्ले घरका लागि रु. तीस हजार उपलब्ध गराइनेछ । सक्रमणकालीन सुविधा स्वरुप जम्मा ३१ वटा एक तल्ले र १३ वटा दुई तल्ले घरको लागि अनुमानित रकम रु. दश लाख दश हजार लाग्नेछ । प्रत्येक परिवारलाई विस्थापन अवधिभर प्रति मासिक रुपमा

६ महिनाको अवधिका लागि प्रति महिना रु. दश हजार रकम उपलब्ध गराइनेछ । यसरी तत्कालका लागि विस्थापन स्वरुप जम्मा ४४ वटा घरका लागि रु. छब्बिस लाख चालिस हजार लाग्नेछ ।

आयोजनाबाट प्रभावित घरपरिवारहरु (PAFs) लाई क्षतिपूर्तिबाट प्राप्त हुने रकमलाई प्रभावकारी रुपमा प्रयोग गर्नका लागि परामर्श सुविधा उपलब्ध गराउने छ । यो परामर्शको लागि रु. दुई लाख छुट्याइएको छ । आयोजनाले निर्माण कार्यमा संलग्न कामदार तथा कर्मचारी र स्थानीय जनतालाई व्यावसायिक स्वास्थ्य र सुरक्षा सम्बन्धी शिक्षा दिने काम गर्नेछ । कामदारको जीवन वीमा सम्बन्धमा आयोजना निर्माण गर्ने ठेकेदारसँग गरेको सम्झौता अनिवार्य शर्तका रुपमा लागू हुनेछ छ । कामदारलाई प्रोत्साहित गर्नका लागि उनीहरुको लगनशिलता र अनुशासनलाई मध्यनजर गर्दै प्रत्येक वर्ष ५ जना कामदारहरुलाई रु. पच्चिस हजार का दरले पुरस्कृत गरिनेछ जसका लागी ५ वर्ष सम्म रु. छ लाख पच्चिस हजार छुट्याइएको छ । निर्माण कार्यको ५ वर्षको अवधिमा परियोजनाले रोजगारी उपलब्ध गराउँदा लैङ्गीक समानतालाई ध्यान दिदै आयोजना निर्माण गर्दा कुनै पनि किसिमका बाल श्रमिकको प्रयोग गर्ने छैन । दाहसंस्कार गर्नका लागि आयोजना क्षेत्रको नदी किनारमा घाट निर्माण गर्नेछ, र धार्मिक कार्य गर्नका लागि छुट्टै धारा समेत जडान गरिनेछ । यसको लागि रु. पचास लाख व्यवस्था गरिको छ । बिष्फोटनको प्रभावको सम्भावना उक्त क्षेत्रबरिपरि रहने छैन तर आयोजना गतिविधिको कारणले कुनैपनि व्यक्ति वा सरंचनामा क्षति पुग्न गएमा त्यस्को रोकथाम र क्षतिपुर्ति आयोजनाले गर्नेछ । हेडवोर्क्सबाट पानी बाहिर फाल्नु अगाडी जनमानसलाई जानकारी गराउन हेडवोर्क्सदेखि विद्युत गृहसम्म प्रत्येक एक किलोमिटर दुरी फरकमा साइरन जडान गरिनेछ ।

९. वातावरण व्यवस्थापन योजना

वातावरणीय अनुगमनका साथसाथै वातावरण संरक्षणका उपायहरु कार्यान्वयनका लागि योजना, संगठनात्मक संरचना, कर्मचारी, समन्वय संयन्त्र, रिर्पोटिङ र बजेट रहेको वातावरण व्यवस्थापन योजना तयार पारिएको छ। यसलाई कार्यान्वयन गर्नको लागि आयोजनाले एउटा छुट्टै वातावरणीय र सामाजिक व्यवस्थापन इकाई स्थापना गर्नेछ । यो इकाईको व्यवस्थापन र रेखदेख विगतमा वातावरणीय अनुगमन सम्बन्धी अनुभव हासिल गरिसकेका परामर्शदाताद्वारा गरिनेछ । यो इकाई आयोजनाको सिभिल निर्माण कार्य शुरु हुनु कम्तिमा ६ महिना अगाडी स्थापना गरिनेछ। आयोजनाले वातावरण व्यवस्थापन योजनामा उल्लेख भएका पक्षहरुलाई आयोजनाको डिजाइनलाई अन्तिम रुप दिँदा यथासम्भव एकीकृत गर्नेछ एवम् निर्माण र सञ्चालन गर्दा कार्यान्वयन गर्नेछ। आयोजनाले पूर्व-निर्माण, निर्माण तथा सञ्चालन एवम् मर्मत-सम्भार अवधिभर वातावरण संरक्षणका उपायहरु कार्यान्वयन गर्नेछ । जस अर्न्तगत निम्न सह-योजनाहरु पर्दछन ।

क) अनुमति र अनुमोदन योजना

ख) आयोजना सूचना व्यवस्थापन योजना

ग) प्रदूषण न्यूनीकरण योजना

घ) भूक्षय न्यूनीकरण र फोहोर व्यवस्थापन योजना

ङ) निर्माण शिविर र ट्राफिक व्यवस्थापन योजना

च) जीव सम्बन्धी व्यवस्थापन योजना

छ) जलचर सम्बन्धी व्यवस्थापन योजना

ज) जन स्वास्थ्य र पेशागत सुरक्षा व्यवस्थापन योजना

झ) पुर्नस्थापना व्यवस्थापन योजना

ञ) आपत्कालीन व्यवस्थापन योजना

आयोजनाले पूर्व-निर्माण, निर्माण तथा सञ्चालन एवं मर्मत-सम्भार अवधिभर वातावरण संरक्षणका उपायहरु कार्यान्वयन गर्नेछ, अनुगमनलाई संस्थागत गर्नेछ र वातावरणीय परिक्षणको आधारमा कार्यान्वयन भएका उपायहरुको प्रभावकारिता समेत मूल्याङ्कन गर्नेछ ।

योजना तर्जुमा: आयोजनाको सगंठनात्मक सरंचनाको रुपमा रहेको वातावरणीय व्यवस्थापन इकाईले के, कहाँ, कहिले, कस्ले र कति आर्थिक लगानीमा वातावरण संरक्षणका उपायहरु कार्यान्वयनमा सहयोग गर्ने तथा परिपालना र प्रभाव मूल्यांकनको अनुगमन गर्नेछ ।

संगठनात्मक संरचना: वातावरण व्यवस्थापन योजनाको कार्यान्वयनको लागि आयोजना स्थलमा आवश्यक कर्मचारी र बजेटको व्यवस्था गरी वातावरण व्यवस्थापन इकाई स्थापना गरिने छ । यो इकाईले वातावरण संरक्षणका उपायहरुको कार्यान्वयनमा सहयोग गर्ने तथा परिपालना अनुगमन गर्नुको अतिरिक्त, अभिलेख राख्ने, ठेकदारलाई प्राविधिक सेवा उपलब्ध गराउने कुराको र प्रभावको अनुगमन गर्नेछ । प्रस्तावकले वातावरण व्यवस्थापन इकाई वा स्वतन्त्र अनुगमन टोली वनाई प्रभाव अनुगमन गर्नेछ । वातावरण व्यवस्थापन इकाईका कर्मचारीले आयोजना निर्माण तथा सञ्चालनमा संलग्न कर्मचारीसंग नजिकको सम्पर्कमा रही वातावरण व्यवस्थापन योजनाको कार्यान्वयन सुनिश्चित गर्नेछन् ।

निर्देशन तथा समन्वय: विद्यमान नीति एवं कानुनको विश्लेषणको आधारमा तथा संस्थाहरुको जिम्मेवारीलाई विचार गर्दा यो आयोजना कार्यान्वयनका लागि कुनै अतिरिक्त वातावरणीय निर्देशन आवश्यक पर्ने देखिदैंन । आयोजनाले स्थानीय निकाय तथा समुदायमा आधारित संस्थाहरुसंग आवश्यक समन्वय गरी आयोजनाको कार्यान्वयन गर्न हर-सम्भव प्रयास गर्नेछ ।

प्रतिवेदन: वातावरण व्यवस्थापन इकाईले आयोजना निर्माण अवधिमा वर्षको दुई पटक र सञ्चालनको समयमा एक पटक अनुगमन प्रतिवेदन तयार गरी सम्बन्धित निकायहरुलाई पठाउनेछ । प्रभाव अनुगमन प्रतिवेदन सार्वजनिक गरिने छ ।

बजेट: वातावरण व्यवस्थापन, प्रभाव न्यूनीकरण तथा अनुगमनका लागि आयोजनाको कूल बजेटको ३.२ प्रतिशत अर्थात नेरु. एक अरब छैसट्ठी करोड तेह्र लाख दश हजार छ सय बाह्र अनुमान गरिएको छ । यसमा क्षतिपुर्ती रकम रु. एक अरब पैतिस करोड छब्बिस लाख एकासी हजार दुई सय समावेश गरिएको छैन । मरिन खोलामा बाढीको सरंरक्षण गर्न रु. एकासी करोड पाचँ लाख चौरासी हजार एक सय एकानब्बे रकम अनुमान गरिएको छ ।

१०. निष्कर्ष

बाँध निर्माणको कारणले आयोजनाले धेरै क्षेत्रफल जलमग्न बनाउँदछ । विशेषगरी यस्ले निजि सम्पत्तिमा प्रभाव पार्दछ र सार्वजनिक सम्पत्तिमा कमै प्रभाव पर्दछ । यद्यपि, यस आयोजनाबाट प्रभावित मानिस र समुदायका अलावा अन्य मानिसहरुबाट सकारात्मक प्रतिक्रिया पाइएको छ । आयोजनाले जग्गा, सम्पत्ति तथा खाद्यान्न वाली नष्ट भएवापत वा स्थानान्तरण वा विस्थापन भए वापत प्राप्त क्षतिपूर्ति स्वरुप नगद रकम दिन प्रस्ताव गरेको छ ।

यस आयोजनाले वार्षिक रुपमा २५०.५९४ गिगावाट-घण्टा विद्युत उत्पादन गर्नेछ । यसमध्ये १२५.००४ गिगावाट-घण्टा सुख्खायाममा र १२५.६९१ गिगावाट-घण्टा वर्षायाममा विद्युत उत्पादन हुनेछ । यस आयोजनाले खासगरी प्रदेश नं.२ को बारा, रौतहट, धनुषा, महोत्तरी, सर्लाही गरी तराइका ५ जिल्लाहरुका १२२,००० जमिनका लागि सिंचाइ पानी उपलब्ध गराउनेछ । वर्तमान परिप्रेक्ष्यमा, देशले खाद्यान्न संकट सामना गरिरहेको छ र खाद्यान्न आयात गरिरहनु परेको छ । खेतीयोग्य जमिनमा सिंचाइ सुविधा उपलब्ध गराउनु अहिले देशमा टड्कारो आवश्यकताको रुपमा देखिएको छ ।

यस सुनकोशी मरिन डाइभर्सन बहुउद्देश्यीय आयोजना अर्न्तगतको जलविद्युत अंशलाई यस आयोजनाको अर्को फाइदाको रुपमा लिइएको छ । तथापि विद्युत उत्पादन खर्च प्रति मेगावाट रु. एक अरब एकसट्ठी करोड चालिस लाख चवालिस हजार नौ सय दश लागत अनुमान गरिएको छ । आयोजनाको विस्तृत सम्भाव्य अध्ययनले EIRR को १७.०५ प्रतिशत र B/C ratio को १.९४ सहित आर्थिक रुपमा धान्न सकिने निष्कर्ष निकालेको छ । नेपाल सरकारले यस आयोजनालाई एउटा राष्ट्रिय प्राथमिकताको आयोजनाको रुपमा घोषणा गरेको छ ।

आयोजनाको स्वरुपलाई ध्यानमा राख्दै, यस्को स्थान, जनमानसको सकारात्मक प्रतिक्रिया, मूल्याङ्कन गरिएका वातावरणीय प्रभावको प्रकृति एवम् कार्यान्वयन गर्न सकिने व्यवहारिक प्रतिकूल प्रभाव न्यूनिकरणका उपायहरु, जलस्रोतको उपयोग एवम् वातावरण सम्बन्धी विद्यमान नीति तथा कानुनलाई ध्यानमा राख्दै, यो प्रतिवेदनमा उल्लिखित वातावरण व्यवस्थापनसंग सम्बन्धित सबै पक्षहरु पूर्ण रुपमा कार्यान्वयन हुने प्रतिवद्धता सहित यो आयोजना कार्यान्वयनको लागि सिफारिस गरिएको छ। आयोजनाको स्वीकृतिको लागि अन्य कुनै वातावरणीय अध्ययन आवश्यक देखिदैन। हाल पहिचान वा आङ्कलन गर्न नसकिएका तर आयोजना निर्माणको अवस्थामा देखा पर्न सक्ने सम्भावित वातावरणीय प्रभावहरुलाई आयोजनाले आफ्नै स्रोतमा सकेसम्म चाँडो हटाउने वा घटाउने कार्य समेत गरी यो आयोजनलाई वातावरण-मैत्री र दिगो वनाउने प्रतिवद्धता समेत गर्दछ।

EXECUTIVE SUMMARY

1. INTRODUCTION

The Proponent of this proposal is Sunkoshi Marin Diversion Multipurpose Project (SMDMP), Department of Water Resources and Irrigation. The main objectives of this project is to provide round year irrigation facilities through Bagmati Irrigation Project to 122,000 ha area of Bara, Rautahat, Dhanusha,Mahottari and Sarlahi districts of Province no. 2 by diverting water from Sunkoshi River to Marin Khola. It proposes to construct 12 m high barrage across the Sunkoshi River and divert a discharge of 67 m^3/s through 13.1 km long tunnel to Kusumtar located in Ward no. 2 of Kamalamai Municipality and generate 28.62 MW of hydroelectric power. The increase discharge in the Marin Khola is likely to affect the ward no 1 and 4 of Kamalamai Municipality, ward no 1,2,3,4,5,7 and 8 of Marin Rural Municiplaity and ward no 2,4,5,6 and 8 of Hariharpurgadi Rural Municipality.

As per the Rule 3 of the Environmental Protection Rules (1997) and its schedule 2, this EIA study has been carried out to comply with the legal provisions related to the inter basin water transfer. Since the project area is located in Chure-Terai Madhesh Conservation Area and requiring more than 5 ha of forest area, the proposed project should undergo EIA process to comply with the annex -2 of regulation 3. Thus, the EIA Report is prepared for the proposed project. The scope of this EIA study covers construction of the hydropower components, including the construction of the project roads, collection of construction materials, and operation of the quarry sites for the purpose of construction of the project. But it does not cover transmission line to evacuate the generated electricity and irrigation canal component of the multipurpose project.

The installation capacity of the project was 42.3 MW during the approval of the scoping document and terms of reference. After optimization of the project during the feasibility study, the project was found most economical and viable for 28.62 MW installed capacity

2 PROJECT DESCRIPTION

The Sunkoshi Marin Diversion Multipurpose Project (SMDMP) is located in Sindhuli and Ramechaap districts of Bagmati Province of Nepal. The project aims to divert the water of Sunkoshi River to Marin Khola, one of the tributaries of the Bagamati River. The diverted water will generate 28.62 MW of hydroelectric power and augment the discharge to the existing Bagmati Irrigation Canal. The proposed multi-purpose project consists of different structural components; inundation area within Sunkoshi Rural Municipality, Khadadevi Rural Municipality and Manthali Municipality with a ponding level at 476 m and area of 312 ha. The inundated areas lie within three local bodies, namely; ward no. 6 of Sunkoshi Rural Municipality and ward no. 4 of Khadadevi Rural Municipality and ward no. 6 of Manthali Municipality. The structure of dam and sediment tank is located at ward no 7 of Sunkoshi Rural Municipality. The headrace tunnel is proposed to be constructed by (Tunnel Boring Machine) TBM.

The main components of the project comprise of a diversion weir (barrage), intake, connecting canal, desanding basin, power conduit, headrace tunnel, surge tank, penstock, surface powerhouse and switchyard. The project is likely to affect 900 meter of BP highwayin which 425 m of B. P. Highway will be inundate and another stretch of 475 m of B. P. Highway will have to be relocated to accommodate the intake, desander and other structures. This cause 2.3 km highway to be relocated and newly constructed. The generated power is planned to be evacuated to the national grid at the Dhalkebar sub-station through 37.2 km long double circuit transmission line.

The total land area required for the project is 346.89 ha. Out of which 340.51 ha would be required permanently and 6.39 ha would be for temporary use. Of the permanent use, 69.46 ha is private land with land ownership certificate and 18.37 ha is cultivated land without land ownership certificate. Rest 252.68 ha is government land in different uses (categories). Among them government forest land is 4.48 ha and community forest is 3.40 ha, bush 11.5 ha, water way 50.68 ha and flood plain 182.63 ha. Among the land required for temporary use, 2.04 ha is river flood plain and 4.35 ha is cultivated land without land ownership certificate.

The total construction period is 5 years. All preparatory works including tender document preparation, land acquisition, construction of camp facilities and infrastructure development will be executed in the first year. The main construction work of the project is scheduled to be commissioned within 4 years duration from the award of contract.

The project cost is estimated based on the prevailing market rates of 2019. The total project cost is NRs. 46,193,965,321 (forty-six billion one hundred ninety-three million nine hundred sixty-five thousand three hundred twenty-one) for the hydropower component of 28.62 MW. The cost per MW is NRs. 1,614,044,910 (one billion six hundred fourteen million forty-four thousand nine hundred ten). The feasibility study has justified the project cost

with EIRR of 17.05 % with the benefit from the irrigation component. The hydropower component is considered as the by-product of multipurpose project. As irrigation component is the major component of the project the unit cost of hydropower component seems to be higher.

3. METHODOLOGY

During the preparation of this EIA report, secondary information was collected through published and unpublished reports and interpretation of maps, and primary information was collected using household questionnaires, checklist, sampling, survey, measurements, laboratory analysis, key informant survey, and interaction meetings in the field. Both primary and secondary information were analysed using standard methods.

Project-related beneficial and adverse Impacts were identified and predicted by employing methods such as expert judgement, checklist, and map overlays. Matrix has been used to present the impacts. Impacts were evaluated using the numerical values, list of regulated use of plant species, discussion within study team members, consultation with experts, and consideration of national policies, laws and local customs. National EIA guideline was followed for judging the significance of the impacts.

Based on the processed data, this EIA report has been prepared including impacts, which were identified and predicted taking into consideration the baseline environmental conditions. The report includes benefit augmentation measures and adverse impacts mitigation measures to enhance the beneficial impacts; and avoid, minimize and compensate adverse impacts respectively. An Environmental Management Plan (EMP) has been included as an integral part of this EIA report which focuses on the implementation of the environment protection measures, conduction of environmental monitoring and auditing along with implementation responsibilities, organization, staffing, reporting, budget, and co-ordination aspects.

In accordance with Rule 7(2) of the EPR (1997), a public hearing was held on Srawan 17, 2076 at the premises of Kusumetar Community Forest building, located at ward 2 of Kamalamai Muicipality. Public notice was published on 2076/04/07 in HimalayaTimes national daily indicating the time, date and venue for public hearing to inform stakeholders for their participation. The notice was also pasted at different institutions, concerned Municipalities, and District Offices at the Project site. The deed of the same (Muchulka) was also prepared. Recommendation letter for the project implementation was also collected from the concerned municipalities and affected community forests.

4. POLICIES, LAWS, GUIDELINES

During the EIA Study, the recent policies and plans on the environment, forests, hydropower and electricity development as included in the periodical plans, sectoral policies and strategies have been thoroughly reviewed. The Hydroelectricity Development Policy of 2001 is the umbrella policy related to this project. In addition, the Water Resources Strategy, Nepal Biodiversity Strategy and Nepal Water Plan were reviewed.

Related laws that should be complied with during the project implementation were thoroughly reviewed. While implementing this project, the provisions of the Hydropower development policy (2058), National Forest Policy (2075), EPA (2019), EPA (1997) and its Rules (1997), Water Resources Act (1992) and its Rules (1993), Electricity Act (1992) and its Rules (1993), Forest Act (2019) and Forest Rules (1995), will be attracted and should be complied with. In addition, provisions as mentioned in the Land Act (1964), Local Government Operation Act (BS 2074), Inter-Governmental Fiscal Management Act 2017, Solid Wastes Management Act (2068), Aquatic Life Protection Act (1961), Land Acquisition Act (1977), Explosives Act (1961) and Public Road Act (1974), President Chure-Tarai Madhes Conservation Development Board Formation Order (BS 2071) including species conservation related conventions were also reviewed.

The EIA guidelines and manuals of water resources and forestry sectors have been used to prepare this report. In addition, roles and responsibilities of the local level institutions such as Rural Municipality, Municipality, district and central level organisations in particular the Ministry of Energy, Water Resources and Irrigation, Ministry of Forests and Environment were reviewed.

The existing policies, environment-related laws, guidelines and manuals oblige the proponent to integrate environmental measures into the project to avoid, mitigate or compensate adverse environmental impacts, and this integration has been done in this report.

5. EXISTING ENVIRONMENTAL CONDITION

Physical Environment: The project area lies at the elevations between 390 m and 490 m above mean sea level in the Sindhuli and Ramechap Districts of Bagmati Province of Nepal. The lowest level of the project tail race is 410.0 m and the inundation level (highest) level of the project is at 474.00 m. The project area has a moderate summer season with a maximum temperature ranging from 27.6°C to 37.5°C. The minimum temperature during winter ranges from 3.4° to 20.7°C. The average annual rainfall is approximately 1586 mm.

Sunkoshi River is one of the major tributaries of Koshi River Basin. The mean annual flow ranges from 85.8 m3/s in the month of March to 1750.5 m^3/s in the month of August. As per the average annual flow and the proposed projects in the river, the design flow is taken as $67 m^3/s$.

The intake of the project area belongs to the Ranimata Formation whereas the power house belongs to the Siwalik rocks. The Ranimata Formation consists of thick to thin bedded, fine grained, and grey to greenish-grey quartzite intercalated with grey phyllite, whereas the Lower Siwalik consists of alternation of Sandstone and Mudstone.

The project area does not show potential risks for slope instability and it will not be the problem at different structural sites of the project area, including access road corridor. The slope is reasonably moderate and the geological conditions also confirm the stable slope conditions with bedrocks at shallow depths for good foundation of the project structures. The estimated sediment in this river is 18,976,056.00 m^3/s out of which, 87% of the total sediment will be suspended sediment

The project area lies in a rural setting with no industrial activities. Field observations showed that there is no point-source for degrading the water quality. Even noise level and air pollution is limited to the vehicular traffic. .

According to the inventory study of Glaciers, Glacier Lakes and Glacier Lake Outburst Flood (GLOF) of Nepal published in 2015 by the International Centre for Integrated Mountain Development (ICIMOD), number of glaciers lakes retreated in the Sunkoshi River basin and Tamakoshi River basin. Tsho Rolpa is still the potentially dangerous lakes even though 3 meters lowering is made and a channel is constructed at the outlet. ICIMOD modeling results also indicate that flood routing along the valleys downstream differs among the lakes.

The recent update of the seismic intensity map from the different sources (USGS) indicates that the Sunkoshi Marin Diversion Multipurpose Project area lies in VI-VII zone having moderate potential risk. The recommended value of PGA is 0.27 g for the headworks and 0.25 g - 0.27 g for the power house.

Biological Environment: The forest type is Sal, Khair, Sissoo, and Karma mixed forest. The study area of Project includes mainly inundations sites lying on either sides of the Sunkoshi River and Tamakoshi River and location of the project infrastructures such as headwork, desilting basin at the headworks site and surge tanks, powerhouse, penstock pipes, work camp and disposal sites etc. at the powerhouse site. Most of the dominant species in the headworks and inundation area are Khair, Sissoo, and Simal. Vegetation in inundation area is in the form of small patches in flooded private khet land or along the river banks. The powerhouse site has sal forest.

Forest is being widely used for meeting fodder, fuel wood and timber. Number of Non-Timber Forest Products (NTFP) grew naturally in the form of trees, shrubs, herbs and small climbers. These NTFPs are non-traded commercially at present but there is potential for commercial cultivation.

As per local people, leopards and jackle were spotted frequently. The field survey reported 11 types of mammals, equal number of bird species, 8 types of reptiles and 43 species of fishes in the Sunkoshi River.

Socio-Economic and Cultural Environment: The project area means the wards of rural municipalities and municipalities where the project infrastructures will be made. The total population of the project affected wards of the municipalities is 15,872 with 3,026 households and average household size of 5.25 persons. Nearly 53.50 percent of the total population is economically active. Among them, about 73 percent are engaged in fulltime agricultural works. Tamang and Chetri is the majority ethnic group accounting for 22.26 % and 20.63 % of the total population followed by magar and Brahmin. About 96 percent of houses are made of stone masonry with mud mortar and wood, and corrugated sheets for roofing. All households own a small house for living, hut (shed) for cattle, goat and for storing firewood, dry fodder or straw.

The literacy rate of 6 years of age and above is about 65.5 percent, which is lower than district average of 67 percent. The common diseases are general fever; worm infections, cold coughs, cholera, diarrhoea and dysentery. Only 68.8 percent households of the project area are supplied with tap water. Only 49 percent of the households reported to have toilet facility. Sanitation is reported to be satisfactory.

The major economic activities include agriculture, livestock rearing. 92.5 percent of the households are still using firewood for cooking.

Socio-economic Status of Project Affected Families (PAFs): Only 532 households constituting 4,234 persons are categorized as PAFs and will be directly affected by the project activities due to acquisition of land. Mainly the project will directly affect 44 houses (24 in inundation area and 20 in powerhouse area), 37 sheds (19 in inundation area and 18 in powerhouse area), 30 cattlesheds, 3 generator house, 15 tubewells, 2 solar panels of drinking water supply system, 900m of BP highway. The average size of the PAFs is 7.96 persons. Economically active PAFs constitute about 52 percent. Almost 90 percent of the affected people in the inundation area are Majhi. About 73 percent of the total PAFs are literate and only about 20 percent have education equivalent to SEE and above. About 73 percent of PAFs are engaged full-time in agricultural production and livestock rearing. Majority of PAFs own house.

Majority of the PAFs has less than 5 ropani of land. Paddy, wheat, maize, and millet are the major cereal crops, and pulse and vegetable are among cash crops grown in the project area. Nearly 21 percent of the total PAFs produce enough food for more than a year whereas large numbers of households do not produce enough food for their consumption. Animal husbandry is a major contributor to their household income.

During data collection, average annual income and expenditure of PAFs was NRs. three hundred eighty thousand nine hundred thirteen and NRs. three hundred forty-three thousand two hundred sixteen respectively. The sources of income are agriculture, service, livestock, remittance and others. The PAFs spend more money on food items than on non-food items.

The major source of energy for lighting is electricity. Almost 86.81 percent of PAFs have access to piped drinking water, and sanitation condition is better.

All PAFs expect cash compensation for their lost assets. 50.91 percent and 42.59 percent of the total PAFs wanted to work as unskilled and skilled labour in the project activities respectively. PAFs expectation from the project is good compensation in cash, employment opportunity, support in development activities of the area, and subsidy in the electricity.

6. ENVIRONMENTAL IMPACTS

Beneficial Impacts

During the construction stage, the project will provide employment to about 840 numbers of skilled, semi-skilled and unskilled persons. Priority will be given to the local people in employment. The project intends to use unskilled labours from the local area. Apart from that large amount of financial resources will be pumped in the local economy during the construction period. The project will provide training to the local people in construction skill and income generation and in enhancing the technical skills and know-how. The project area will benefit from community support programme that will be implemented by the project. Boating and other tourism activities could be developed in the inundation area of 312 ha. Fish will be released in the inundation area, also to revive the traditional fishing activity of the Majhi community.

During the operation phase, the project will generate 250.594GWh hydroelectricity per year and would augument flow in the Bagmati River to provide irrigation water to additional 122,000 ha (5 districts Bara, Rautahat, Dhanusha, Mahottari and Sarlahi districts of Province no. 2) command area of Bagmati Irrigation Project. This will be the major benefit to the country. Government of Nepal will sell the energy to Nepal Electricity Authority. Certain benefit received from the sale of the energy could be allocated to the affected Province and local bodies. As per the existing legal provisions, the local government will receive 25 percent, the Province government will receive 25 percent and the Federal government will receive remaining 50 percent royalties from the generation of hydroelectricity. Apart from that local people of the affected area could subscribe the share in the hydropower generation. The local people will be benefited from the dividend of their investment in the project. Furthermore, project will have to make provision of 0.75 % of the project cost for the community support programs of the affected area which will be equivalent to Rs 345.4 million. While collecting the suggestion during the preparation of the scoping document, local people expressed their willingness to invest in the project in the form of public share which was reiterated during the public hearing. In order accommodate this demand; the project will have to be implemented under company model Boating will be promoted in 312ha inundation area of the project. The Project will support to develop greenery, park and tourist centre.

Adverse Impacts

Physical Environment: The main adverse impact of the project in the physical environment is due to inundation of 312 ha. The inundation will affect different infrastructures namely: (i) 24 houses; (ii) 19 sheds; (iii) 3 pump houses; (iv) 2300 m of B P Highway (v) 1.59 km of local road; (vii) 15 no. of tube wells; (viii) 2 small solar panels; (ix) large solar panel, well and pump house of Large Water Supply System of Khadadevi Rural Municipality; (x) 1600 m and 16 poles of transmission line; (xi) about 794 m of irrigation canal; (xii) 3 suspension bridges, and (xiii) 1 cremation place. In addition, the project would affect 12.38 ha of land, 800 m of Dharan Chatara Road and 20 no. of houses and 18 sheds in the powerhouse area. Other construction related impacts such as change in land use, soil erosion due to excavation works, air pollution, high noise level; stock piling of construction materials in the private land, muck disposal, operation of the quarry sites, change in river morphology, operation of the work camps and reduced flow zone in the Sunkoshi River and increase in flow in Marin Khola are some of the potential adverse impacts under the physical environment.

Earthworks and plying of vehicles from intake to powerhouse sites and transportation of construction materials will add emission of carbon monoxide, sulphur dioxide and dust in the local atmosphere.

Construction work at weir site will increase water turbidity for about 4 months. The construction workers might exert pressure on local people's drinking water system, and might induce sewerage disposal problem. This additional waste may accelerate pollution nearby water source.

The proposed quarry site in the flood plain of Sunkoshi River could disturb the landscape and could change the river morphology. Furthermore, the operation of the crushing plant will increase dust emission.

Light and heavy vehicles will use diesel and petrol, engine oil, gear oil, brake oil etc. Leakage of oil and grease and other liquid materials might pollute water surface and reduce the dissolved oxygen, and would induce detrimental impact on the aquatic life.

With the diversion of water there will have inadequate water at the stretch of Sunkoshi River from barrage to powerhouse for 7 months from November to May. Low amount of water will likely increase the temperature in this zone. On the other hand the discharge in the Marin Khola will increase substantially and will change the complete flow pattern. The temperature of water of Marin Khola is likely to decrease by 0.09^{0}C in month of May to 4.35 ^{0}C in month of May.

Biological Environment: The project will require 252.68 ha of government land. Out of which 4.48 ha is forest and 3.4 ha community forest (Kusumetar Community Forest) 11.5 ha bushes and rest 233.3 ha is water body and flood plain. The project would need 6.39 ha of government land for disposal sites; All 3 disposal sites are located on the side of Marin Khola. Disposal site 1 covering 3.46 ha is located near the tail race. This area is covered by maize cultivation. Disposal site 2 and 3 is located at upstream of the existing bridge across the Marin Khola. Site clearance of these areas is likely to affect 416 no. of trees and 1939 no. of pole size plants. Affected vegetation is located in the flood plain of Sunkoshi River, Tamakoshi River and Marin khola, and most affected species are sirishand khair.

Water diversion from weir would reduce flow significantly in Sunkoshi River from the proposed barrage to next tributary. This could have significant negative impact in the aquatic life of Sunkoshi River whereas the flow in Marin Khola will increase significantly and temperature of the water is likely to decrease. This could be positive impact on the aquatic life of the Marin Khola.

The project area is not good niche to the wild animals, birds and reptiles. Wildlife disturbance is sporadic and limited to small spots. Hence, it is predicted that the loss and/or fragmentation of the habitat will have insignificant impact on the wildlife population, as the area is not the core habitat of, and breeding site for any wildlife.

Socio-economic and Cultural Environment: Altogether 69.46 ha of private cultivated land and 18.37 ha of cultivated land without land ownership paper will be affected by the project activities. Loss of agricultural land will lead to loss of agricultural products (paddy wheat, maize etc.) and loss of top soil. In addition 44 houses (24 in inundation area and 20 in powerhouse area), 37 sheds (19 in inundation area and 18 in powerhouse area), will also be affected by the project.

The concentration of large number of people with varied social and cultural backgrounds might cause the pressure on the existing health and sanitation, law and order situation of the project area.

The cumulative impact of the series of hydropower development in river may lead to long stretch of reduced flow zone during the dry season.

Summary of Land Requirement for the Project

S.no	Description	Government Land	Private Land	Total
1	Permanent Land	252.68 hec.	87.83 hec.	340.51 hec.
2	Temporary Land	6.39 hec.	-	6.39 hec.
	Grand Total			346.89 hec.

7. ALTERNATIVE ANALYSIS

Initially, environmental impact of 'with and without' project options was evaluated. As 'with project' option was found appropriate, alternative analysis was carried out for multiple alternatives 'within' project. Based on alternative analysis for different installed capacity of electricity generation as considered by the detailed feasibility study, most appropriate alternative is 28.62 MW installed capacity. As the assigned area for the project consisted of forest area, the project development without forest option was not possible. Possible alternatives for the hydropower such as micro-hydro, solar power and thermal power was also considered.

8. ENHANCEMENT AND IMPACT MITIGATION MEASURES

Benefits Enhancement Measures

During the construction stage, employment will be provided to PAFs and local people in the order of priority. The employment will increase the income level of these families. A binding clause in the contractor's agreement will be included to give first priority to PAFs and local people while hiring both skilled and unskilled labourers and to give wages not less than the district approved rate.

The project will designate certain places, within the project area, for the operation of tea stalls and grocery shops to sell local products. The project plans to train 532 persons (one each from the project affected family) to enhance skills in modern techniques of cash crop and livestock productions and in enterprise development to best utilise the compensated amount. Equal number of the local people will be trained to enhance technical know-how and skill in the specialized areas such as electromechanical works, house wiring etc.

The project will provide 0.75 % of the construction cost which will be equivalent to NRs. three hundred forty-six million five hundred thousand for the community support programme for the development activities of affected Rural Municipalities and Municipality. The support will be NRs 1 crore per annum (total 5 crore) for the construction period of 5 years. This support will be spent for the improvement of the education, health, drinking water, support in agriculture development, conservation of local forest and biodiversity and other local development activities. A Coordination Committee having the representation from each affected ward of the Municipalities will be formed. This committee will prioritize the need of the affected people and Municipalities. The balance amount will be allocated for the operational phase. In addition, affected Municipalities will also be receiving fund from the project through the royalties of the electricity generation. The project proposes to make subscription of shares of the local people towards the end of the fund requirement so that the gestation period is short.

Adverse Impacts Mitigation Measures:

Physical environment: In order to mitigate the possible change in air quality from dusts, water spraying will be carried out in gravel and earthen roads one time a day for four dry months (February to May) in a year. All project vehicles will comply with the national emission standards and regular (monthly) check-up for maintenance of all vehicles will be carried out every 3000 km. The construction workers will be provided with the necessary safe gears and they will be covered by the accident insurance policy.

Safe drinking water that meets the NDWQS and WHO guidelines will be provided to project staffs and workers. All solid waste will be recycled to the extent possible. Biodegradable wastes will be used for making compost, liquid wastes will be collected in the settling basin, and pass through the biological measures before discharging into the water bodies.

In order to reduce noise level, use of explosives will be limited. Muffling of construction area will be done. Ear plugs will be provided to the construction workers. Noise producing engines such as air compressors will be fitted with noise reducing equipment. All vehicles plying in the construction area will be maintained regularly as per the manufacturer's recommendations.

The required land for the stockpiling of construction materials will be taken on lease. The spoils will be disposed in the designated area only. Construction of drainage ditch will be connected up to the permanent water bodies. The leased area will be properly levelled, reclaimed for reuse and back to the owner.

Top soil of affected cultivated land will be preserved and reused. The budget for the top soil management would be NRs. thirty-five million one hundred twenty-nine thousand.

During the operational and maintenance stage, the retaining structure such as stone masonry rip rap of 2.0 m is proposed along the critical part of the periphery of the reservoir for the protection of the cultivated land and settlement. Total length of the riprap would be 34 km. This cost of this protection measure is included as a part of the project cost.

The project has prepared flood protection plan for the Marin Khola. .Likely affected existing agricultural land will be protected through 34 km long dikes along the banks of Marin River on both sides at priority locations. Total 18 no. of spurs have been proposed for protection of infrastructures and adjacent land by controlling bank erosion. Total 16 number of drain outlets has been proposed in the newly proposed dikes to let the drainage water to pass safely to river. The total cost of the flood protection work is NRs. eight hundred ten million five hundred eighty-four thousand one hundred ninety-ones, including contingencies and VAT.

All affected infrastructures will be either relocated or reconstructed. Total estimated cost for the relocation or reconstruction of infrastructures is NRs. **one hundred twenty-two million nine hundred sixty thousand.**

Biological Environment: The project will provide land compensation for the loss of forest land and will carry out compensatory plantation for the loss of vegetation. Forest land will be compensated as per the Directives for Acquiring the Forest Area for the National Priority Projects, 2076. An amount of Rs. two hundred fifty-five million nine hundred eighty-one thousand has been estimated for acquiring 251.68 of government land. Total loss of trees and pole size plants is 2355. At the rate of 1:10 as compensatory plantation, a total of 23550 nos. of plants will be planted in 14.68 ha. This will be at the rate of 1600 plants per ha. In addition, plantation will be carried out in temporarily acquired/used area. Hence, planation area totals to 16.76 ha. Cost of plantation would be NRs. ten million five hundred fifty-eight thousand eight hundred. The project will seek the assistance of the Division Forest Office in carrying out compensatory plantation.

About 100,000 fingerlings of the local fish species will be released in the inundation area of the Sunkoshi River for at least 5 years after the construction of the barrage. Cost of stocking is estimated at NRs. ten million per year. Total cost would be Rs. fifty million. It is expected that fish diversity and population will revived from releasing fingerlings. Fish poisoning and direct current use will be prohibited for fishing. This provision will help in reviving not only the traditional fishing practice but also improve in the economic status of Maghi community.

Socio-Economic and Cultural Environment: All participants attending the scoping exercise and public hearing preferred for cash compensation at the market rate. The rate of compensation will be decided by the Compensation Fixation Committee that would be form in accordance with Land Acquisition Rules of Nepal. Based on the government rate and the market price of the respective locations, that ranges from NRs Rs five million to NRs. one million per ropani, a total of NRs. one billion two hundred twenty-two million nine hundred thirteen thousand six hundred thirty-six has been estimated for the compensation of 87.82 hectare of the private land located at the different locations. The Land Acquisition Act obliges the proponent to provide compensation of land and value of total production of crops for one year from the land to be acquired. Based on current price of different crops, total compensation cost for crops is NRs. seven million one hundred twenty-three thousand four hundred forty-two.

The project will compensate the loss of 24 numbers of house, 19 numbers of sheds and 2 generator house of Ramechap district and 4 sheds and 1 generator of Sindhuli district that would be affected by the inundation. The proposed powerhouse and work camp at Kusumetar, Kamalamai municipality will be affecting 20 numbers of houses and 18 no. of sheds. All these structures will be compensated at market value without depreciation. Total estimated cost for the compensation of the building structures will be NRs. one hundred six million five hundred one thousand one hundred twenty-nine. Apart from the compensation, house owners will be allowed to take away reusable materials of the demolished structures. The Project will provide NRs. twenty thousand for a single storied house and Rs. thirty thousand for double storied as the transportation of reusable materials to the new site. Total

transportation cost for 31 single storey and 13 double storey is estimated NRs. one million ten thousand. Similarly a monthly hardship and displacement cost (rental) at the rate of NRs. ten thousand per household per month will be provided to each household for 6 months. Total hardship and displacement cost for 44 houses is estimated to be NRs. two million six hundred forty thousand. The project will provide counseling service to PAFs for the effective utilization of the compensation money. An amount of NRs. two hundred thousand has been allocated for counseling to the project affected families. The project will make own facilities such as drinking water supply, pit latrines and health clinics along with necessary medicines to the workers and their dependents. The project will educate construction workers, staff and local people on occupational health and safety. The accident insurance of the workers shall be made mandatory in the condition of contract of the construction contracts. In order to ensure discipline among the workers, a cash prize of NRs. twenty five thousand per person will be awarded to five diligent and disciplined workers every year. For the construction period of 5 years, NRs. six hundred twenty-five thousand has been allocated for this purpose. The project will make effort to maintain gender balance during the employment, and will not involve children for construction works. Project will relocate the cremation site located at the confluence of Sunkoshi River and Tamakoshi River in consultation with respective local community and make provision of stand post tap for performing the rituals. An amount of Rs. 50 lakhs has been budgeted for the relocation of the cremation site. Apart from the identified impact, the project is committed to mitigate or compensate to any damage to the people or infrastructure that would be affected by the project activities during its construction and operational stages.

9. ENVIRONMENTAL MANAGEMENT PLAN

To ensure that the EIA recommended mitigation and monitoring actions are duly implemented, monitored, assessed, evaluated and disseminated to the stakeholders for feedback and improvement, the PMO will establish a separate Environmental and Social Management Unit (ESMU) of its own. The ESMU will be managed by the consultants with previous experience in environmental monitoring of the projects. The project ESMU shall be established at least six months before project's civil construction award. The enhancement, compensation and mitigation measures will be implemented by elaborating this EMP into an execution plan, if necessary. This will include following action plans:

a. Permits and approvals action plan
b. Compensation management plan
c. Project information management action plan
d. Pollution abatement action plan
e. Erosion control and muck/spoil management action plan
f. Construction camps and traffic management action plan
g. Terrestrial ecology management action plan
h. Aquatic ecology management action plan
i. Public health and occupational safety management action plan
j. Rehabilitation and reinstatement management action plan
k. Emergency management action plan

The EMP has been prepared in detail that comprises of planning, organization and staffing, directives and coordination mechanism, reporting and budgeting for the implementation of environment protection measures (EPMs, benefits augmentation measures and adverse impacts mitigation measures), as well as for environmental monitoring. The project will implement EPMs during pre-construction, construction and operational and maintenance stages.

Plan Formulation: Compliance and impact monitoring will be carried out by environmental and social management unit which will be placed in the organizational structure of the project.

Organizational Structure: In order to implement EMP, an Environmental and Social Management Unit, as mentioned above, will be established at the Project site with necessary staffing and budget. The ESMU will support the proponent in implementing EPMs, and focus on compliance monitoring, record keeping, and providing technical inputs to the contractor(s), and conduct impact monitoring. The proponent will conduct impact monitoring through its ESMU or might hire an independent team for impact monitoring. The ESMU staff will work closely with the construction and operation personnel to ensure EMP implementation.

Directives and Coordination: Based on the analysis of the policy and legal provisions and roles and responsibilities of the concerned institutions, this project could be implemented smoothly without any additional environmental directives. The proponent will make every effort to ensure necessary coordination with local governments, NGOs and CBOs during EMP implementation.

Reporting: The ESMU will prepare, submit to the concerned institutions, and disseminate monitoring report twice a year during the construction stage, and annually during the operational stage. The impact monitoring report will be made public.

Budgeting: Total provision for EMP implementation is 3.2 % of the project cost which is estimated to be NRs. one billion six hundred sixty-one million three hundred ten thousand six hundred twelve which is excluding the compensation cost of NRs. one billion three hundred fifty-two million six hundred eighty-one thousand two hundred seven. The major mitigation cost is for flood protection in Marin Khola and it is estimated at NRs. eight hundred ten million five hundred eighty-four thousand one hundred ninety-one.

10. CONCLUSIONS

The project will inundate large area due to the construction of a barrage and will have significant impacts on the private property and insignificant impact on public property. However affected people and communities have positive response for project implementation. . Cash compensation for the acquisition of land, property and crops, relocation and reconstruction has been proposed for the affected structures.

The project will generate 250.594GWh average energy annually. Out of which 125.004 GWh will be generated in dry season and 125.691 GWh wet season. The project will provide irrigation water to 122,000.00 ha (5 districts Bara, Rautahat, Dhanusha, Mahottari and Sarlahi districts of Province no. 2) in terai. This year-round irrigation facility will increase food production.

The hydropower component of the SMDMP is the secondary benefit of the project, Though the cost per MW is estimated to NRs. one billion six hundred fourteen million forty-four thousand nine hundred ten, the detailed feasibility study of the project has concluded that the overall project is economically viable with EIRR of 17.04 % and B/C ratio of 1.94. The Government of Nepal has declared the project as one of the national priority projects.

Taking into consideration the nature of project, its location, people's positive response, evaluated environmental impacts and practical mitigation measures, including existing policies and laws on water resources utilization and the environment, this project is recommended for implementation subject to the implementation of the EMP. No further environmental study will be required for project clearance. The proponent commits to implement appropriate mitigation measures to any unforeseen environmental impacts identified during the construction and operational stages.

ACRONYMSANDABBREVIATIONS

Amsl	-	Above Mean Sea Level
BA	-	Basal area
CBD	-	Convention on Biological Diversity
CFUGs	-	Community Forest User Groups
Cum	-	Cubic meter
CITES	-	Convention on International Trade in Endangered Species of Wild Fauna and Flora
dbh	-	Diameter at Breast Height
DCC	-	District Coordination Committee
DoED	-	Department of Electricity Development
DFO	-	Division Forest Office
DWR	-	Drawings
DWRI	-	Department of Water Resources and Irrigation
EIA	-	Environmental Impact Assessment
EL	-	Elevation
EMEP	-	Environment Management and Execution Plan
EMP	-	Environmental Management Plan
EPA	-	Environment Protection Act
EPMs	-	Environmental Protection Measures
EPR	-	Environment Protection Rules
ESMU	-	Environmental and Social Management Unit
FGD	-	Focus Group Discussion
GHG	-	Greenhouse Gas
GLOF	-	Glacier Lake Outbursts Flood
GoN	-	Government of Nepal
GP	-	Rural Municipality
GPO	-	General Post Office
GPS	-	Global Positioning System
GWH	-	Giga Watt Hour
Ha	-	Hectare
HRT	-	Head Race Tunnel
ICIMOD	-	International Centre for Integrated Mountain Development
ILO	-	International Labour Organization
INPS	-	Integrated Nepal Power System
IUCN	-	International Union for Conservation of Nature and Natural Resources
JV	-	Joint Venture
Km	-	Kilometer
kV	-	Kilo Voltage
L	-	Length
LRMP	-	Land Resources Mapping Project
m	-	Meter
M	-	Municipality
MFSC	-	Ministry of Forests and Soil Conservation
MoE	-	Ministry of Energy
MoEWRI	-	Ministry of Energy, Water Resources and Irrigation
MoFE	-	Ministry of Forests and Environment
MoPE	-	Ministry of Population and Environment

MVA	-	Megha Voltage Amp
MoWR	-	Ministry of Water Resources
MW	-	Megawatt
NBCDP	-	Nepal Building Code Development Project
NEA	-	Nepal Electricity Authority
NGO	-	Non-Governmental Organisation
NTFPs	-	Non-Timber Forest Products
ODC	-	Over Dimensioned Consignments
OHS	-	Occupational Health and Safety
PAF	-	Project Affected Family
PGA	-	Peak Ground Acceleration
PH	-	Powerhouse
PLCC	-	Power Line Cable Communication
PMO	-	Project Management Office
PPE	-	Personnel Protection Equipment
PRA	-	Participatory Rural Appraisal
PRECAR		Project Engineering Consultancy and Research Pvt. Ltd
r		Radius
RCC		Reinforced Cement Concrete
RM	-	Rural Municipality
SMDMP	-	Sunkoshi Marin Diversion Multipurpose Project
SPAF	-	Severely Project Affected Family
ToR	-	Terms of Reference
TLC	-	Tail Race Channel
TBM	-	unnel Boring Machine
TMS	-	Total Management Services
USGS		United States Geological Survey
WECS	-	Water and Energy Commission Secretariat

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CHAPTER – 1

1 INTRODUCTION

1.1 BACKGROUND

Nepal has a large hydropower generation potential with a preliminary estimate of about 42,000 MW of technically feasible capacity. By mid-March 2019, electricity generated in Nepal is total of 1,142 MW (MoF, 2019). Over 90% (1,029.58 MW) of the country's total electricity is contributed from hydropower sector and 53.4 and 27 MW is from thermal plant and solar respectively. Nearly 78 percent of the total population has access to electricity. Still, necessary electricity to all people has not been produced and this gap is met from import of electricity from India. In order to minimize load-sheding, Nepal has imported nearly 1,835 Gigawatt Hour from India by mid-March 2019. The gap between demand and supply is 20 MW in FY 2075/76 (Falgun) (MoF, 2019).Annual consumption of electricity in Nepal is about 100 kWh/person and US has more than 12,000 kWh/ person.

The Government of Nepal (GoN) has planned for easy access to 'energy for all' by 2030 while meeting sustainable development goals (SDGs) and national campaign of 'prosperous Nepal, happy Nepali'. The GoN has also declared BS 2075-'85 periods as 'energy and water resources decade'. It has also planned to add at least 1,000 MW of hydroelectricity in the national grid by mid-2020. It has also launched 'Nepalko Pani, Janatoko Lagani' campaign and will implement 18 projects to generate 3,500 MW (Budget Speech, 29 May 2019). Furthemore, GoN has given high priority to generate 10,000 MW by 2025 (BS 2082) under this campaign as declared by then Minister for Energy in 2017.

There is shortage of power and the forecast carried out by NEA predicts that there will be a continuous shortage of power supply even after the year 2019. Implementation of diversion projects such as SMDMP with the installed capacity of 28.62 MW of power will not only help to reduce gap between demand and supply, to some extent, but also augment the flow in Bagmati River for Stage II development of Bagmati Irrigation Project.

1.2 RATIONALITY FOR CONDUCTING EIA

Existing policies, laws and guidelines of the Government of Nepal obliges to prepare the Environmental Impact Assessment (EIA) report before implementation of this typed of development proposal. The Environment Protection Act (EPA) 1997 and the Environment Protection Rules (EPR) 1997 provide details on provisions to prepare and approve the EIA report of the hydroelectric project. As per the rule 3, schedule 2, f (7), EIA report should be prepared and approved before implementation of proposal related to inter basin water transfer use. The project area is located in Chure-Terai Madhesh Conservation Area. As per the rule 3, schedule 2, a (12), EIA study process has to be followed for the project that would require forest area more than 5 ha. This project requires 4.48 ha government forest and 3.40 ha community forest area altogether 7.88 ha forest as mentioned in Table 2-6.. Hence, EIA should be prepared as the national legal regime on the environment.

The Ministry of Forests and Environment (MoFE) approved the Term of Reference (TOR) for the EIA study on 2076/01/10. The copy of the approved Terms of Reference (TOR) is presented in Appendix-A. This EIA does not cover the transmission line component. The installation capacity of the project was 42.3 MW during the approval of the scoping document and terms of reference. After optimization of the project during the feasibility study, the project was found most economical and viable for 28.62 MW installed capacity. Hence the feasibility level design has been carried out of 28.62 MW.

1.3 SCOPE OF THE STUDY

This EIA report has been prepared as per the determined Scoping Document and Terms of Reference (ToR) approved by the Ministry of Forests and Environment on 2076/1/10. The ToR provides details on the scope of work.

1.4 OBJECTIVES OF THE STUDY

The objectives of the EIA study are to:

- Document the existing environmental condition of the project area;
- Identify, predict and evaluate the potential impacts of the Project on the local environment;
- Calculate loss of different categories of land, property, forest and other resources as a part of site clearance;

- Recommend (i) benefits augmentation measures, (ii) preventive, curative, and compensatory measures to minimize the adverse environmental impacts and (iii) environmental management plan;
- Provide information on associated cost for benefits augmentation and adverse impacts mitigation; and
- Prepare plans for the implementation of beneficial and mitigation measures, environmental monitoring and auditing.

1.5 THE PROJECT PROPONENT

1.5.1 The Proponent

The Proponent of this proposal is Sunkoshi Marin Diversion Multipurpose Project (SMDMP), Department of Water Resources and Irrigation.

Name and Address of the Proponent

Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Department of Water Resources and Irrigation
Sunkoshi Marin Diversion Multi-purpose Project (SMDMP)
Jawalakhel, Kathmandu
Phone:01-5535382
E-mail: info@doi.gov.np

1.5.2 Organization Responsible for Preparing the Report

A Joint Venture (JV) of consultants namely; GEOCE Consultants Pvt. Ltd., Total Management Services Pvt. Ltd. (TMS) and Project Engineering Consultancy and Research Pvt. Ltd. (PRECAR), "referred after the Consultants" has prepared this EIA report. Consultants have signed the contract with SMDMP in May2018 to carry out Environmental Impact Assessment of the Sunkoshi Marin Diversion Multi-Purpose Project located in Sindhuli and Ramechap districts.

Name and Address of the Consultant

Joint venture of
GEOCE-TMS-PRECAR
GPOBox4266
Kathmandu Sanepa, Lalitpur
Telephone:01-5521175/5545542
Email: geoce@info.com.np

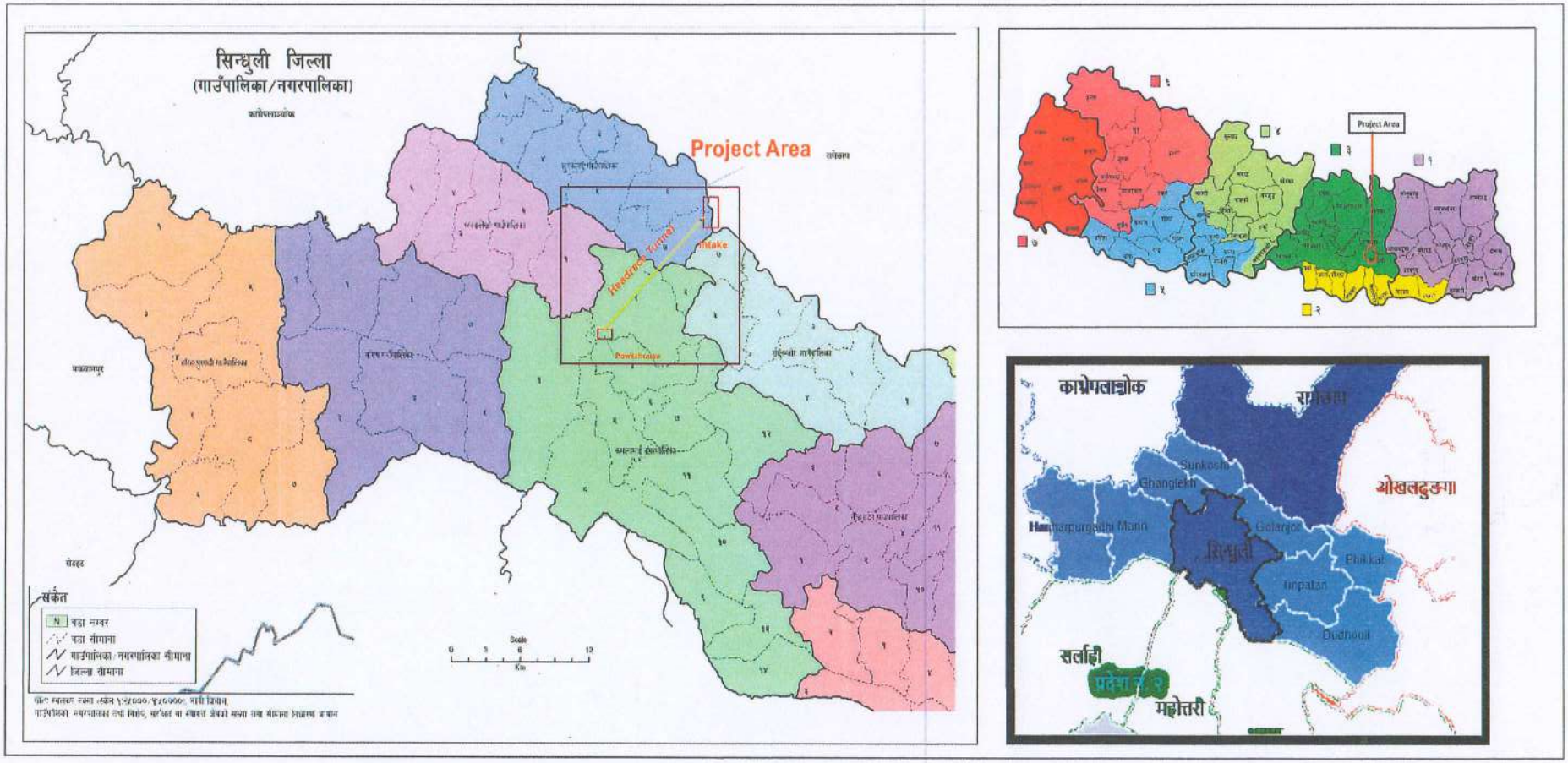
CHAPTER – 2

2 PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The Sunkoshi Marin Diversion Multi-purpose Project (SMDMP) is located in Sindhuli and Ramechaap districts of Bagmati Province of Nepal. The project aims to divert 67m^3/s water of Sunkoshi River to Marin Khola, one of the tributaries of the Bagamati River. The diverted water will generate 28.62 MW of hydropower and augment the discharge to the existing Bagmat irrigation Canal. A location map of the project components presented in Fig 2-1. The project affected palikas is shown in Fig.2-2. The proposed multi-purpose project consists of different structural components; inundation area within Sunkoshi Rural Municipality, Khadadevi Municipality and Manthali Municipality with a pond level 474m. Additional 2.0 m from the pond level has been considered as the inundation level to accommodate the afflux. The location map of the project components is shown in Figure 2-3. The inundation area of the project area is presented in Fig 2-4. The headwork and its associated structures are located in ward no.7 of Sunkoshi Rural municipalities shown in Fig. 2-5 and powerhouse site is located in ward no. 2 of KamalaMai Municipality as shown in Fig.2-6. The project would create large inundation area due to the construction of 12 m high barrage across the river. The inundation will be covering part of ward no 6. Of Sunkoshi Rural Municipality, part of ward no. 4 of Khadadevi Rural Municipality and ward no. 6 of Manthali Municipality. The water is diverted to Marin Khola. The diverted water augments the flow in the Bagmati River and provides additional discharge to the Bagmati Irrigation Project. The augmented flow in the Marin Khola will affect the land along the Marin Khola located in Marin Rural Municipality and Hariharpurgadi Rural Municipality. The present study is only for the hydropower components of the multi-purpose project. The river stretch of Marin khola from the proposed powerhouse site i.e. confluence of Bagmati River is also considered as the project affected area as the increase discharge in the Marin Khola could have significant impacts on the river banks.

Figure 2-1: Project Location Map



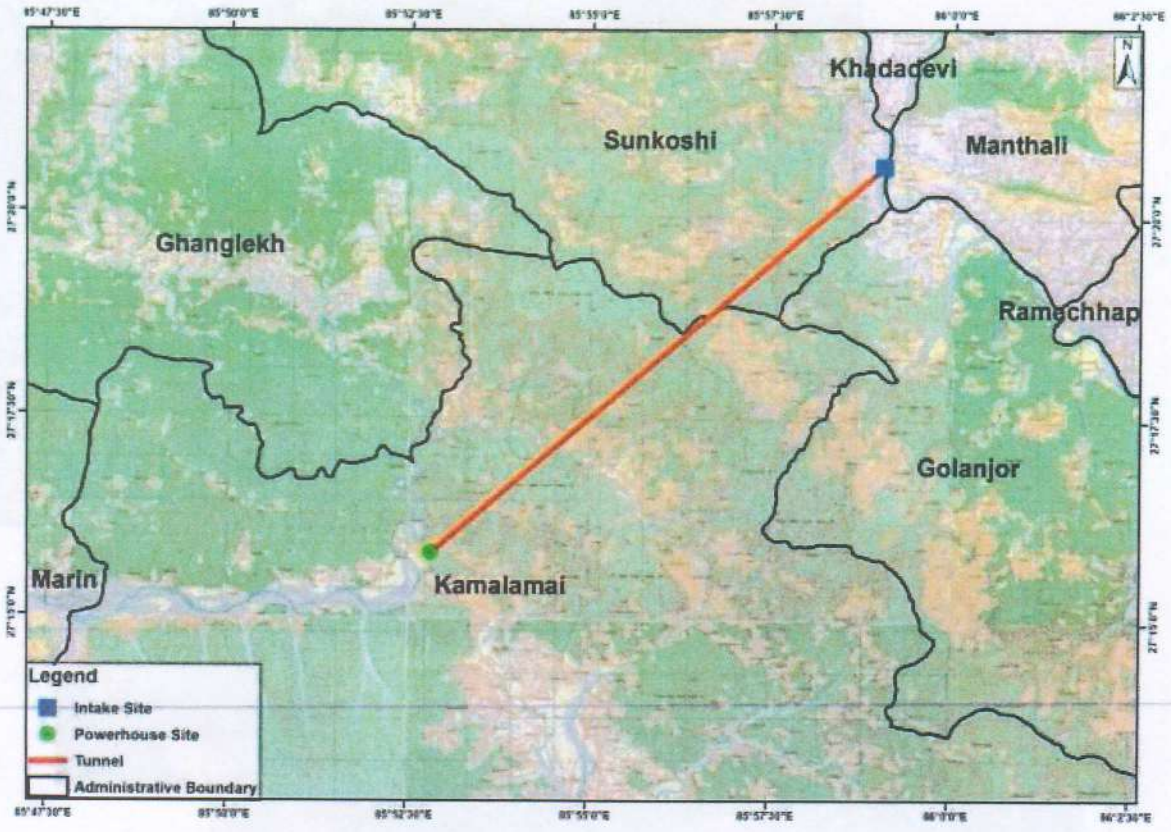


Figure 2-2: Project Affected Palikas (Source: Detailed Feasibility Report, 2018)

Figure 2-3 : Project Major Component Map (Source: Detailed Feasibility Report, 2018

Figure 2-4: Map of the Inundation Area of Sunkoshi Marine Diversion (Source: Detailed Feasibility Report, 2018)

Figure 2-5: Proposed Hydropower Components (Source: Detailed Feasibility Report, 2018)

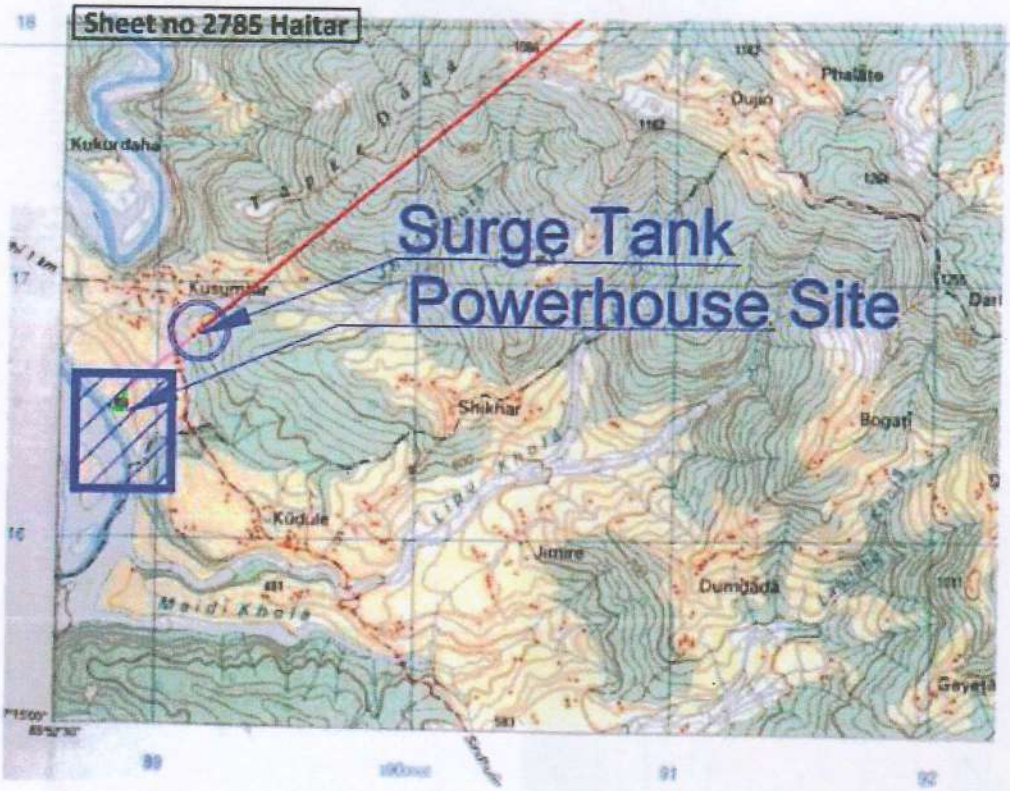


Figure 2-6: Proposed Power House Location Map (Source: Detailed Feasibility Report, 2018)

2.2 PROJECT LAYOUT

The general arrangement of the main structures has been determined from the optimization of the individual structures. The general arrangement is shown in Figure 2-7.

2.3 PROJECT SALIENT FEATURES

The salient features of the project are presented in Table 2.1.

Table 2-1: Salient Features of the Project

Description	Details
Name of Project	Sunkoshi Marine Diversion Multi-Purpose Project
Name of River	Sunkoshi River and Marin Khola
Location	
Longitudes	85° 59' 03.90287" E To 85° 52' 29.99232" E
Latitudes	27°20' 38.64476" N To 27°15' 31.5237" N
District	Sindhuli and Ramechap
Province	Bagmati
Headwork	Sunkoshi Rural Municipality
Powerhouse	Kamalamai Municipality
Affected area due to increase in discharge in Marin Khola	Ward no 1 and 4 of Kamalamai Municipality Ward no 1,2,3,4,5,7,8 of Marin Rural Municipality Ward no 2,4,5,6 and 8 of Harihaipurgaddi Rural Municipality
Irrigation Command area/ location	122000.00 hector in Bara, Rautahat, Dhanusa, Mahottari and Sarlahi district
Access	
BP Highway from Kathmandu	115km (headwork)
Headwork to Manthali	18km
Project Accessibility	
Kolkata–Raxual in India	757km
Raxual-Birgunj	3km
Birgunj-Bardibas	124km
Bardibas–Sindhulibazar	65km
Sindhuli bazar to Marin Powerhouse site	11km
Hydrology	
Catchment area	10,155sq. km
Design Discharge	67.0m3/s at rated head
Design Flood(at main headwork site)	12.741m3/s (1in500years)
Diversion Weir (Barrage bay)	
Type	Concrete weir with gates
OperatingLevel	EL.474.00m
Crest Level	EL.462.00m

Description	Details
Length of Overflow Section	96.00m
Length of span	12.0m
Total Length	118m
Flood discharge capacity of Weir	9692m3/s
Diversion Weir (Undersluice bay)	
Type	Concrete weir with gates
Operating Level	EL.474.00m
Crest Level	EL.459.50m
Length of Overflow Section	24.0m
Length of span	12.0m
Total Length	28.0m
Flood discharge capacity of Weir	3053m3/s
Barrage Bay	
Nos.	8
Type	Radial gate
Size	12.0mx16.0m
Under sluice	
Nos.	2
Type	Radial gate
Size	12.0mx18.5m
Sill level	EL 459.50m
Intake	
Type	Side Intake
Nos.	4
Sill level	EL.469.8m
Design Discharge	73.7m^3/switch flushing discharge
Intake Gates	
Nos.	4
Size	6.0mx4.0m
Type	Vertical lift roller gate
Hoist	Gravityy Crane
Desander Chamber	

Description	Details
Type	RCC
Shape	Rectangular
Nos.	2
Size	130m(l),30m(w)
Flow	Free flow
Bed slope	1:50
Depth of flow	6.3 m
Power Conduit	
Shape	Square with chamfer
Length	166.5.0 m
Size	5.5 mx 5.5.0m
Head RaceTunnel (HRT)	
Type	RCC Lined Tunnel
Shape	Circular
Size	5.5 m dia.(finished)
Thickness	300mm(Segmental)
Flow	Pressure flow
Length	13,100m
Surge Shaft	
Type	Restricted Orifice
Diameter	22.0dia
Max.Surge Level	EL.485.98m
Min.SurgeLevel	EL.434.36m
Height frm invert	75.22m
Wall thickness	1.0m
Penstocks	
Type	Steel Penstock, buried
No.of Penstocks	1
Internal diameter	4.4 m
Total length	360m
Penstock inside tunnel	268m
Exposed tunnel	80m

Description	Details
Manifold	42.2m
Power House	
Type	Surface type
Size of Machine Hall(outertoouter)	47.8 mx26.1m
No.of Bays	3unit bays and one Service bay
No.of Units and Capacity	3Units of 9540kweach
Turbine floor level	EL.410.0m
Generator floor level	EL.414.5m
Control Room level	EL 420.0m
Tail Race	
Length	157.8m
Total bed width	9.0m(double Chambered)
Chamber Dim.(WxH)	7.0x4.0 m
Bed Slope (V:H)	1:1000
Tail water level	EL 410.0m
Turbines	
Type	Vertical Francis
Gross head	64.0m
Headloss	16.23m
Rated head	47.77 m
Rated Discharge per unit	22.33m^3/s
Rated speed	375rpm
Efficiency at rated output	93%
Generators	
Type	Synchronous
Rated output	11.223MVA(three units)
Rated speed	375rpm
Generator efficiency	98%
Switch Yard	
Size including access road	102.00mx74.0m
Power and Energy	
Installed capacity	28.62MW

Description	Details
Total Energy Generation	250.594(GWh)
Total wet energy	125.691(GWh)
Total dry energy	125.004(GWh)
Sellable Wet Energy	118.212 (GWh)
Sellable Dry	117.566(GWh)
Total Project Cost	NRs 83,517,615,321.00
Project Cost of Hydropower Component	NRs. 46,193,965,321
Project Cost of Irrigation Component	NRs. 37,323,650,000
EIRR	17.05 %
B/C ratio (10% discount rate)	1,94
NPV (10% discount rate)	NRs. 55,095,220,000

Source: Detailed Feasibility Study, 2019

2.4 GENERAL ARRANGEMENT OF THE SUNKOSHI MARIN DIVERSION PROJECT

The main components of the project comprise of a diversion weir, intake, connecting canal, desanding basin, power conduit, headrace tunnel, surge tank, penstock, surface powerhouse and switchyard. The general layout of the headworks is shown in Figure 2.7. The headwork is located in Sunkoshi River, approximately 750 m downstream from the confluence of Tamakoshi and Sunkoshi and about 1 Km upstream of Khurkot. A 13.1 km long headrace tunnel and 360 m long penstock conveys water to the power house at left bank of Marin Kholato generate 28.62 MW of power. A tailrace canal will discharge the water to Marin Khola, a tributary of Bagmati river thereby augmenting discharge to BIP (Bagmati Irrigation Project) for irrigation purpose.

2.4.1 Headwork

The SMDMP headworks consist of a gated weir, undersluice, intake, graveltrap, connecting canal and a double chambered settling basin. A concrete gravity weir with broad crestand gated spillway across the Sunkosh River has been proposed. A stilling basin of 100.0m length and 3.7m depth is proposed for energy dissipation downstream of the weir. Undersluices and intakes are located at the right bank of the river. A gravel flushing channel is located immediately after the intake with a connecting canal conveying water from gravel trap to the settling basin on the right bank of SunkoshiRiver.

The proposed headwork of the SMDMP may create the afflux of 4.0m considering the high flood level of 12,741m3/s (500 years return period. The flood level will be 478 m corresponding to 500 years return period. However as per the instruction of the Project, the inundation level is considered as 476 m. The total area of inundation area including the river water way is 312 ha with the extension up to 6.5 km in the Tamakoshi side and 7.5 km in the Sunkoshi side.

2.4.2 Weir and Undersluice

A gated broad-crested weir is proposed across the Sunkoshi River for river diversion and for passing the flood discharge. The proposed weir is 122.0 m long at its crest, consisting of eight radial gates with size 12 m x 16 m (B x H). The deepest bed level of the river is at El. 459.0 m and the crest level is kept at El 462.0 m. The normal operating level in the barrage is fixed at 474.0m. To the right of the weir, two under sluice openings with size 12m x 18.5m (B x H) have been proposed to pass the bed load accumulated in front of the intake during monsoon flood season and to minimize the sedimentation in the reservoir. Guide walls have been provided at both left and right banks of the river to guide the flow of the river. The weir is designed for a discharge of 12,741m3/s (500 years return period flood) with the capability of passing safety check flood of 14,071 m3/s (1000 years return period). The weir diverts a flow of 73.7m3/s, which is equal to the design discharge plus the required flow for sediment flushing. A divide wall of8m separates the barrage bay portion

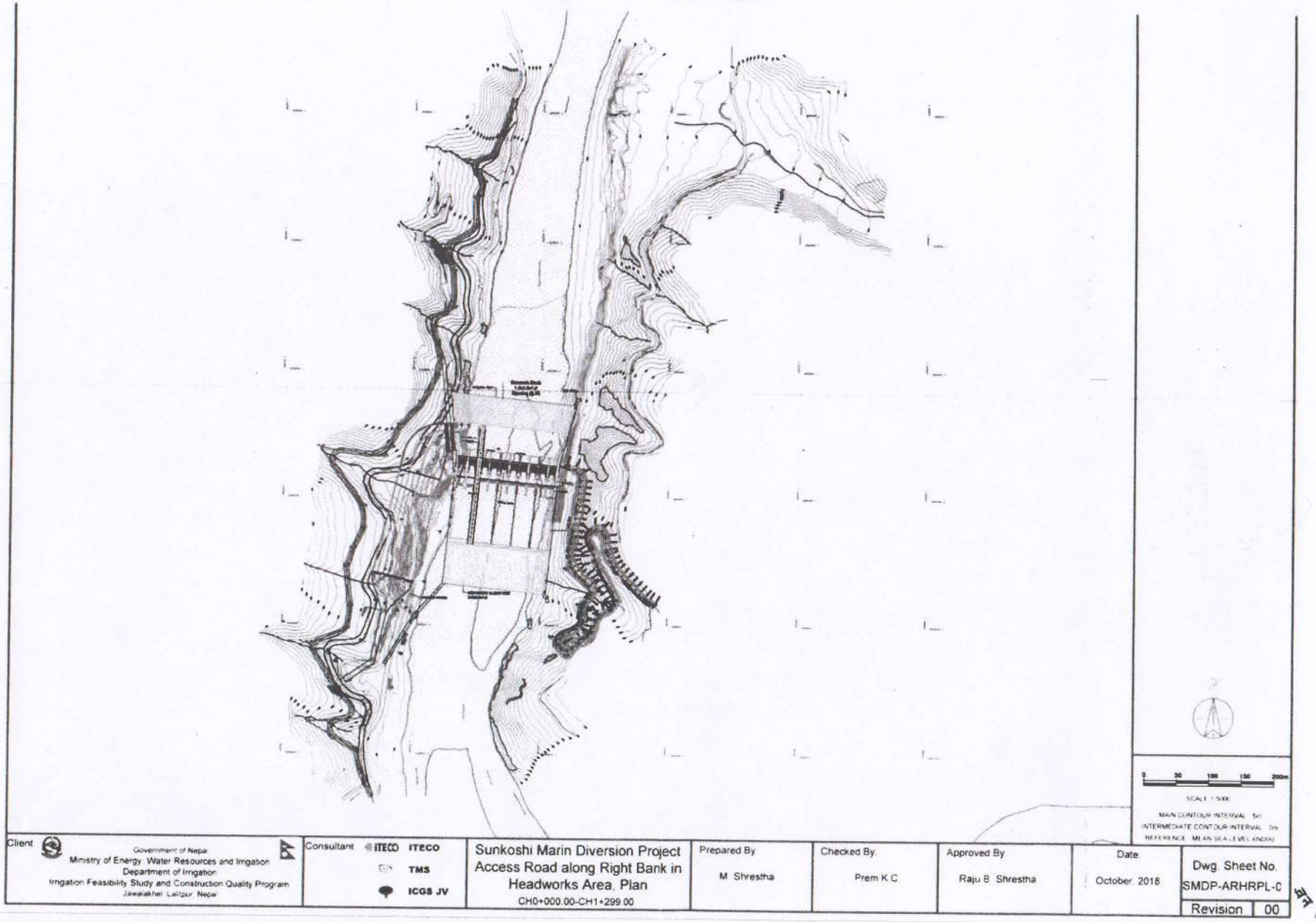
from the under sluice portion. A fish passage of 2m width is proposed within the divide wall. The divide wall is supported by four piles each at upstream and downstream ends.

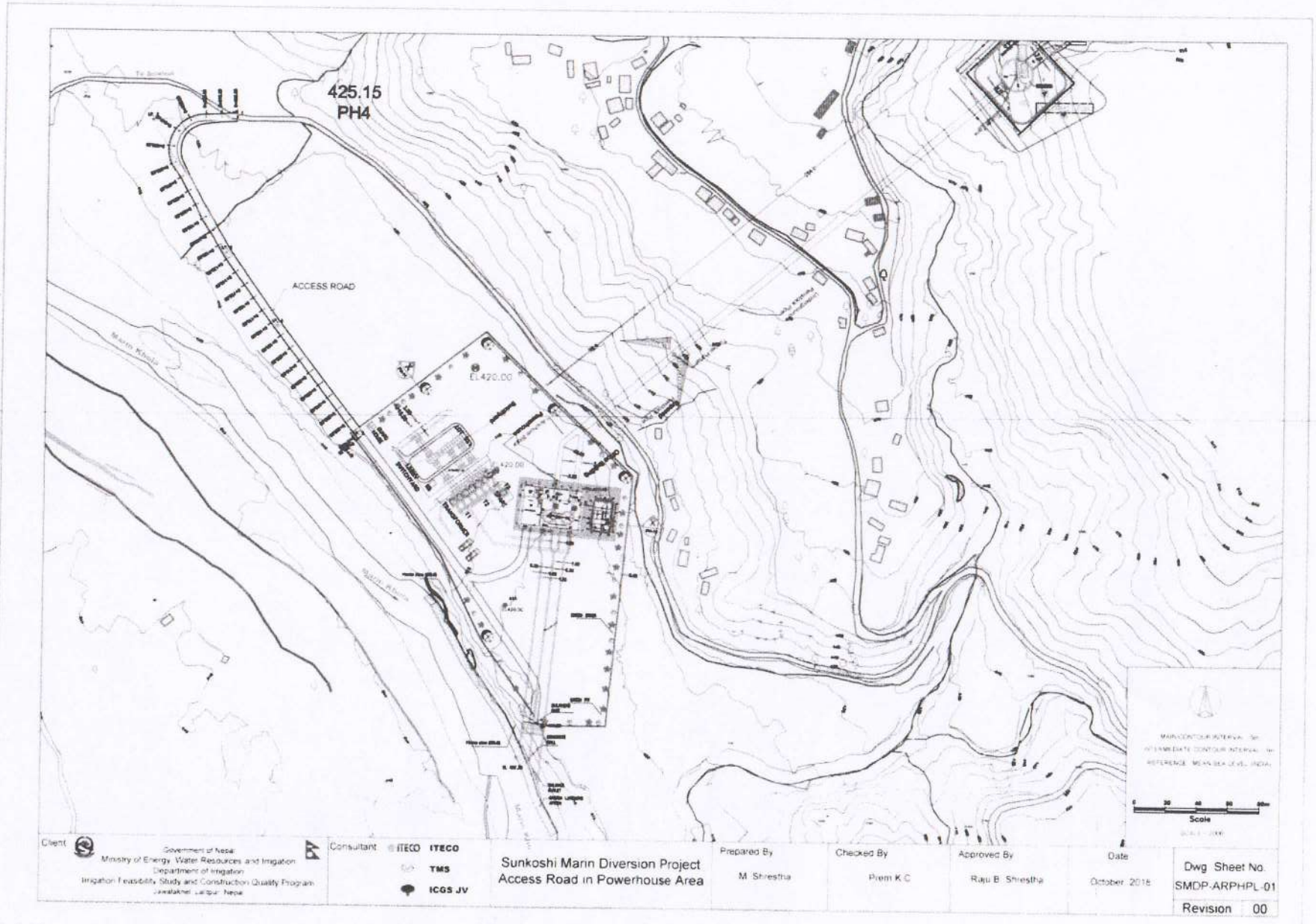
2.4.3 Intake

A side intake is proposed adjacent to the under sluice at right bank of Sunkoshi river. The intake is designed to pass the diversion discharge of 67m3/s and an additional 6.7m3/s of discharge for flushing requirement. The intake consists of 4 orifices of size 8.0 m x 4.0 m (B x H). The silt level of the intake is fixed at 469.8masl.


Updated Powerhouse Layout
100 50 0 100 200
m
नेपाल सरकार
वन तथा वातावरण मन्त्रालय
सिंहदरबार काठमाडौं

Figure 2-7: General Layout of Project.





Which is 10.8m above the river bed level so as to avoid entry of river bed material into the water conveyance system through the intake? Four intake gates are provided to regulate the flow (through the intake). A coarse trash rack will be placed in front of intake to avoid entry of trashes. Gravel flushing channel of 2m width is provisioned immediately downstream of the intake to settle bigger sized sediment with flushing culverts provided to flush the sediment from gravel trap by flushing gates.

2.4.4 Approach Canal

Approach canal starts immediately after the gravel flushing channel. Transition length of about 60m is provided after the gravel flushing channel. The approach canal is branched into four compartments to pass the flow to the desander.

2.4.5 Desander

The hilly streams generally carry significant quantities of coarse silt and sand during the monsoon season. It is, therefore, necessary to provide a desander to exclude coarse particles so as to minimize the abrasion to the turbine runners, where abrasion effect becomes more pronounced. A surface desander basin is proposed downstream of intake for removal of sediment. A small section of about 425 m of BP Highway will have to be relocated to accommodate the basin.

The proposed settling basin is of "rectangular" shape having two chambers of 130.0m length,30.0m width and 6.3m effective depth designed fora discharge of 73.7m3/s which include 10% additional discharge for flushing operation. The settling basin have three sections; inlet section, the settling section and the outlet section. The water flow depth is 6.3 m and the depth of hoppers is 2.5 m. Under normal operating conditions the average flow-through velocity at settling basins will be 0.197 m/s. The outlet of the settling basin consists of a wall at the end which consists of four gated openings of size 9.75m x 4.0m (W x H) in each basin. The sill elevation of the outlet opening has been fixed at El 471.8 m. These openings are designed such that the full design discharge can be drawn from each settling basin with acceptable limits of head loss during maintenance and sediment flushing of the other basin. During normal operation, the slide gates shall be used to adjust the opening to pass the required design discharge.

2.4.6 Power Conduit, Tunnel Inlet and portal

The power conduit connects the desander to the tunnel inlet. The power conduit is provided in the form of a RCC barrel of dimension 5.5m x 5.5m. The length of power conduit is 166.5m. Minimum submergence of 5.1m required to prevent vortex formation is provided in accordance with the Gordon's formula. The invert level of the power conduit at inlet is fixed at 463.2 m.

The tunnel inlet is located in an exposed rock outcrop at the end of the power conduit. Before the inlet portal, a smooth transition is provided from rectangular section to circular section. The dimension of rectangular section is 5.5m x 5.5m and circular section is 5.5 m diameter.

2.4.7 Headrace Tunnel

The headrace tunnel (HRT) conveys the flow from the Sunkoshi River to the powerhouse located at the bank of Marin Khola. As the tunnel will be driven by the Tunnel Boring Machine (TBM), the finished section will be circular. The optimization of the HRT has revealed an optimized finished diameter of 5.5 m. The HRT will be provided with segmental lining throughout the length. The flow through the conduit at rated head and rated output of 28.62 MW is 67 m3/s. Total length of the tunnel would be 13.1 km.

The headrace tunnel will be excavated by TBM and will be fully concrete lined. Additional rock supports such as rock bolting have been proposed. The proposed rock support for the HRT is shown in Table 2-2.

Table 2-2: Proposed Support for the Head Race Tunnel

Chainage	Rock type	Qroof Qwall	Rock Class Quality	Effective Span, De	Support Class	Support Description
0.0-1.5	Sandstone, Mudstone	0.3 0.75	E Very Poor	5.0	S5	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
1.5-3.2	Sandstone, Mudstone	0.2 0.5	E Very Poor	5.0	S5	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
3.2-4.0	Conglomerate	0.001 0.01	G Exceptionally poor	5.0	S7	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
4.0-4.5	Slate	0.06 0.06	F Extremely Poor	5.0	S6	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
4.5-5.5	Schist, Quartzite and Granite	6.4 16.0	C Fair	5.0	S3	At roof, systematic bolting length 3.0m @ 2.1m spacing and segmental lining of 0.3m
5.5-6.3	Phyllite, Metasandstone	4.5 11.25	C Fair	5.0	S3	At roof, systematic bolting length 3.0m @ 2.1m spacing and segmental lining of 0.3m
6.3-6.6	Quartzite	22.5 112.5	B Good	5.0	S1	At roof, systematic bolting length 3.0m @ 2.5m spacing and segmental lining of 0.3m
6.6-9.5	Gneiss and Granite	0.4 1.0	E Very Poor	5.0	S4	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
9.5-10.0	Quartzite	7.0 17.5	C Fair	5.0	S3	At roof, systematic bolting length 3.0m @ 2.1m spacing and segmental lining of 0.3m
10.0-11.55	Phyllite, Metasandstone	2.5 6.25	E Very Poor	5.0	S3	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m
11.55-13.1	Schist, Quartzite, Granite	0.2 0.5	E Very Poor	5.0	S5	At roof, systematic bolting length 3.0m @ 1.3m spacing and segmental lining of 0.3m

Source: Detailed Feasibility Study, 2019.

2.4.8 Surge Tank

A surge tank is provided at the end of the headrace tunnel to allow the mass oscillation caused due to pressure transients followed by load rejections and load acceptance. The upper part of the surge shaft will be exposed to the ground surface.

The surge shaft will be a restricted orifice type and will be connected to the headrace tunnel by a concrete lined throttle of 4m diameter. The diameter of the surge shaft is fixed based on the minimum area requirement as suggested by the Thoma's criterion. Accordingly, a shaft of 22m diameter is provided. The height of the surge shaft is calculated considering the free board requirements, submergence and possible surges due to various loadings such as full load rejection and full load acceptance.

The height of surge shaft is 75.00 m from the tunnel invert. The surge shaft is connected to the tunnel by a 4.0 m diameter concrete lined riser shaft which has been offset from the headrace tunnel by a short distance to allow construction to continue unhampered by construction activities in the tunnel.

The surge shaft is designed as are inforced concrete and water tight structure. The wall thickness (lining) is designed to withstand the submerged weight of the rock mass due to the extended water pressure switch an assumed ground water table. Areas of high-water in flows encountered during construction will be pressure grouted to reduce the quantity of inflow during dewatering of conduit. Internal pressure loadings are as summed to be resisted by the surrounding rock mass.

2.4.9 Penstock pipe

The flow further from the surge shaft is conveyed through a pressure shaft. The optimum diameter of the penstock has been worked out as 4.8m considering the minimum total cost of the penstock and revenue loss due to the resulting head loss in the pressure shaft. The thickness of the penstock pipe has been designed to resist the maximum dynamic head resulting from the mass oscillations.

The penstock pipe of total length of 360m takes off from the downstream end of the surge tank. An exit portal is proposed at the end of penstock tunnel. Required transition is provided in the joint of tunnel and penstock. The penstock is buried to protect the pipe from the environment. Anchor blocks are provided at the bends with saddle supports, wherever necessary to hold the penstock pipe. Length of exposed penstock pipe is 80 m up to bifurcation point. After that, the pipe is bifurcated into two steel manifolds of internal diameter 3.4m each45 m long to provide required water to turbines.

2.4.10 Powerhouse

The powerhouse structure is located on the left bank of the Marin Khola. It is proposed to house the three generating units of 9.54 MW capacities each in the surface powerhouse, which will have the provision of a service bay of 9m long. The overall dimension of the powerhouse including service bay is 48.8 m x 26.1 m. The Power House is proposed to be covered with galvanized sheet roofing supported on steel trusses. The powerhouse contains 3-Vertical Francis turbine units directly coupled to generators, each with an installed capacity of 9.54 MW. Flows from the powerhouse are discharged through a tailrace channel, 160 m long to Marin Khola. In order to maintain the minimum tail water, gate is required at the end of tailrace.

Power from the units is evacuated to a switchyard 73.0 m long and 63.0 m wide located on the right side of the powerhouse at an elevation of EL. 420.0 m, where 3-single phase transformers are also located. Access to the powerhouse is from the downstream end by an access road. The detail plans of the access road are shown in the drawings. The access road leads to the main access door which is located on the left side of the powerhouse. The 4 m by 4 m access door leads directly to the erection bay where the various items of mechanical and electrical equipment can be off-loaded for erection or later removed for repair by the powerhouse crane. The 50 ton overhead crane travels the whole length of the powerhouse and can readily accesses all items of heavy mechanical and electrical equipment.

The powerhouse has four floors. The floor at El. 410.0 m serves as an access to the turbines. The generator floor is at El. 414.5 m with the generating units and auxiliary electrical equipment necessary to control the units and the machine hall floor is set at El. 420.0 m. The high flood level corresponding to the return period of 1 in 1000 years is El. 415.97m. Hence, the machine floor level is safe against the floods up to 1 in 1000 years event.

An area for office space, electrical and mechanical workshops has been provided adjacent to the powerhouse. The emergency diesel generator is housed in a separate building (control room building) at the rear of the powerhouse.

2.4.11 Tailrace

From the draft tubes the water is discharged into the tailrace. Separate vertical gates are provided at the outlet points of draft tubes. Tailrace will be founded on alluvial deposit. The total length of the tailrace is 160m. The tailrace is of a reinforced concrete box-culvert in a cut and cover structure. The width of the tailrace is 7m with walls of thickness 1m.

In order to maintain the required submergence on the units, a weir will be necessary at the end of the tailrace. The tailrace level of Marin is 2 m higher than the center line of the units.

2.4.12 Transmission Line

The power evacuation from SMDMP will consist of the generated power output of 28.62 MW which will be connected to the switchyard. The transmission line will be 132 kV, Double circuit transmission line of about 37.2 km length, connecting switchyard to Dhalkebar switchyard. Based on field reconnaissance trips and routing studies using available maps, the transmission line routing length between the SMDMP switchyard and Dhalkebar has been determined to be approximately 37.2 km.

2.5 ACCESSIBILITY

The proposed project site is located in Sindhuli District, Kathmandu, the capital city of Nepal, is about 115 km away from the project headworks site and about 145 km from the powerhouse site. The proposed headworks and powerhouse sites are connected by BP Highway and there is no requirement of additional access road. There is a track road to Marin valley, the powerhouse site, providing very easy access to the project sites. This access road has to be upgraded including one bridge. The major port is also connected by rail to the nearest bordering town of Nepal.

Access Roads: The project site is easily accessible from Katmandu. The headworks site at Khurkot is 115 m away from Kathmandu connected by BP Highway and the powerhouse site is 11 km from Sindhuli bazar which is 19 km from Khurkot. Sindhuli bazar is 65 km from Bardibas which lies in East West Highway. The headworks site is also accessible from Manthali which is 18.4 km away. Thus, there is a good facility for the transportation of equipment and materials from the capital city and from the plains.

The nearest dry port for electro-mechanical equipment is Birgunj Dry Port. It is 300 km from Katmandu and 150 km from Bardibas. The route for transporting electro-mechanical equipment to the project site is Kolkata- Birgunj- Bardibas- Sindhuli bazar- Project Site.

2.5.1 Transportation Method

The main equipment and other imported materials are planned to be loaded in Kolkata port where the infrastructure for unloading storage area and railway yards are available, as it is one of the major ports of India on Eastern side and most convenient sea port for the Project. Therefore, it is considered as the primary port of entry.

(i) **Railway Transport**

Railway lines are available from Kolkata up to Raxual, the terminal station bordering with Nepal. The broad gauge rail distance is about 757 km.

(ii) **Road Transport**

The goods from Raxual will be transported to the project site where adequate storage facilities are provided. The road route proposed is Raxual-Birgunj-Bardibas-Sindhuli Bazar. The total length of the road from Raxual to the project is 223 km. The largest parts of permanent equipment items which cannot be shipped in sections are main transformers. The other sectionalized items such as turbine runners, stay rings, pit liners, draft tube parts and gate parts etc. and TBM parts which can be classified as over dimensioned consignments (ODC) must be transported in special wagons with due consideration for the maximum transportable sizes by train and on road.

The routes of transportation proposed are:

Kolkata – Raxual in India. (757 km), Raxual-Birgunj – 3 km, Birgunj-Bardibas – 124 km and Bardibas – Sindhuli bazar (65 km), Sindhuli bazar to Marin Powerhouse site (11 km) = Total 960 km.

Further, the construction materials such as structural and reinforcement steel, cement, blasting materials, admixtures, roofing materials, pipes, shuttering materials, tiles, paints etc. are proposed to be procured in local market or India and transported by road.

2.6 INFRASTRUCTURE FACILITIES

2.6.1 Construction Power

Construction power will be supplied primarily by Two 2000 KW diesel generators required for the operation of TBM. A 12 Km long 33kV line from Sindhuli to SMDMP powerhouse site will be constructed as back up supply.

Alternatively, 132 kV Sub-Station existing at Bardibas can be utilized to draw construction power to the required extent at the Powerhouse point. The activities in the weir area, tunnels, surge shaft and penstocks will be carried out with the help of temporary power supply from DG sets to be provided by the contractors.

2.6.2 Work camp and Labour camp Facility

The major activities of the Project are concentrated near the site of headworks where the weir, intake, desander and HRT intake are proposed and the powerhouse site where surge tank, penstock powerhouse and tailrace are located. Major activity at the powerhouse site will be the activities related to tunnel excavation with the use of tunnel boring machine (TBM). In view of this, the work camp and camping facilities are required for the labour, supervisory staff, Contractor's office and storage yards mainly near the weir site and powerhouse site. It is expected that about 850 human resources will be camping at these locations during the peak construction period. The details are shown in Table 2-3. Suitable bachelor accommodation for supervisory staff and family accommodation for the labour are proposed at two powerhouse and headworks sites. The camp site at the powerhouse will be of permanent nature whereas the work camp and labour camp at the headworks will be of temporary nature located at the Seleghat within the inundation area. A dormitory, canteen & mess with recreation facilities and medical facility are proposed for the supervisory staff near the powerhouse which is near to Sindhuli bazar next to Mad[illegible]handari Highway (Dharan Chatara-Hetauda road). The location of the camping facilities

and project facilities like material storage yard, crushing plant, batching plant etc. at the headworks and powerhouse are shown in Figure 2-8and Figure 2-9respectively.

Table 2-3: Requirement of the Human Resources

Works	Managers and Supervisors	Highly Skilled	Skilled	Unskilled	Total
Weir and Desander	20	20	40	80	160
H R T	35	50	90	100	275
Surge Shaft and Penstock	10	20	40	80	150
P H and TRC	30	50	85	100	265
Total	**95**	**140**	**255**	**360**	**850**

Source: DetailedFeasibilityStudy, 2019

2.6.3 Water Supply

The water supply for the camps will be made separately. Water supply system is planned to off take water for the camps at two locations. For both camp sites, intake structures with filtration plants will be installed. In the headworks site, two water tanks each of 10cu.m will be installed and three numbers at powerhouse site. From each source, tapped water will be delivered to the water tank with 50 mm GI pipe.

2.6.4 Communication

Currently a telephone network exists nearby the project area. Mobile communication equipment will be used to communicate with the various project sites. Once the project is commissioned, power line cable communication (PLCC) will be used for information exchange between the powerhouse and the load dispatch center.

2.6.5 Disposal Sites

The detailed feasibility study has identified 3 disposals along the Marin Khola. The locations are shown in Figure 2-10. The area covered by each disposal site is presented in Table 2.6.

2.7 CONSTRUCTION PLANNING

2.7.1 Contract Packages

There are three main activities involved in the construction of this project. They are (i) the works near the weir, intake and desander (ii) Headrace Tunnel, Surge Shaft, Penstock tunnel and Penstocks (iii) Powerhouse. Though, one construction agency will ideally suit the works for coordination, it is felt that for the facility of ensuring the target commissioning dates, works will be divided into the following packages:

- **Civil Work Contracts (Package I):** Headworks area, Powerhouse area and Hydraulic Steel Structures
- **Civil Work Contracts (Package II):** Headrace Tunnel and Surge Tank
- **Electro Mechanical and Hydro-mechanical works (Package III):** Generators, Turbines and related accessories.
- **Transmission Lines (Package IV)**

The concerned Civil Contractor will also be entrusted with the construction of camp facilities, storage facilities, access roads and bridges near the respective components.

The election of the consultants will be completed in about 5 months. After the approval of the estimates, the selection of contractors may require up to 7 months including the prequalification and tender evaluation procedures. The selection of contractors for the electro-mechanical works and transmission lines will be done about 1 year later than the selection of contractors for the civil works.

Figure 2-8: Location of Camp Facilities and Disposal Sites at the Headworks

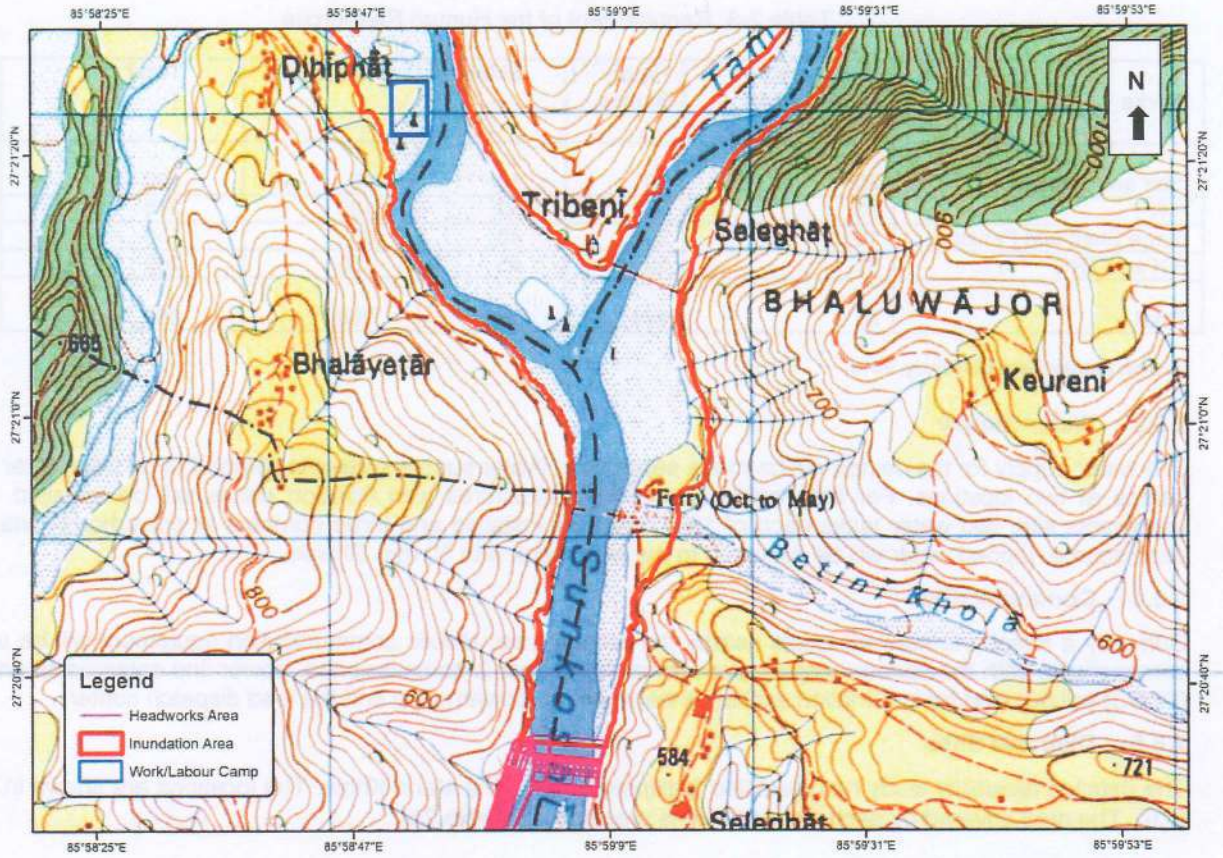
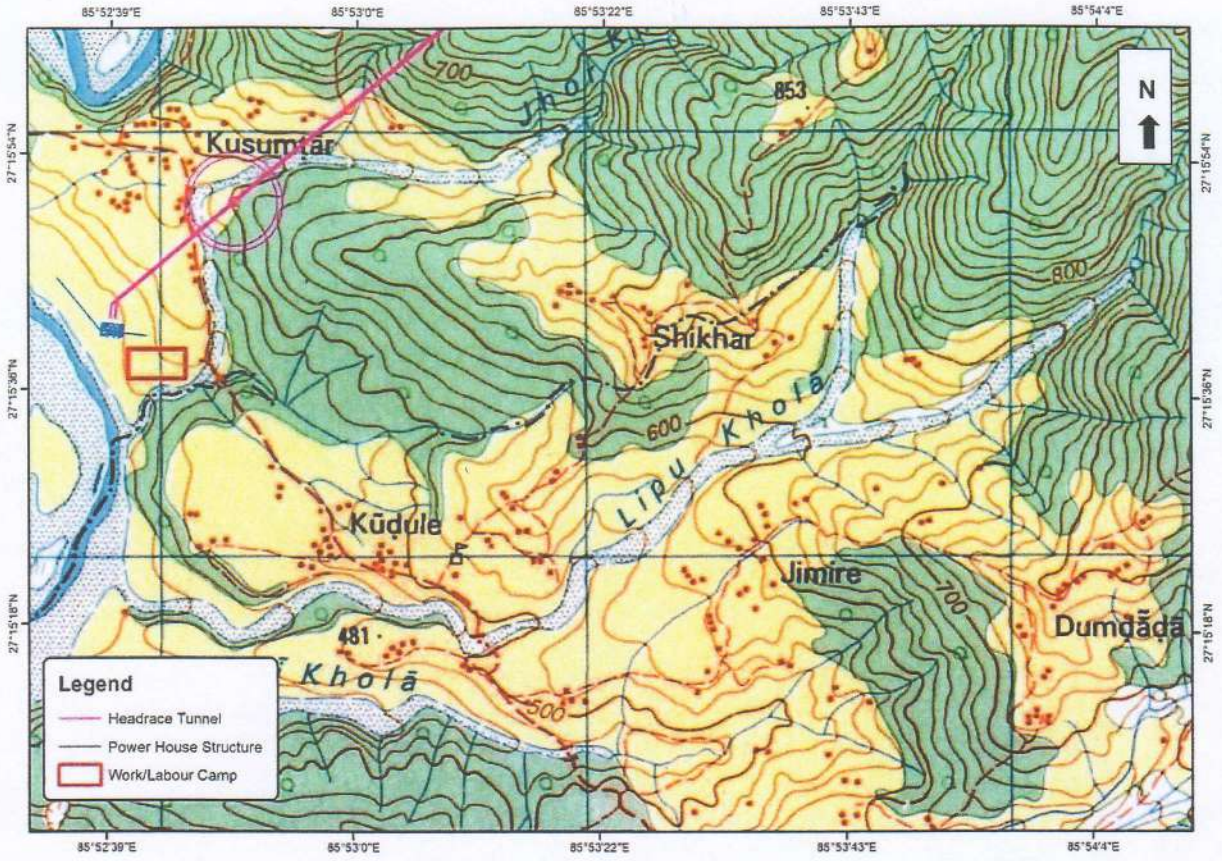


Figure 2-9: Location of Camp Facilities and Disposal Sites at the Powerhouse Site



2.7.2 Implementation Schedule

The Project is proposed to be commissioned in 60 months from the construction start date. After the award of work, the contractors will mobilize within one month and develop the extra infrastructure required for the construction within 8 months including camps, plant, and preparation of borrow areas. The access and construction power works are scheduled to be completed in 2 months and the Headworks and the powerhouse camp are scheduled to be completed in 8 months.

The main components of the work in the project are:

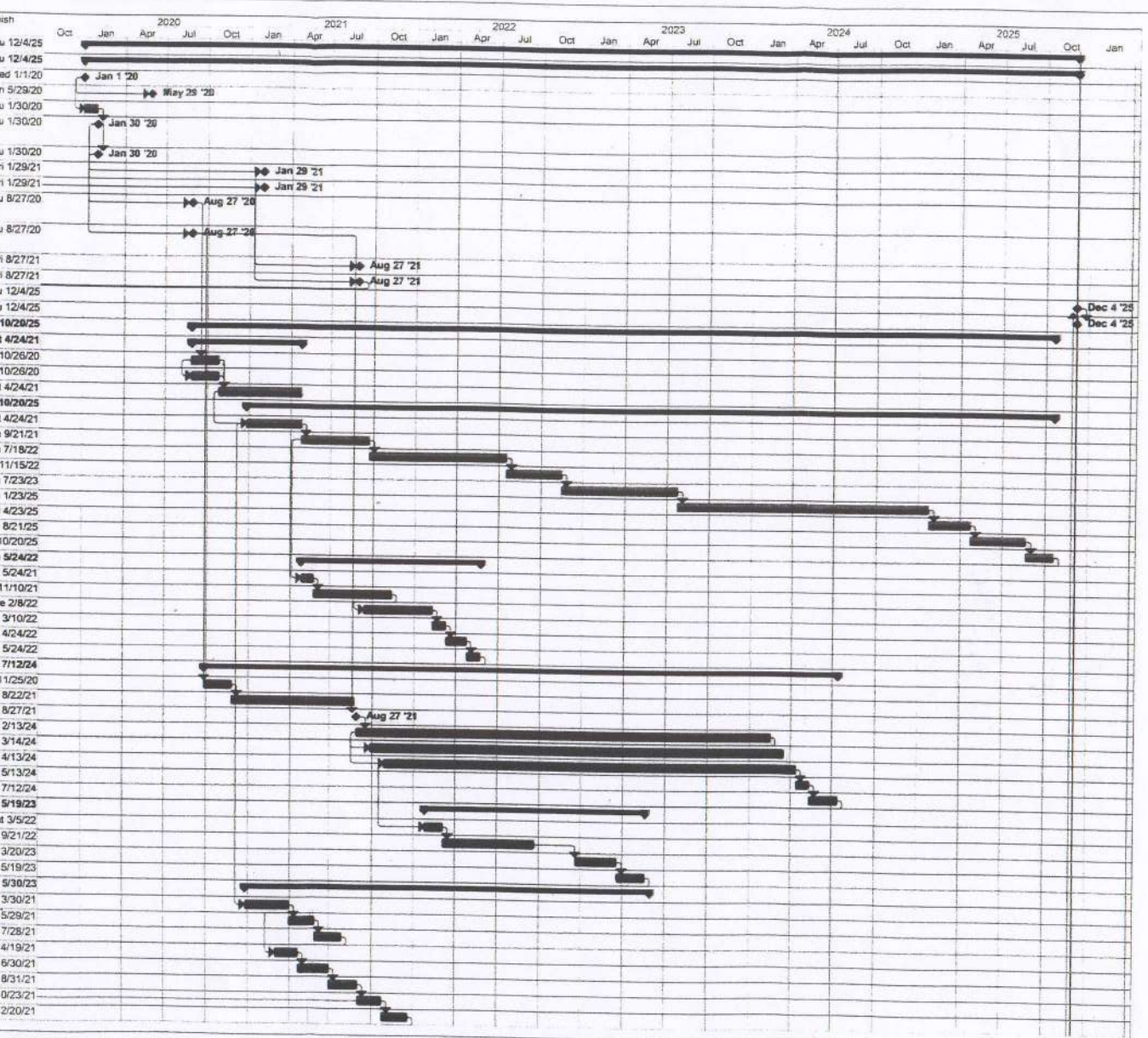
- Gated weir and undersluice.
- Intake, desander and Headpond
- Head race tunnel
- Surge tank
- Penstock tunnels and penstock
- Powerhouse, tail race channel and switch yard works
- Electro-mechanical works including erection, testing and commissioning of units.
- Transmission lines

The hydro mechanical works will be carried out along with the civil works of the various components in coordination. An implementation schedule of the project is presented in Figure 2-11.

The hydro-mechanical works will be carried out along with the civil works of the various components in coordination.

Figure 2-10: Implementation Schedule

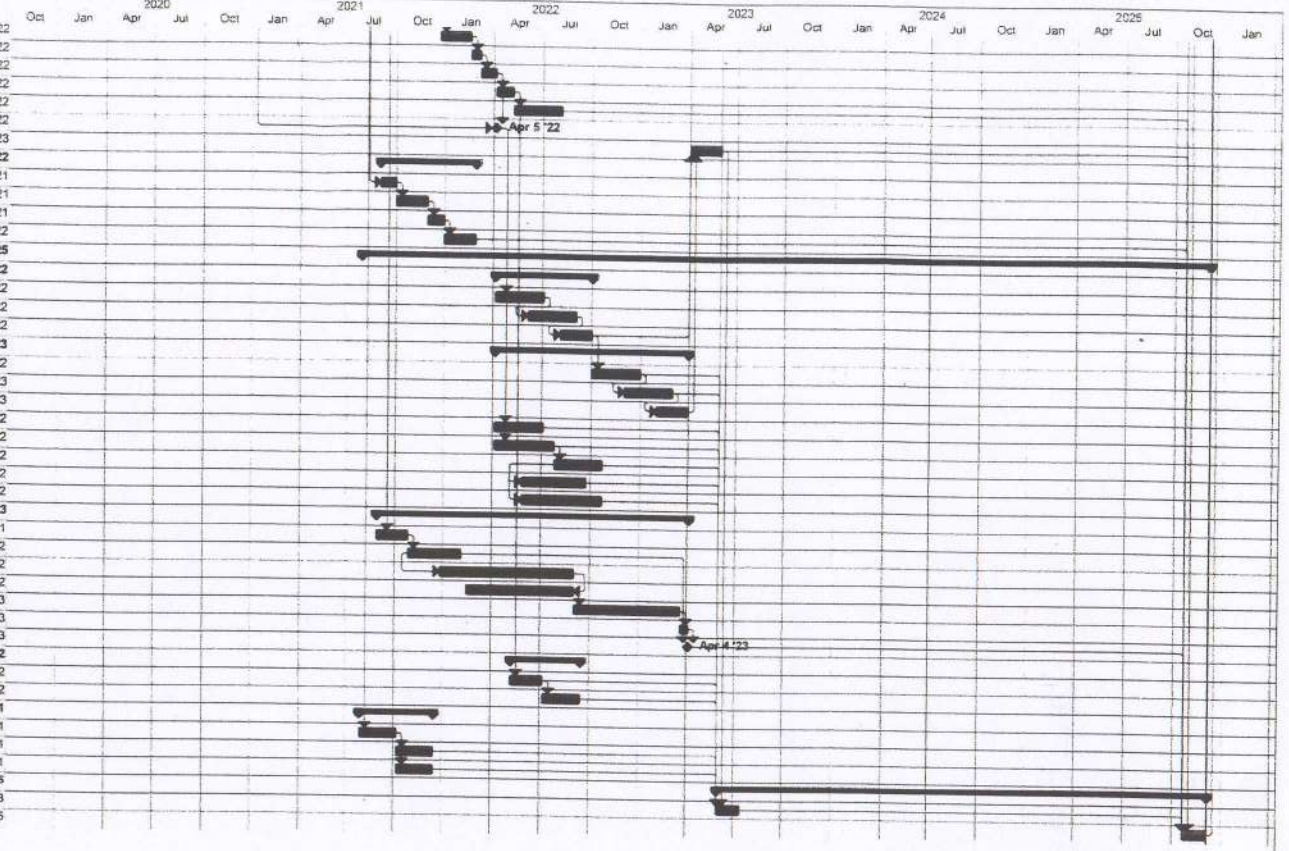
ID	Task Name	Duration	Start	Finish
1	**Overall Project Schedule**	**2165 days**	**Wed 1/1/20**	**Thu 12/4/25**
2	**Milestones**	**2165 days**	**Wed 1/1/20**	**Thu 12/4/25**
3	Consulting Package Notice Float	0 days	Wed 1/1/20	Wed 1/1/20
4	Consulting Contract Award	0 days	Fri 5/29/20	Fri 5/29/20
5	Estimate Approval	30 days	Wed 1/1/20	Thu 1/30/20
6	Lot 1 Headworks, PH and Infrastructure Package Notice	0 days	Thu 1/30/20	Thu 1/30/20
7	Lot 2 Tunnel and Surge tank Package Civil Notice	0 days	Thu 1/30/20	Thu 1/30/20
8	Lot 3 Electromechanical Package Notice	0 days	Fri 1/29/21	Fri 1/29/21
9	Lot 4 Transmission line package Notice	0 days	Fri 1/29/21	Fri 1/29/21
10	Lot 1 Headworks, PH and Infrastructure Package Commencement	0 days	Thu 8/27/20	Thu 8/27/20
11	Lot 2 Tunnel and Surge tank Package Civil Commencement	0 days	Thu 8/27/20	Thu 8/27/20
12	Lot 3 Electromechanical Package Commencement	0 days	Fri 8/27/21	Fri 8/27/21
13	Lot 4 Transmission line package Commencement	0 days	Fri 8/27/21	Fri 8/27/21
14	Commission of the project	0 days	Thu 12/4/25	Thu 12/4/25
15	Start of commercial operation	0 days	Thu 12/4/25	Thu 12/4/25
16	**General and Civil Works**	**1880 days**	**Fri 8/28/20**	**Mon 10/20/25**
17	**Site access and facilities**	**240 days**	**Fri 8/28/20**	**Sat 4/24/21**
18	Track Opening	60 days	Fri 8/28/20	Mon 10/26/20
19	Construction power	60 days	Fri 8/28/20	Mon 10/26/20
20	Camps and facilites	180 days	Tue 10/27/20	Sat 4/24/21
21	**Headworks Construction**	**1760 days**	**Sat 12/26/20**	**Mon 10/20/25**
22	First Stage River Diversion	120 days	Sat 12/26/20	Sat 4/24/21
23	Excavation For Undersluice and Intake	150 days	Sun 4/25/21	Tue 9/21/21
24	Concreting for undersluice and intake	300 days	Wed 9/22/21	Mon 7/18/22
25	Second Stage River Diversion	120 days	Tue 7/19/22	Tue 11/15/22
26	Excavation for Barrage Bay	250 days	Wed 11/16/22	Sun 7/23/23
27	Concreting for Barrage Bay	550 days	Mon 7/24/23	Thu 1/23/25
28	Hosting arrangement at Dam and Intake	90 days	Fri 1/24/25	Wed 4/23/25
29	Erection of Hydraulic Steel Works	120 days	Thu 4/24/25	Thu 8/21/25
30	Finishing Works	60 days	Fri 8/22/25	Mon 10/20/25
31	**Settling Basin and Headpond**	**395 days**	**Sun 4/25/21**	**Tue 5/24/22**
32	Filling and Surface Preparation	30 days	Sun 4/25/21	Mon 5/24/21
33	Excavation for desander and Headpond	170 days	Tue 5/25/21	Wed 11/10/21
34	Concreting for desander and Headpond	150 days	Sun 9/12/21	Tue 2/8/22
35	Hosting arrangement at Desander	30 days	Wed 2/9/22	Thu 3/10/22
36	Erection of hydraulic structure u/s and d/s	45 days	Fri 3/11/22	Sun 4/24/22
37	Finishing works	30 days	Mon 4/25/22	Tue 5/24/22
38	**Tunneling Works**	**1385 days**	**Sun 9/27/20**	**Fri 7/12/24**
39	Survey and Fixing Alignment	60 days	Sun 9/27/20	Wed 11/25/20
40	TBM Portal Construction	270 days	Thu 11/26/20	Sun 8/22/21
41	Arrival of TBM after Contract Award	0 days	Fri 8/27/21	Fri 8/27/21
42	Excavation from the Powerhouse Front	900 days	Sat 8/28/21	Tue 2/13/24
43	Laying of Ribs and Support	900 days	Mon 9/27/21	Thu 3/14/24
44	Shotcreting and Lining	900 days	Wed 10/27/21	Sat 4/13/24
45	Testing	30 days	Sun 4/14/24	Mon 5/13/24
46	Finishing works	60 days	Tue 5/14/24	Fri 7/12/24
47	**Surge Tank**	**480 days**	**Tue 1/25/22**	**Fri 5/19/23**
48	Preparatory works for surge tank	40 days	Tue 1/25/22	Sat 3/5/22
49	laying and finishing of surge pipe	200 days	Sun 3/6/22	Wed 9/21/22
50	Concreting bottom part	90 days	Wed 12/21/22	Mon 3/20/23
51	Finishing works	60 days	Tue 3/21/23	Fri 5/19/23
52	**Powerhouse and Swith Yard**	**886 days**	**Sat 12/26/20**	**Tue 5/30/23**
53	Excavation PH and Switchyard	95 days	Sat 12/26/20	Tue 3/30/21
54	Foundation works at switchyard	60 days	Wed 3/31/21	Sat 5/29/21
55	Finishing works at switchyard	60 days	Sun 5/30/21	Wed 7/28/21
56	Concreting EL 400	50 days	Mon 3/1/21	Mon 4/19/21
57	Concreting EL 408	72 days	Tue 4/20/21	Wed 6/30/21
58	Concreting El 410	62 days	Thu 7/1/21	Tue 8/31/21
59	Concreting EL 414.5	53 days	Wed 9/1/21	Sat 10/23/21
60	Concreting El 420	58 days	Sun 10/24/21	Mon 12/20/21



Project: Sunkoshi Marin Construction
Date: Thu 5/30/19

Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Critical
Critical Split
Progress
Deadline

ID	Task Name	Duration	Start	Finish
61	Concretig EL 424	58 days	Tue 12/21/21	Wed 2/16/22
62	Concreting EL 428 (Crane Level)	18 days	Thu 2/17/22	Sun 3/6/22
63	Gantry Crane Construction	30 days	Mon 3/7/22	Tue 4/5/22
64	Concreting EL 430.5	32 days	Wed 4/6/22	Sat 5/7/22
65	Roofing and Finishing Works	90 days	Sun 5/8/22	Fri 8/5/22
66	Ready for Electro Mechanical Erection	0 days	Tue 4/5/22	Tue 4/5/22
67	Second Stage Concreting	60 days	Sat 4/1/23	Tue 5/30/23
68	**Tailrace Outlet Structure**	**180 days**	**Wed 9/1/21**	**Sun 2/27/22**
69	Excavation	30 days	Wed 9/1/21	Thu 9/30/21
70	Concreting	60 days	Fri 10/1/21	Mon 11/29/21
71	Erosion Protection Works	30 days	Tue 11/30/21	Wed 12/29/21
72	Finishing Works	60 days	Thu 12/30/21	Sun 2/27/22
73	**Electromechanical and Transmission Line**	**1590 days**	**Thu 7/29/21**	**Thu 12/4/25**
74	**Mechanical Installation**	**180 days**	**Wed 4/6/22**	**Sun 10/2/22**
75	Installation of Unit 1 Turbine	90 days	Wed 4/6/22	Mon 7/4/22
76	Installation of Unit 2 Turbine	90 days	Sun 6/5/22	Fri 9/2/22
77	Installation of Unit 3 Turbine	60 days	Thu 8/4/22	Sun 10/2/22
78	**Electrical Installation**	**360 days**	**Wed 4/6/22**	**Fri 3/31/23**
79	Installation of unit 1 Generator	90 days	Mon 10/3/22	Sat 12/31/22
80	Installation of unit 2 Generator	90 days	Fri 12/2/22	Wed 3/1/23
81	Installation of unit 3 Generator	60 days	Tue 1/31/23	Fri 3/31/23
82	Transformers	90 days	Wed 4/6/22	Mon 7/4/22
83	220 kV Swithchgears	110 days	Wed 4/6/22	Sun 7/24/22
84	Cable and Outdoor Switchgear	90 days	Mon 7/25/22	Sat 10/22/22
85	Auxiliary Power and Cable	120 days	Thu 5/26/22	Thu 9/22/22
86	Control and Telecom	150 days	Thu 5/26/22	Sat 10/22/22
87	**132 KV Transmission Line**	**585 days**	**Sat 8/28/21**	**Tue 4/4/23**
88	Alignment Survey	60 days	Sat 8/28/21	Tue 10/26/21
89	Foundation Excavation	100 days	Wed 10/27/21	Thu 2/3/22
90	Tower Erection	250 days	Sun 12/26/21	Thu 9/1/22
91	Rivetments	200 days	Mon 2/14/22	Thu 9/1/22
92	Stringing of Conductors	200 days	Fri 9/2/22	Mon 3/20/23
93	Testing and Commissioning	15 days	Tue 3/21/23	Tue 4/4/23
94	Ready for Connection	0 days	Tue 4/4/23	Tue 4/4/23
95	**Air Conditioning and Fire Fighting**	**130 days**	**Sun 5/8/22**	**Wed 9/14/22**
96	Installation of air conditioning system	60 days	Sun 5/8/22	Wed 7/6/22
97	Fire detection system	70 days	Thu 7/7/22	Wed 9/14/22
98	**Gene. Trans. And 415 KV Switch Gear/11 KV**	**140 days**	**Thu 7/29/21**	**Wed 12/15/21**
99	Aux. transformer 11/0.4 KV	70 days	Thu 7/29/21	Wed 10/6/21
100	415 V AC Switchgear (erection and test)	70 days	Thu 10/7/21	Wed 12/15/21
101	11 KV Switchgear (erection and test)	70 days	Thu 10/7/21	Wed 12/15/21
102	**Commissioning**	**919 days**	**Wed 5/31/23**	**Thu 12/4/25**
103	Dry Commissioning	45 days	Wed 5/31/23	Fri 7/14/23
104	Wet Commissioning	45 days	Tue 10/21/25	Thu 12/4/25



Project: Sunkoshi Marin Construction
Date: Thu 5/30/19

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Critical
Split	External Tasks	Inactive Summary	Manual Summary	Critical Split
Milestone	External Milestone	Manual Task	Start-only	Progress
Summary	Inactive Task	Duration-only	Finish-only	Deadline

The details of construction methodology for the various components of works are as follows:

2.7.2.1 Weir and Undersluice

The construction of gated weir and undersluice includes the following works: river diversion, excavation for foundation, foundation treatment, concreting works and gate erection. The boulder mixed soil and rocks are expected to be encountered at the headworks site as per the geological investigation. Hence, driving of sheet pile will be difficult in that condition. For seepage control, the proposed foundation works for the barrage consists of the in-situ bored concrete piles and curtain grouting filling the gaps between the piles. In case hard rock is encountered above the designed levels of the bore piles, appropriate anchoring mechanism has to be installed during construction.

2.7.2.2 River Diversion

The structures to be constructed will not be completed in a single season. Roller compacted concrete coffer dams will be constructed in two stages. The maximum flood discharge considered for the diversion during construction is 4154m^3/s which corresponds to annual flood (considered as 1 in 2 years flood). The flood estimate at the diversion site was derived from flow data from year 1968 to 2009. This is considered as diversion flood for planning diversion arrangements.

(i) First Stage Diversion

The river diversion in SMDMP comprises of two stages. In stage one, a cofferdam will be constructed along the right bank side of the river diverting the flow in the left river channel to construct undersluice, part of the intake and divide wall as shown in DWG. SMDMP-RD-01. Due to topographical considerations, diversion of flow through tunnels or closed conduits is not possible. Hence, diversion is contemplated on the left side of the river bank by forming diversion channel of width of 57 m.

Roller compacted concrete coffer dam with a top width of 2.0 m and 112 high will be constructed as shown in the drawing. The coffer dam will be approximately 620m long. This cofferdam construction will require about 4 months as shown in the construction schedule. The water level for the diversion flood of 4154m^3/s flowing over the broad crested weir works out to about EL 469.0 m. Hence, considering a free board of 1.0 m over the flood water level the top of the bund during diversion is about EL 470 m.

The construction works of the undersluice bays will require excavation upto the level of El 443.0 which is 16m below the average bed level. Hence, the provision of grouting throughout the length of the cofferdam will be required to prevent seepage of water into the working area.

(ii) Second Stage Diversion

Second diversion will facilitate the construction of the main weir by diverting the flow through the in place undersluice as shown in Drawing SMDMP-RD-02. The second stage coffer dam will be a roller compacted concrete dam which will extend upstream and downstream of the divide wall. Hence, diversion is contemplated on the right side of the river bank by forming diversion channel of width of 36 m.

Coffer dam with a top width of 2.0 m and bottom width of 5.0m will be constructed. This dam will be approximately 548m long. This cofferdam construction will require about 4 months. The water level for the diversion flood of 4154m^3/s flowing over the broad crested weir works out to about EL 471.9 m. Hence, considering a free board of 1.1 m over the flood water level, the top of the bund during diversion is about EL 473 m.

The construction works of the barrage bays will require excavation up to the level of El 446.0 which is 13m below the average bed level. Hence, the provision of grouting throughout the length of the cofferdam will be required to prevent seepage of water into the work area.

(iii) Construction works

Excavation for the under sluice section of the dam and the intake will start immediately after completion of the first stage cofferdam. This activity will take about five months and concrete work will start after the completion of excavation. The concreting of the undersluice, dividing wall and the intake up to the invert level will take up to six months. This will facilitate the construction of the upper part of the structure while diverting flow. The concreting of the intake piers and the decks is scheduled to be completed in four months. The complete undersluice, intake and dividing wall works will start from month 17 and will be completed in month 30 as shown in the construction schedule.

The second stage cofferdam will protect the left bank of the river channel diverting the flow through the undersluice, allowing excavation and treatment of the foundation. The excavation of the weir foundation will be started soon after the completion of the second stage cofferdam and is scheduled to take about eight months.

The river bed level at the axis of the proposed Weir site varies from EL 459.0 m to EL 460.0 m over a width of 175 m. Since the foundation grade rock is not expected to be available at reasonable depth, the weir is designed considering permeable foundation conditions.

During month 43, the concreting of the weir structures will be started including spillway crest and is scheduled to take up to nine months. After concreting of the piers, the deck and stilling basin will be constructed inn nine months.

The installation of the hoisting arrangement and spillway gates is scheduled after the concreting of the weir and will require about seven months for the completion.

2.7.2.3 Headworks

The construction of the desanding basin and headpond will be started from month 16 and will be completed in 14 months. The excavation of the basin and the treatment of the foundation are scheduled to be completed in six months and the concrete works at all of the sections to be completed in eight months.

2.7.2.4 Head Race Tunnel

The head race tunnel is of 5.5 m diameter and circular shaped. The tunnel, 13.1 km long, will be excavated by means of TBM method from the inlet portal located near the powerhouse site at the end of the tunnel. The TBM will be available 12 months after the beginning of the works. The TBM inlet portal of about 155m long will be excavated to enable the erection of TBM which will require about 9 months. This also includes preparation of the launching area of the TBM.

After the arrival of TBM, the actual excavation and concreting of the tunnel will require about 30 months. The linings of the tunnel will be erected with the advance of TBM. The concrete lining will be performed by the TBM with the segmental concrete liners of 0.3m thickness.

2.7.2.5 Surge Shaft

An orifice type surge shaft of 22m internal diameter is proposed for SMDMP Project. The orifice is 4.0 m dia. in the surge shaft. The top EL of the shaft is EL 500.00m and the bottom EL 424.78 m. Thus, the total height of surge shaft is 75.22 m.

The top portion of about 8-10 m gets exposed when completed. The surface excavation shall be followed by the pilot shaft hole excavation. After the pilot shaft excavation is completed, the main shaft excavation shall start from the top where the muck shall be collected at the bottom and shall be transported via the access through tunnel.

The rate of pilot shaft hole excavation has been taken as 2 m /day and with this rate, it would require about 40 days to excavate 75.22 m. Once the pilot shaft hole is completed, the shaft enlargement can take place with a raise bore. This activity has been scheduled to be completed in three months after which the shaft can be enlarged to the final diameter. The duration required for the shaft to be enlarged to the final dimension will require nine months. The lining can be performed with the enlargement of the shaft and will require twelve months. The total required duration comes out to be about 26 months.

The complete excavation shall be followed with the concrete lining of the shaft. The concreting shall be done from the bottom going upwards with a lift height limited to 3 m. The last conical part, which is located at the base of the surge shaft, shall be done only after the shaft lining is completed.

The last conical shape part at the bottom of the surge shaft shall be done at the later stage when the shaft lining is completed and the installation of penstock pipe at that point is completed. Due to its complicacy the duration has been estimated as 26 days.

The approach to the Surge shaft is from the portal of horizontal penstock tunnel of internal diameter 4.4 m which is located at the bottom of surge shaft.

The location of the Pilot holes is so selected that the progress of HRT work through the Surge Shaft is not hampered while the work of excavation in surge shaft continued.

2.7.2.6 Penstock

Penstock tunnel of 4.4 m diameter and 360 m length takes off from Surge Shaft. The work is similar in nature to the HRT works. The open penstock of 4.4 m dia. trifurcates into 2.6 m dia. about 40 m long penstocks leading to three turbines.

The time considered for completion of this work is 20 months, which is reasonable with reference to the quantities involved.

2.7.2.7 Power House, Tail Race Channel & Office Building

One of the most important components of the project in view of its complexity and requirement of co-ordination between various agencies viz., Civil, Hydro-Mechanical and Electro-Mechanical is planned to be completed in 40.6 months. The civil works of powerhouse will be completed in 22 months.

The Construction of Hydropower Station is systematized in recent times. Considering the planned time, the work of Powerhouse, TRC and Switch Yard can be completed as planned.

The concreting of the powerhouse structure shall be done with the concrete pump having the pumping capacity of 50 to 60 cum per hour. At least one concrete pump should be readily available throughout the period of construction. Furthermore it is necessary to install one tower crane at the powerhouse for the ease of delivery of construction materials such as reinforcement, formworks etc. to the specific location. The tower crane could also be used for the concrete works however this provision has not been taken into account. The total estimated backfilling quantity is about 91000 cum. A bulldozer shall be used for spreading and compaction.

The most important component of the project in view of its complexity and requirement is co-ordination between various agencies.

2.7.2.8 Quality Control

The laboratory for the testing of construction materials (cement, sand, soil, aggregate, reinforcement bars, concrete, etc.) will be set-up at the site by the civil contractor. However, some tests which cannot be conducted at the site will be carried out at other recognized laboratories outside the project area.

2.8 CONSTRUCTION MATERIALS

The project would require large volume of construction materials. The estimated quantity of the material requirement is presented in Table 2.4.

Table 2-4 Estimated Quantity of Construction Material

SN	Item	Unit	Quantity
1	Aggregates	Cum	93.775.33
2	Sand	Cum	43,105.71
3	Cement	Mt	65,177.0
4	Reinforced Steel	Mt	8,125.27
5	Structural steel	Mt	1.284.74

Source: DetailedFeasibilityReport, 2019

Figure 2-10 and 2-11show material survey locations together with areal distribution of construction materials and muck disposal area.

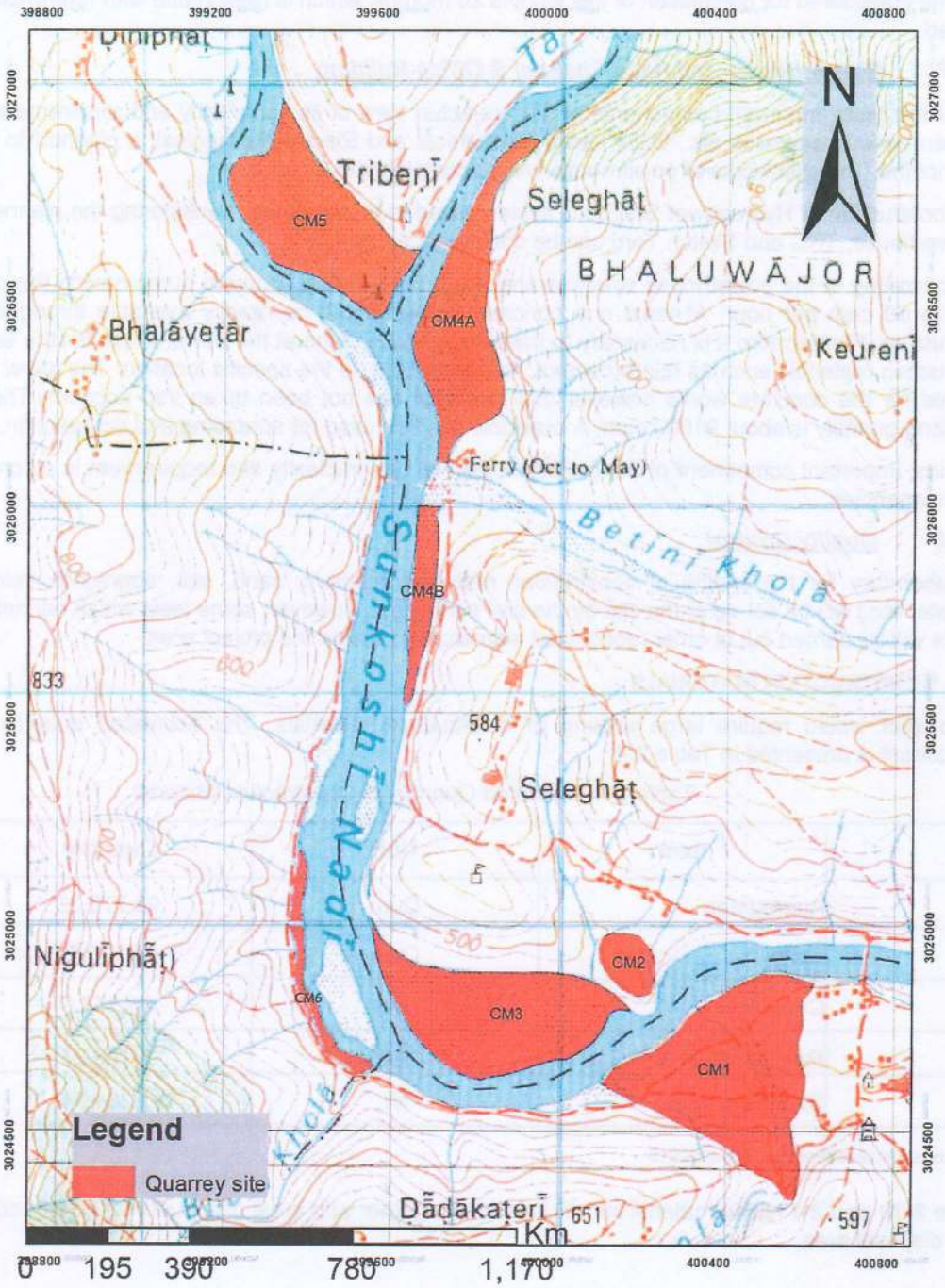


Figure 2-10: Location map of proposed construction material sites (CM1-CM6).

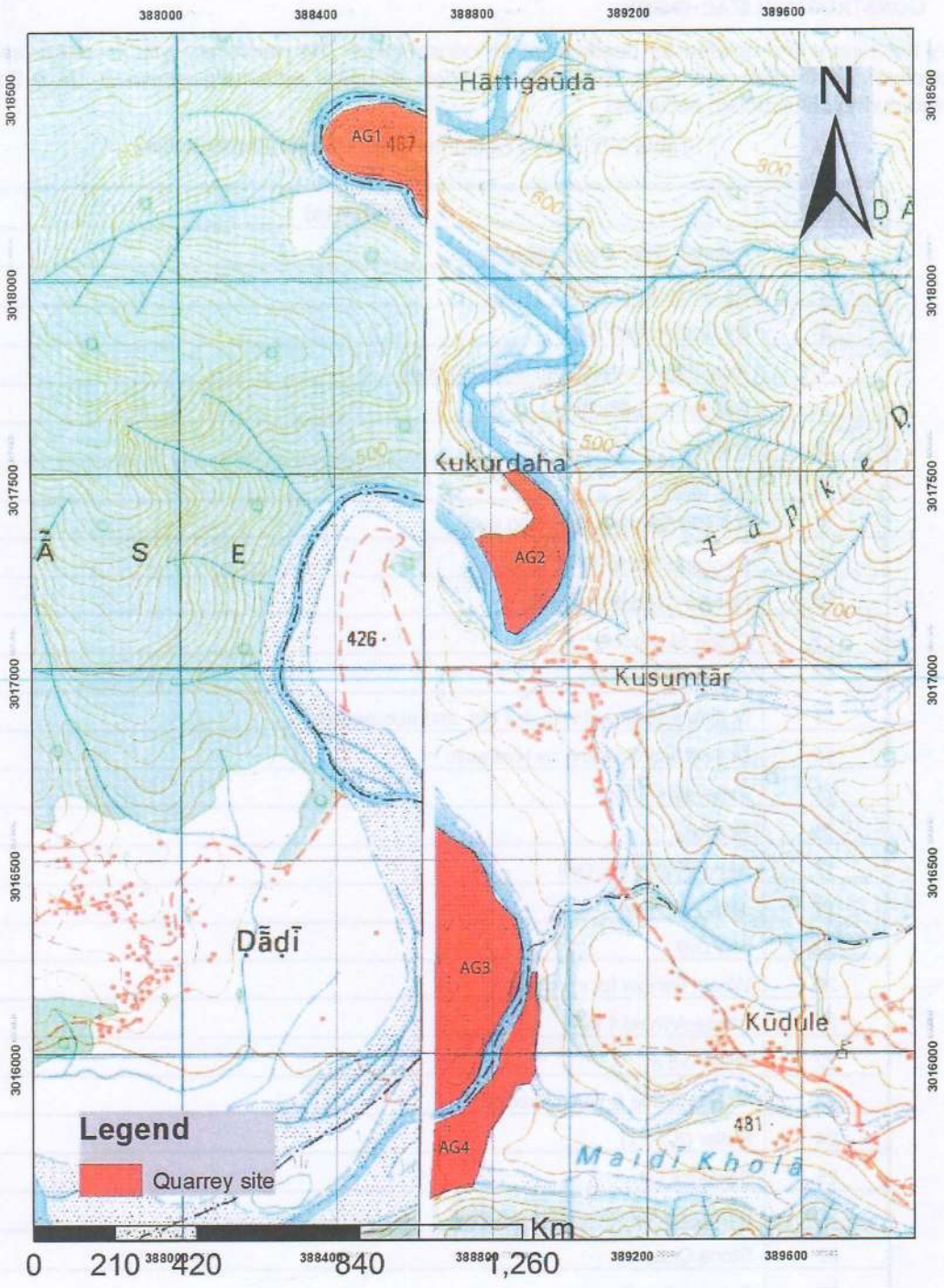


Figure 2-11: Location map of proposed construction material sites (A91-A94).

Cement, steel plates and reinforcement steel required for the project will be imported from India and will be transported by road to the stocks yards and stores located the near project sites.

Explosives required will also be procured from India and stored in the Magazine of adequate capacity near the project site.

2.9 CONSTRUCTION MACHINERY

Heavy machinery is proposed for deployment for construction. The machinery will be readily available with the prospective construction agencies. The following types of heavy equipment shown in Table 2.5 are generally required during construction activities.

Table 2-5: Heavy Equipment required for Construction

S.No.	Equipment
1	Agitator Truck 4 cum capacity
2	Air Compressor (14 m^3)
3	Air Compressor (9 m^3)
4	Axial Flow Exhaust Fan including duct
5	Bar Bending Machine
6	Bucket
7	Bull Dozer
8	Potable batching plant 500 liter
9	Concrete Pump 15 m^3/hr.
10	Needle Concrete Vibrator
11	Crane 5t capacity
12	Crane 12t capacity
13	Drilling Equipment with drill rod and accessories
14	Drilling and Grouting by Hydraulic
15	Excavator 0.8 m^3
16	Grader
17	Hand Pneumatic Drill
18	Jack Hammer
19	Leg Drill
20	Wheel Barrow for mucking
21	Loader/Wheel 1 m^3
22	Mixer 0.5 m^3
23	Mobile Crane 5 Ton Capacity
24	Roller (8-10 T)
25	Scissor's Lift
26	Shotcrete Machine (Mixture) Wet
27	Stone Crusher
27	Submersible Pump
28	Tipper Truck (15 Ton Capacity)
29	Tipper Truck (Small)
30	General Purpose Truck (6-8 Ton Capacity)
31	Vibrating Roller (8-10 ton capacity)
32	Vibrating Roller (1-2 ton capacity)
33	Water Pump Mono-block
34	Welding Generator
35	Wheel Loader 1.8 m^3

S.No.	Equipment
36	Winch 5 t capacity
37	Concrete Vibrator
38	Vent fan
39	Compressor
40	Shotcrete Machine (Mixture)
41	Locomotive
42	Loader (KLD)
43	Tipper (6 Cum)
44	Diesel Air Compressor (XA 280)
45	Shotcrete Machine (HPZU-5B)
46	Pressure Grouting (2 SNS, 6375)
47	Hand Pneumatic drill
48	Vertical Drilling Machine
49	Water Pump
50	Axial flow Exhaust Fan (Z90-1)
51	Down Hole Drill
52	Winch
53	Winch
54	Winch
55	Jeep 10 seater
56	Total Station
57	Concrete mixer (0.4 m^3)
58	Agitator (1.25 m^3)
59	Grout Pump

A full-fledged workshop will be maintained by the construction agencies for repair of equipment and machinery employed on construction activities. Sufficient inventory of spares and critical items will be stored.

2.10 LAND REQUIREMENT

The total permanent land required for the project is 340.51 ha permanently. Component wise land requirement and the total area required for each component is presented in the Table 2.6.

Table 2-6 Land Requirement for the Project

Sl	Components	Government Land						Total Government Land	Private		Total Private Land	Area in ha	Remarks
		Forest		Bush	River course	Sand Bar deposition	agricultural land		Cultivated land/ barren land				
	Permanent Land Requirement	Gov	CF						Deregistered	Registered			
1	Inundation Area	2.94			49.34	180.81		*233.09*	18.37	60.54	*78.91*	312.00	
2	Intake Structures like weir, intake, settling basin, approach cannal etc	0.53			1.34	1.47		*3.33*			-	3.33	
3	Area required for the affected roads			11.50				*11.50*			-	11.50	Existing road track (2.3 km)
4	Power house site with surge tank, penstock, switchyard, audit, work camp etc		2.10					*2.10*		8.92	*8.92*	11.02	
5	Access Road	1.01	1.30			0.35		*2.66*			-	2.66	
	TOTAL	4.48	3.40	11.50	50.68	182.63		*252.68*	18.37	69.46	*87.83*	340.51	
	Temporary Land Requirement												
3	Muck Disposal Area												
	D1						3.65	*3.65*			-	3.65	near power house
	D2				0.46		0.70	*1.16*			-	1.16	Upsteam from the road bridge
	D3				1.58			*1.58*			-	1.58	

Note: All government land is considered as forest land

CHAPTER – 3

3 METHODOLOGY

3.1 GENERAL

Available information was collected through literature review and field works. Secondary information was collected through published and unpublished reports and interpretation of maps and photographs. Primary level of information was generated through household level questionnaire, key informant survey, focused group discussion, measurement and walk through survey etc. Local people were contacted and interviewed to solicit and update information. Four key informant surveys (KISs) were carried out at the affected settlements. The district level offices, municipality/ rural municipality office, and community groups were also contacted to verify data and information, and to solicit their concerns.

The EIA study comprised of:

- Literature review and map interpretation;
- Preparation of checklists and questionnaires;
- Field study to collect primary information and verify secondary information through interview and participatory discussion with the local people;
- Data processing/analysis, and impact assessment;
- Preparation of the draft report;
- Conduction of public hearing at the project site; and
- Preparation and submission of the final report.

In order to meet the objectives of this study and the requirements of the approved Scoping Document and the ToR, necessary information was collected and analyzed by forming a multidisciplinary study team as given below and employing the methods explained below in Section-2.4.

3.2 STUDY TEAM

The EIA study team comprised of following key professional from multi-disciplinary field.

1.	Subarna B. Joshi	-	Team Leader/Environmental Specialist
2.	Amod Kumar Thapa	-	Hydraulic /Irrigation Engineer
3.	Dr Rabindra Shrestha	-	Ecologist/Forestry Expert
4.	Raj Kapor Napit	-	Aquatic Life Expert
5.	Saroj Adhikari	-	Sociologist
6	Niraj Pandey	-	Environment Engineer
7	Milan Kumar Rai	-	GIS specialist

Apart from above key professionals, necessary support staffs were mobilized to complete this study.

3.3 PROJECT AREA DELINEATION

The study area of proposed multi-purpose project is as follows:

- Inundationarea within Sunkoshi Rural Municipality (RM), Khadadevi RM and Manthali Municipality with a ponding area of 312ha.and maximum depth of the inundation to be12m above the weir crest level.
- Major hydropower components such as headwork and its associated structure including tunnel alignment located in Sunkoshi Rural Municipality and Kamalamai Municipality ,and powerhouse site locatedin Kamalamai Municipality,
- Area required for the disposal sites, work camp, labor camp, employers camp, contractor camp located in Sunkoshi Rural Municipality and Kamalamai Municipality,
- River stretch of Marin Khola from the proposed tailrace of the powerhouse to the confluence of Bagamati River due to the augmented flow located Kamalamai Municipality, Marin and Hariharpurgadi Rural Municipality.

The physical locations of the above components are considered **directly impact** area whereas the respective RM and Municipality is **indirect impact area**.

The generated electricity will be connected to the national grid of transmission line hence the zone of influence will be at the national level whereas the command area of the Bagamati Irrigation Project will be specific zone of influence. Irrigation and transmission lines are broader components of the project and are not the scope of this EIA study.

3.4 METHODOLOGY

As mentioned above (#3.1), several methods were used to generate data and information on physical and chemical, biological and socio-economic and cultural aspects of the environment, including socio-economic data of the project affected families.

3.4.1 Desk Study

a. Literature Review

In order to collect the physical information and provide project highlights, the detailed feasibility study of the Project, Report of Flood Protection Plan of Marin Khola and the other relevant reports were thoroughly reviewed. In addition, data and information of the topographical survey, river cross sections and access road surveys and other surveys for drill holes, test pits, borrow areas, including geological and geotechnical investigations and location of quarry sites for the construction materials were reviewed.

b. Map Interpretation

The following maps were interpreted to extract necessary information, particularly on physical aspects. They were;

a) 1:50,000 scale topographic map of the project area prepared by the Department of Survey;
b) 1:50,000 scale land use, land system and land capability map prepared by LRMP, Department of Survey;
c) 1:125,000 scale district map of Sindhuli and Ramechap District;
d) 1:1,000 scale topographical maps of the headworks site and desanding basin, pressure shaft, penstock alignment, and powerhouse sites;
e) 1:1,000 scale topographical maps of the project road alignment;
f) 1:5,000 scale project area layout with 5m contour interval; and
g) 1:1,000 scale engineering geological maps covering the headworks, penstock and powerhouse sites.
h) Drone map of the inundation area and headworks
i) Drone map of the Marin Khola from proposed tailrace to Bagmati River confluence

3.4.2 Preparation of Check-lists / Questionnaires and Field Study

For the detail field study, checklists were prepared to gather information on the physical parameters and on biological resources, particularly the terrestrial flora and fauna. Attention was given to accommodate issues as contained, *inter alia*, in the National EIA Guidelines (1993), EIA Guidelines for Forestry Sector (1995), , Environmental Management Plan for EIA Study of Hydroelectric Projects in Nepal prepared by DoED, other issues as contained in the Schedule 6 of the EPR (1997)and the approved ToR.

A checklist was used to collect information on the composition of plants and animals and their status in the direct and indirect impact areas. A data sheet was prepared and used to record girth and height of each tree found at the intake site, approach canal, powerhouse site, construction adit, employers camp, muck disposal and project road. A simple checklist was used to collect ethno-botanical information with particular focus on usage of plants including the parts used, method and purpose of use. Similar checklist was prepared for plants in trade, animals and their status. Information sheet was also used to collect necessary information on community forests. The checklist for the collection on biological environment is presented in Annex-1.1.

A structured Household Survey questionnaire was prepared to solicit the information on socio-economic and cultural aspects of the environment (Annex-1.2). Furthermore, a checklist (Annex-1.3) was prepared for the key informant survey, which was used to crosscheck and verify the information.

3.4.3 Field Survey and Investigation

Information on physical environment was collected through drone survey and walk through survey.

A drone survey of the inundation area was carried out to collect data. The inundation level of 476.00 m was marked on the drone map and the impacts within the inundation level were collected and verified from the field survey.

Information on biological environment such as vegetation was collected by inventory, while wildlife occurrence and distribution in the project area were collected through pug marks of the wild animals, jungle trek and observation method including discussion with the local people. Fishery information was generated by capture-recapture method, and by asking local people and site observation.

i) Physical Environment

Following approaches were adopted to collect baseline information and to identity and predict impacts on the environmental domain:

- Use of topographical (1:25,000scale) and landuse maps.
- Drone map of the project area
- Cadastral maps of the project affected areas
- Field observation by concerned experts and sub-ordinate field staffs
- Photo documentation of settlements, topography and critical sections of the project area
- Collection of water samples from the Sunkoshi River and Marin Khola;
- Collection of air quality data at the headworks site
- Noise level measurement at the project sites.

As also referred above, most of the information on the physical environment was compiled from the detailed feasibility study report and several site visits. The field observation and walkthrough method was adopted to verify information on geological condition, drainage system, slope stability, landslide-prone areas, work camp and labor camp, spoil disposal site and other construction-related environmental issues. Checklist was used to generate information on erosion problem and possible accumulation of construction wastes in the water bodies or the land system, whereas topographical map was used to locate landslides and areas of slope failure.

ii) Biological Environment

As required by the ToR, the field survey was carried out at all sites of the project, including inundation area. Standard methods were followed to collect the site specific data on plants.

Site specific floral assessment was total enumeration, measuring every tree and pole size plants were adopted while counting natural regeneration they were not differentiated into seedlings and saplings since distinguishing seedling and sapling based on their height and diameter would confuse. Hence, regenerations from 0 to 10 cm Diameter at Breast height (dbh) were considered as a natural regeneration. Likewise simple and commonly used equipment like sunto-clinometer and diameter tape were used to measure tree height and dbh directly. To calculate standing volume of each species a standard Volume Table developed by the Forest Survey and Statistics Division of the then Ministry of Forests and Soil Conservation (MFSC) in1990 was used. But for those species not included into the Volume Table, a hill miscellaneous column of the Volume Table was used to calculate the volume. Similarly to calculate foliage and fuel wood biomass of the species a "Biomass and Volume Tables with Species Description for Community Forest Management" (TISC Technical Paper Series No. 101 published in 2000 by then Department of Forests, MFSC) was used. In addition, a Nepal Forestry Handbook (FORSPA Publication No.32/2002) was used for foliage biomass.

Detail information on the presence and visits of wildlife within the project sites were collected through meeting and interactions with local people.

Data collected on wild plants and animals during the field work are presented in Annex-2.

For the aquatic life, field survey was carried out by a team of fishery experts and, and support staffs in fish and aquatic life of river system. The field survey and investigation was lasted for 4 days (30 May 2019 to 2 June 2019). The field survey included collection of fish specimen, Prephyton and aquatic insects from different sampling locations, identification and characterization of fish habitat and collection of information about fish migration and spawning pattern. Check list was developed and used for the fish data collection. Potentialfish habitats were observed (visual method). Topographical map of 1:25000 Scales was used for river habitat identification and characterization. Possible spawning habitat conditions such as type, cover and shelter were recorded by walking along side of river bank. The fish habitat such as run, riffle and pool in different section of Sunkoshi River and Marin Khola was recorded by observation during the field visit. The number of efforts employed by fishermen was recorded to determine Catch per Unit Effort (CPUE). The collected fish species were identified at site, to the extent possible. Measurements of total length, weight and other morphological characteristic were recorded. Detailed study of local fishes was carried out for determining dominant species, species diversity, taxonomic and endemic characteristics for local and global listing. Standard data sheet was

developed and used for data collection. Fish species caught during the field visit at each sampling site was identified using standard method of taxonomy (Shrestha, 2008).

The number of fish was caught and test like measuring the length and weight of sample fish with photograph was carried out. After completing the collection of required data and information, the fish was then released in the river immediately. The formats used for the aquatic life survey is presented in Annex 1-4.

iii) Socio-economic and Cultural Environment

The property owners (including land) within the direct impact area (the area where the land use will be changed due to project implementation) were identified and categorized as the project affected families (PAFs). Household questionnaire was administered with about 20 % of the PAFs who were available in the project area during the period of filed study. The 5key informant survey (KIS) were held in 'to be' project-affected settlements, namely (i) right bank of Tamakoshi River, Khadadevi Rural Municipality- 4, Rajgaun; (ii) leftbank of Tamakoshi River, Manthali Municipality-6, Hattitar; (iii) right bank of Sunkoshi River, Sunkoshi Rural Municipality-6, Khalte; (iv) left bank of Sunkoshi River,Khadadevi Rural Municipality-4, Puchighat; and (v) Kamalaimai Municipality-2, Kusumetar. Two focused group discussions were held -one with women group in Kusumetar, and second one with Mijhi community in Hattitar. Outcome from these meetings is presented in Annex 3. The study team also made extensive discussion with the Rural Municipality and Municipality officials and local people with the objectives of collecting and verifying the site-specific socio-economic data and information.

Possible loss of land and property was estimated by overlaying project infrastructures prepared by detailed feasibility study team on the drone map and cadastral maps. Social service facilities such as health, education, drinking water; and infrastructures such as irrigation canal, drinking water pipes etc. within the project area and other areas that will be affected by the project activities were noted.

The data on socio-economic aspects collected during the field work are presented in Annex-3. Attempts were made to quantify baseline condition of the project sites to the extent possible.

3.4.4 Consultation Meeting

During the field study, the study team organized a number of consultative meetings with the local people and local leaders in the nearby settlements of the headworks site, access road, and powerhouse site. Local people were contacted to offer their concerns and opinions on biological and socio-economic aspects and they have been duly documented in the report at appropriate places.

3.4.5 Data Processing

Primary and secondary information were analyzed and processed. Information on physical environment was processed based on secondary information and ground observation. Water quality analysis was carried out by using standard methods (reference). The standing wood volume of trees was estimated using the following quarter-girth formula (MoFSC, 1995).

Volume = (Girth^2 / 16) x height

Net Volume = Volume x 0.7854

Each plant and wild animal was listed. The total number of plant species has been extrapolated using the sampled data.

Socio-economic and cultural information were cross-checked, analyzed and thoroughly edited. Standard conversion tables were used to convert local units into metric system. All data were processed and synthesized using Microsoft Access Program. Processed information are incorporated and illustrated adequately with tables and maps at appropriate places in the text.

3.4.6 Impact Assessment Method

Impacts were identified by employing the methods such as expert judgment, checklist, and map overlays. Matrix method was used to identify the possible beneficial and adverse impacts due to implementation of the proposed project. For easy understanding, direct impacts were identified through maps overlays.

Normative technique and professional judgment were used to predict the impacts, to the extent possible (IUCN, 1996; Lohani et al., 1997; and Uprety, 2003). Significance of the identified and predicted impacts was evaluated using the numerical values as included in the National EIA Guidelines 1993 (NPC, 1993), use of regulated list of wild plant (also called banned NTFPs) and animal species (HMG, 1973, and GoN, 2010), discussion amongst the study team members, consultation with the experts, and consideration of national policies, laws and local customs (Uprety, 2003). Impacts have been presented in the matrix form. The following criteria were arbitrarily considered in this study to evaluate the significance of the identified and predicted adverse impacts of the project activities on the environment:

1. If the total points of impact magnitude, extent and duration is greater than 75, 50 to 75, and less than 50 (using the National EIA Guidelines, 1993), the impact has been considered significant, moderately significant and insignificant respectively.
2. If the species of wild plants and animals protected under the legal system of Nepal and the species as included in the CITES appendix 1 and 2 are to be clear felled, the impact has been considered significant.
3. Any loss of rare, endangered and endemic species or critical or productive habitat is considered significant impact.
4. If the number of legally unprotected species over 15 is to be removed from the project site as a part of site clearance, the impact has been considered significant. If the number of legally unprotected species ranging from 5 to 14 will be removed from the project site as a part of site clearance, the impact has been considered moderately significant. The impact has been considered insignificant if the number of species (less than 5) will be removed from the project site.
5. Any impact(s) to the PAFs have been considered significant.
6. Displacement of any family and temple (religious place or site) has been considered significant. Also direct impact on women and disadvantageous group has been considered significant.
7. Impact will be significant, if any portion/parcel of the prime agricultural land will be lost (at site-specific level) due to project activities.
8. Impacts resulted due to demolition of social service and infrastructure facilities including archaeological, historical and cultural sites have also been considered significant.

In addition, an impact is assessed as long-term if it lasts for 20 years or more. An impact is assessed as medium term if it lasts for 5 years, and an impact is assessed as short-term if it lasts only for 3 years. In classifying the extent, impact limited up to the project area is site-specific, limited up to the affected Rural Municipality and Municipalitys is local and an impact extending beyond the affected Rural Municipality and Municipality has been considered regional.

Similarly, the magnitude of the impact is considered to be serious or high if the adverse impacts cannot be mitigated. The magnitude of the impact is considered moderate to low if the resources could be used with inconvenience to the public or the impact could be lessen to certain extent depending upon the type of the impact.

In case of beneficial impacts, the following criteria have been used in this study:

a) Impacts that generate socio-economic benefits such as employment, local income, and poverty reduction without depleting the natural resource base have been considered significant.
b) Also long-term beneficial impacts on natural resources, in particular the forests, have been considered significant.

These criteria are not exhaustive but are 'forward looking' to evaluate impacts. For significant impacts, environmental protection measures have been proposed to augment the beneficial impacts, and to mitigate the adverse impacts by grouping them into preventive, rehabilitative and compensatory measures based on professional judgment. For other impacts, the compensation will follow the existing policies and legal provisions.

3.4.7 Public Consultation

Public Consultation was sought at the different stages of EIA report preparation. During this EIA report preparation, interactions with the local people were made through focused group discussions, KIS and household survey of project affected families.

The photographs of the project area and the field survey are presented in Annex-4.

3.4.8 Draft Report Preparation

Based on the processed data, the draft EIA report had been prepared. The report is comprised of baseline information on physical, biological, socio-economic and cultural environment, project impacts both beneficial and adverse. The draft report also includes benefit augmentation measures to enhance the beneficial impacts and mitigation measures for adverse impacts to avoid, minimize and/or compensate adverse impacts. The proposed

compensatory and mitigation measures are based on the consultant's earlier experience of EIA report preparation and environmental monitoring of development projects and government decisions on the compensatory measures for the loss of forest area and trees. An Environmental Management Plan (EMP) has been included as an integral part of this EIA report, which focused on the implementation of the environment protection measures, environmental monitoring and auditing requirements along with implementation responsibilities, organization, staffing, reporting, budget, and co-ordination aspects. Besides, the draft report also contains information as suggested in the format supplied by the Ministry of Energy, Water Resources and Irrigation which are presented in Annex-5.

3.4.9 Public Hearing

A public hearing programme on "Environmental Impact Assessment Study of Sunkoshi Marin Diversion Multipurpose Project" was organized by the proponent, SMDMP on 17th Srawan, 2076 in the premises of the Kusumetar Community Forest Group; ward no 2, Kamalamai Municipality. The programme was chaired by Mr. Hari Bol Gajurel, elected parliamentarian Sindhuli area 2.The programme was attended by a number of elected parliamentarians from Province no 3, officers representing from various organizations such as District Administration Office, District Development Committee, Division Forest Office, and political parties and social workers as well. Large number of the people attended the hearing programme. Out of them, 364 people have signed the public hearing attendance sheet. The proceeding of the public hearing is presented in Appendix- B,

3.4.10 Finalization of EIA Report

This Final EIA report has been prepared incorporating the issues/suggestions raised and/or provided during the public hearing meeting.

3.4.11 Recommendation Letters from the affected Rural Municipalitys

As per Rule 10 of EPR, 1997, recommendation letter from the directly affected local governments were collected for the project implementation. Similarly the recommendation letters from the affected community forest users groups namely Shree Kusumetar Community Forest were also collected and are presented inAnnex-B.6 of Appendix- B.

CHAPTER – 4

4 REVIEW OF RELEVANT POLICIES, PLANS, LAWS, STANDARDS AND CONVENTIONS

This chapter summarizes existing policies, plans, laws, standards, conventions and institutions related to this Project in order to inform the decision-makers and stakeholders about their implications on the project functioning. For easy reference, they have been summarized below:

4.1 CONSTITUTION OF NEPAL

Article 30 of the Constitution of Nepal proclaims that: (1) "every citizen shall have the right to live in a clean and healthy environment; (2) the victim shall have the right to obtain compensation, in accordance with law, for any injury caused by environmental pollution or degradation; and (3) this Article shall not be deemed to prevent the making of necessary legal provisions for a proper balance between the environment and development, in development works of the nation. In order to meet this Constitutional right, EIA study provides impact-based measures to mitigate environmental pollution, facilitate environmental enhancement, and balance environment and development.

Under Policies of the State, Article 51 (G) (policies relating to protection, promotion and use of natural resources) includes assertion to protect, promote, and make environmental-friendly and sustainable use of natural resources.... to make multi-purpose development of water resources,....., to conserve, promote, and make sustainable use of, forests, wildlife, birds, vegetation and biodiversity, by mitigating possible risks to environment ... and to pursue the principles of environmentally sustainable development,".

4.2 RELEVANT POLICIES AND STRATEGIES

GoN started to integrate environmental aspects in development planning and administration since 1980s. From Sixth Plan (1980-1985) government policies emphasized to carryout EIA study of major development projects. The policy commitment was reinforced in Seventh Plan (1985-1990),to 14th Plan (2016-'19).The 14th Plan focused on development of sectoral guidelines and manuals, environmental monitoring and auditing and use of strategic environmental assessment (NPC, 2016).

4.2.1 The Approach Paper of the 15th Plan (BS 2076/77-2080/81) on environment has, *inter alia*, considered EIA as an integral part of infrastructure development, and committed to make report approval process transparent and easy, and allocate certain percentage to minimize impacts-generated risks (NPC, 2019). The 15th Plan has a vision to make Nepal prosperous through the sustainable use of water resources and emphasizes, *inter alia*, on watershed management effective. Furthermore, the Plan has an objective of increasing productivity, production and environmental services from forests, biodiversity and watershed. It has the working policy of, *inter alia*, integrating bio-engineering as an integral part of infrastructure and development projects. The Plan has planned to ensure compensatory plantation through the Nepal Forest Agency (Nigam), which is established in early August 2019.

4.2.2 The 20-year **Chure-Terai Madesh Conservation and Management Master Plan 2072** (2016), with the motto of 'soil of Chure to Chure, and clean water to all', has envisioned for economic prosperity through conserved and naturally balanced Chure-Terai Madesh landscape and sustained supply of environmental goods and services. The Master Plan has goals of supporting national targets of poverty reduction and prosperity through natural resource conservation, sustainable management, and promotion of ecosystem services (PCTMCDC, 2016)[1]. The Plan has focused, *inter alia*, to reduce natural resources degradation, increase productivity and environmental stability, reduce climate change- and water-induced disasters and risks, and manages integrated river system resources, including stabilization of soil erosion-prone areas. The Plan equally emphasizes on tree development outside forests, expansion of renewable energy technologies, and promotion of emergency disaster management activities. The Master Plan has adequately prioritized for conservation and management of forests and plants.

[1] PCTMCDC. 2016. *Chure-Terai Madesh Conservation and Management Master Plan*. Government of Nepal, Prime Minister Chure-Terai Madesh Conservation Development Committee, Kathmandu.

4.2.3 National Water Plan: In the spirit of the Water Resources Strategy (2002), the Water and Energy Commission Secretariat (WECS) has prepared the National Water Plan, which has identified action programmes to develop cost-effective small and medium hydroelectric projects.

As the project components include hydropower generation in forest area, the key and relevant provisions of the following policies are summarised below:

4.2.4 National Forest Policy, 2075 (2019): The Policy has specified ownership of national forests and conservation area on Federal Government, ownership of forest products with the concerned forest management agency or community or organisation, and private forest with land owner (MoFE, 2019). It means forest of the project area is owned by the Federal Government. The Policy focuses, *inter alia*, in promoting sustainable, participatory and responsible management forests, developing green enterprises, contributing to national prosperity, and also promoting biodiversity conservation, watershed management and environmental services.

4.2.5 Hydroelectric Development Policy, 2058 (2001): The Policy has an objective of, *inter alia*, generating electricity at low cost. The working policy on environment focuses on implementing programmes as identified by EIA study and release at least 10 percent of the minimum monthly average of discharge of the river/stream or the minimum required quantum as identified in the EIA study report (MoWR, 2001),

4.2.6 National Policy on Land Acquisition, Resettlement and Rehabilitation in Infrastructure Development Projects 2071 (2015): The Policy provides clear guidelines to screen, assess and plan land acquisition and resettlement aspects in development projects. The Policy highlights the need to handle resettlement issues with utmost care and forethought particularly in case of vulnerable groups. There are provisions of voluntary land donation by non-poor owners. Voluntary donation will be accepted if a) donation of land is <10% of his/her agriculture land; b) The donation is unforced, not the result of community pressure and MOU should be signed and is witnessed by third party; c) Land donating HHs should not be from vulnerable group and poor families; d) APs is fully consulted informed about their rights. Non-titled (encroachers/squatters) are eligible for compensation for their property except land compensation for structure; crops and tree should be calculated scientifically not less than market price.

4.2.7 National Climate Change Policy, 2076 (2019): The Policy has a goal of contributing to socio-economic prosperity of the country by developing climate-resilient society. The Policy has the objectives of advancing capacity on climate change adaptation, developing ecosystems resiliency, promoting green economy by adopting low carbon economic development concept, mobilizing national and international finance, making the information service effective, mainstreaming or internalizing climate change into relevant policy, strategy, plan and programmes, and also mainstreaming gender and social including in climate change mitigation and adaptation programmes.On water resources and energy sector, the Policy calls for ensuring energy security by promoting multiuse of water resources and low carbon energy production, including use of energy efficient technologies. It also calls for selecting environment-friendly locations for the construction of hydroelectricity and irrigation infrastructures and use of climate-friendly technologies, and adopting measures to mitigate adverse impacts in river ecosystem while producing hydroelectricity (MoFE, 2019b).

4.2.8 Land Use Policy 2072 (2015): The Government has issued the Land Use Policy in 2015 to make optimum use of available land and land resources, and manage lands in a sustainable manner. The Policy has the objectives of: (a) categorising entire lands of the country into various land use zones; (b) devising level-wise (Federal, Provincial and Local) land use plans; (c) ensuring land uses on the basis of land use plans; and (d) mitigating natural and human created-disastrous hazards (MoLRM, 2015)[2]. The Policy has classified the entire land of the country into several zones namely agriculture, residential, commercial, industrial, mines and mineral, cultural and archaeological, river and lake-reservoir, forest, public use and open space, building materials excavation, and other zones. The Policy provides provisions to prepare and implement land use plans at Federal, Provincial and Local levels while the Provincial and Local Plans will be in conformity with the Federal plans. The rural and urban land use plans will be in detail. The Policy promotes to use land and land resources based on specific land use zones and land use plans. The Policy equally emphasises conservation and optimum use of forests and other natural heritages with the strategy of afforestation of equivalent area if forest area is to be used for national priority projects. To ensure forest conservation, other strategies are, *inter alia*, related to forest protection, preparation and implementation of a special plan to conserve Churia Bhabhar Hill areas, take special measures to conserve watersheds. The Policy also intends to identify vulnerable zones to keep balance between development and environment to mitigate natural and human created-hazards.

[2] MoLRM, 2015. *Land Use Policy 2015*. Ministry of Land Reform and Management. Kathmandu.

4.2.9 Irrigation Policy 2070 (2013): The long-term vision of this Policy is to provide sustainable and year-round irrigation service to all agriculture land and help to increase agricultural productivity. In addition, it has also the following features (MoI, 2013):

- implement reservoir-based and inter-basin water transfer types of projects on a priority basis;
- emphasise effective involvement of local bodies and water users' association in planning and construction of irrigation projects;
- implement climate and disaster risk management programmes to address effect of climate change by considering adaptation and mitigation
- minimise possible negative effects of the project on the environment;
- conduct IEE or EIA under the prevailing laws and tie-up and implement major recommendations of IEE and EIA report;
- utilise only the remaining water for irrigation purposes upon maintaining minimum required water flow in the river/rivulet;
- include/conduct protection works of irrigation infrastructures from river cutting, flood and landslide; and
- Plan irrigation projects based on Integrated Water Resources Management (IWRM) principles.

4.2.10 Water Resources Strategy (WRS) 2002: The Strategy realises interdependencies between water resources development and environmental conservation, and has adopted environmental principles related, *inter alia*, to the integration of ecological aspects at every level of hydroelectric development projects, conserve biodiversity, watersheds, and adopt ecosystem approach. The activities are also related to ensure compliance with environmental regulations, promote community participation for the sustainable management of watersheds and aquatic ecosystems (WECS, 2002).

4.2.11 Forestry Sector Strategy (2016-'25): The Strategy has of goal of protecting, sustainably managing and making climate-resilient forests, biodiversity, plant resources, wildlife, watersheds and other ecosystems. It has identified 7 key thematic areas, including managing ecosystems, conserving biodiversity, and managing watersheds which are relevant to this project (MoFSC, 2016). It outlines, *inter alia*, to adopt people-centric approaches for management of floral and faunal diversity, conserve biodiversity hotspots and rehabilitate degraded and fragile ecosystems, and promote integrated watershed management.

These policies and strategies open avenues to ensure the integration of environmental aspects in hydro-electricity development. These have been given due consideration during the preparation of this report.

4.3 RELEVANT LAWS

Existing regulatory instrument – the law that includes Acts and Rules – provides the proponent with an opportunity to identify and mitigate environmental problems associated with the projects. The regulatory agency is also obliged to assist the proponent in achieving environmental management goals.

Nepal has a wide range of regulatory frameworks towards the protection of the environment and promotion of development activities. They provide an opportunity to mobilize the natural resources for the benefits of the nation and to protect the environment and also to prevent further damage due to physical development activities including that in the water resources development sector. The following are the relevant laws that are attracted on the development of the proposed project.

4.3.1 Environmental Law

The Environment Protection Act (EPA), 2053 (1997) and the Environment Protection Rules (EPR), 2054 (1997) are the principal regulatory instruments to make the development programmes and projects environment-friendly and sustainable. The law entered into force since June 1997 and contains several provisions to internalise environmental assessment system and to maintain a clean and healthy environment by minimising the adverse impacts on human beings and other life forms and physical objects. With regard to EIA, Sections 3 to 6 of the EPA and Rules 3 to 14 of the EPR are directly related to this project and they have been duly considered during the preparation of this report.

The EPA, 1997 obliges the proponent not to implement the proposals without approving IEE or EIA reports for the prescribed projects (Section 4). Section 6 empowers the Ministry of Forests and Environment to approve the

EIA report. The EPR, 1997 provides detail provisions with regard to the approval of the EIA report and responsibilities related to environmental monitoring and auditing (MoPE, 1997).

The fourth amendment of EPR issued on BS 2073/01/13 has made special provisions for the approval of national pride, national disaster and natural calamity or government-designated 'immediate implementation' projects. In addition to provisions related to environmental scoping, it has shorten time to 7 days public notice (by Ministry) seeking suggestions on the EIA report, and receive comments or suggestion within 10 days of the first date of publication of the notice. The ministry shall approve the EIA report within 20 days of its receipt.

The EPR, 1997 empowers the concerned agency – the Ministry of Energy, Water Resources and Irrigation in this case -- for environmental monitoring and MoFE for environmental auditing after two years of service start by the project. The GoN has tabled the Environment Protection Bill 2075 (2019) and it is expected to be approved by the Federal Parliament soon (Information here is as of 15 September 2019)

The Environment Protection Act (EPA), 2076 (2019) has entered into force on 1st Kartik 2076 and it has repealed the EPA 2053 (1997). The Act provisions for preparing separate report of: (a) brief environmental study; (b) Initial Environmental Examination (IEE); (c) Environmental Impact Assessment (EIA); (d) Strategic Environmental Analysis (SEA); and (e) Supplementary EIA for the prescribed proposals. The first three types of studies are kept under 'enviornmental study report' (ESR). The Act also provisions for preparing EST for all prescribed proposals and submitting the reports for approval by complying with the prescribed procedures. As per Section 3 of the Act, the proponent shall submit the brief environmental study report or IEE report to the prescribed agency, and EIA report to the Ministry of Forests and Environment (http://hr.parliament.gov.np/uploads/attachments/twbwno5djdtd0ayj.pdf. Accessed: 5 November 2019). In case of development-construction activity or project-related proposal within the jurisdiction of the Provincial Government and Local Level, it should comply with the provisions of the Provincial Law.

The EPA (2019) has provisioned for conducting 'public hearing' while preparing ESR (brief environmental study, IEE and EIA report) [Section 3(5)]. The Act provides provisions for alternative analysis of all envrionemntal studies, and recommending implementation of alternative based on basis and reasons along with preliminary, medium- and long-term adverse impacts with corresponding mitigation measures. It also provisions for approving Scoping Document and Terms of Reference (ToR) for EIA and only ToR for carrying out brief environmental study and IEE reports. The proponent should prepare ESR in the prescribed format and by following the quality standards as set by the Government of Nepal. The consultant, if prepares ESR without complying with the quality standards, will not be given opportunity to prepare such report for upto five years (Section 6). Section 7 of the Act provides provisions related to the approval of the ESR.

Section 8 of the EPA 2019 prohibits implementing any proposal without approving its ESR. As mentioned above, the Act has included a clear provision for: (a) conducting Strategic Environmental Analysis of the prescribed Policy, Programme or Project (Section 9); (b) preparing environmental management plan (Section 10) with clear mitigation measures for adverse impacts for project construction, and post-construction or implementation stages; and (c) Supplementary EIA, if necessary. The Act obliges the Ministry or prescribed agency to carry out environmental auditing after two years of services by the project and then within six months (it means within two and half-year). The Act also provisions for immediate stop and/or may punish according to the degree of offence for any activities if implemented without approving the ESR or non-compliance with the approved report.

This MoFE may approve this EIA report based on Section 3 (3) of the EPA, 2019 as the final EIA report of this Project was submitted before the enforcement of this EPA (2019).

4.3.2 Water Resources and Electricity Laws

The *Water Resources Act, 2049 (1992)* and the *Electricity Act, 2049 (1992)* are the two legal instruments for the development of hydroelectric projects. The *Water Resources Act, 1992* empowers the government and the private sector to make necessary arrangements for the rational utilization, conservation, management and development of water resources. The Act provides an opportunity to minimize pollution, and to prevent adverse environmental impacts during the utilization of the water resources. The Act also provides for a committee as prescribed for the settlement of disputes regarding the usage of water resources (Section 7).

The Act provides provisions to minimize environmental damage while developing hydroelectric projects. It makes the environmental study a mandatory pre-requisite for water resources and electricity projects. Section 8 (1) of the Act requires any person or corporate body wishing to survey or use specific water resources to apply to the

prescribed authority for *environmental study*. Furthermore, it obliges the proponent who wishes to use water resources to submit the environmental study report before obtaining an implementation license.

The Act contains provisions for land and property acquisition or use, if necessary, for the construction of a hydroelectric project with appropriate compensation for any loss of the property or land (Section 16). The Act provides for necessary arrangements to be made by the government to protect the infrastructures related to the utilization of water resources at licensee's expenses (Section 17).

Section 18 empowers the government to fix and maintain quality standards of water resources for various usages. Section 19 (1) empowers the government to prescribe a pollution tolerance limit for water resources. Section 20 emphasizes on the need for avoiding or minimizing the impacts of soil erosion, landslide, flood or other significant adverse environmental impacts during the utilization of water resources. The Act also empowers the government to frame rules related to, *inter alia*, environment protection and pollution control (MoWR, 1992).

The *Water Resources Rules, 2050 (1993)* elaborates the above provisions and oblige the proponent to, *inter alia*, analyse environmental impacts of the proposed actions and include environment protection measures including arrangements for the settlement of displaced people (Rule 17). While resolving any conflict, the Water Resources Utilization Investigation Committee should consider environmental impacts likely to occur from a proposal (Rule 28) by collecting site-specific information on likely environmental impacts of the concerned project (Rule 28).

The *Electricity Act, 2049 (1992)* contains provisions about the survey, generation, transmission and distribution of electricity and to standardize and safeguard electricity services. Based on Section 4, sub-section (1) of the Act, any person or corporate body wishing to conduct survey, generation, transmission or distribution of electricity over 1 MW should submit an application to the prescribed officer along with environmental study report. The Act forbids negative impacts on the environment such as soil erosion, floods, landslides and air pollution while producing, transmitting and distributing electricity (Section 24). Section 33 deals with the utilization and acquisition of land and houses through compensation mechanisms (MoWR, 1992).

The *Electricity Rules, 2050 (1993)*, oblige the proponent, willing to produce and transmit electricity, to analyse environmental impacts of the proposed projects and include environment protection measures including arrangements for the settlement of the displaced people (Rules 12 and 13). Any person or corporate body desiring to produce or transmit electricity should submit an application requesting for the use of such land (Rule 66) and such land should be compensated (Rule 87), as determined by the Compensation Fixation Committee (Rule 88).

The Irrigation Rules, 2056 (2000), Promotes plantation of trees in right of way of canal and WUA could also function as the CFUG with the permission from the respective DFO. Even authorizes the selling of the felled trees along the canal alignment (Rule 12). It details formation and administration of water users associations (WUAs).

4.3.3 Forest Law

The Forest Act 2076 (2019) has entered into force on 8th day of the date of authentication (BS 2076/06/27) by the President of Nepal. Section 3 of the Act prohibits to change land use, and to transfer ownership of the national forest without decision of the Government (cabinet level) (http://hr.parliament.gov.np/uploads/attachments/dxupzhfwfnvapjw9.pdf. Accessed: 6 November 2019). A land use plan of the specified national forest may be implemented to conserve and manage forests sustainably and to maintain balance between environment and development (Section 10). The Act empowers the Government to instruct not to implement the user group prepared or amended action plan in the community forests if it adversely impacts the environment [Section 18 (6)]. The Act obliges the user group to spend at least 25 percent of the total income for the development, conservation and management of forests (Section 22). Similar provisions are made for collaborative forests.

Section 42 of the Forest Act (2019) empowers the Government to provide a part of the national forest area to implement national priority project, a plan approved by the Investment Board, national pride projects, in case of no alternative to forest area and if it does not adversely and significantly affect the environment based on environmental examination (that includes brief environmental study, IEE and EIA). If forest area is provided to implement the project, proponent is required to provide equal area of land for plantation if possible in the project area close to the national forest or of similar geographic area or ecosystem or a land area appropriate to develop it as forests. If such area is not available, the project proponent shall provide cash (money) to arrange land for forest development. The proponent shall also provide necessary budget (money) to care and maintain plantation area for five years. Such money should be deposited in the Forest Development Fund established as per Section 45 of the Act).

As there is no alternative to the forest area to implement this Project, the Government may wish to provide forest area based on Section 42 of the Forest Act (2019) to implement this Project as proposed.

International Trade in Endangered Species of Wild Fauna and Flora Control Act, 2073 (2017): This Act has been enforced to implement the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1973) to which Nepal is a Party. This Act states about the regulation and control of international trade of such endangered flora and fauna species. The species listed in CITES Appendices I, II, and III are protected against over exploitation and trade. This Project will not be engaged in any trade of wild species of wild fauna and flora and it will make efforts to conserve species as per the provisions of this Act.

The Project will also duly consider the protection of the species as listed in the schedule of the National Parks and Wildlife Conservation Act, 2029 (1973).

4.3.4 Land Use and Land Acquisition Law

Land Use Act, 2076 (2019) empowers the government to implement land use programme (Section 3) and categorise land into agriculture, residential, commercial, industrial, mineral, forests, wetland, public use, cultural and archaeological and other zones (Section 4) (http://hr.parliament.gov.np/uploads/attachments/ysucsng42x3ntaqz.pdf. Accessed: 6 November 2019). The Act provides provisions to prepare land use map of each local level within a year (Section 5) and to consider inter-Provincial projects, national priority natural and physical heritage of conservation needs, including areas of environmental cleanliness and biodiversity conservation while preparing the land use plan (Section 6). The Act empowers the Government to change existing land use to implement national pride or priority development projects (Section 8). The Act provisions for implementation arrangement of land use plans. The Chapter 9 (Provisions on Compulsory Saving and Debt) of the Land Act 2021 has been repealed.

The Land Act, 2021 (1964) contains provisions related to compensation issues, particularly on the maximum size of individual landholdings. According to the Act, a landowner may not be compensated for more than he/she is entitled to hold the land. The Land Act also specifies the compensation entitlements of registered tenants on land sold by the owner or acquired for development purposes.

Although the *Water Resources Act* and *Electricity Act* open avenues for the acquisition of land and property required for the development of the hydro-electricity project(s), the *Land acquisition Act, 2034 (1977)* is attracted for the implementation of this project. This Act empowers the government to acquire land for public purposes, by providing compensation for the private land and properties, as determined by the Compensation Fixation Committee.

Local Government Operation Act, 2074 is enacted to make legal provisions on providing qualitative services through the local governments. Under the Section 11 (5), Municipality (Municipality) and Rural Municipality (Rural Municipality) are empowered under the heading of additional functions, duties and powers to formulate land use policy, plan, action plan and implementation as per federal and provincial level laws.

Relating to environmental protection and biodiversity, local government is empowered to prepare local policy, law, standard, plan formulation, implementation, monitoring and regulation [Section 11, Sub-section 2 (j) (#12)]. It also provisions for reducing local level environmental risk and pollution (#13 and 14) and sanitation and solid waste management(#15), adoption of low emission and environmental-friendly development(#16), conservation and promotion of green areas (#17), determination and management of local level environmental protection area (#18), and other activities related to environment protection and biodiversity (#19).

Relating to watershed, wildlife and minerals, the Act provides provisions to formulate local policy, law, standard and formulation and implementation of a plan, including water source protection, watershed management, use of gravels, stones, sands, soil and minerals and mineral products [Section 11, Sub-section 2(u)].

4.3.5 Other Laws

With regard to species conservation, the *Aquatic Life Protection Act, 2017 (1960)* is also attracted. The Act is enacted to make provisions on the protection of aquatic animals. The Act (Section 3, 4, and 5 provides legal protection of the aquatic animals and their habitats. It prohibits use of any kind of electric current, explosive or poisonous substances, including closing or demolishing doors of fish ladder and structure. Section 5a permits only the use of safe poison in case any poisonous substance recommended by technical officer is to be used for catching aquatic animal. The Act obliges the proponent to construct fish ladder at the dam site to ensure the movement of the aquatic animals, particularly the fish. If it is not possible, the proponent should establish a fish hatchery and aquatic animal nursery, close to the dam site of the water resources projects, for artificial breeding of aquatic animals (Section 5b).

During the construction stage, the project is expected to use explosives in small quantity. If the project uses the explosive materials, it will comply with the provisions of the *Explosives Act, 2018 (1961)*.

The access road will be constructed to have transportation facility to the project area and the borrow areas, and, therefore, relevant provisions of the *Public Road Act of 2031 (1974)* will be attracted. Based on this Act, the proponent, therefore, should plant trees on both sides of the road and handover it to the local bodies for management and utilisation purposes (Section 16). The Act also provides provisions to operate quarries and borrow pits and other facilities during road construction (Section 17).

Inter-Governmental Fiscal Management Act 2017 is enacted for inter-governmental fiscal management of center, state and local government. Section 7 has provisioned that GoN shall create the federal divisible fund to deposit obtained from the royalty in accordance with Federal law and subsequently Schedule-4 of the Act has provisioned that Natural Resources Revenue distribution mechanism in federal, provincial and local level government. Based on this, concerned municipalities will receive 25 percent of the total royalty.

The **Labor Act, 2017** has replaced the previous Labor Act, 1992. The Labor Act has enacted to make provisions for the rights, interest, facilities and safety of workers and employees working in enterprises of various sectors including construction industries (Section 85). The Act has regulated eight hours per day and forty eight hours (Section 28) per week as working hours. Similarly, overtime related issues as well provisioned (Section 30), which allows 4 hours per day and 24 hours per week. The overtime wages is also continued to be one and half time of his/her ordinary rate of wages (Section 31).

The Act has made a condition that where twenty or employees are engaged, employer entails to constitute (section 74) a Safety and Health Committee. Similarly, the Act provisioned that where ten or more employees are engaged in the entity, employer entail to constitute the Collective Bargaining Committee (Section 116). The Act has required engagement of outsource employees (Section 58) can be hired for specific or prescribed work in entity by the Ministry by publishing a notice in Nepal Gazette upon recommendation of Central Labor Advisory Council (CLAC)..

The Soil and Watershed Conservation Act, 2039 (1982) and its Rules 2042 (1985) contain several provisions to regulate activities in the declared watershed areas.

Child Labor Prohibition and Regulation Act, 2001 is the major Act related to child labor in Nepal. Section 3 (1) of the Act prohibits the employment of any child, as labour, below the age of 14 years.

Section 4 of ***Solid Wastes Management Act, 2011*** makes the person or institution responsible for processing and management of wastes. The Local Body may manage the solid waste or allow the institution to use the Sanitary Landfill Site by levying fees as determined by the Local Body. The Act emphasizes on 3R (reduce, reuse and recycle) principle for waste management.

Solid Waste Management Regulation, 2070 (2013): The Regulation is provisioned that local government is responsible for segregation and disposal of solid wastes. In the meantime, Regulations has made everyone be responsible for harmful wastes.

Public Roads Act, 2031 (1974) empowers the Government to prohibit any person from building any kind of permanent structure or building within specified distance (Section 3A) and acquire any land for the development, expansion or improvement of public road in accordance with the laws in force (Section 4) (http://www.lawcommission.gov.np/en/wp-content/uploads/2018/10/public-roads-act-2031-1974.pdf. Accessed: 6 November 2019). The Department of Roads may also temporarily require land to store construction materials and equipment required, build a separate temporary road as required to continue traffic or transport materials and equipment. However such required land should be returned to the concerned landowner in the same condition, to the extent possible, after the completion of the purpose of requisition (Section 14). The Act obliges the Department of Roads to plant trees on both sides of the public road and considers duties of the concerned municipalities to take care of protect the planted trees (Section 16). The Act also empowers to use soil, stone or sand from any land in vicinity of the proposed road by paying compensation for any damage (Section 17). If a person roots out or cuts any tree planted, such person shall be punished with a fine up to two thousand Rupees (Section 30).

Considering the road as a public product, the **Consumer Protection Act, 2075** (2018) states that every consumer has the right to obtain quality goods and services along with the right of easy access to goods and services, and right to obtain compensation against any harm and injury caused with the use goods or services (Section 3) (http://www.lawcommission.gov.np/en/archives/category/documents/prevailing-law/statutes-acts/the-consumer-protection-act-2075-2018. Accessed: 6 November 2019). The Act empowers the Government to determine the standards of quality of

goods or services by fulfilling the process as prescribed (Section 5). The Act also provisions for compensation. However, this Act is more related to consumable product produced, imported, hoarded, transported, sold and distributed.

Review of existing legal regime on the environment and sectoral legislation calls upon the proponent to integrate and implement environmental protection measures to avoid, mitigate or compensate adverse environmental impacts.

4.4 INTERNATIONAL INSTRUMENTS

4.4.1 Conventions

Nepal is aParty to the Convention on Biological Diversity (CBD), Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) and World Heritage Convention, which are related to species conservation, international trade of species and their products, and conservation of wetlands, and natural and cultural heritage. Nepal should implement the Convention's provisions and a single Project may not be responsible for its compliance. The project area does not contain World Heritage Sites and Wetlands of International Importance. Furthermore, the Project will not be involved in the international trade of wild fauna and flora. This study complies with the provision(s) of the Convention on Biological Diversity, particularly with its Article 14, which is related with carrying out EIA. The Project will make every effort to respect the provisions of environment-related instruments related to this project activities.

Nepal is also a Party to the ILO Convention 169 (Convention concerning Indigenous and Tribal Peoples in Independent Countries, 1989) which provides opportunities for consultation and participation of indigenous people, in Nepalese context, in development programmes if their livelihood is going to be affected. Although the Convention entered into force in September, 1991, Nepal ratified this on 14 September 2007. The project will make efforts to ensure the participation of indigenous people to be affected by the project activities, if any.

4.4.2 Agreements

The project understands provisions of bilateral cooperation for water resources. As the Sunkoshi River lies in the catchment of Koshi River, the Koshi Agreement concluded on the 25th April 1954 and revised on 19th December 1966 may be attracted. However, the revised agreement states:

"The Government of Nepal shall have every right to withdraw water from the Koshi River or within the Koshi basin from any other tributaries of the Koshi River as may be required from time to time for irrigation and for any other purpose in Nepal. The Union shall have the right to regulate all the balance of supplies in the Koshi River at the barrage site then available from time to time."*

This provision empowers Nepal to use of water of Sunkoshi River for power generation and irrigation.

4.5 ENVIRONMENTAL ASSESSMENT GUIDELINES AND MANUALS

As preparation and approval process of EIA report is covered by the legislation, EIA guidelines and manuals are procedural in nature. With this realisation, the proponent has best utilised the National EIA Guidelines (1993), EIA Guidelines for Forestry Sector (1995), and Manual for preparation of IEE Report in the Forestry Sector (2004). Similarly, the proponent has used WECS-prepared two separate guidelines, namely (i) Guidelines for Environmental Monitoring and (ii) Environmental Auditing of Water and Energy Projects while preparing this report.

During the implementation of this project, an access road should also be constructed and this road can be made environment-friendly by considering the issues and aspects as included in the Environmental Management Guidelines, 1997 and the IEE/EIA Policy Document for the Road Sector (DoR, 1997 and 2000). **Guidelines for Collection, Sales and Distribution of Forest Products, 2073 (2016) :** The Guidelines provides detail process for cutting and collection permit for timber and firewood, transportation and storage, measurement and grading of timber and firewood of both standing and fallen trees, Regarding site clearance the project will follow this Guidelines.

* *It denotes the Government of India.*

Community Forest Inventory Guideline, B.S. 2062 (2003/2004): The guideline aims to support forest user groups to monitor species and their number in community forests, estimate growing stock, annual increment, and harvestable amount of forest products. This guideline will be used in preparing the inventory of the forest products before forest clearing for project requirement.

Procedure with Standard for the Use of National Forests for National Priority Project, 2076 (2019): As per Section 72 (K) of the Forest Act (2049), GoN has published this Procedure on 3 September 2019 to provide forest area for national priority projects. The Procedure obliges the concerned Ministry to avoid forest area, to the extent possible, by conducting study on feasibility and alternative. If the project needs national forests, it should select alternative that ensures minimum use of forest area or cutting of minimum trees to construct/implement the project. The Procedure details out the processes and specifies documents required by MoFE to process for forest area issuance for the project. The concerned Ministry should submit documents related to justification of the need for national forest area, project license, approved programmes with detailed project report, feasibility and alternative study report, and approved IEE or EIA report or environment management plan to process for issuance of forest area. As this is the national priority project without alternative to forest area, the Government may use this Procedure to provide a small part of national forest area for project construction (http://mofe.gov.np/downloadsdetail/ 2/2018/43993951: accessed on 15 September 2019). This Procedure also provisions to provide land or money as compensation (Schedule 1). It also elaborates provisions on afforestation, environment and forest products management and requires compensatory plantation @ 1:10 [Chapter 4, # 17 (3) of the Procedure], manage for 5 years and handover to concerned Forest Office after 5 years of plantation and maintenance.

Manual for Preparing Environment Management Plan (EMP) for Hydropower Projects, 2002: The manual provides guidance to the project developer to include mitigation measures of EIA report in implementation framework. The manual provided basis to develop EMP for this project.

Manual for conducting public hearings in the Environmental Impact Assessment Process for Hydropower Projects, 2004: This manual provides general guidelines for conducting public hearing for hydropower projects.

In a nutshell, these project relevant guidelines and manuals were used while preparing this report, as appropriate and applicable.

In addition, environmental standards related to air quality, wastewater discharge, noise level, and drinking water will be complied with during project implementation. All applicable environmental and occupational health and safety (OHS) standards will be used to evaluate the significance of the environmental impacts that are likely to occur during project construction and operational stages. The project will make every effort to comply with the national standards related to noise level, air quality, dust emission and OHS during its construction and operational stages.

Environmental Impact Assessment Manual, 2018 This Environmental Impact Assessment (EIA)1 Manual has been developed by the Ministry of Forests and Environment to facilitate the sustainability of the hydropower sector development process in Nepal and provide guidance on "good practices".

This Manual enforces a comprehensive EIA adhering to the spirit of Environment Protection Act and associated Environment Protection Rules2 and National EIA Guideline and international good practices for sustainable hydropower development. This Manual has been developed within the framework of existing Policies, Acts and Regulations of the Government of Nepal to be used as a reference document and will not supercede prevailing laws.

The Manual outlines the approach for preparing, submitting, reviewing and implementing EIAs related to hydropower in Nepal.

1. Section 4 - Stakeholder engagement and public participation
2. Section 5 - Screening process for hydropower project proposal
3. Section 6-Scoping and developing terms of reference for the EIA study
4. Section 7, 8 & 9-Identifying, assessing and managing environmental and social impacts
5. Section 10-Reporting Section and
6. Section 11- Reviewing EIAs

4.6 RELEVANT INSTITUTIONS

During the construction and operation of this project, some organisations will be directly involved. They are grouped under local and national level institutions. The local institutions include both village and district level organisations.

4.6.1 Local Institutions

(i) Local Governments

The headworks and inundation area is located in Sunkoshi Rural Municipality of Sindhuli district and Khadadevi Rural Municipality and Manthali Municipality of Ramechhap district. Powerhouse and work camp is located in Kamalmai Municipality of Sindhuli district. Marin Rural Municipality and Haruharpurgadi Rural Municipality are also project-affected Rural Municipalities as the diverted flow in the Marin Khola pass through these Rural Municipalities. The affected Municipalities can facilitate the project in land and property acquisition and compensation issues, and educate the local people in assisting project construction in time. Based on the Local Government Operation Act, 2074, the Municipalities can plan and implement the environmental conservation programmes and the project can assist in such activities of the Municipalities.

(ii) District Administration Office (DAO)

The District Administration Office (DAO), of Sindhuli and Ramechhap district could assist the project on land and property acquisition and compensation issues, and avoiding and/or resolving any conflicts during the project construction and implementation. Similarly, the Chief District Officer (CDO) should facilitate the process of issuing the permit for the use of necessary explosives.

(iii) District Coordination Office (DCO)

The Sindhuli and Ramechhap DCOs could play a pivotal role in educating local people and coordinating local governments in relevant activities for timely completion of the project.

(iv) Municipalities

The proponent will have to work in close coordination with affected local governments. It is expected that affected local governments will fully support project implementation as they receive one-fourth of the total revenue from hydroelectricity generation.

(v) Other District Organisations

The Division Forest Office and Land Revenue Office might provide technical assistance for the conservation and management of forests and re-greening the project area, transfer the land ownership in the name of the proponent once the private lands and properties are compensated. Furthermore, the District Water Resources Committee might contribute to resolve any conflict on water use(s) raised at different stages of the project implementation.

4.6.2 National Institutions

(i) Department of Water Resources and Irrigation

As the proponent of this project, DoWRI intends to make this project environment-friendly and sustainable by implementing all applicable mitigation measures.

(ii) Ministry of Energy, Water Resources and Irrigation

In this project, the Ministry of Energy, Water Resources and Irrigation can facilitate the EIA report approval process by timely sending it, with its comments and suggestions, if any, to the Ministry of Forests and Environment. It can also facilitate land and property acquisition process for the smooth implementation of the project. As per the EPR (1997), the ministry should be involved in environmental monitoring.

(iii) Ministry of Forests and Environment (MoFE)

As per the *EPR (1997),* the Ministry of Forests and Environment approves the EIA report. The MoFE will conduct environmental auditing after two years of operation of the project.

The Ministry might promptly issue permission to use barren land and forests, including felling of trees as a part of site clearance. The DFO might be involved in providing technical inputs on forestry matters to the project, and in environmental monitoring of the forestry sector.

The President Chure-Terai Madesh Conservation Development Board has been established as a separate legal entity to formulate and implement necessary policy, strategy, and management action plan for the protection of the Chure Region, The Board is empowered to identify vulnerable and highly sensitive areas and formulate and implement plans for their protection. It coordinates with bodies implementing development plans and makes every effort to protect the Chure Region from further degradation. This project will contact the Board as and when necessary while implementing activities in its Chure-Madesh area.

In general, the proponent commits to implement this project through effective collaboration with the concerned agencies and by complying with the existing legal regime on the environment and natural resources. Existing policies and laws, and institutional mandates provide ample opportunities to implement this project effectively.

CHAPTER – 5

5 EXISTING ENVIRONMENTAL CONDITION

5.1 DISTRICT PROFILE

5.1.1 Introduction

The Sunkoshi Marin Diversion Multipurpose Project (SMDMP) is located in Sindhuli and Ramechap districts of Province no. 3 of Nepal.

Sindhuli district is surrounded by Makwanpur and Kavrepalanchowk districts in the East, Ramechap and Okhaldhunga in the North, Udayepur in the West and Dhanusa, Mahhotari and Sarlahi districts in the South, and is located 134.7km south-east from the capital district, Kathmandu. The total area of the district is 2435.62 sq. km (243562 ha). It comprises of 136,302 ha forests land, 25,708 ha shrub area, 71,842 ha agriculture, 1,268 ha water bodies area, and 8442 ha barren land. Majority of its area is covered with 56 % (136,302 ha.) forest area and remaining 44% (107,260 ha) of land is covered with non-forest land.

This district consists of one constituent area. It has nine municipalities out of which two are urban municipalities and seven are rural municipalities. The 2011 population census showed 296,192 constituting 142,123 (47.98%) male and 154,069 (52.02%) female. There were 57,581 households with average household size of 5.14 persons. Sindhuli madhi is the headquarters of the district. Ethnically, Major groups are Tamang, Chhettri, Magar, Brahaman, Newar and others represent from Kami, Majhi, Sarki, Damai, Rai, and Gharti/Bhujel.

Ramechap District is surrounded by Kavrepalanchowk district in the East, by Dolakha in the North, Solukhumbu and Okhaldhunga in the West and by Sindhuli district in the South, and is located 144.7km south-east from the capital district, Kathmandu. The total area of the district is 1,601.28 sq. km (160,128 ha). It comprises 48,477 ha forest land, 33,076 ha shrub area, 67,900 ha agriculture, 620 ha water bodies area, and 6,149 ha of barren land. Out of the total area of the district, majority of the area is covered with 30.27 % (48477 ha.) forest area and 69.8% (111651 ha.) non-forest land.

This district consists of one constituent area with two Municipalities and six Rural Municipality. The population census of the district in 2011 showed 202,646.0 constituting 93,386.0 (46.08%) male and 109,260.0 (53.92%) female. There were 43,910 households with average household size 4.62 persons. Manthali is the headquarter of the district. Ethnically, major groups are Chhettri, Tamang, Magar, Brahaman, Sunuwar, Kami, Sarki, Majhi, Gurung, Sherpa and others.

Table 5.1 represents the land use pattern of the Districts and project area.

Table 5-1 : Land Use Pattern of Sindhuli and Ramechap Districts

Land type	District				Project area	
	Sindhuli		Ramechap			
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Forest	136302	56	48477	30.27	2.94	0.94
Shrub	25708	10.5	33076	20.65	0	0
Agriculture	71842	29.5	67900	42.40	43.055	13.80
Water bodies	1268	0.5	620	0.39	49.335	15.81
Barren land	8442	3.5	6149	3.84	37.758	12.10
Snow	0	0	3906	2.45	0	0
Other (Sand Bar)	0	0	0		178.912	57.34
total	**243562**		**160128**		**312**	**100**

Source: Districtwise landuse pattern (2001)

5.1.2 Economic Activities

Sindhuli: According to district profile, about 53.39 percent of total population is economically active, of which about 53% totally depend upon agriculture. The remaining 47% are engaged in non-agricultural occupation such as trade/business, transport, services etc.

The main cereal crops of the district are paddy, maize, wheat, millet, and barley. Paddy is cultivated in about 13,000 ha with the annual production of 41,600 MT, maize in 23,620 ha with 58,500 MT, wheat in 5,681 ha with 15,310 MT, millet in 11,800 ha with 9,350 MT and barley in 55 ha with 90 MT. Potato and oil seed are the cash

crops in the district with annual production 20778 MT potato and 4800 MT oil seed in 5174 ha. A total of 10,450 MT of milk, 3,155 MT of meat, and 4,575,000 eggs were produced as the livestock products in 20016/17.

Other major economic activity in the district is fruits production like junar, orange, lemom, mango, banana and pineapple etc. Sindhuli district is no 1 in list for the production of junar (sweet orange).

Ramechap: About 55.19 percent of total population of the district is economically active, of which about 58% totally depend upon agriculture. The remaining 42% are engaged in non-agricultural occupation such as trade/business, transport, services etc.

The main cereal crops are paddy, maize, wheat, millet, and barley. Paddy is cultivated in about 9408 ha with the annual production of 26164 MT, maize in 21,398 ha with 53,922 MT, wheat in 4750 ha with 9,120 MT, millet in 5,060 ha with 4,550 MT and barley in 80 ha with 68 MT. Potato and oil seed are the cash crop in the district with annual production 34,940 MT of potato, and 691 MT of oil seed in 793 ha. A total of 9,345 MT of milk, 2,835 MT of meat and 4,085,000 eggs were produced as the livestock products of the district in 20016/17.

5.1.3 Social Services

5.1.3.1 Education

Sindhuli: There are total 925 schools with 585 primary, 215 lower secondary, and125 secondary schools. There are 3,919 teachers with 2794 in primary, 696 in lower secondary and 429 teachers in secondary school. The literacy rate of 6 years of age and above in the district was69.5% in 2016/17.

Ramechap: There are total 762 schools. In which 485 are primary; 181 lower secondary and 96 secondary schools. There are 3,120 teachers with 2141, 614 and 365 teaches in primary, lower secondary and secondary schools respectively. The literacy rate of 6 years of age and above was 63.5% in 2016/17.

5.1.3.2 Health

Sindhuli: The district has one district hospital and two private hospitals, 4 health centres, 125 health posts, 26 sub-health posts and one Ayurvedic centre, and 5 ayurvedic Aushadhalayas (clinic). In the district, there are about 330 numbers of ANM, AHW, MCHW, and VHW. About 700 women health volunteers are active in providing the health services to the women of the district. The most common diseases prevalent in the district are headache, typhoid, gastritis, intestinal worms, respiratory tract infection and tonsillitis.

Ramechap: The district has one district hospital, one private hospital, 2 health centres and 18 health posts. About 450 women health volunteers provide health services to the women of the district. The most common diseases are headache, typhoid, gastritis, intestinal worms, tonsillitis and dysentery.

5.1.3.3 Communication

Sindhuli: There is one district post office, 12 regional divisional post offices and 42 additional post offices in the district. Telephone lines total to 2213. CDMA, GSM, Ncell and Smart mobile are working in the district. There are three F.M.Radio and three daily and 9 weekly newspapers publishing in the district.

Ramechap: There is one district post office, 10 regional divisional post offices and 44 additional post offices in the district. There are 526 telephone lines distributed in the district. From different company, 42,166 mobile are distributed in the district. There are two F.M. Radio, and 7 weekly newspapers published regularly.

5.1.3.4 Water Supply and Sanitation

Sindhuli: Water use percent is 58.08% tap water, 26.90% well, 6.40% tub well, 3.73% spring, 4.20% river and 0.69% others. The Department of Water Supply and Sewerage work is in progress in the district to provide additional drinking water. Only 33.15 percent of the total population of the district have toilet facilities. The Sewerage condition is poor in the district.

Ramechap: Water use percent is 79.53% tap water, 10.25% well, 6.26% spring, 2.83% river and 1.13% others. Only 63.44 % of the total population of the district have toilet facilities. The Sewerage condition is poor in the district.

5.1.3.5 Energy use

Sindhuli: About 37.87 percent of the total household of the district enjoys electricity supply in their houses through small hydropower, Peltric set and micro hydropower projects. Local people have also installed individual solar panels and 26.87 percent enjoys from this, while even 22.26 percent use kerosene oil for lighting.

About 90.96 percent of the total household of the district use firewood for cooking, 4.99 [illegible] gas, 2.76 percent bio-gas and 0.48 percent kerosene oil.

Ramechap: About 45.5 percent of the total household enjoy with electricity supply through hydropower, Peltric set and micro hydropower projects. About 23.4 percent of the total population use individual solar panels, while even 30.05% use erosion oil for lighting.

About 95.46 percent of the total household use firewood for cooking, 2.42 percent l.p.gas, 0.19 percent bio-gas and 0.69 percent kerosene oil.

5.1.3.6 *Transportation*

Sindhuli: This district is connected with National Highway and it is about 134.7km from Kathmandu with black top road. District Transport Master Plan includes 68 roads, in which 9 roads are all weather and 59 roads are sessional. The district has 66 Km black top road like Sindhulimadi- khurkot and Bardibas- Sindhuli. The total roads length is 1003.6 Km in the district. The district is also connected with through air transport services.

Ramechap: Connected black topped National Highway; it is about 144.7km from Kathmandu. District Transport Master Plan in rolled 85 roads. The district has 36 Km black top road and 560Km sessional road. Local Road Network length is 933Km.

5.2 PROJECT AREA PROFILE

5.2.1 Physical Environment

5.2.1.1 *Topography and Land Use*

The project area lies at elevations between 390 m and 490 m above mean sea level in the Sindhuli and Ramechap Districts. The headworks site is located at about 0,5 km of Khurkot and powerhouse site in Kusumetar of ward no 2 of Kamalanai Municipality of Sindhuli District. Geographically, their locations are between latitudes 27^0 20' 38.64" N and 27^0 15' 31.52" N and longitudes 85^0 59' 03.90" E and 85^0 52' 29.99" E.

The lowest level of the project, the tail race is at 410 m and the inundation level (highest) level of the project is at 474.00 m. The land use pattern of the project area is presented in Table 5.2.

Table 5-2: Land use pattern of the project area

Land type	Project Area	
	Area (ha)	Percentage
Forest	2.94	0.94
Shrub	0	0
Agriculture	43.055	13.80
Water bodies	49.335	15.81
Barren land	37.758	12.10
Snow	0	0
Other (Sand Bar)	178.912	57.34
Total	**312**	**100**

Sources: Field Survey 2019

5.2.1.2 *Catchmet Area*

The catchment of the river at the proposed intake site has characteristics of mountainous, snow fed catchment. The elevation ranges from 560.0 m to about 8180.0 masl with its origins at Tibet, flowing from north to south of Nepal. During dry season, there is a significant contribution of snowmelt to the flow of the river. The project area belongs to the Middle Mountains of the Lesser Himalayan region of Eastern Nepal, while the upper catchment of the Sunkoshi River extends to the Himalayan region covering the zones of snow and glaciers

5.2.1.3 *Climate*

The project area experiences sub-tropical monsoon climate with wet and dry seasons. The wet season starts from June and ends in September while the dry season continues from October to May. Altitude of the Sunkoshi River basin varies from about 355 m to 7950 m above the mean sea level. The catchment of this river lies in the High Mountain Region, and its physiographic characteristics influence the climate prevalent in this region. This river basin experiences from temperate to Alpine type of climate. The catchment area experiences severe cold, sub-tropical to temperate climate for rest of the year. The southwest monsoon season is dominant from the month of June to the end of September in the catchment as other parts of Nepal. The region receives approximately [illegible] of the annual rainfall during the monsoon period. Rainfall intensities vary throughout the

catchment basin with the maximum intensity occurring on the south facing slopes of the mountains. During the monsoon period, relative humidity reaches the maximum and the temperatures are lower as compared to the pre-monsoon period.

The mean monthly rainfall of the project area is presented in Table 5.3.

Table 5-3: Spatial Mean of the Monthly Rainfall Data

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Khopasi	19	19	29	54	128	244	365	283	197	60	10	14	1421
Nagdaha	8	15	30	73	150	239	372	288	182	39	11	7	1441
Charikot	17	23	40	76	159	310	560	528	268	67	11	16	2104
Melung	14	12	27	71	127	229	340	309	162	40	5	13	1343
Sirwa	15	18	32	69	136	294	480	451	266	54	14	11	1822
Spatial Average using Thiesen Polygon	13	17	32	69	143	257	412	349	207	50	10	11	1586

Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

The mean monthly temperature ranges from 15^{0}C in January to 26.7^{0}C in June and July. The temperatures pattern and extremes of the nearest meteorological station is presented in Table 5.4.

Table 5-4: Mean Monthly Temperature Pattern and Extremes

Month	Temperature ^{0}C for 28 years at Sindhuligadhi Station (1107)						
	Max	Min	Mean	Standard Deviation	Absolute Extreme		
					Max	Min	Mean
January	22.3	7.7	15.0	2.4	32.2	5.0	25.3
February	24.7	9.6	16.9	1.5	27.6	7.4	19.4
March	29.1	13.3	20.9	1.6	31.8	8.5	22.9
April	32.4	16.9	24.3	2.4	40.4	8.3	28.3
May	32.2	19.7	25.5	2.7	37.5	6.9	28.4
June	32.0	22.3	26.7	2.7	36.2	15.3	29.3
July	31.2	23.1	26.7	2.6	36.4	20.7	29.6
August	31.0	23.0	26.5	2.5	33.9	20.6	28.5
September	30.7	21.9	26..3	1.0	34.7	19.2	28.5
October	29.9	18.1	24.0	1.1	33.5	15.6	26.4
November	27.2	13.2	20.2	0.9	30.7	11.0	21.9
December	24.2	8.6	16.2	1.5	30.7	3.4	19.9

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

5.2.1.4 Hydrology

(i) Mean monthly Flow

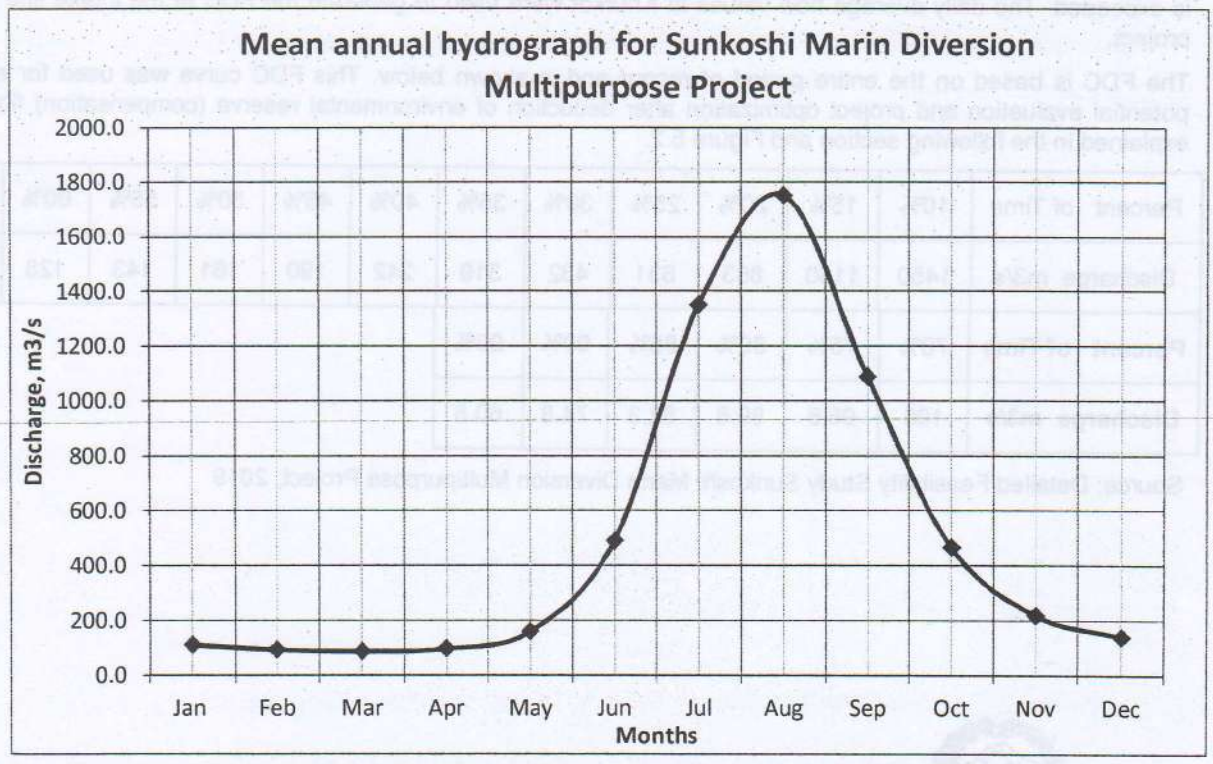
During the period of 1968 and 2015, mean monthly minimum flow 85.8m^3/s in March and maximum flow is 1750.5m^3/s in August at headwork site (Table 5.5) and its hydrograph is presented in Figure 5.1.

Table 5-5: Long Term mean monthly flows (m^3/s) at Intake, Khurkot

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	128	118	119	117	137	406	1480	1570	917	696	238	143
1969	104	81	76	77	117	351	1130	1390	1020	369	175	112
1970	84	72	66	74	103	392	1440	1940	764	407	222	144
1971	106	85	82	108	150	1150	1480	1700	825	479	235	143
1972	105	89	86	84	162	291	1210	1420	949	390	205	131
1973	96	77	84	99	159	731	1140	1740	1380	680	270	157
1974	114	87	77	94	124	331	1380	1820	1160	473	231	150
1975	116	100	83	109	157	487	1430	1360	1390	706	279	171
1976	132	107	87	96	147	543	1080	1530	1090	387	214	142
1977	107	90	78	98	123	308	1360	1730	929	464	249	165
1978	130	104	106	126	289	817	1750	2060	1020	608	279	176
1979	126	117	98	102	157	363	1300	1430	831	359	206	156
1980	114	97	93	105	139	496	1690	1780	1010	395	216	149
1981	117	99	87	102	152	408	NA	NA	1030	319	197	136
1982	109	102	96	118	134	366	890	1210	738	264	177	126
1983	102	88	83	91	151	230	906	1220	1150	532	219	142
1984	111	91	79	80	145	405	1400	1170	1600	404	318	172
1985	138	104	82	73	72	125	442	1240	917	582	341	196
1986	119	95	77	66	97	294	809	1850	1270	611	261	154
1987	114	96	89	103	122	454	1740	1800	937	822	272	162
1988	113	93	94	99	165	448	1620	2250	1030	445	202	146
1989	104	98	107	113	207	645	1460	NA	NA	NA	NA	NA
1990	94	96	90	104	135	818	1473	NA	NA	NA	NA	NA
1991	103	82	81	84	134	381	866	1560	1060	297	154	110
1992	90	76	64	62	86	218	635	1220	911	372	181	118
1993	92	77	66	85	130	321	894	1750	1000	380	170	112
1994	89	77	64	62	86	216	629	1220	909	372	181	118
1995	77.40	68	63	69	244	604	1300	1590	839	341	200	118
1996	107	88	88	88	151	446	1260	2380	1720	701	338	220
1997	121	102	91	102	122	399	1650	1590	651	147	61	46
1998	85	71	73	97	193	486	1430	1900	830	270	74	43
1999	107	89	80	110	249	630	2340	2080	1320	569	231	139
2000	[illegible]	[illegible]93	80	97	209	859	1970	2570	1570	384	201	134

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	105	89	78	81	163	773	1510	2550	1240	434	NA	NA
2002	108	94	87	106	210	469	1960	2350	837	323	140	89
2003	111	107	101	120	136	523	1800	2210	1840	469	204	146
2004	136	109	97	106	191	512	1980	1870	738	391	155	101
2005	82	68	65	87	190	805	1070	2150	917	518	262	170
2006	126	107	102	127	260	631	1660	1550	1200	487	231	160
2007	119	117	111	122	182	501	1590	1900	1760	645	288	179
2008	133	100	96	95	131	849	1710	2290	1260	485	236	156
2009	113	91	81	97	148	251	1200	1720	977	480	249	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	151	110	85	77	114	207	1030	1490	1140	659	194	113
2015	87	81	108	134	295	562	936	1620	959	395	207	148
Mean	**110.1**	**92.8**	**85.8**	**96.4**	**158.4**	**488.7**	**1349.5**	**1750.5**	**1086.5**	**464.5**	**218.6**	**139.8**

Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019



Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

Figure 5-1: **Mean Annual Hydrograph for Sunkoshi Marin Diversion Multipurpose Project**

The mean monthly flow of Marin Khola before and after the addition of the flow is presented in Table 5-5a.

Table 5-5a: Mean Monthly flow of the Marin Kholat

Month	Averagre monthly flow in m^3/s	Downs tream release m^3/s	Total discharge in m^3/s	Increase in discharge	Original water depth in m
January	0.96	67.00	67.96	7079%	
February	0.78	67.00	67.78	8690%	
March	0.66	67.00	67.66	10252%	
April	0.68	67.00	67.68	9953%	
May	1.47	67.00	68.47	4658%	
June	5.52	67.00	72.52	1314%	
July	21.13	67.00	88.13	417%	
August	19.62	67.00	86.62	441%	
September	14.45	67.00	81.45	564%	
October	5.26	67.00	72.26	1374%	
November	1.34	67.00	68.34	5100%	
December	1.24	67.00	68.24	5503%	

Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

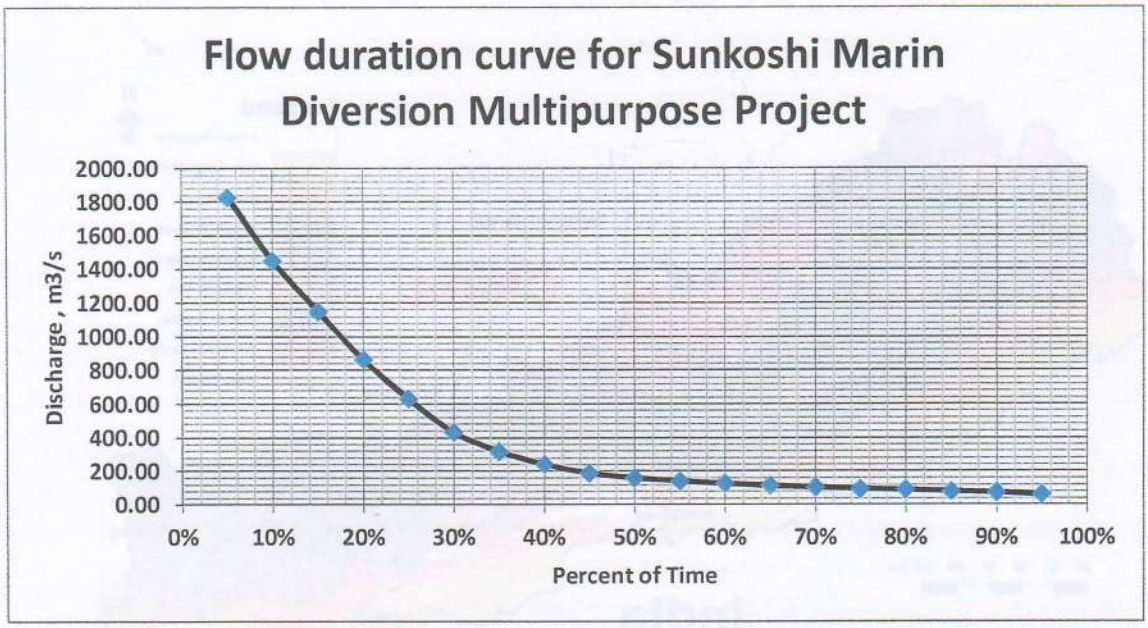
(ii) Flow Duration Curves at Intake

The flow duration curve (FDC) is a plot of the discharge as a function of the percentage of time that the discharge is exceeded. The daily average flow values at Khurkot were used to generate the FDC at the intake site of the project.

The FDC is based on the entire period of record and is shown below. This FDC curve was used for energy potential evaluation and project optimization after deduction of environmental reserve (compensation) flows as explained in the following section and Figure 5.2.

Percent of Time	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%
Discharge m3/s	1450	1150	863	631	432	319	242	190	161	143	128	115
Percent of Time	70%	75%	80%	85%	90%	95%						
Discharge m3/s	105	96.6	89.6	82.3	74.8	60.8						

Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019



Source: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

Figure 5-2: Flow Duration Curve at Intake based on daily flow data from 1968 to 2009

(iii) Downstream Release Flow

The long term mean monthly flow adopted for the driest month, March at the intake site is 85.8m^3/s. The project will be diverting only 67m^3/s. Even during the driest month 18.8 m^3/s. of water will be remaining in the river which comes to about which comes to nearly 22 percent and it is above the requirements of 10 percent release as mentioned in the Hydropower Development Policy (2001).

(iv) Peak Flood Flow estimation

The detailed feasibility study of the project has used different methods to estimate peak flood flow at the headworks site. The estimated flow flood of 12,741m3/s for the return period obtained from Log Pearson Type III has been adopted for the design of headworks of SMDMP.

5.2.1.5 Geology

The Sunkoshi-Marin Diversion Multipurpose Project site is located in the Lesser Himalayan zone of eastern Nepal. The intake of the project area belongs to the Ranimata Formation whereas the powerhouse belongs to the Siwalik rocks (DMG, 1987). The Ranimata Formation consists of thick to thin bedded, fine grained, and grey to greenish-grey quartzite intercalated with grey phyllite, whereas the Lower Siwalik consists of alternation of Sandstone and Mudstone.

Surface observations at the intake site show boulders as well as outcrops of gray to greenish gray phyllite, stones and quartzites. In the powerhouse site, siltstones, mudstones, and sandstones of Lower Siwaliks are observed. Current studies in existence of glaciers and glacier lakes in Nepal (WECS, 1993) show glacier lakes in the Sunkoshi watershed.

Project Location in Geological Map of Nepal is presented and Geological map of the project area is presented in Figure 5-3.

The project area geology report components wise is presented at Annex 8.

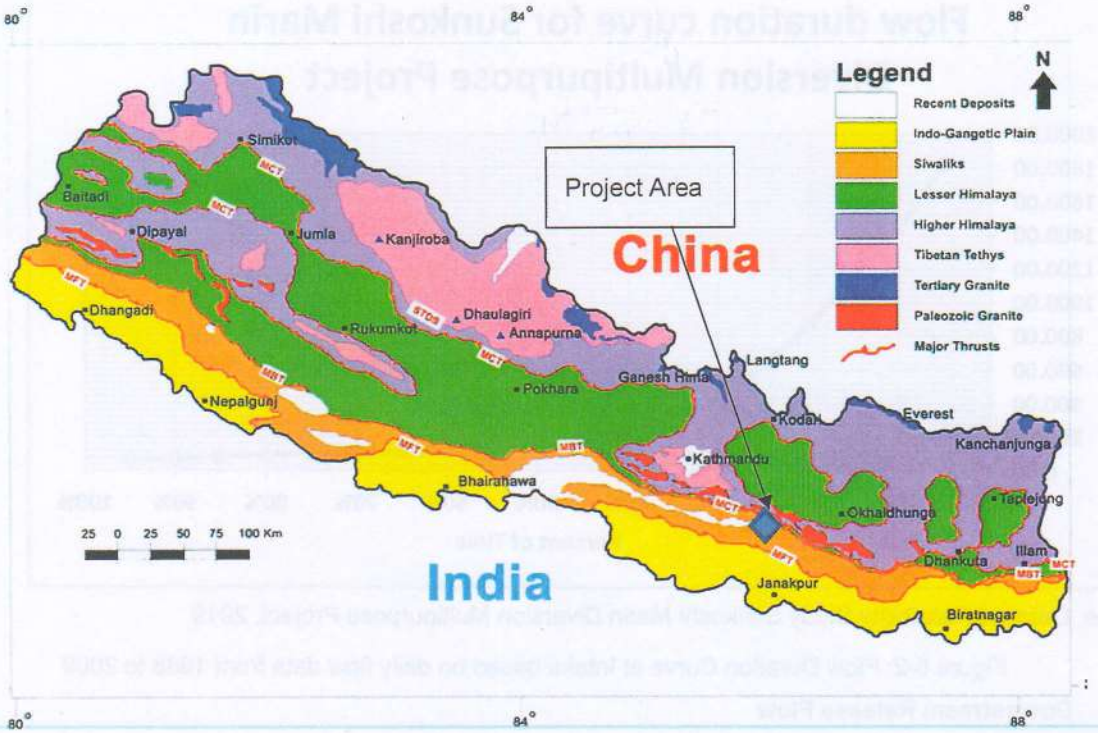


Figure 5-3: **Project Location in Geological Map of Nepal**

5.2.1.6 Slope Stability

The project area does not show potential risks for the instability of the slopes. Slope instability will not be the problem at different structural sites of the project area including the access road corridor. The slope is reasonably moderate and the geological conditions also confirm the stable slope conditions with bedrocks at shallow depths for good foundation of the project structures. However, fluctuation of water level at the inundation area could drag down the hill slope and lead to instability.

5.2.1.7 Sediments

The detailed feasibility study has considered relationship between river discharge and sediment concentration to prepare a sediment discharge rating curve for the estimation of sediment transport (Figure 5.4).

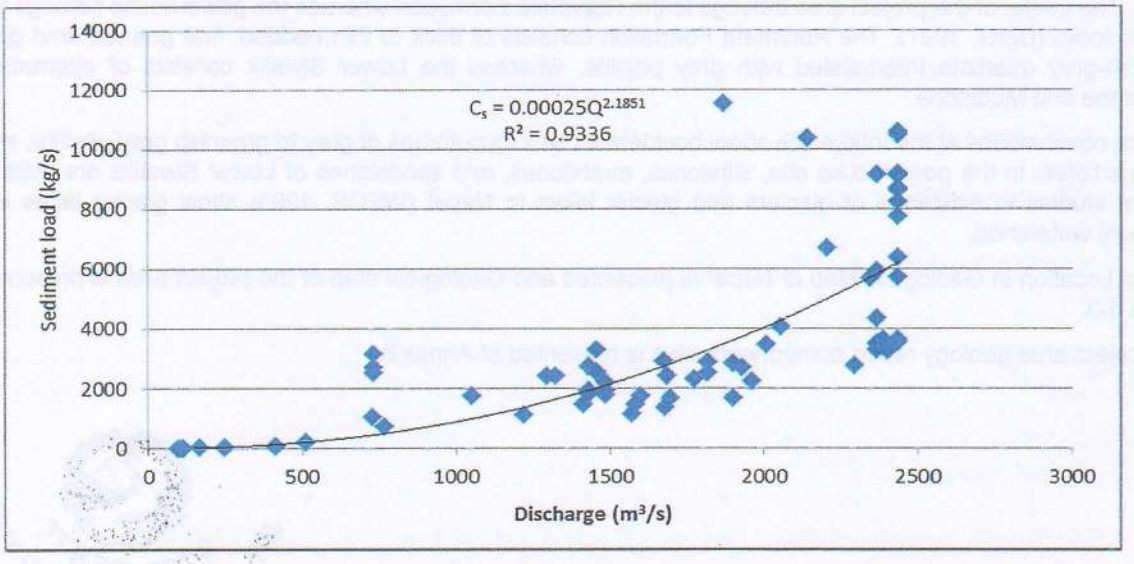


Figure 5-4: **Suspended sediment rating curve**

The average monthly sediment flow in the Sunkoshi River has been estimated based on the average discharge at SMDMP headworks and the rating curve developed from measured data. The results are shown in Table 5-6.

Table 5-6: Estimation of monthly suspended sediment load

Month	Discharge, m3/s	Suspended Sediment concentration , ppm	Suspended Sediment load, kg/s	Suspended Sediment load, ton/month	Bed @15% of suspended sediment,t on/month	Total Sediment load, ton/month
Jan	110.1	64.8	7.1	19,098	2,865	21,963
Feb	92.8	52.9	4.9	11,874	1,781	13,655
Mar	85.8	48.2	4.1	11,075	1,661	12,737
Apr	96.4	55.3	5.3	13,825	2,074	15,899
May	158.4	99.7	15.8	42,282	6,342	48,625
Jun	488.7	378.7	185.1	479,744	71,962	551,705
Jul	1349.5	1262.0	1703.1	4,561,631	684,245	5,245,875
Aug	1750.5	1717.8	3006.9	8,053,814	1,208,072	9,261,886
Sep	1086.5	976.1	1060.6	2,749,014	412,352	3,161,366
Oct	464.5	356.6	165.6	443,666	66,550	510,216
Nov	218.6	146.0	31.9	82,716	12,407	95,123
Dec	139.8	85.9	12.0	32,183	4,827	37,010
			Total (Ton/yr)	**16,500,921**	**2,475,138**	18,976,059

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

5.2.2 Estimation of Bed Load

The estimation of bed transport rates is complicated because of the difficulty in obtaining accurate measurements of bed load quantities for either theoretical or laboratory analyses. Instruments designed to measure the bed movement disturb the natural movements of the bed material thus introducing a bias into the measurements, and it is almost impossible to determine the magnitude of this bias. Simultaneous measurements often provide estimates that differ by several hundred percent. The difficulty arises because of an array of factors associated with variations in flow patterns, bed surface characteristics, and particle shape. While these difficulties are recognized, a number of estimation methods have been developed from the theoretical and laboratory analyses. Empirical equations have also been derived from field measurements.

Bed load measurement data are almost non-existent in Nepal. The bed load is the function of the sediment carrying capacity, which in turn depends on the flow velocity. Therefore, for steeply sloping mountainous rivers, the bed load component in percentage of the total load may be quite high. It needs to be assessed based on the actual measurement of the bed load for at least for one monsoon period.

Two methods can be used for the estimation of the bed load viz. the stream sampling method and analytical or empirical method. Various types of samplers such as the box type sampler and the slot type sampler are used for this purpose. The reliability of these samplers is questionable.

In the absence of site specific data, the bed load is estimated as a percentage of the suspended sediment. In the upper Lesser Himalayas with steep slopes, the bed load is taken as 40 to 60 percentage of the suspended sediment load. Similarly, at the lower Lesser Himalayas, the bed load is taken as 5 to 15 percentage of the suspended sediment load (Schumm 1977, Galay et al 1995).

Average monthly bed load sediment is estimated considering 15% of suspended sediment load and presented in Table 5-6. Annually, bed load @ of 15 percent suspended sediments is estimated at 2.4 million tons and the total sediment load is 18.9 million ton/annum.

5.2.2.1 Water Quality

In order to know water quality of the area, water samples were collected in May 2019 from Sunkoshi River and Marin Khola. The water analysis indicated that all parameters are within the NDWQS, 2062. The water quality analysis report is presented Annex 6.

5.2.2.2 Air Quality

The project area lies in a rural setting with no industrial activities. No major parameters affecting air quality at present are found in the area and its vicinity. The B.P Highway and use of firewood for cooking purpose would have some impact. The air sample has been taken with high volume sampler. The air quality analysis report is presented in Annex 6.

5.2.2.3 Noise Level

No sources for generating high noise level were found in the project area. Hence, noise level is not a major concern at present.However the noise level measurement was carried out at 3 locations. The result is presented in Table 5-7.

Table 5-7: Noise level record on project site

s.no	location	Noise level (dB)		
		Max (dB)	Min (dB)	Avg (dB)
1	Headworks site	22	15	18.5
2	Powerhouse site	20	10	15
3	Access Road	50	30	40
4	Settlement Area	30	20	25

Field Survey 2019

5.2.2.4 Glacier Lake Outburst Flood (GLOF)

A recent report published by ICIMOD(http://geoportal.icimod.org/?map=nepalglakes; retrieved on 27 March 2018) reported 21 potentially dangerous lakes in Nepal. Hu, Mool and their colleagues have found that 13, out of the 21 glacier lakes they studied, had increased in size by 24—162 per cent between 1991 and 2012. These studies indicated that glaciers are retreating rapidly in the Himalayas.(https://www.scidev.net/south-asia/water/feature/glacial-lake-outburst-floods-threaten-tibet-nepal.html, accessed on 09 June 2016).

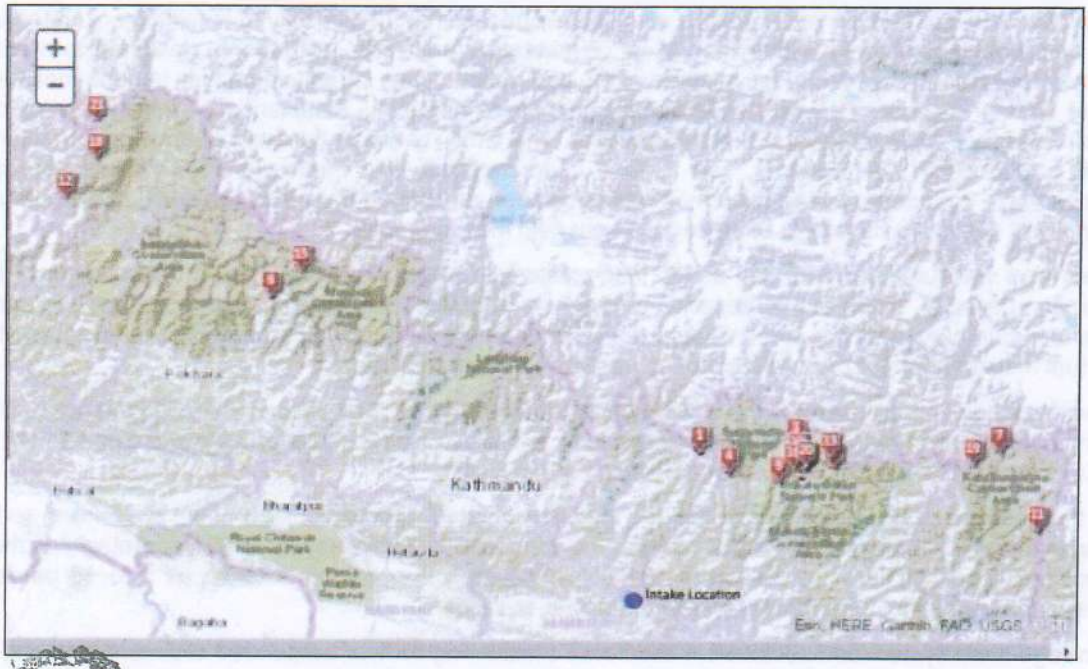


Figure 5-5: Glacier and Glacier Lakes in Nepal (Source- ICIMOD)

In addition, there are also dangerous glacial lakes in Tibet Autonomous Region (TAR) of China which are drained by streams crossing into Nepal. The outburst incidents in Tibet cause downstream damage in Nepal. There are two major river basins in the study area – (1) Upper Sunkoshi river basin and (2) Tamakoshi river basin, where there are studies carried by various researchers and agencies on glaciers risk assessments.

(i) UPPER SUNKOSHI RIVER BASIN

Sunkoshi is a trans-boundary river that originates in TAR and flows across the high mountain region into Nepal and then to India. The Uppermost basin of Sunkoshi also extends to TAR which is called the Poiqu watershed. The same Poiqu River is named as Bhote Koshi/Sun Koshi in Nepal. The Figure shows the watershed of Poiqu in TAR and watershed area up to Dolalghat in Nepal. Five GLOF events have been reported in this watershed since 1935.

Figure 5-6: Location map of upper Sunkoshi watershed up to Dolalghat (Source-Khanal et al, 2015)

By using satellite imagery, Khanal, N. R, Hu, J.M and Mool P (2015) has mapped 74 glacial lakes in the watershed of Upper Sunkoshi river (http://dx.doi.org/10.1659/MRD-JOURNAL-D-15-00009.S1). All lakes showed increasing trend in area as seen in other sub-basin in Sapta Koshi river basin.

Table 5-8: Comparison of number and area of glacial lakes between the 2001 and 2009

Basin/ Sub-basin	Lakes in 2001 inventory		Lakes in 2009 inventory		Comparison 2009/2001	
	Number	Area (sq.km)	Number	Area (sq.km)	Number (%)	Area (%)
Tamor	356	7.32	209	6.57	-41.29	-10.22
Arun	109	2.53	81	3.28	-25.69	29.53
DudhKoshi	473	13.10	243	13.19	-48.63	0.89
Likhu	14	0.22	13	0.31	-7.14	40.78
Tama Koshi	57	1.26	24	2.15	-57.89	71.07
Sun Koshi	35	0.41	17	0.31	-51.43	-25.73
Indrawati	18	0.28	12	0.11	-33.33	-60.79
Basin sub-total	**1,062**	**25.1**	**599**	**25.92**	**-43.60**	**3.30**

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

Based on the characteristics of the lakes, glaciers, dams, and surroundings, 10 lakes were identified as below having a critical potential for a GLOF event in Sunkoshi Marin Diversion Multipurpose Project (SMDMP) (Khanal, Hu, and Mool, 2015). The range of possible peak discharges estimated using published empirical equations were very large.

Table 5-9: Estimated volume of water and maximum possible discharge for critical glacial lakes

S.N	Lake	Volume (m^3)			Possible discharge (m^3/s)	
		Equation 1	Equation 2	Equation 3	Minimum	Maximum
1	Jia-Long-Co	14,816,799	14,359,974	15,595,175	2,382	15,913
2	Ci-Ren-Ma-Co (Zhangzangbo)	12,053,438	11,546,753	12,597,886	2,063	12,808
3	Co-Jiang-Gu	8,578,076	8,061,512	8,862,414	1,627	8,957
4	You-Mo-Jian-Co	14,577,312	14,114,907	15,334,605	2,355	15,643
5	Qie-Ze-La-Co	7,716,201	7,208,408	7,934,309	1,511	8,013
6	Ta-La-Co	4,522,615	4,099,721	4,571,891	1,041	4,569
7	Ga-Long-Co (PhuChhu, Lumichimi)	366,611,694	425,706,145	430,367,197	20,211	464,628
8	Gang-Xi-Co	365,991,732	424,945,729	429,614,687	20,188	463,802
9	Pa-Ju-Co	28,376,289	28,526,831	30,534,462	3,734	31,515
10	Cha-Wu-Qu-Dong	19,876,222	19,584,869	21,130,471	2,923	21,673

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

Based on the expansion rate, area and type of glacial lakes, 67 rapidly expanding glacial lakes were identified in the central Himalayan region Nie, Liu, and Liu, 2013) that need to be closely monitored in the future. Out of them the following 3 glacier lakes fall within Sunkoshi basin corresponding to Sunkoshi Marin Diversion intake point.

I. Galongco which is located 85.838902E,28.321298N, has increased in area by 104 % (1986–2001), 117 % (1977–2003), and 116 % (1988–2009)

II. Gangxico which is located 85.873906E, 28.360054N, has increased in area by 118% (1986–2001), 87% (1977–2003) and 51% (1988–2009).

III. Cirenmaco which is located at 86.065828E, 28.067165N, has increased in area by 155 % (1986–2001), 345 % (1992–2009). This had a GLOF event in 1981.

The maximum discharge in the 1981 GLOF was observed in 23 minutes after bursting which was estimated to be 15,920m^3/s. The flood lasted for 60 minutes, and the total outflow was 19 million m^3 (Xu, 1988). The peak discharge of 2,316m^3/s (gauge height of 6.99 m) at Barhabise, about 50 km downstream was 16 times greater than the average annual flood (maximum flow). However, intake location of Sunkoshi-Marin Diversion is far downstream, about 150 km or more from potential glacial lakes' region in TAR. So, likely impact will be highly reduced to the intake area and project may have more time to adapt to such events. Further studies are needed to improve estimates of peak discharge and understand the contribution of sediment in modeling GLOF. And, it would be appropriate for the installation of a monitoring and early-warning system to manage some of the risk from a potential GLOF to the intake structure. Being Trans-boundary River, bilateral mechanisms are also needed for sharing information on GLOFs between TAR and Nepal.

(ii) TAMA KOSHI RIVER BASIN

Tamakoshi River is a major tributary which joins Sunkoshi before diversion location. This basin contains Tsho Rolpa Glacier Lake which is one of the glacier lake threats to SMDMP, drained to Tamakoshi River.

The Modelling Results of Tsho Rolpa Glacier lake is given in the report "Glacial Lakes and Glacial Lake Outburst Floods in Nepal" (ICIMOD, 2011). Tsho Rolpa has a narrow end moraine in which there is a possibility of piping developing (formation of water channels inside the moraine due to seepage and leading to instability). Seepage was detected at the toe of the outer wall of the moraine dam, but it was found later that it was not coming from the main lake. Follow-up investigations will be needed to identify the source of the seepage which could be the melting of dead ice or from local drainage. Regular monitoring will also be needed as discharge and debris from side valleys drop into the lake. Temporary blockage of the lake outlet over the moraines by freezing water and snow barriers, or lake ice debris is very unlikely because the lake outlet has a wide artificial channel through the moraine dam that functions as a spillway. Field investigation by ICIMOD team has noted that the gated artificial outlet channel was functioning satisfactorily, but they have also noted vibrations in the anchor blocks as well as subsidence in the gabion walls. Monitoring of the hanging glaciers and likelihood of its breaking off is one of the major practical challenges in the hazard assessment of Tsho Rolpa.

Dam-breach analysis and flood simulation - the NWS breach model - was used for numerical estimation of breaching times and possible breach peak floods from Tsho Ropla. The breach height for Tsho Ropla lakes was derived as 20 m with breaching times of 0.62, 0.92, and 2.69 hours and peak flows at the time of flow as 7,242; 5,817 and 4,750 cumecs for Tsho Rolpa, (Figures) Beding, Suri Dovan, Lamatar, Khimti, and Rajgaun located at 9.6, 40.8, 75.5, 82, and 99.7 km from the Tsho Rolpa outlet, can expect flood arrival times of 0.79, 1.48, 2.76, 3.83, and 5.76 hours, respectively (Figure 5-7 to Figure 5-9).

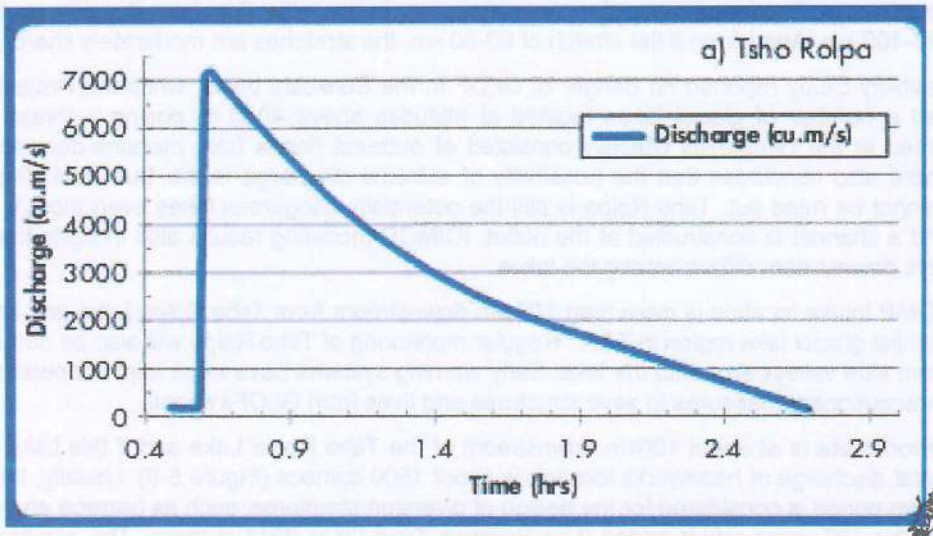


Figure 5-7: Hydrograph of a potential breach

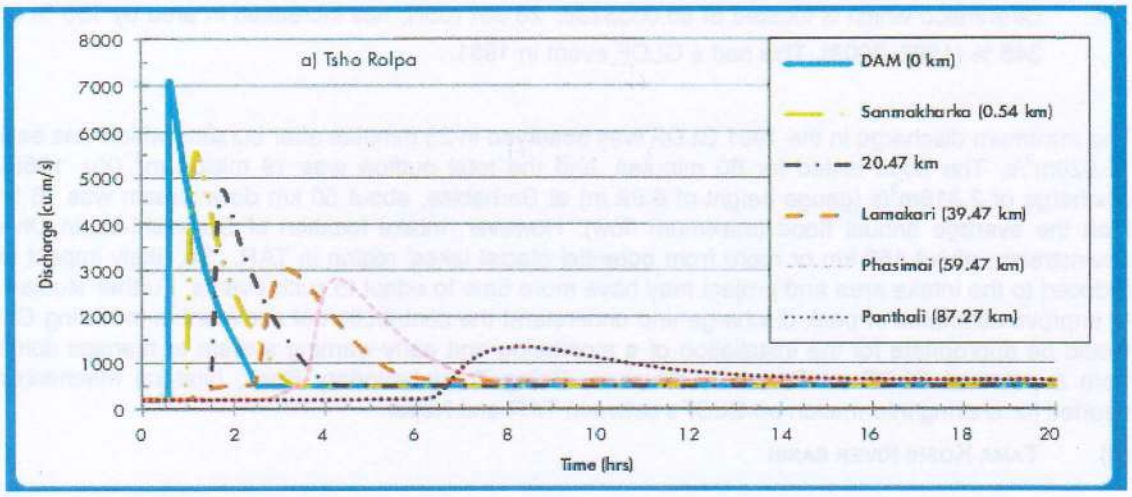


Figure 5-8: Flood attenuation at various downstream locations

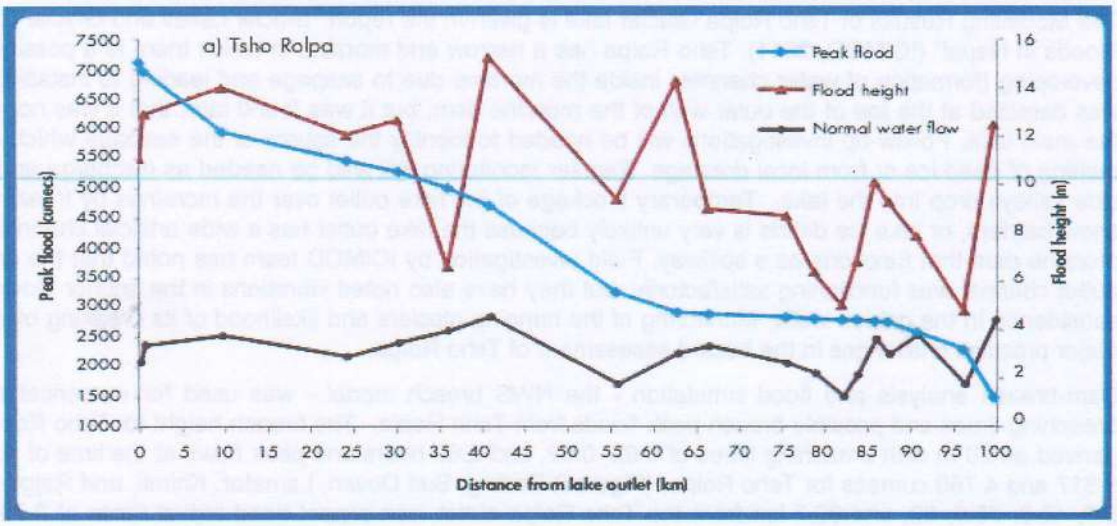


Figure 5-9: Peak flood and flood height of Tsho Rolpa lake

Tsho Rolpa's peak flood decreases sharply in stretches, in the initial flow from the dam up to 10 km, then at 40-60 and 90-100 km. Apart from a flat stretch of 60-90 km, the stretches are moderately sharp (Figure 5-9).

The Feasibility Study reported no danger of GLOF in the Sunkoshi basin, while the Project Formulation Report had listed a number of glacial lakes located at altitudes above 4000 m posing a threat. Most GLOF events documented in the Himalayas typically consisted of outburst floods from moraine-dammed glacial lakes. This assessment also concludes that the possibility of extreme discharge in the Sunkoshi River resulting from the GLOF cannot be ruled out. Tsho Rolpa is still the potentially dangerous lakes even though 3 meters lowering is made and a channel is constructed at the outlet. ICIMOD modeling results also indicate that flood routing along the valleys downstream differs among the lakes.

The SMDMP intake location is more than 100 km downstream from Tsho Rolpa Lake and about 150 km or more from potential glacial lake region in TAR. Regular monitoring of Tsho Rolpa will also be needed as discharge and debris from side valleys drop into the lake. Early warning systems have to be kept in operation and/or installed to enable precautionary measures to save structures and lives from GLOFs events.

As headworks site is at about 100km downstream of the Tsho Rolpa Lake and if this Lake breaches, estimated incremental discharge at headworks location is about 1500 cumecs (Figure 5-9). Usually, the design flood of 100 years return period is considered for the design of diversion structures, such as barrage and weirs. The estimated discharge for 100 years return period (Log Pearson Type III) is 9911 cumecs. The combined discharge of 100 years return period and GLOF consideration from Tsho Rolpa is 11,411 cumecs. The design discharge of 500

years return period 12,741 cumecs has been taken in the design of headworks structures to accommodate the possibilities of GLOF and LDOF.

5.2.2.5 Seismicity

Seismicity studies for the hydroelectric projects in Nepal are based on earthquake generating seismo-tectonic features of the project area and data on historical earthquakes of the region. In the present context, information on the major historical earthquake is the most valuable basis for judging the seismic coefficient values for the design purpose. The seismicity map and seismic hazard map of Nepal published by the Department of Mines and Geology are equally valuable for acquainting with the general seismicity characteristics of the country.

The Seismic Hazard Mapping and Risk Assessment component of the NBCDP contains detailed analysis of the earth activity and the tectonic structure of Nepal, and had identified groups of earthquakes with major tectonic features leading to the identification of seismic zones of assumed uniform seismicity. The three seismic zones thus identified in Nepal are shown on Figure 5-10.

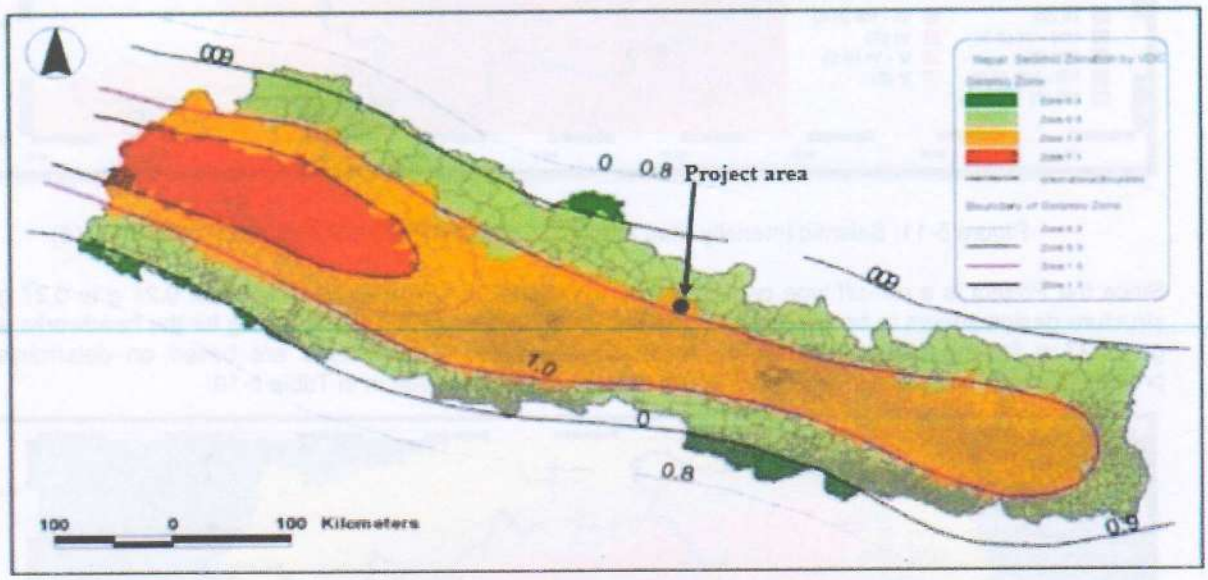


Figure 5-10: Seismic Zonation Map of Nepal

The Maximum Design Earthquake (MDE) is the maximum earthquake or equivalent level of PGA for which the structure is designed such that the project executes without catastrophic failure of uncontrolled release of reservoir. For this project, the MDE has been considered 10% chance of exceedence of PGA value in a 100-year period. Proceeding, Operating Basis Earthquake (OBE) is the level of PGA for which structures remain operating without any significant damages. The OBE is usually incorporated 50% chance of exceedance of PGA in 100 years (a return period of 200 years).

The recent update of the seismic intensity map as from the different sources (USGS) indicates that the Sunkoshi Marin Diversion Multipurpose Project area lies in VI-VII zone having moderate potential risk zone as shown in Figure 5-11. The corresponding value of PGA from Figure 5-11 is determined to be 0.21 g to 0.230 g.

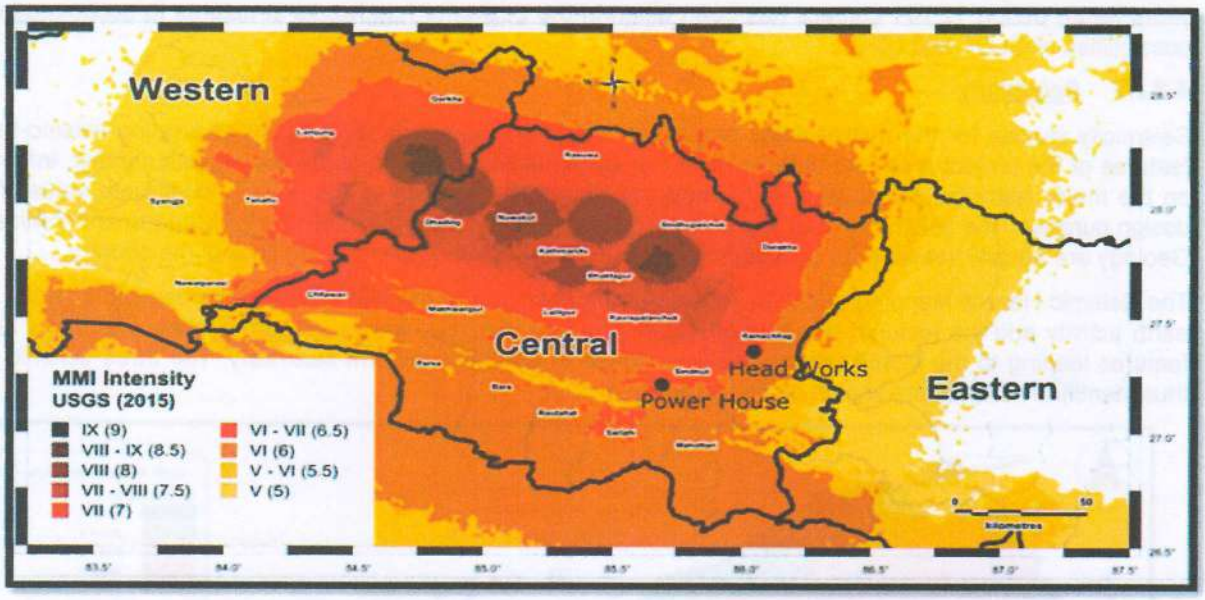


Figure 5-11: Seismic Intensity Map after 2015 Gorkha earthquake (Source: USGS, 2015)

Since the Project is a run-off type project without poundage facility, a value of MDE of 0.21 g to 0.27 g for the structure design seems to be appropriate. The recommended value of PGA is 0.27 g for the headworks and 0.25 g - 0.27 g for the power house. The recommended seismic coefficients are based on deterministic and probabilistic approaches from different hydroelectric projects are given in in Table 5-10.

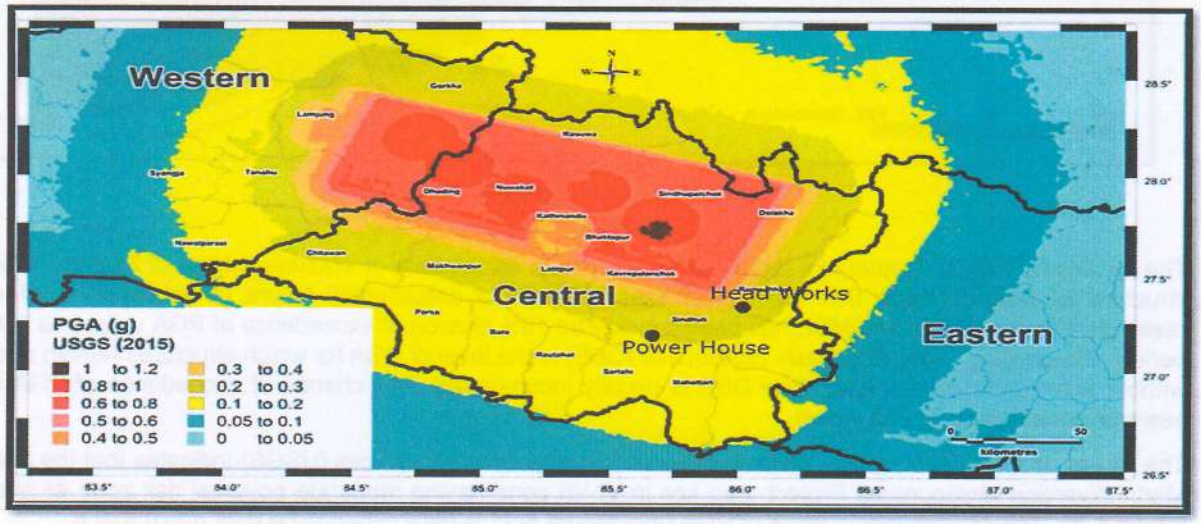


Figure 5-12: Peak Ground Acceleration values after 2015 Gorkha earthquake (Source: USGS, 2015)

Table 5-10: Seismic design parameters for different Hydropower Projects in Nepal

S.N.	Name of Project	Recommended Seismic coefficient
1	Arun - III	0.12 g for all components design
2	Upper Arun	0.12 g for dam 0.062 g for underground powerhouse
3	Mulghat (Tamur)	0.20 g
4	Tamur-Mewa	MDE = 0.21 g - 0.27 g OBE = 0.12 g - 0.20 g
5	Dudhkoshi - I	MDE = 0.37 g OBE = 0.22 g - 0.23 g
6	Kaligandaki - A	OBE = 0.30 g
7	Khimti - I	OBE = 0.25 g for Type I Soil (BCDP) OBE = 0.30 g for Type II Soil (BCDP)
8	Middle Marsyangdi	MDE = 0.33 g - 0.32 g for soil and 0.25 g for bedrock OBE = 0.29 g - 0.27 g for soil and 0.22 g for bedrock
9	Upper Tamakoshi	MDE = Expected PGA 5.05 m/s^2 for 500 yrs OBE = Expected PGA 3.46 m/s^2 for 200 yrs
10	Seismic Hazard Map of Nepal	0.25 g - 0.30 g (AnticipatedbedrockPGA)

Note: OBE is Operation Basis Earthquake and MDE is Maximum Design Earthquake

5.2.2.6 Other Hydropower project in Project area vicinity

All the Sunkoshi high dams were planned considering the height and maximum water level (HWL) of Saptakoshi High Dam. It is located downstream of Triveni and about 1.6 km upstream of Barahachetra.

In the upstream courses of Saptakoshi High Dam site, construction of three dams in Sunkoshi River was considered. The Sunkoshi – I dam site was selected at Kurule in consideration of the high water level (HWL) of the Saptakoshi High Dam and future inter-basin diversion project from Sunkoshi to the Terai area.

The Sunkoshi-II dam site was selected with river elevation coinciding with the highest water level of the Sunkoshi –I Dam. Similarly, the dam site for Sunkoshi-III was selected at the coincidence of the HWL of Sunkoshi-II with the river elevation. Features of these dams are shown in table 5-11.

Table 5-11: Features of Sunkoshi-I, II and III Projects

S.No.	Dams/Barrage	Sunkoshi - I	Sunkoshi - II	Sunkoshi - III	SMDMP Barrage
	Locations	Kurule Beshi	Chyakutar	5 km D/S from Pachuwar village and D/S of Jakadi Purano Gaoun	0.75 km D/S from the confluence of Sunkoshi and Tamakoshi
1	HWL (m) of Reservoir	424.6	575	700	Barrage FSL=477.86 /473.88 m
2	Dam ht (m)	147	166	140	-
3	Gross reservoir (Mm^3)	1500	4370	1220	-
4	Effective reservoir (Mm^3)	40	3040	560	-
5	Maximum discharge (m^3/s)	1400	1050	570	87
6	Installed capacity (MW)	1357	1110	536	42.2
7	Annual power generation (Gwh)	4640	4760	2070	365.69

The planning of Sunkoshi high dams and Sunkoshi Multipurpose scheme was done before the construction of BP Highway. With the beginning of the construction of this highway, settlement area along the banks of Sunkoshi River has largely been increased. This highway connects the capital city Kathmandu to the central and eastern Terai which is now in operation. It also provides linkages to other roads joining hilly districts in the central and eastern region. After this highway came into operation, a lot of economic activities have been built up along the highway and surrounding areas.

Both Sunkoshi-I and II dams are located downstream of SMDMP Headworks site. The Sunkoshi- III dam lies in the upstream of the SMDMP. Since the HWL of Sunkoshi-I is lower than the D/S FSL of proposed SMDMP barrage, there will be no effect of Sunkoshi-I on the SMDMP project. But the diversion discharge of SMDMP (67 m^3) will be decreased for SU-I once SMDMP comes into operation.

Sunkoshi-III dam is located upstream of SMDMP headworks site and will not have significant effect on SMDMP project in so far as water levels are concerned. But this dam has to release water constantly at least to make 67m^3/s in conjunction with the discharge of Tamakoshi River. But the implementation of Sunkoshi-II will have significant effect on SMDMP project which are analyzed under different scenario as follows:

(i) Scenario-I: SMDMP is implemented first and Sunkoshi-II is not taken up

The SMDMP project has been planned as diversion project separately irrespective of Sunkoshi-I, II and III. There will be no problem for the implementation of SMDMP until Sunkoshi-II is considered for its implementation. If Sunkoshi-II dam project is not taken up, then the hydropower potential envisaged by the Master Plan of this dam project would be up in the air and likely environmental and settlement issues too would not have occurred.

(ii) Scenario-II: SMDMP is implemented first and Sunkoshi –II is implemented later on

In this case, the height of the Sunkoshi-II dam has to be reduced so that the diversion structure of SMDMP constructed earlier is not submerged and hydraulically not affected. By doing so, the power generation and reservoir capacity of Sunkoshi-II will have to be reduced drastically. But if the FSL of Sunkoshi-II is kept at 575.0 masl as mentioned in the Master Plan Study, then the SMDMP Barrage including its intake and desander will completely submerged and has to be abandoned. But still the tunnel and powerhouse of SMDMP constructed earlier could be used by making a new side intake in the reservoir at higher elevation. The additional head created as a result of reservoir can be used in hydropower generation by constructing a new powerhouse immediately downstream of the new intake i.e. at the planned headrace tunnel of SMDMP feeding water into the SMDMP. This power will be in addition to the power generated at the powerhouse located at the side of the Marin River. With this arrangement, additional energy can be generated without affecting the irrigation facilities served by the SMDMP.

(iii) Scenario-III: SMDMP and Sunkoshi-II dam projects are implemented simultaneously

In this case planning and design of both the projects will have to be combined or synchronized. The dam of Sunkoshi-II would function as diversion structure for SMDMP. Only a side Intake is required in the reservoir to let the water into the diversion tunnel. The elevation of Intake and tunnel will have to be matched with the water level of live storage of the reservoir. The higher level of intake will provide higher head for power generation in SMDMP. Also, Sunkosh-II dam will create head and discharge to produce planned hydroelectricity of 1110 MW.

(iv) Scenario-IV: Sunkoshi-II is implemented and SMDMP is dropped

Hydropower could be generated through the Sunkoshi-II high dam as projected by the Master Plan Study, however, Bagmati Irrigation Project will not have any discharge augmented to irrigate 122,000 ha land of central Terai. Since the SMDMP has been declared as one of the national pride projects, this scenario is no more valid.

(v) Scenario-V: Both Sunkoshi Multipurpose Scheme and SMDMP projects are implemented

Construction of Sunkoshi Multipurpose Scheme will not affect the SMDMP project. However, operation of SMDMP will decrease the discharge of Sunkoshi by the quantity it diverts into Marin River.

Construction of SMDMP will submerge 312 ha land including cultivated land, forest and flood plain upstream of the headworks and submerge 425 m length of BP Highway. It will have an installed capacity of 28.62 MW and produce 250.694 GWh energy annually. In addition, it will provide reliable year-round irrigation facilities to the 122,000 ha in the central Terai. It will have a less environmental impacts and resettlement issues in comparison to the high dams especially Sunkoshi-II.

Construction of Sunkoshi-II will submerge the whole section of BP Highway that lies on the right bank of the Sunkoshi River and all settlement area on either bank upstream of the dam and in this reach has to be shifted in the new safe location. The spot height of Manthali airport (493 masl) is lower than the HWL of Sunkoshi-II. If the

above mentioned FSL of Sunkoshi-II is retained, then the Manthali Airport and Manthali town will be submerged along with the settlement areas of river banks. This will incur a huge cost and create a wide range of environmental issues. The extent of submergence area and resettlement issues will be identified only after the completion of feasibility study of Sunkoshi-II.

5.2.3 Biological Environment

5.2.3.1 The Forest and Vegetation

Major part of the project lies in the Sindhuli district along the Sunkoshi River and Marin Khola and some part in Ramechap district along the Tamakoshi River.

The study area of SMDMP project is mainly inundations sites lying on either sides of the Sunkoshi and Tamakoshi River. In study area, type of vegetations is mostly in a form of small patches which are either developed in the flooded private khetland or just left over flooded sandy or gravel sites along with alluvial deposits along the river banks.

District forest monitoring report published in 2070 of Sindhuli district has made the following classification of forest type based on the species:

- **Mixed forest of Pine, Katus and Chilaune forest which is located at the altitude between** 1219 m amsl to 2387 m amsl with a main tree species like – Sal (*Shorea robusta*), Chilaune (*Schima wallichii*), Okhar (*Juglans regia*), Champ (*Michelia champaca*) , Lali gurans (*Rhododendron arboretum*), Kafal (*Myrica esculenta*) etc. The area has also having shrub land besides the forest.

- **Mixed forest of Sal, Asna and Karma** forest largely found along the Churia range with sal dominating at the altitudinal range of 610 m asl to 1219 m asl. This forest is comparatively less dense due to excess illegal felling of trees continued from the adjoining district. Except sal the area is having its other associates like – Karma (*Adina cordifolia*), Asna (*Terminalia alata*), Jamun (*Syzygium cumini*), chilaune, Amla (*Phyllanthus emblica*) etc.

- **Sal, Khair, Sissoo, Karma mixed forest** is more confined along the river banks and its adjoining area. This forest is found commonly at an altitudinal range of 168 to 610 m amsl. The forest mainly dominated sal situated far from the river bank and along the river banks the commonly found species are Khair (*Acacia catechu*), Sissoo (*Dalbergia sissoo*), Simal (*Bombax ceiba*), Karma, Bans, Harro (*Terminalia chebula*), Asna etc. The study area is largely more or less belong to this kind of forest type which are confined to inundated area developed into a small patches of green tree stands which are either developed into the flooded private farmland or very recently form alluvial sandy/gravel filled area left over the river and its banks.

The project infrastructures such as headwork, desilting basin, surge tanks, powerhouse, penstock pipes, and disposal sites etc. have forests, scattered trees and other plants .Ininundation site, vegetation is mostly in a form of small patches which are either developed in the flooded private khet land or just left over flooded sandy or gravel sites along with alluvial deposits along the river banks.

Similarly, small part of **Ramechap district** area along the river Tamakoshi is under the inundation area. About 6.5 km has similar type of vegetation like that of Sindhuli, the Riverine forest, in a recently deposited alluvial soil by the Tamakoshi River.

Most parts of the project sites are small in size. Inundation area on either sides of Sunkoshi and Tamakoshi rivers are narrow in shape and lack green vegetations in a long stretch. Patches of small tree stands are found on the flooded private lands and each tree and pole-sized plant was measures and sapling and seedling were counted to assess their quantitative loss.

In the study area, dominant species are Khair, Sissoo, Simal, Jamun and Siris. In dam site, settling basin/BP highway, surge tank, penstock pipes, three disposal sites, and powerhouse areas, small sized trees are recorded. Majority of these sites are under private ownership. Proposed disposal sites are left over river banks with largely poor soil mixed with sand and gravels. The penstock alignment passes through the small patch of Kusumetar community forest and comprises of tree species like Sal, Karma, Jamuna, and Chilaune.

Shrub species Dhusre (*Colebrookia oppositifolia*), Sishnu (*Urtica Dioca*), Titepati (*Artemisia vulgaris*), Tapre (*Cassia tora*) etc. and grass species like Siru (*Imperata spp.*), Dubo (*Cynodon dyctilon*), Akaon etc. are commonly found along the sandy area of the river banks.

Large part of the require forest area about 3,4 ha is located in the Kusumtar Community Forest. Community forest guideline 2071 will be attracted while working the community forest.

(i) Vegetation in the Damsite

Vegetation is very sparse in the proposed damsite with few trees of Khair, Simal, Sissoo and other species like Bayer (*Ziziphus incurve*). Out of 20 total trees, only 4 are above 30 cm dbh and rest of pole-sized (Annex 2). The area has regeneration potential. Regeneration is estimated more than 3800/ha which is comparatively high. Field study estimated seedlings and saplings of sissoo more than 650 and 400 respectively, and other species have more than 1300 seedling and 100 saplings.

(ii) Vegetation in the Settling basin

Just after the damsite, settling basin will be located and the proposed basin area has 47 pole-sized trees with 27 trees of Khair, followed by Sirish (10). In this area, two trees of Sissoo, and one each of Jamun and Simal, including 5 trees of miscellaneous species were counted (Annex 2). The area covered by dam site and settling basin is 3.33 ha.

(iii) Vegetation in the Surge tank

Surge tank will located in the private upland (Bari) and it has 15pole-sized trees with one Chilaune and other tree species are categorised as miscellaneous species (14).

(iv) Vegetation in the Penstock –Surge tank to Powerhouse

Area covered by this structure including surge tank is 11.02 ha. Out of which 2.1 ha is located in the Kusumtar Community Forest and 8.92 ha is farm land and settlement. Seventy two pole-sized trees have been recorded in this area with Sal trees (5) and its associates – Botahdeyaro (*Lagerstroemia parviflora*) (3), Jamun (2), Karma (2) and other miscellaneous species (55). A huge tree of Karma having 100 cm dbh is recorded, along with Jamun and Botadheyaro.

Other species like ipil ipil (*Leucaena leucocephala*) Khasure (*Ficus auriculata*) Kutmero (*Litsea monopetala*), Koiralo (*Bauhinia variagata)*, kimbu (*Morus alba*) are also recorded (Annex 2).

(v) Vegetation in the Inundated area:

Inundation site lies on either side of Sunkoshi and Tamakoshi rivers which runs 7.5 Km of Sunkoshi river in Sindhuli and 6.5 Km in either sides of Tamakoshi River in Ramechap district. Total inundated area is 312 ha. Based on topo sheet, about 2.98 ha is categorised as forest along the left bank of the Tamakoshi River. Land use of the inundation area is presented in Table 5-12. Over 55 percent of the proposed inundation area is occupied by sand bar.

Table 5-12: Land use of inundated area of the project

SN	Land use	Area in ha
1	Degraded forest	2.98
2	Cultivated land or private land	43.1
3	Water body	49.3
4	Sand bar	178.9
5	Bush/barren land	37.91
	Total inundated area	312

Source: Field Survey 2019

Most of the cultivated private land which was once flooded has now small tree species. Over 80% are of pole-size trees having dbh below 30 cm. Among the trees (above 30 cm dbh) Simal (113), Sissoo (68), and Khair (33) are dominant species and other species (miscellaneous) have 121 trees. Similarly, 703 poles of Siris 284 of Khair, 84 of Jamun, 68 of Sissoo (68) and 594 of other species have been enumerated in the inundation area (Annex 2).

(vi) Vegetation in the powerhouse area and work camp

The area lies in the private land with few scattered trees. Out of total 17 trees, 12 are of pole-size tree (including 1 pole of Sal) and 5 are above 30 cm dbh. It is the area at a riverine to sub tropical part of vegetation. Enumeration of vegetation in the inundation area is presented in Annex 2.

(vii) Vegetation in the project road at the powerhouse to surge tank

The length of the project road to the surge tank is 0.7 km. It passes mainly through the community forest (Kusumtar community forest). It comprises of 13 numbers of trees and 49 number of pole size vegetation. Enumeration of vegetation in the inundation area is presented in Annex 2.

(viii) Vegetation in the Disposal sites

Out of the 3 disposal sites, Site 1 is located nearby the proposed tailrace, currently cultivated. It comprises of 6 and 2 pole-sized Sissoo and Siris respectively. Site 2 is located at the left bank of Marin Khola, presently occupied by maize crop covering 0.7 ha and flood plain 0.46 ha. It has 5 tree size and 5 pole size plants. Site 3 is also located at the left bank of Marin Khola comprising of 8 pole sized treespecies (4 Simal, 3 Karma and 1 Bhotdhairo) (Annex 2). All 3 disposal sites are government land.

(ix) NTFPs in the Project Area

The forest is being widely used for livestock grazing and for fodder, fuelwood and timber. Non-Timber Forest Products (NTFPs) are found in the form of trees, shrubs, herbs and climbers and are sometimes used as medicine and income generation. Sisnu, Lajbanti, Lajgedi,'Ashuro, Aak, Banmara, Titepati, Ashuro, Aiselu, Niguro etc are commonly used in the area. Plants with their local uses are given in Table 5.13.

Table 5-13: Plants with their local uses of the project

SN	Local name	Scientific name	Local uses	Remark
1	Sisnu	*Urtica dioca*	Tender leaves consumed as a good green vegetable and sold in market	
2	Lajbanti	*Mimosa pudica*	Seeds used by goldsmith for weighing gold.	
3	Lalgedi	*Mimisa spp*	Its root good for cough	
4	Titepati	*Artemisia indica*	Good for stopping blooding and a good antibiotic. Alsoleaf used as green tea	
5	Ashuro	*Adhatoda vasica*	Locally used for cold and cough	
6	Banmara	*Ageratina adenophora*	Fodder for goat and making charcoal brackets	
7	Niguro	*Fern spp*	Good green vegetable also commonly sold in the market	
8	Ainselu	*Rubus ellipticus*	Fruit is commonly eaten and also sold in the market apart from using to make local liquor	
9	Aak	*Calotropis giganta*	Its latex good for muscular crack and fruit's cotton used with a medical value and leaf for diabetic patient	
10	Bel	*Aegle marmelos*	The fruits can be eaten either fresh from trees or after being dried and produced into candy, toffee, pulp powder or nectar. If fresh, the juice is strained and sweetened to make a drink similar to lemonad.	

Source: Field Survey 2019

5.2.3.2 Ethno-botanical values of species

The values of NTFPs found in the project area are presented in Table 5-13. The commercial extraction or harvesting of these commodities has not been reported.

5.2.3.3 *Wildlife in the Project Area (Fauna)*

Presence of wildlife in the sites is known through indirect means. Interaction and discussion with the locals and field assistance hired for survey work provided information about wildlife (Table 5.15). Some bird species were locally identified. None of the sites have any wildlife niche/habitat.

(i) Mammals:

Chituwa and barking deer were rarely spotted by the locals in the adjoining area of the sites. List of mammals reported in the Project area is presented in Table 5.14.

Table 5-14 : Mammals as recorded in the project sites

SN	Mammal		Method of confirmation		Remarks
	Local name	Scientific name	Direct observation	Reported	
1	Chituwa	*Panthera pardus*		Ö	included in CITES; IUCN, Near Threatened
2	Jackal	*Canis aureus*		Ö	
3	Monkey	*Macaca mallata*	Ö		
4	Rabbit	*Lupus sp.*	Ö		
5	Fox	*Vulpes bengalensis*		Ö	
6	Languor	*Presbytis entelius*		Ö	
7	Malsapro	*Martes flaviguia*		Ö	
8	Dumsi	*Hytrix indica*		Ö	Cultural value
9	Nayurimusa	*Herpestes edwardsi*	Ö		
10	Lokharke	*Funambulus pennant*	Ö		
11	Barking deer	*Muntiacus muntjak*		Ö	
12	Shalak	*Chainese pagolian*		Ö	included in CITES; IUCN,

Source: Field Survey, 2019

(ii) Birds

Birds like common crow (*Corvus splendens*), Bhangera (*Passer domesticus*), dove, stork (*Ciconia cicoina*), eagle (*Falco spp.) are* seen in the area. Birds reported in the project area are presented in Table 5-15.

Table 5-15 : Bird as recorded in the project sites

SN	Birds		Method of confirmation		Remarks
	Local name	Scientific name	Direct observation	Reported	
1	Saras	*Clconial nigra*	O		
2	Strok	*Ciconia cicoina*	O		
3	Bhangera	*Passer domesticus*	O		
4	Eagle	*Falco spp*	O		
5	Dhanas	*Aceros nepalensis*		O	
6	Vulture	*Neophron perconopterus*	O		
7	Kalo titra	*Francolinus franodinus*		O	
8	Nyaulee	*Megalaima virens*		O	

9	Dove	*Steeptopelia chinensis*	O		
10	Kuthurke	*Magalaima asiatica*		O	
11	Crow	*Corvus mavrohynchos*	O		
12	Julfae Juralle	*Pycnonotus leucogenys*		O	
13	Fistta	*Orthotomus sutorius*	O		
14	Rani charre	*Pericrocotus flammeus*		O	

Source: Field Survey, 2019

(iii) **Reptiles**

Cobra (*Naga naga*) was encountered by the inventory group and other reported species are like Gohoro (*Varanus flavescens*), lizard (*Calotes versicolor*), and common frog (*Rana tigrana spp.)*.

Table 5-16 : Reptiles as recorded in the project sites

SN	Reptiles and others		Method of confirmation		Remarks
	Local name	Direct observation	Reported	Direct observation	
1	Goman	*Naja naja*		O	
2	Ajingar	*python molurus*	O		
3	Sungohoro	*Varanus flavescent*	O		included in CITES
4	Lizard	*Calotes sp.*		O	
5	Bhakuta	*Rana tigrana*	O		
6	Karat	*Bungarus Coeruleus*	O		
7	White butterfly	*Peiris brassica*	O		
8	Aringal	*Julus sp.*	O		

(Source: Field survey 2019)

5.2.3.4 Aquatic Life

(i) Prephyton and Micro-invertebrate

Prephyton: The major classes of prephytons recorded in the project area are Bacillariophyceae, Chlorophyceae, Coscinodiscophyceae and Zygnematophyceae. Eight genuses of prephytons were collected in the sampling station of Marin Khola SMDMP 1 (Table 5-17) and six genuses in sampling station of Sunkoshi River (SMDMP).

Table 5-17 : Prephyton Recorded at Sampling Station Marin Khola (SMDMP- 1)

Sl	Phylum or Division	Class	Order	Family	Genus
1	Charophyta	Zygnematophyceae	Desmidiales	Desmidiaceae	Cosmarium
2	Bacillariophyta	Bacillariophyceae	Cymbellales	Cymbellaceae	Cymbella
3	Bacillariophyta	Bacillariophyceae	Tabellariales	Tabellariaceae	*Diatoma*
4	Bacillariophyta	Bacillariophyceae	Tabellariales	Tabellariaceae	*Meridion*
5	Bacillariophyta	Bacillariophyceae	Fragilariales	Fragilariaceae	*Fragilaria*
6	Bacillariophyta	Bacillariophyceae	Naviculales	Naviculaceae	*Gyrosigma*
7	Bacillariophyta	Coscinodiscophyceae	Melosirales	Melosiraceae	*Melosira*
8	Cyanobacteria	Cyanophyceae	Cyanophyceae	Oscillatoriaceae	*Oscillatoria*

(Source: Field survey 2019)

Table 5-18 : Prephyton Recorded at in Sampling Station at Sunkoshi River (SMDMP – 2)

Sl	Division	Class	Order	Family	Genus
1	Bacillariophyta	Bacillariophyceae	Cymbellales	Cymbellaceae	Cymbella
2	Bacillariophyta	Bacillariophyceae	Cymbellales	Cymbellaceae	Cymbopleura
3	Bacillariophyta	Bacillariophyceae	Tabellariales	Tabellariaceae	*Meridion*
4	Bacillariophyta	Bacillariophyceae	Fragilariales	Fragilariaceae	*Fragilaria*
5	Chlorophyta	Chlorophyceae	Sphaeropleales	Microsporaceae	*Microspora*
6	Cyanobacteria	Cyanophyceae	Nostocales	Stigonemataceae	*Stigonema*

(Source: Field survey 2019)

Micro –invertebrate: Seven species of Micro invertebrate were recorded in the sampling station of Marin Khola and Sunkoshi River. Recorded sepcies are presented in Table 5-19.

Table 5-19 : Micro Invertebrate Recorded at different Sampling Station

S.No.	Taxa	Abundance	
		Station 1	Station 2
1	Gomphidae	1	
2	Torleya	1	
3	Cinygmina	17	
1	Macrobranchium		1
2	Tabanidae		5
3	Corydalidae		1
4	Cheumatopsyche		7
5	Torleya		1
6	Cinygmina		4
7	Choroterpides		1

(Source: Field survey 2019)

(ii) Fish Species

Sunkoshi River once reported to have high fish diversity is facing decline to a great extent. The development activities along the Sunkoshi River increased demand for fish. People also used DC current and poison to collect fishes in the past, by completely destroy the aquatic habitat. In addition, Sunkoshi River is a source of local construction materials such as sand and gravel. Number of quarry sites is operated in the Sunkoshi River. Within the proposed inundation site, 2 quarry sites exist. Mining of sand and gravels from these sites has destroyed even the spawning area of the fishes.

In total, 19 fish species were reported in the Sunkoshi River by the local fishermen and 25 species in the Marin Khola. Out of them 5 species are long distance migratory, 4 are middle range migratory rest are local resident. While sampling 13 species and 19 species were collected in Sunkoshi River and Marin Khola respectively (Table 5-20).

Table 5-20: Fish Species in the Sunkoshi River and Marin Khola

S.No	Scientific Name	Local Name	Oder	Migrotory species	Sunkoshi River		Marin Khola	
					Collected fish species	Reported Species	collected fish species	Reported Species
1	*Anguilla bengalensis*	Rajbam	Anguiliformes	LM	-	-	-	1
2	*Bagarius yarelei*	Gonch	Cypriniformes	LM	-	-	-	1
3	*Barilius barila*	Faketa	Cypriniformes	R	-	-	1	-
4	*Barilius bendilesis*	Faketa	Cypriniformes	R	1	-	1	-
5	*Barilius Vagra*	Faketa	Cypriniformes	R	-	-	1	-
6	*Batasio batasio*	Tengra	Siluriformes	R	-	-	-	1
7	*Botia dario*	Baghi	Cypriniformes	R	1	-	-	1
8	*Botia geto*	Baghi	Cypriniformes	R	-	-	1	-
9	*Botia lohachata*	Baghi	Cypriniformes	R	1	-	1	-
10	*Channa gachua*	Hile	Perciformes	R	-	1	-	1
11	*Channa punctatus*	Pahelo hile	Perciformes	R	-	1	-	1
12	*Clupisoma garua*	Jalkapoor	Siluriformes	LM	-	-	-	1
13	*Crossocheilus latius*	Lohari	Beloniformes	R	1	-	1	-
14	*Garra annandalei*	Lahare Buduna	Cypriniformes	R	1	-	1	-
15	*Garra gotyla*	Nakte Buduna	Cypriniformes	R	-	1	1	-
16	*Glyptothorax pectinopterus*	Kabre	Siluriformes	R	1		-	1
17	*Glyptothorax telchitta*	kabre	Siluriformes	R	-	1	-	1
18	*Glyptothorax trilineatus*	kabre	Siluriformes	R	-	1	-	1
19	*Heteropneustes fossilis*	Singhi	Siluriformes	R	-	-	-	1
20	*Labeo dero*	Gardi	Cypriniformes	MM	-	1	1	-
21	*Labeo pangusis*	Pausi	Cypriniformes	R	-	-		-

S.No	Scientific Name	Local Name	Oder	Migrotory species	Sunkoshi River		Marin Khola	
					Collected fish species	Reported Species	collected fish species	Reported Species
22	*Macrognathus pancalus*	Chuche Bam	Synbranchiformes	R	-	1	1	-
23	*Mastacembalus armatus*	Kalo bam	Synbranchiformes	R	-	1	-	1
24	*Mastacembalus pancalus*	Pataiya gainchi	Synbranchiformes	R	-	1	-	1
25	*Mystus cavasius*	Seto tengra	Siluriformes	R	-		-	1
26	*Nemacheilus beavani*	Gadela	Cypriniformes	R	-	1	-	1
27	*Neolissochilus hexagonolepis*	Katle	Cypriniformes	MM	-		1	-
28	*Noemacheilus botia*	Gadela	Cypriniformes	R	-	1	1	-
29	*Noemacheilus horai*	Gadela	Cypriniformes	R	-	1	1	-
30	*Oxygaster bacaila*	Chelwa	Cypriniformes	R	-	1	-	-
31	*Physoschistura elongata*	Gadela	Cypriniformes	R	1	-	-	1
32	*Pseudecheneis sulcutus*	Rato kabre	Siluriformes	R	1	-	-	1
33	*Psilorhynchoides pseudecheneis*	Tite	Siluriformes	R	-	1	-	1
34	*Puntius conchonius*	Pothia	Cypriniformes	R	-	1	-	1
35	*Puntius savana*	Sidra	Cypriniformes	R	-	1	1	-
36	*Puntius sophore*	Sidra	Cypriniformes	R	1	-	1	-
37	*Puntius ticto*	pothia	Cypriniformes	R	-	1	-	1
38	*Salmostoma acinaces*	Chelwa	Cypriniformes	R	1	-	-	1
39	*Schistura savona*	Gadela	Cypriniformes	R	1	-	-	-
40	*Schizothoraichthys progastus*	Chuchche asala	Cypriniformes	MM	-	1	-	1
41	*Schizothorax richardsoni*	Buchche asla	Cypriniformes	MM	1	-	-	1

S.No	Scientific Name	Local Name	Oder	Migrotory species	Sunkoshi River		Marin Khola	
					Collected fish species	Reported Species	collected fish species	Reported Species
42	*Tor putitora*	Sahar	Cypriniformes	LM	1	-	-	1
43	*Tor tor*	Sahar	Cypriniformes	LM	-	1	-	1
	Total				13	19	15	25

(Source: Field survey 2019)

LM- Long Distance Migratory Species; MM - Mid Distance Migratory Species, R –Residence

(A) SPECIES ABUNDANCE AND FISH COMPOSITION

Fish species recorded in Sunkoshi River and Marin Khola is presented in Table 5-21 and percentage of abundance in Table 5-22.

Table 5-21 : Species Diversity and Distribution Pattern

S.No.	Scientific Name	Local name	No. of fish caught by hired Fishermen using Castnet	
			Number of fish caught	Percentage of fish caught
1	*Barilius barila*	Faketa	1	0.29
2	*Barilius bendilisis*	Faketa	74	21.33
3	*Barilius Vagra*	Faketa	12	3.46
4	*Botia dario*	Baghi	8	2.31
5	*Botia geto*	Baghi	2	0.58
6	*Botia lohachata*	Baghi	3	0.86
7	*Crossocheilus latius*	Lohari	18	5.19
8	*Garra annandalei*	Lahare Buduna	136	39.19
9	*Garra gotyla*	Nakte Buduna	14	4.03
10	*Glyptothorax pectinopterus*	Kabre	1	0.29
11	*Labeo dero*	Gardi	3	0.86
12	*Macrognathus pancalus*	Chuche Bam	2	0.58
13	*Neolissochilus hexagonolepis*	Katle	9	2.59
14	*Noemacheilus botia*	Gadela	2	0.58
15	*Noemacheilus horai*	Gadela	3	0.86
16	*Physoschistura elongata*	Gadela	7	2.02
17	*Pseudecheneis sulcutus*	Rato kabre	4	1.15
18	*Puntius savanna*	Sidra	13	3.75
19	*Puntius sophore*	Sidra	3	0.86
20	*Salmostoma acinaces*	Chelwa	8	2.31
21	*Schistura savona*	Gadela	2	0.58
22	*Schizothorax richardsoni*	Buchche asla	21	6.05
23	*Tor putitora*	Sahar	1	0.29

S.No.	Scientific Name	Local name	No. of fish caught by hired Fishermen using Castnet	
			Number of fish caught	Percentage of fish caught
		Total	**347**	**100**

Source: *Field survey, 2019*

Table 5-22 : Percentage Abundance at sampling station (using cast net)

Station	Sites	Number of Fish caught	Total Weight o fish caught (gms)	Number of species	Catch Percentage	Percentage of fish caught Weight
SMDFS 1	Dam site in Sunkoshi River	117	726	13	33.72	31.27
SMDFS 2	Powerhouse site in Marin Khola	230	1595.5	15	66.28	68.73
	Total	**347**	**2321.5**		**100.00**	**100.00**

(Source: Field survey 2019)

(C) Catch per Unit effort (CPUE)

A total of 347 fish were caught in 2 sampling stations. Attempt catch ratio in Sunkoshi River and Marin Khola is 1:0.249 and 1:0.511 respectively (Table5-23).

Table 5-23: Catch per Unit Effort (CPUE) at different Sampling Station

Name of Sites	Level of Effort	No. of Fish caught	Catch per unit effort (CPUE)	Attempt Catch Ratio
Sunkoshi Marin Diversion Multi – Purpose Project Dam site in Sunkoshi River	470	117	0.249	1:0.249
Sunkoshi Marin Diversion Multi – Purpose Project Power house site in Marin Khola	450	230	0.511	1:0.511
	920	**347**	**0.377**	**1:0.377**

(Source: Field survey 2019)

A detailed fishery report is presented in Annex 2-1.

5.2.3.5 Biodiversity and Habitat

i. PLANT AND WILDLIFE SPECIES DIVERSITY

As mentioned above, major parts of the project is inundated area and majority of the vegetation is in private land. Riverine forest dominates the area with species of – khair, sissoo, simal, and miscellaneous species. Most of the trees are pole-sized (below 30 cm dbh) and regeneration exists. These sites are being least harvested except some free grazing.

In addition, jackal, monkey, squirrel are being reported by the local and a snake, cobra was encountered during the field work by the inventory group.

ii. THREATENED, ENDEMIC, RARE AND PROJECTED SPECIES

The project sites have most common species like – small (a resting and nesting tree) and Khari tree. Species included in the CITES are not reported. Sal, Simal and Khair are 'use regulated species' and require government approval for cutting.

5.2.4 Socio-Economic and Cultural Environment

5.2.4.1 Socio-Economic and Cultural Features of the Project Area

The socio-economic characteristics of affected wards are presented below:

i. Population Distribution

The total population of the affected Municipality and Rural Municipality is presented in Table 5-24. The total population of affected ward (Table 5-25) is 15878 having 7506 (48.39%) male and 8372 (51.61%) female). The total number of households is 3026 and average household size is 5.25.The population distribution of the affected population is presented in Table 5-26. The economically active group of age between 16 – 59 years has 53.50 % whereas the not-active group of 46.5 %. The occupational status of 73% of the total population is agriculture, followed by business 4 % and labour 8%.

Table 5-24: Population Distribution of Project affected Municipality and Rural Municipality

Manthali Municipality					Khadadevi Rural Municipality					Sunkoshi Rural Municipality					Kamalamai Municipality				
		Population					Population					Population							
Ward No	House hold	Total	Male	Female	Ward no	House hold	Total	Male	Female	Ward no	House hold	Total	Male	Female	Ward no	household	Total	Male	Female
1	1720	6265	3275	2990	1	716	3434	1550	1884	1	571	2748	1304	1444	1	937	4804	2262	2542
2	678	3325	1517	1808	2	435	2293	1054	1239	2	439	2225	1062	1163	2	848	4415	2074	2341
3	554	2695	1176	1519	3	764	3253	1392	1861	3	677	2796	1297	1499	3	395	1806	822	984
4	764	3612	1611	2001	4	651	3909	1964	1945	4	517	2541	1209	1332	4	1444	6170	2973	3197
5	500	2141	970	1171	5	526	2483	1131	1352	5	1015	4707	2161	2546	5	1328	6045	2856	3189
6	715	3496	1603	1893	6	422	1911	825	1086	6	812	4058	1865	2193	6	2644	9783	4871	4912
7	820	3936	1832	2104	7	838	3925	1814	2111	7	526	2398	1090	1308	7	1357	6005	2813	3192
8	686	3187	1412	1775	8	574	2475	1129	1346						8	789	3615	1612	2003
9	635	3008	1296	1712	9	428	2078	903	1175						9	1024	4246	1965	2281
10	476	2366	1036	1330											10	718	3549	1698	1851
11	705	3009	1267	1742											11	891	4683	2185	2498
12	562	2643	1161	1482											12	794	4198	2004	2194
13	644	2974	1375	1599											13	490	2230	1024	1206
14	640	2759	1219	1540											14	620	2837	1303	1534
Total	10099	45416	20750	24666		5732	25761	11762	13999		4557	21473	9988	11485	Total	14315	64386	30462	33924

Source: CBS 2011

Table 5-25: Population Distribution of Project affected Municipality and Rural Municipality ward wise

Municipality/ Rural Municipality & Ward No.	*Ward No*	*Household*	*Population*		
			Total	*Male*	*Female*
Manthali Municipality	6	715	3496	1603	1893
Khadadevi Rural Municipality	4	651	3909	1964	1945
Sunkoshi Rural Municipality	6	812	4058	1865	2193
Kamalamai Municipality	2	848	4415	2074	2341
Total		3026	15878	7506	8372

Source: CBS 2011

Table 5-26: Population Distribution by Age Category of Project Area

S.No.	Age Category	Total Population	Percentage (%)
1	<5 years	641	4.04
2	6 - 15 years	5187	32.67
3	16- 59 years	8494	53.50
4	>60 years	1556	9.80
	Total	15878	100

Source: CBS, 2011

Table 5-27: Occupation of the People of Project Area

Occupation	Percentage (%)
Agriculture	73
Service	1
Service (Police, Army etc)	<1
Business	4
Industry	0
Labour	8
Others (if any)	13
Totals	100

Source: Field Survey, 2019

ii. ETHNICITY

Chettri is the dominant ethnic group in the project affected wards constituting 24.76% of the total population (Table-5.28). Othersare Newar (18.04%), Tamang (15.75%), Majhi (12.67%), Mager (7.63%), Brahmin (5.22 %), and Sarki (5.16%) and so on .In the project area, all groups are living together with similar style and pattern.

Table 5-28: Distribution of Population by Ethnicity

SN	*Ethnicity*	*Percentage (%)*
1	Chettri	24.76
2	Newar	18.04
3	Tamang	15.75
4	Majhi	12.67

SN	Ethnicity	Percentage (%)
5	Mager	7.63
6	Brahmin-hill	5.22
7	Sarki	5.16
8	Damai/ Dholi	3.77
9	Kami	2.93
10	Sunwar	0.61
11	others	3.37

Source: CBS 2011

iii. Settlement Patterns

In the project area, people live in separate clusters based on their ethnicity and status. Housing patterns are more or less same throughout the project area. Most of the houses (about 96%) are made of stone masonry with mud mortar with wood partition walls and corrugated zinc sheets for roofing. Many of them are with two stories and some have three storeys. A courtyard is generally found in the front side of most of the houses. The courtyard is used for various activities such as resting, meeting people etc. Most of the households have a hut or shed for cattle, goat and for other purposes such as storing firewood, dry fodder or straw.

iv. Education Service

In the project area, literacy rate is 63.73 %. It is lower than national literacy rate (70%) as well as literacy rates (67 %) of both districts. Male are ahead than female literacy. Both Municipality and Rural Minicipality are developing in education service.

v. Health Service

The project area lies in district headquarter like Manthali Municipality and Kamalamai Municipality as well as Rural Minicipality's - Sunkoshi and Khadadevi. So health service is available to affected people. Fever, worm infections, cold coughs, cholera, diarrhoea and dysentery are most common diseases in the area. People usually visit Kathmandu for treatments of serious health problems. Generally, 65% of the people go to health posts for the first aid and 15% to traditional healers and remaining 20% to Ayurvedic clinics.

vi. Water Supply and Sanitation

About 68.8% of total households are supplied with tap water (pipe line); others depend on traditional water supplies such as wells, water springs and streams. Most of the cluster/settlements have dug well at the bank of river and using electrical pump for water lifting. About 49% HHs has a toilet facility and rest are without toilet. It shows poor condition in sanitation.

vii. Communication

The means of communications in the area are television, radio, post office, landline telephones, CDMA system and mobile phones. All services are said satisfactory. At present more than 58 % people are using mobile phones.

viii. Transportation

This project area is connected with black top road - B.P. Highway at headworks site and powerhouse is connected by Dharan-Chatara-Hetauda Road. Headworks and powerhouse are connected by all-weather road.

ix. Energy use

In the project area, 74.22% households use electricity for lighting (Table 5-29), whereas 10.60% households use kerosene for lighting purpose and 15.18% households use solar for lighting purpose. Many households have installed solar power panels for electrification. The government is providing 50 percent subsidies on the costs of such installations of solar. Such installations are becoming popular among households of the area. Majority of the household, i.e., 92.5% households use firewood for cooking (Table 5.29), whereas 4% households use LPG,1.5% each household use kerosene and bio-gas and 0.5% household use electricity for cooking purpose.

Table 5-29: Energy Use in the Project Area

S.No	Description	% of Family who Cooks	% of Family who lights
1	Firewood	92.5	0
2	Kerosene	1.5	10.60
3	L.P.Gas	4	0
4	Bio-gas	1.5	0
5	Solar	0	15.18
6	Electricity	0.5	74.22
Total		100	100

Source: Field Survey, 2019

x. MARKETS

The main market place is the districts' headquarter, including Khurkot. Sindhulimadi and Manthali are district headquarters of Sindhuli and Ramechap districts.

xi. CULTURAL AND RELIGIOUS ACTIVITIES

Indigenous peoples Majhi worship Rajeshorbhimsen whereas Lhosar festival is celebrated as the New Year eve by the Tamang community. Every ethnic people of the project area also observe festival namely Dashain (biggest festival of all Nepalese worshipping goddess Durga Bhawani), Tihar (festival of worshipping Laxmi, the goddess of wealth), Shree Panchami (the festival of worshipping Saraswoti, the goddess of knowledge), Maghe Sakaranti and Sawane Sakaranti. People celebrate these festivals with joy. Women have special festival Teej (worshipping lord Shiva for long live of their husband and family members). No religious sites are located in the direct impact area.

xii. MIGRATIONS

Migration phenomenon is not common in the project area. In- and out-migrations are rare. A picture of migration in project affected wards is listed below (Table-5.30).

Table 5-30: Migration from Project Area (Affected wards)

Migration							
Families that have been Migrated to this Village during last 10 years				**Families that have been out-Migrated from this Village during last 10 years**			
No. of Families	Total Persons	Female	Male	No. of Families	Total Persons	Female	Male
4	24	16	8	6	31	18	13

Source: Field Survey, 2019

xiii. ECONOMIC ACTIVITIES

Agriculture and business are the major economic activities in the project area. 71% of the people are involved in agriculture and 14% in business whereas only 10% of the total population work as labours and others in army, service and industry.

a. AGRICULTURAL

Majority of the people have their own land in the project area. There are about 2035 ha. of cultivated land in the project area. No one is landless. Thirty percent of households have less than 0.25 ha of land, 47 % have less than 0.75 ha of land and 23 % have more than 0.75 ha land (Table 5-31).

Table 5-31: Land Holding Size in Project Area (Affected wards)

S.No	Land Holding Size	Household (%)
1	Landless	0
2	0 - 0.25 ha.	30
3	0.26 - 0.75 ha	47
4	.0.76 - 1 ha.	19
5	1 ha - above	4
	Total	100

Source: Field Survey, 2019

The agricultural practice in the area is conservative and traditional. Local people cultivate crops in Pakho (upland) and Khet (low land). Paddy, wheat, maize, millet and pulses are the major cereal crops grown in the area whereas potato, mustard and green vegetables are the major cash crops grown. Table 5-32 shows area and production of crops grown in the area. Some land is uncultivated due to labour problems.

Table 5-32: Area and Production of Crops in Project Area

S.No	Crop	Area (Hector)	per ha (MT)	Production (Ton)
I.	**Cereal Crops**			
1	Paddy	446	2.66	1186.36
2	Wheat	207	1.77	366.99
3	Maize	933.34	2.1	1960.01
4	Millet	317.66	0.9	285.89
5	Pulses	6	0.07	4.2
II.	**Cash crops**			
1	Potato	95	1.8	171
2	Mustard	10	0.06	0.6
3	vegetables	20	3.1	62
Cropping Intensity		**122.00%**		

Source: Field Survey, 2019

b. Business

Business is another economical boosting factor for this district. Over 14% people are involved in business and increasing day to day.

Land transaction is rare and land holding is stable. The prevailing prices of land are highly variable depending upon the quality of land. The local farmers, whose land properties are likely to be affected by implementation of the proposed Project, are willing to sell the land if appropriate compensation is offered.

c. Others

Other economic activities in the area are to work as labour in the nearby areas of the district. Some young people have gone to foreign countries for jobs. Remittance has also been one of the sources of income for some households in the project area.

Majhi are professional fisherman in the project area, but they are not depended on fishing. Few people were found involved in occasionally in fishing activities in project area.

xiv. COMMODITY PRICE

Commodity price is found more or less same in the project area. The prices of the major commodities are NRs 30/- for paddy, NRs 50/- for wheat, and NRs 50/- for maize. The details of price list of other commodities are given in Annex 3.1

xv. USE OF SUNKOSHI RIVER

The Sunkoshi water is used for drinking and irrigation purposes. People have made well in the river bed and use water pump to irrigate land.

xvi. CREMATION SITE

The bank of Sunkoshi River is used as the cremation places for local communities. One cremation place exists in the project area, i.e., at the confluence of Tamakoshi and Sunkoshi River at Beni Ghat.

xvii. AVAILABILITY OF LOCAL LABOUR FORCE

About 53% of the total population is economically active in the project area. People of the project area and surrounding the project area can be considered as potential source of labour force for the project. There are also skilled labourers in the area like - carpenters, plumbers, masons and other remaining have different skills.

xviii. STATUS OF WOMEN AND DISADVANTAGE GROUPS

In rural areas in general, men take leadership. Mostly, women are engaged in household works such as cooking, cleaning, washing, food processing, household maintenance, hygienic and sanitation activities. About 55% of the women are literate and able to read and write. In Rai and Tamang community, position of women in their families is better than in other ethnic groups. They are very active and are engaged in income generating activities such as ghee making, knitting, bamboo goods, poultry farming, vegetable growing and operating tea stalls. In fact, women are more active than men of the respective ethnic groups. Women participations in the social and political activities are very much limited. Those women who participate are actually for filling the number of women quota approved by the government organisation(s). Very few women have lands and houses registered in their names. The average age of girls at marriage is in between 20 and 22 years. This is an improvement as compared to many other places of the country.

There are no disadvantaged groups in the project area.

xix. **LOCAL DEMANDS**

All discussions have more or less resulted similar type of demand and suggestions. Their demands and suggestions are as following:

- Project should rehabilitate and reconstruct all project-affected infrastructures such as road, irrigation, drinking water, solar power etc.
- Project should provide compensation for lost properties at the market price so that they could replace their lost land and buildings.
- Project has to give first priority in employment to project- affected communities.
- Project should support in the development activities of the project-affected areas

The focussed group discussion with women group in Kusumetar area insisted on income generation training such as vegetable forming, raring of buffalo, goat and pigs, and poultry and fishery farms,

5.2.4.2 Socio-Economic Status of Project Affected Families (PAFs)

The socio-economic status of the PAFs has been presented from the survey of 91 households. Total population of the survey households is 725, with 378 (52.14%) male and 347 (47.86%) female population (Table 5-34). The average household size of the PAFs is 7.96. . Population distribution of the PAF is presented in Table 5.33.

i. DEMOGRAPHIC STRUCTURE

Of the total PAFs, 6.90% are above 60 years of age while 32.12% are below 16 years. The economically active population of the project affected families are in between 16-59 years are 59.96% (Table 5-34).

Table 5-33: Population of PAFs

S.N.	HHs	Population			Household size
		Male	Female	Total	
1	91	378	347	725	7.96
Percentage (%)		52.14 %	47.86 %	100 %	

Source: Household Survey, 2019

Table 5-34: Distribution of PAFs by Age Group

S.No.	Age Category	Total Population	Percentage (%)
1	<5 years	79	10.90%
2	6 - 15 years	154	21.24%
3	16- 45 years	357	49.24%
4	46- 60 years	85	11.72%
4	>60 years	50	6.90%
Total		725	

Source: Household Survey, 2019

ii. Ethnic Composition

The dominant ethnic composition in the inundation area is from the Majhi community which accounts to nearly 64 percent. Overall composition of the ethnic group among the PAFs is presented in Table 5.35.

Table 5-35: Ethnic Compositions of PAFs

S.N.	Ethnic Group	Percent (%)
1	Majhi	63.7
2	Brahamin	9.9
3	Thing	9.9
4	Newar	4.4
5	Bhujal	4.4
6	Chhetri	2.2
7	Dalit	2.2
8	Other	3.3
Total		100

Source: Household Survey, 2019

iii. Education

The literacy level of PAFs is 63.03 %, which is higher than district level. About 43.18 % have received informal education. While 12.73% has passed equivalent to SEE level, 5.15 % undergraduate and 1.97 % graduate level of education. Table 5-36 presents the education level of the PAFs.

Table 5-36: Educational Level of PAFs

S.N.	Level of Education	Population	Percent (%)
1	Illetrate	244	36.97
2	Read/Write	285	43.18
3	S.E.E.	84	12.73
4	Undergraduate	34	5.15
5	Graduate	13	1.97
Total		600	100

Source: Household Survey, 2019

iv. Occupation

Agriculture, labour and business are main occupation of PAFs as their principal sources of income. Majority of PAFs are engaged in agricultural (73%), labour (8%) and business works (4%). Table 5-37 shows the occupational distribution of PAFs. Though 63 % of the households are from majhi community, fishing and boat ferry were not reported as their occupation.

Table 5-37 : Occupational Distribution of PAFs

Occupation	Percentage (%)
Agriculture	73
Service	1
Service (Police, Army etc.)	<1
Business	4
Industry	0
Labour	8
Others (if any)	13
Totals	100

Source: Household survey 2019

v. Land Holding

Majority of PAFs have their own land. Table 5-38 show 62 % PAFs have less than 5 ropani of land and only 6 % have more than 15 ropani of land (Table 5-38).

Table 5-38: Land Holding Size of PAFs

S.N.	Description	Percent (%)
1	Landless	0
2	0 - 5 Ropani	62
3	6 - 10 Ropani	15
4	11 - 15 Ropani	17
5	above - 15 Ropani	6
	Total	100

Source: Household Survey, 2019

vi. Crop Area and Production

Paddy, maize and millet are main cereal crops grown by PAFs. Crops such as Potato and Mustard are major cash crops grown in the project area by PAFs. Table 5-39 shows quantity of cereal and cash crops produced and their values and composition of crops in total agricultural production by PAFs.

The productivity in the core project area is low in comparison to the national average.

Table 5-39: Production of Different Crops

Headworks Innundation	Area in ha	Total Production	Yeild/ ha in MT	Area in ha	Total Production in MT	Value in NRs	Reamrks
Paddy	5.34	17.5	3.28	32.63	106.95	2,459,788.27	
Wheat	2.62	5.5	2.10	15.99	33.61	1,008,360.41	
Maize	11.74	25.83	2.20	46.18	101.60	2,438,436.60	
Millet	0.53	0.60	1.10	2.08	2.29	59,628.15	
Pulse	0.70	0.75	0.82	2.75	2.26	270,958.38	
Vegetable	0.87	14.20	12.50	0.05	4.01	200,733.45	
Powerhouse				-			
Paddy	3.36	8.53	2.54	6.74	17.12	393,860.93	
Wheat	1.83	3.02	1.65	3.68	6.07	182,060.99	
Maize	0.71	1.49	2.10	2.17	4.57	109,614.93	
					Total	7,123,442.12	

Source: Household Survey, 2019

vii. Food Sufficiency and Sources of Funds to Purchase Food

Out of 91 households of the PAFs, 19households (21%) produce enough food for them for whole year. Thirty-three percent households produce food for only three months, whereas 37% households produce for six months and 9% households produce for nine months only. Table 5.40 shows the food sufficiency of PAFs and Table 5-41 shows the sources of funds to purchase food. About 79 % of the total PAFs, who produce insufficient food to feed themselves for 12 months, purchase their required food from income of business and labour. PAFs manage food from income of service, business, and labour.

Table 5-40: Food Sufficiency in PAFs

S.no	Food Sufficiency	no of HH	PAFs (%)
1	Insuffidient for Whole Year	0	0
2	Enough for 3 months	30	33
3	Enough for 6 months	34	37
4	Enough for 9 months	8	9
5	Enough for Whole year	19	21
Total		91	100

Source: Household Field Survey, 2019

Table 5-41: PAFs' Sources and Means to Fulfil Food In-sufficiency

S.no	Food Sufficiency (How do they Manage)	PAFs (%)
1	Service-11	12.09
2	Business- 14	15.38
3	labour- 57	62.65
4	Others-9	9.88
Total		100

Source: Household Field Survey, 2019

viii. Livestock Holdings

Livestock farming is an integral part of agricultural system. Animal husbandry is also a major contributor to the household income of PAFs. Cattles, buffaloes, goats, pigs and poultry are the main livestocks of PAFs. Cattles and buffaloes are kept for milk, ghee and manure. Pigs and goats are kept for meat and for sale. Poultry are kept for eggs, meats and for sale. In average, one household of PAFs has holdings of 10 livestock. A total of 4,304 livestock were recorded from 91 households during the field survey. Table 5-42 shows total number of livestock kept by PAFs.

Table 5-42: Livestock Population Holding by PAFs

S.N.	Description	Numbers	Percent (%)
1	Cow	128	2.97
2	Ox	142	3.3
3	He Calves	54	1.26
4	She Calves	61	1.41
5	Buffalo	76	1.76
6	He Buffalo	19	0.44
7	He Goat	268	6.23
8	She Goat	255	5.93
9	Goat	634	14.74
10	Duck	24	0.55
11	Pigeon	25	0.58
12	Chicken	2490	57.86
13	Others	128	2.97
Total		4304	100

Source: Household Field Survey, 2019

ix. Settlement Pattern

PAFs are found to live in separate clusters based on their ethnicity and status. Housing patterns are more or less the same throughout the project area irrespective of ethnicity and economic condition of the households.

x. Income of PAFs

The average annual income of PAFs is NRs. 380,912.66. The main source of income is from labour, remittances and business which come to 42%, followed by agriculture 39%. Table 5.43 shows contributions of different activities in the annual income of PAFs.

Table 5-43: Average Annual Income of PAFs

SN	Description	Amount (Nrs)
A.	**Agriculture**	
1	Cereal Crops	56,333.80
2	Cash Crops	22,577.46
3	Fruits / Others	10,205.63
	Total (A)	89,116.89
B.	**Livestock**	
1	Animal Husbandry	1,323.94
2	Dairy Product	12,619.72
3	Sale of Cow / Bull	6,978.87
4	Sales of Buffalo	5,295.77
5	Sale of Goat	37,309.86
6	Sale of Pig	6,338.03
7	Sale of Chicken/Duck	10,169.01
	Total (B)	80,035.20
C.	**Others**	
1	Service	27,056.34
2	Wage Labour	112,690.14
3	Pension	1,690.14
4	Trade / Business	39,929.58
5	Cottage Industry	-
6	Sale of Services	2,155.60
7	Sale of Fish	18,549.30
8	Others(remittance)	11,563.38
	Total (C)	213,634.48
	G. Total (A+B+C)	**380,912.66**

Source: Household Survey, 2019

xi. Expenditures of PAFs

The annual average expenditure of PAFs is NRs. 343,215.91. The PAFs spend more money on food items than on non-food items. The average income and expenditure pattern is not encouraging although average income is slightly more than expenditure. Table 5-44 shows the annual expenditure of PAFs in different items.

Table 5-44: Annual Average Expenditure of PAFs

SN	Description	Annual Expenditure (Nrs)
1	Rice	51,288.73
2	Pulses	8,935.21
3	Maize	34,109.86
4	Vegetables	18,370.42
5	Milk / Curd	15,549.30
6	Meat / Fish	33,690.14
7	Oil /Ghee	12,642.25
8	Salt	1,271.13
9	Spices	4,340.85
10	Sugar	4,156.34
11	Tea	1,022.25
12	Fuel Wood	14,307.04
13	Electricity	4,018.31
14	Kerosene	7.04
15	Medicine	29,464.79
16	Education	42,211.27
17	Clothes	27,014.08
18	Festivals	31,887.32
19	Others	8,929.58
	Total	**343,215.91**

Source: Household Survey, 2019

xii. Poverty Status

As could be seen from the tables 5-43 and 5-44 above, a family on average makes a saving of Nrs. 37,696.75 per annum, indicating better situation in average. However, some of the families have food insufficiency (Table 5-40) and experience hardship.

xiii. Energy Use

The table 5-45 show the use of energy of PAFs. More than 85 % of the PAF still use fire-wood for cooking purpose and about 97 percent of the total PAFs are benefitted from electricity for lighting.

Table 5-45: Source of Energy of PAFs in Percentage

S.N	Description	Cooking Percent (%)	Lighting Percent (%)
1	Fire - Wood	85.5	0
2	L.P.Gas	10	0
3	Electricity	0	97.5
4	Bio-gas	4.5	0
5	Solar	0	2.5
		100	100

Source: Household Survey, 2019

xiv. Source of Drinking Water of PAFs

Most of PAFs 86.81% has access to piped drinking water. About 9.89 % are dependent on well water for drinking (Table 5-46).

Table 5-46: Source of Drinking Water of PAFs

SN	Description	No. of HHs	Percentage (%)
1	Piped Water	79	86.81
2	River / Stream	3	3.30
3	Well	9	9.89
4	Spring Water	0	00.00
	Total	91	100.00

Source: Household Survey, 2019

xv. Status of Women

Women involvement in the decision making of households is presented Table 5-47. In general, decisions are made in consultation between male and female partners but final decisions are made by male partners with few exceptions. Women involvement is highest (76%) in agriculture activities.

Table 5-47: Level of Decision making power of Senior Female Member of Household

SN	Women Involvement	Involvement (%)
1	Education of Children	62
2	Health and Treatment of Sick Children	69
3	Purchasing Clothes for Family	52
4	Agricultural Activities	76
5	Purchasing of HHs	40
6	Sale and Purchase of Property	18
7	Marriage of children	25
8	Domestic Entertainment	40

Source: Household survey 2019

xvi. Expectation of PAFs for Compensation

Almost all PAFs expect cash compensation to their lost assets. They are capable to handle their cash compensation on own wills. Table 5-48 shows willingness of PAFs for compensation of the project area.

Table 5-48: Willingness of PAFs for Compensation

S. No.	Description	PAFs (%)
1	Cash	100
2	Land for land	0
3	House for house	0
4	**Others**	-
Total		**100**

Source: Household survey 2019

xvii. Use of Compensation

About 99 % of total PAFs expressed their desire to use cash compensation for purchasing land. Whereas 10% of PAFs wanted to trade and 79.80 % wanted to construct house. Table 5-49 shows willingness of PAFs to use compensation amount.

Table 5-49: Uses of Cash Compensation

SN	Description	Percentage (%)
1	Purchase of Land	99.30
2	Construction of House	79.80
3	Payment of Loan	23.45
4	Trade	10
5	To Educate Child	30.17
6	Others	0

Source: Household survey 2019

xviii. Members of PAFs who want to work in the Project

The project area does not have economic and development activities at present. About 51% of the total PAFs want to work as unskilled labors in the project whereas 43% have skills to work as skilled laborers. The 65% showed interests in administrative works and 6.5% in executive post. Table 5-50 shows the willingness of PAFs members to work in the project in different capacities.

Table 5-50: Members of PAFs Who Want to Work in the Project

S. No.	Description	PAFs (%)
1	As unskilled labours	50.91
2	As skilled labours	42.85
3	In administration	65
4	As executive officer	6.5

Source: Household survey 2019

xix. Expectation of PAFs from the Project

About 87.5% urged that the project should contribute to local area development (Table 5-51) and nearly 81.5% expected that the project should contribute for electricity.

Table 5-51: Expectations of PAFs from the Project

S. No.	Description	PAFs (%)
1	Good compensation (cash)	98.5
2	Employment opportunities	94.5
3	Development of local area	87.5
4	Electricity	81.5
5	Others	1.45

Source: Household survey 2019

xx. Majhi Community along the River Banks of Sunkoshi River and Tamakoshi River

The Sunkoshi River and Tamakoshi River were well known for fishes in the past. Hence large number of Majhi community resided along the river banks. This community had mainly two occupations namely taking the people across the river by boat and fishing as their livelihood. Later they also stated cultivation along the fertile land along the river. Majority of the land along the Sunkoshi River and Tamakoshi River are owned by Majhi community. Table 5-52 presents the number of affected households affected in the community. Out of 491 number of affected household along the Tamakoshi River and Sunkoshi River 417 households are from the majhi community.

Table 5-52: Affected Households along the Sunkoshi River and Tamakoshi River

District	Area	Number of households					
		Majhi	Chetri	Newar	Backward	Unidentified	Total
Along Tamakoshi River	Hattitar 1	50	2		1	5	58
	Hattitar 2 *	91	1				92
	Seleghat	36		3			39
	Simladi	19	1	6			26
	Puchighat	11					11
	Rajgaun	12					12
	o	47	3		1		51
	Khosai 1	45					45
	Khosai 2	18					18
	Khalleri	31	5		1		37
Along Sunkoshi River	Sitalpati 1 kha	33	3	2		2	40
	Sitalpati 2 ga	1	2				3
	Sitalpati 9 ka	11	3			2	16
	Sitalpati 9 gha	12	25	5	1		43
	Total	417	45	16	4	9	491
	percentage	85%	9%	3%	1%	2%	

However, traditional livelihood of the fishermen community such as (i) ferrying the people across the river had been lost due to construction of suspension bridges; and (ii) fishing have been reduced substantially due to widespread use of DC current and poisoning for fishing. These methods of fishing kill all aquatic life. Hence, agriculture is the main livelihood for this community.

CHAPTER – 6

6 ENVIRONMENTAL IMPACT

Both beneficial and adverse environmental impacts have been identified, predicted and evaluated for prioritized issues as included in the approved TOR for the EIA study. Beneficial impacts are described in sub-section 6.1 and adverse impacts are described in sub-section 6.2. Impacts evaluation have been made to know their environmental significance with due consideration on aspects as mentioned in chapter 3 (methodology). Any other adverse impacts that are not identified or anticipated at this stage, if later significant during construction and operation phases, the Proponent will mitigate and/or compensate in due course of time.

6.1 BENEFICIAL IMPACT

The construction of the project ensures for continuous supply of hydro-electricity to the people. The project will generate 28.62 MW of hydroelectricity and augment the flow in Bagmati River to provide the irrigation water to 122,000 ha in the five districts Bara, Rautahat, Sarlahi, Mahottari and Dhanusha of Province no 2. Apart from the direct benefit of generating hydroelectricity and irrigation water, the project will provide employment and other benefits during the construction and operational stages. The following sub-section describes beneficial impacts of the project. Appropriate augmentation measures have been proposed to enhance the beneficial impacts.

Apart from that, the project will support for development activities in the project affected Rural Municipalitys and Municipality.

6.1.1 Construction Stage

The following five beneficial impacts will occur during its construction stage:

(i) Increase in job opportunity for local people

During the construction of the project, large number of skilled, semi-skilled and unskilled manpower will be required. Based on detailed feasibility study report, in average 840 person of workforce will be required daily for the implementation of the hydropower component. The socio-economic survey revealed over 50 percent of the PAFs interested to work as unskilled laborers and 43 percent as skilled laborers. The employment opportunity will increase the income level of the project affected and local people.

During the construction period, workers from outside the project area will reside in the designated work camp for considerable period of time. Since workers will have good purchasing power, there will be increased demand for different types of food, beverage and other daily necessary items. More tea stalls, grocery shops and restaurants will be operated to cater services. As a result, significant amount of cash will be channeled into the local economy.

Nature of the impact is direct. Magnitude, extent and duration of this identified impact have been rated as high, regional and short-term respectively.

(ii) Increase in trade and business

The construction camps will be located at the headworks site and powerhouse site. Nearest market of the headworks site is Khurkot which is already developed market place and new market center could be developed at Kusumtar near powerhouse site. The workforce will be located at the both construction camps. The workforce will also require significant quantities of vegetables, cash crops (fruit, vegetables etc) and livestock products such as milk, ghee, meat and eggs. This increased demand will encourage local people to be self-employed in horticulture and animal husbandry. From the sales of the products they will be able to increase their income levels and improve the living condition.

Marketing of the local products to the project employees and the employment in the construction works will increase income of the local people. Furthermore, construction workers and project staffs will have good purchasing power. Similarly, the increase of consumption of local production will improve the local economy, it will also result to the flow of significant amount of cash into the local economy and additional income generation opportunities will be opened.

Taking into account the experience of similar projects, magnitude, extent and duration of the identified impact have been rated as high, regional and short-term respectively.

(iii) Skill enhancement of locals

The project will provide technical skill training on construction works and income generating training to one member of the project affected family so that they could be employed in construction activities or run enterprises of its own. A total of 532 people will be trained. Area of training could be in specialized area such as masonry works, carpentry, gabion weaving, electro-mechanical works, house wiring and maintenance, road slope stabilization, spoil handling, etc.

The magnitude of the identified impact has been considered high, while the extent and duration have been predicated local and long-term respectively.

(iv) Induced Development in Project area

Economic activities in the project area and cash inflow may induce development activities in the project area or project affected Rural Municipalities as well as surrounding Rural Municipality.

The magnitude, extent and duration of this beneficial impact are predicted low, local and short-term respectively.

(v) Local area development through Community Support Programme (CSP)

Apart from the compensation and mitigation measures, the government has made provision of allocating 0.75 % of the project cost for the community support programme in the project affected area which is equivalent to Rs 346.454 million for the entire project period. Annually, Rs 1.0 crore will be allocated for the construction period of 5 years for the local area development of the project affected wards of Palikas in education and health sectors and infrastructure for community benefits. This budget will be channeled through the Local Coordination Committee that will be formed with the representation from the affected Rural Municipalitys/Municipalities. This budget is proposed to be used in development activities of Sunkoshi Rural Municipality-6, Kamalamai Municipality-2, Manthali Municipality-6 and Khadadevi Rural Municipality-4. Balance remaining will be allocated for the operation phase. During the operation phase, local government will also receive 25 % of the total royalty of the electricity generation from the project.

The magnitude of the CSP impact will be high with local extent and long-term duration.

6.1.2 Operation Stage

(i) Availability of Clean Energy

The project will generate 250.694 GWH of hydroelectricity per year and will feed into the national grid. This will be big input in the national level power planning and will reduce power import from India.

Nature of impact is direct. The magnitude, extent and duration of this identified impact have been rated high, national and long-term respectively.

(ii) Increase in job opportunities for the local people

After the construction work is over, the project will require some permanent post for the smooth operation and regular maintenance of project components such as equipment, surge tank and powerhouse. Local people will be recruited for administrative and technical work according to their qualifications and skills. These will give permanent income source to some project affected people and/or local people. The number of posts required could be quantified during the operation stage.

These impacts would be of indirect nature. The magnitude, extent and duration of the impacts are low, local and long-term respectively.

(iii) Irrigation of 122,000 ha of land

The project will be diverting 67 m3/s of water from Sunkoshi River to Marin Khola to generate 28.62 MW of hydroelectric. The water from the tailrace of the powerhouse will be discharged into the Marin Khola. This flow is added in the Bagmati River and the water will be used for irrigating additional 122,000.00 ha in Bara, Rautahat, Sarlahi, Mahottari and Dhanusha districts in the Province no 2for the extension of the Bagmati Irrigation Project.

The agriculture benefit from the irrigation of 122,000 ha command area will be quite large. The impacts would be of direct nature. The magnitude, extent and duration of this identified impact has been rated high, regional and long-term respectively

(iv) Increase in revenue and local development activities

As per the provision in the Inter-Governmental Fiscal Management Act (2017), 50% of the total revenue will be allocated to the central government and Province Government and Local Government each will receive 25 %. It is a perennial source of revenue and local government may use to implement local development activities. .

The magnitude, extent and duration of this local income and identified impact have been rated as high, local and long-term respectively.

(v) Increase in tourism development

The Khurkot is the junction of the B P Highway, Khurkot – Manthali Road, and starting point of Ramechap Road. Number of people crosses this location daily. Development of appropriate and adequate facilities such as boating, sport fishing and accommodation facilities may attract tourists. In addition, inundation area of 312 ha will have potential for water sport tourism development.

The magnitude of the impact has been considered medium, while the extent and duration have been predicated local and long-term respectively.

(vi) Fish farming in the inundation area

Project is likely to affect 417 households of Majhi along the Tamakoshi River and Sunkoshi River. This community was already deprived of their traditional job such as ferrying and boating to the people across the river due to the construction of suspension bridges and fishing due to reduction in the fish population in the river. Their fishing activities could be revived by fish farming in the large inundation area.

As the activity is revival of the traditional activity of a deprived community, the magnitude, extent and duration of the beneficial impact has been considered high, local and long-term respectively.

(vii) Inter-Province impacts and benefits

The major adverse impact of the project such as loss of private, community and government properties will be located within the Province 3 whereas the long-term major benefit such as hydropower generation will be to the national level and irrigation facilities will be provided in Province 2. This inter-basin diversion project provides inter-Province benefits and it could develop a good model for benefit sharing from hydropower projects.

The magnitude, extent and duration of the impact have been considered low, national and long-term respectively.

(viii) Provision of Shares to the Local People

The draft new hydropower policy has the provision of 10 % shares of the projects to the local people. During the public hearing meeting also, many of the representatives expressed their interest in the investment through share As the ownership of this project lies with the government it is not confirmed that whether this provision will be applicable or not.. Moreover the project cost of hydropower component is quite high. Return from the hydropower component may not be possible.

(ix) Induced Development

Due to increase in economic activities, cash inflow, and project activities, general economic activities will get boost up. The availability of reliable electricity within the country will reduce dependence on imported energy.

Furthermore, CSP programme will be continued during the project operation phase. The affected local governments will have remaining fund from CSP budget (only NRs 5 crore will be spent in construction stage). Local Governments may also use royaltee of electricity generation for the implementation of local development activities. The project impact of the CSP budget may be significant.

Hence, magnitude, extent and duration of the impact are predicted high, local and long-term respectively.

6.2 ADVERSE IMPACTS

The approved scoping document and Terms of Reference for this project has included issues on physical, biological and socio-economic and cultural environment. Efforts have been made to identify, predict and evaluate the environmental impacts of each issue, as applicable, in the following sub-sections:

Considering the project activities, environmental impacts have been assessed as per the National EIA Guidelines 1993 for magnitude, extent, and duration. Identified and predicted environmental impacts have been evaluated to know the level of significance. The following sub-sections include the impacts identified or predicted

6.2.1 Physical Environment

6.2.1.1 Construction Phase

(i) Change in topography and land use

The project will inundate 312 ha of the different category of land due to construction of 12 m high barrage and project will occupy 340.50 ha of different category of land (Table 2.6) due to the construction hydropower infrastructures. This will result to change in topography and land use in the project area. Cropland, barren land and forests will be replaced by concrete infrastructure of project like intake, settling basin, powerhouse, surge tank and staff quarters etc. Sometimes cutting of slopes, disturbance in fragile slopes and clearance of riverine land for quarry and disposal of muck may accelerate landslides in the existing landscape. ,. However, baseline information confirms stable slopes and good foundation of project structures. Impact on topography will occur during operation phase also if the fragile slopes have been disturbed during construction phase.

Taking into consideration the geology of the area, magnitude, extent and duration of this impact is predicted low, site-specific and short-term respectively.

For land required for the disposal area and borrow area, 6.39 ha will be acquired temporarily on lease or rent. Its land use could remain as the original condition or even better after rehabilitation. The magnitude, extent and duration of the impact will be low, site-specific and short-term.

(ii) Land slide and soil erosion due to excavation works

Construction activities will include land excavation, slope cutting, grading, use of heavy equipment etc. these activities on slopes may induce slope failure and mass wasting. The clearing activities of public land and agricultural land for the construction of project structures will make the soil surface loose. So soil erosion may occur during the rainy season especially in the steep slopes. The eroded particles may be transported to the river in monsoon and exacerbate sedimentation in river.

As geological condition is stable, magnitude, extent and duration of this impact is considered low, site-specific and short-term.

(iii) Degradation of air and water quality and increase in noise level

(a) Air quality

Earthworks and plying of vehicles within the project area may degrade air quality, and transportation of construction materials from the quarry site to the construction site and movement of consultant's and contractor's personnel on daily basis will add emission of carbon monoxide and sulphur dioxide and dust in the local atmosphere.

As baseline air quality is good, addition of gaseous and dust emissions may not degrade and cross the national ambient air quality. Hence, magnitude of impact is predicted low with local extent and short-term duration. Impact of dust and gaseous emission is construction-related and, therefore, the overall predicted impact will be insignificant.

(b) Water quality

A temporary river diversion will be made for the construction of barrage. The construction work will temporarily increase water turbidity during the dry season (for about 4 months). The large number of the construction workers during the peak construction period in a limited area likely to induce sewerage disposal problem. In view of existing water quality (which complies with NDWQS, 2062) and water flow (85.8m^3/s in driest month, March) in the Sunkoshi River, additional biological waste may pollute river to a certain extent during the dry season and will self-purify in the downstream.

Though the duration of this impact is short-term, magnitude of the impact is considered moderate as it is related to the human health hazard and the extent is local.

(c) Noise level

The operation of machineries such as the TBM, crusher plants, compressor and diesel generator for 24 hours and the movement of increased number of vehicles along with the use of pressure horn would increase the noise level in the project area. Experience in similar projects has shown that noise level goes up to 130 dbh whereas existing noise level in the project area is less than 40 db. This noise level is sufficiently high from human health point of view. The high noise level may affect the domesticated pregnant animals and local people.

Hence, the magnitude of this identified impact is medium, extent is site-specific and duration is short-term as blasting in tunnel will not take place.

(iv) Stockpiling of Construction Materials

It is the general practice that construction materials are stockpiled near by the construction sites. Stockpiling of these materials will occupy lease or rented land during the construction period. This will be uneasy for the land owner.

The magnitude of the impact will be medium as it will be directly affecting the cropland. Extent will be site-specific with short-term duration.

(v) Muck/spoil disposal

The tunnel excavation will be generating 134,500 m^3 of the muck. Management of the large volume of muck wastes would be challenging. Location of the muck disposal sites have been shown in Figure 2-10.

Apart from the tunnel muck, the construction activities will also be generating large volume of construction wastes or spoils. During construction of the different project components, large volume of spoil will be generated. The impact from this activity is inevitable. Some of spoil could be used in the construction areas as backfill. The rest needs will be disposed at the designated locations.

The magnitude of the impact will be medium. Extent will be site-specific of short-term duration.

(vi) Operation of Borrow Areas/Quarry Sites

Significant quantities of construction materials such as clay, boulders and cobbles, gravels and sand, coarse aggregate and back slope filling materials are required for the construction of the project. The requirement of the construction materials is presented in Table 2.4. The feasibility study has identified quarry sites along the flood plain of Sunkoshi River and Marin Khola.

Locations of construction material sites are shown in Figure 2-10 and Figure 2-11.

Description of each quarry site is given below

1. Construction Material CM1

The CM1 site is located at the right bank of the Sunkoshi River, 50 m downstream from the Bhadaure Khola motarable road (Banepa-Sindhuli-Bardibas Road) as shown in Figure 2-10. The coordinate of the site is 27°20'10.27"N 85°59'29.52"E. The site is accessible by vehicle.

The material is from alluvial deposit, consisting of boulders, cobbles and pebbles of granite, pegmatite, quartzite, gneiss, slate, phyllite, schist and metasandstone. The stability/hydrological condition seems to be stable and dry. Total reserves of available quantity are given below together with the visual estimation of percentages of composition.

Dimension: Length: 150 m, Breath: 100 m, Height: 10 m

Volume: 150,000 m3

Composition: Boulder: 50%, Cobble and Pebble: 35%, Fines: 15%

Furthermore, the visual estimation confirmed percentages of each coarse aggregate in the total available materials for each rock type were determined to be granite: 50%, quartzite: 30%, gneiss: 10%, and slate, phyllite, schist, pegmatite and metasandstone: 10%.

2. Construction Material Site CM2

The construction material site CM2 is located at the old terrace of the Sunkoshi River, 50 m downslope from the Khurkot-Manthali Road, near Seleghat (Figure 2-10). The coordinate of the site is 27°20'16.13"N 85°59'17.89"E. The site is accessible by vehicle.

The alluvial deposit consists of boulders, cobbles and pebbles of quartzite, slate, phyllite, schist, gneiss and marble. The materials were derived from the rocks of Nawakot Complex and Kathmandu Complex. The area is partially cultivated. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 100 m, Breath: 60 m, Height: 10 m

Volume: 60,000 m3

Composition: Boulder: 20%, Cobble and Pebble: 30%, Fines: 50%

Furthermore, the visual estimation confirmed the percentages of each clast in the total available materials for each rock type were determined to be quartzite: 40%, gneiss: 30%, schist: 20%, and slate, marble and phyllite: 10%.

3. **Construction Material CM3**

The construction material site is located at the left bank of the Sunkoshi River, 300 m upstream from the confluence of the Sunkoshi River and the Bhadaure Khola as shown in Figure 2-10. The site is in the flood plain of the Sunkoshi River. The coordinate of the site is 27°20'12.53"N 85°59'9.66"E and the site is accessible by vehicle.

The alluvial deposit consists of boulders, cobbles and pebbles of igneous and metamorphic rocks of pegmatite, quartzite, marble, slate, phyllite, schist and gneiss. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 550 m, Breadth: 150 m, Height: 4 m

Volume: 330,000 m3

Composition: Boulder: 10%, Cobble and Pebble: 40%, Fines: 50%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be quartzite: 30%, gneiss: 30%, schist: 20%, granite/pegmatite: 10%, and marble, slate and phyllite: 10%. The material deposits were predominated with the presence of more than 50% fine materials towards the downstream whereas coarser materials of gravel to boulders were predominated along the upstream segment.

4. **Construction Material CM4A**

The site is located at the left bank of the Sunkoshi River and the Tamakoshi River, down and upstream from the confluence of the Sunkoshi River and the Tamakoshi River as shown in Figure 2-10. The coordinate of the site is 27°21'6.69"N 85°59'2.73"E and the site is accessible by vehicle.

The alluvial deposits contain boulders, cobbles and pebbles of pegmatite, quartzite, marble, slate, phyllite, schist and gneiss. The stability/hydrological condition seems to be stable and dry. Total reserves of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 700m, Breadth: 30m, Height: 2m

Volume: 42,000 m3

Composition: Boulder: 40%, Cobble and Pebble: 40%, Fines: 20%

Furthermore, the visual estimation confirmed the percentages of each clast in the total available materials for each rock type were determined to be quartzite: 30%, gneiss: 30%, schist: 20%, granite/pegmatite: 10%, and marble, slate and phyllite: 10 %.

5. **Construction Material CM4B**

The construction material site is located on the left bank of the Sunkoshi River, downstream from the confluence of the Betini Khola and the Sunkoshi River as shown in Figure 2-10. The site is within the flood plain of the Sunkoshi River. The coordinate of the site is 27°20'50.36"N 85°59'1.53"E and the site is accessible by vehicle.

The alluvial deposit consists of boulders, cobbles and pebbles of pegmatite, quartzite, marble, slate, phyllite, schist and gneiss. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 300 m, Breadth: 15 m, Height: 2 m

Volume: 9,000 m3

Composition: Boulder: 40%, Cobble and Pebble: 40%, Fines: 20%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be quartzite: 30%, gneiss: 30%, schist: 20%, granite/pegmatite: 10%, and marble, slate and phyllite: 10%.

6. Construction Material CM5

The construction material site lies at the left bank of the Sunkoshi River, near the confluence of the Sunkoshi River and Tamakoshi River as shown in Figure 2-10. The site consists the flood plain deposit of the Sunkoshi River and Tamakoshi River. The coordinate of the site is 27°21'14.36"N 85°58'49.34"E and the site is accessible by vehicle.

The material is composed of boulders, cobbles and pebbles of pegmatite, quartzite, marble, slate, phyllite, schist and gneiss. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 600 m, Breadth: 60 m, Height: 2 m

Volume: 72,000 m3

Composition: Boulder: 40%, Cobble and Pebble: 40%, Fines: 20%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be quartzite: 30%, gneiss: 30%, schist: 20%, granite/pegmatite: 10%, and marble, slate and phyllite: 10 %.

7. Construction Material CM6

The construction material site lies at the right bank of the Sunkoshi River, near the big bend of the Sunkoshi River downstream from the Headworks of the SMDMP (Figure 2-10). The coordinate of the site is 27°20'16.74"N 85°58'49.61"E and the site is accessible by vehicle.

The materials contained alluvial deposits consisting of boulders, cobbles and pebblrs of pegmatite, quartzite, marble, slate, phyllite, schist and gneiss. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 400 m, Breadth: 30 m, Height: 3 m

Volume: 36,000 m3

Composition: Boulder: 40%, Cobble and Pebble: 30%, Fines: 30%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be quartzite: 30%, gneiss: 30%, schist: 10%, granite/pegmatite: 20%, and marble, slate and phyllite: 10%.

8. Construction Material AG1

The site is located on the left bank of the Marin Khola, 1 km upstream from the temple as shown in Figure 2-11. The coordinate of the site is 27°16'41.24"N 85°52'15.61"E and the site is accessible by vehicle.

The material contained alluvial deposits consisting of quartzite, schist, gneiss, sandstone and mudstone. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is mentioned below together with the visual estimation of percentages of composition.

Dimension: Length: 100 m, Breadth: 150 m, Height: 7 m

Volume: 105,000 m3

Composition: Boulder: 60%, Cobble and Pebble: 20%, Fines: 20%

Furthermore, the visual estimation confirmed percentages of aggregates in the total available materials for each rock type were determined to be granite: 20%, gneiss: 20%, quartzite: 20%, sandstone: 20%, mudstone: 10% and other rock particles: 10%.

9. Construction Material AG2

The construction material site lies at the right bank of the Marin Khola, 500 m upstream from the suspension bridge near Kusumtar village as shown in Figure 2-11. The coordinate of the site is 27°16'6.16"N 85°52'30.00"E and the site is accessible by means of vehicle.

The materials contained alluvial deposits of quartzite, schist, gneiss, sandstone and mudstone in various sizes. The stability/hydrological condition seem to be stable and dry. Total reserve of available quantity is given below together with the visual estimation of percentages of composition.

Dimension: Length: 100 m, Breadth: 50 m, Height: 2 m

Volume: 10,000 m3

Composition: Boulder: 60%, Cobble and Pebble: 20%, Fines: 20%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be granite: 20%, gneiss: 20%, quartzite: 20%, sandstone: 20%, mudstone: 10% and other rock particles: 10%.

10. Construction Material AG3

The construction material site is located at the right bank of the Marin Khola, near the confluence of the Marin Khola and the Jhor Khola as shown in Figure 2-11. The coordinate of the site is 27°15'33.65"N 85°52'24.66"E and the site is accessible by vehicle.

The materials contained alluvial deposits with boulders, cobbles and pebbles of granite, quartzite, schist, gneiss, sandstone and mudstone. The stability/hydrological condition seems to be stable and dry. Total reserve of available quantity is provided below together with the visual estimation of percentages of composition.

Dimension: Length: 700 m, Breadth: 100 m, Height: 2 m

Volume: 140,000 m3

Composition: Boulder: 40%, Cobble and Pebble: 30%, Fines: 30%

Furthermore, the visual estimation confirmed percentages of coarse aggregates in the total available materials for each rock type were determined to be granite: 20%, gneiss: 20%, quartzite: 20%, sandstone: 20%, mudstone: 10%, and other rock particles: 10%.

11. Construction Material AG4

The construction material site is situated at the left bank of the Marin Khola, near the confluence of the Marin Khola and the Lipu Khola as shown in Figure 2-11. The coordinate of the site is 27°15'23.58"N 85°52'28.98"E and the site is accessible by means of vehicle.

The materials contained alluvial deposits consisting of quartzite, schist, gneiss, sandstone and mudstone. The stability/hydrological condition seem to be stable and dry. Total reserve of available quantity is stated below together with the visual estimation of percentages of composition.

Dimension: Length: 500 m, Breadth: 80 m, Height: 2 m

Volume: 80,000 m3

Composition: Boulder: 50%, Cobble and Pebble: 30%, Fines: 20%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be granite: 10%, gneiss: 10%, quartzite: 10%, sandstone: 30%, and mudstone and other rock particles: 20%.

12. Construction Material Red Clay

The site for red clay is situated at the Sindhuli-Bardibas road near Mulkot (Selfie Dada), 15 km away from the Khurkot Bazar towards Nepalthok. The coordinate of the site is 27°22'55.73"N 85°57'49.69"E and the site is accessible by vehicle.

The materials contained terrace deposit consisting mostly of fine deposits of red clay with few clasts of quartzite, and granite. The area is barren, from where the material can be extracted by quarrying. The stability/hydrological condition seem to be stable and dry. Total reserves of available quantity are given below together with the visual estimation of percentages of composition.

Dimension: Length: 500 m, Breadth: 100 m, Height: 3 m

Volume: 180,000 m3

Composition: Boulder, Pebble and Cobble: 5%, Fines:95%

Furthermore, the visual estimation confirmed percentages of each clast in the total available materials for each rock type were determined to be coarse materials of quartzite and granite: 5% and red clay: 95 %.

13. Operation of quarry sites and daily production requirement

The quarry sites will be operated in two places namely the powerhouse site and the headworks site for producing the required amounts of aggregate and sand as stated in Table 2-4. Equipments and machinery like excavators, crushers etc will be used for excavating, grading and crushing of the construction materials. As per the quantity requirement of aggregate and sand the daily production rate for the construction materials is about 104 cum.

The operation of the quarry sites/borrow areas will disturb/change the landscape, both in horizontal and vertical direction. Furthermore, operation of the crushing plant will increase the dust emission. If the slopes of the quarry sites are not maintained properly, deposited materials will be eroded into the river.

The magnitude of the impact will be medium, extent is site-specific and duration is short-term (construction-related).

(vii) Change in River Morphology

Extensive construction activities during the construction stage such as construction coffer dam will require the diversion of the River at the headworks site. The river bed materials of the Sunkoshi River have been proposed as the quarry sites. The temporary access road will also be built on the flood plain. Again when the coffer dam is demolished, river flow will carry large volume of debris. Hence, river morphology is likely to change during the construction period.

As it is flood plain area, magnitude of the impact from induced change is considered low, extent will be site-specific and duration will be short-term.

(viii) Springs drying along Tunnel Alignment

The spring sources have not been located in the vicinity of the tunnel portals. Experience from other hydropower project indicates possibility of springs drying along the tunnel alignment during the construction stage leading to shortage of drinking water to the people relying on natural springs. This impact has also been covered under effect of tunneling operation stage.

(ix) Leakage of Oil, Grease and other Liquid Materials

Number of light and heavy vehicles will be required for the construction of the project. These vehicles will use diesel and petrol, engine oil, gear oil, brake oil etc. The labor housing would require large volume of kerosene or LPG for cooking purpose.

The possibility of leakage of oil and grease and other liquid materials cannot be overruled. The oil if spilled easily spreads over the ground producing eye sore. The oil spill pollutes water and reduces dissolved oxygen content. The oil leakage would have detrimental impact on the aquatic life.

Taking note of the limited presence of aquatic species, limited use of stream water for other purposes and good practices in handling such materials in similar projects, environmental impact is low in magnitude, extent is site-specific and duration is short-term.

(x) Blasting activities in and around the tunnel

As the TBM will be used for tunnel construction, there will be no blasting for the tunnel excavation.

(xi) Impact on the local infrastructures

Two types of the impact on the local infrastructures will occur.

(a) Existing infrastructures directly affected by the project infrastructures. A list of 'to be' affected infrastructures is presented in Table 6.1

Table 6-1 : Likely Affected Infrastructure by the Project

Categories	Unit	Sindhuli	Ramechap	Total	Remarks
		Quantity(No.)	Quantity(No.)		
Road					
					Inundation
BP Highway	km	0.9		0.9	Inundation
Local rural roads	km		1.59	1.59	Inundation
Dharan Chatra Road	km	0.8			Powerhouse site
Suspension bridges	no	2	1	3	Inundation
Transmission line/Pole	Km/no	–	1.27/16	1.27/16	Inundation
Structures					Inundation
House	no	21	22	43	Inundation and powerhouse
Shed	no	20	10	30	Inundation and powerhouse
Generator/pump House	no	1	2	3	Inundation
Well	no	3	12	15	Inundation
Irrigation Canal	m	–	794	794	Inundation
Solar	no	1	2	3	Inundation
Cremation place	no	1		1	Inundation

* the Generator/pump house is temporary structure

Source: Field Survey 2019

(b) The project will be using the existing infrastructures mainly the roads, electricity, water supply, and communication facilities. The movement of the construction vehicle will deteriorate the existing road and create air pollution. In addition, movement of frequent number of heavy vehicle may damage the roadside structures. The impact is considered high in magnitude, extent is site-specific and duration is long-term.

(xii) Loss of top soils

A total of 878,300 m^2 of agricultural land will be used by the project. Assuming 0.3 m depth of the soil is useful top soil for the agricultural land total 263,490 m^3 of top soil is likely to be affected or will be destroyed if not removed before construction.

The impact will be direct in nature, high in magnitude, site-specific in extent, and long-term in duration

(xiii) Pressure on social sector facilities

The project will have construction camps such as work camp, labour camps, and employer's camp. Among them labour camps are likely to in-house for more than 840 people during the peak construction period. Operation of these camps will need drinking water, and will generate solid and liquid wastes. Influx of large number of outside workers will likely exert additional pressures and will have adverse impact on existing facilities of the project area such drinking water, health service, electricity, and telecommunication.. Management of these facilities would be challenging.

The impact will be direct in nature, moderate in magnitude, site-specific in extent and short-term in duration

(xiv) Scrap dumping

The construction sites will have number of scraps such as cement bags, packaging materials and containers of the equipment, and other materials, small iron pieces, wires, worn out ropes, wood pieces, worn out timbers, used and worn out vehicle tires, damaged plywood planks are generated as solid waste from construction. Haphazard disposal of these construction wastes will degrade the aesthetics of the surrounding area and cause pollution of river banks and bed.

The impact will be direct in nature, moderate in magnitude, site-specific in extent and short-term in duration

(xv) Seismicity

The project area is located in the seismicity zone of VI-VII zone having moderate potential risks. The structures need to consider this aspect in the design.

The impact will be direct in nature if earthquake occurs, low in magnitude, site-specific in extent and long-term in duration.

6.2.1.2 Operation Stage

After construction, the project enters into operation and maintenance stage and electricity is regularly generated from the powerhouse. The operation and maintenance related environmental impacts are given below.

(i) Change in hydrology and sedimentation

There will be some changes in surface and ground water levels in surrounding areas due to ponding of water due to dam construction which can also change the groundwater level. Changes in natural river flow will occur between at the downstream of the barrage the intake and powerhouse areas especially during the dry period,

The flushing of the sediments from the desander will increase the turbidity in the river at the downstream area. Thus it will ultimately deteriorate the physical quality of water and aquatic ecosystem of the downstream.

As 18.8 m^3/s of water will be released into the river, predicted impact is direct, but low in magnitude, local in extent and long-term in duration.

(ii) Decrease in water volume due to diversion in Sunkoshi River

A barrage will be constructed across the Sunkoshi River and flow will be diverted for power generation. The river will have low flow from the headworks to next large tributary; Likhu Khola is located at about 35 km. The diversion is likely to affect (a) micro-climate of reduced flow zone, (b) water quality of the river, and (c) change in river morphology.

(a) **Micro-climate of reduced flow zone**: The diversion of water from the Sunkoshi River will eventually result in some impacts at the downstream of the barrage for about 35 km. Low volume of water (18.8 m^3/s instead of 85.8 m^3/s in dry month March)is likely to increase temperature in the low water flow zone. During summer and monsoon seasons, the rise in temperature might be insignificant as only 67 m^3/s water will be diverted. The changes in micro-climate will eventually alter the ecological status of downstream areas. The impact is direct, low in magnitude in Sunkoshi, local in extent and long-term in duration.

(b) **Water quality of the river**: Due to low volume of water flow in the dewatered zone of Sunkoshi River dissolve oxygen will be decreased in downstream area of the river. As over 20 percent of total water will be still flowing in the river during the dry months (18.8 m^3/s in March), predicted impact is direct, low in magnitude, local in extent and long-term in duration.

(c) **Change in river morphology**: Diversion of water particularly during the lean flow period is likely to reduce abruptly the flow regime in the river which could lead to the change in the river morphology. As the river is braided the reduced flow could be confined to the particular channel and will not like change the river course. Hence the magnitude of the predicted impact will be low, extent is site-specific and duration will be long-term.

Overall impact of reduced flow is predicted low in view of the present non-use of downstream water by the local people. The impact duration is long-term, and extent is local. As the impact is irreversible, it is considered significant impact.

(iii) Increase in water volume in Marin Khola

Addition of 67.0 m^3/s of water in Marin Khola will change its complete flow pattern. There will be significant increase in water volume in this Khola due to diversion of the Sunkoshi River.

The project has prepared Flood Protection Plan for Marin Khola on the Drone survey map with hydraulic simulation. There are 28 farmers-managed irrigation schemes (FMIS) along the Marin Khola covering 645 ha. The aggravated flow in the Khola will erode river banks affecting the diversion locations of the FMISs.Nepal has yet to know the ground level realistic impacts of inter-basin diversion projects.

The magnitude, extent and duration of this identified impact will be high, local and long-term.

(iv) Decrease in water temperature in the Marin Khola

The Sunkoshi River is being snow fed river has lower temperature than the water of Marin Khola. The temperature of Marin Khola water will be decreased due the addition of 67 cumecs of water from Sunkoshi River. Temperature of mixed water has been estimated in Table 6-2. Water temperature may decrease by 4.3^{0}C in May and 3.8^{0}C in April.

Table 6-2 : Estimated Temperature of Marin Khola

Month	Marin Khola			Sunkoshi River			EstimatedTemp in Marin Khola with Diversion Discharge in ^{o}c	Decrease in temp ^{o}c
	Average Monthly Discharge (m^3/s)	Air temp Marin Khola ^{o}c	Water temp Marin Khola ^{o}c	Diversion discharge (m^3/s)	Air temp Sunkoshi River ^{o}c	Water temp Sunkoshi River ^{o}c		
January	1.78	15.58	12.17	67	14.04	12.08	12.08	(0.09)
February	1.52	19.48	15.22	67	15.82	13.61	13.64	(1.57)
March	1.36	24.71	19.30	67	19.57	16.83	16.88	(2.43)
April	1.38	30.01	23.45	67	22.75	19.57	19.65	(3.80)
May	1.84	32.00	25.00	67	23.88	20.53	20.65	(4.35)
June	6.04	32.73	25.57	67	25.00	21.50	21.84	(3.73)
July	18.62	31.95	24.96	67	25.00	21.50	22.25	(2.71)
August	22.45	31.85	24.89	67	24.81	21.34	22.23	(2.66)
September	17.14	31.15	24.34	67	24.63	21.18	21.82	(2.52)
October	7.59	28.12	21.97	67	22.47	19.33	19.59	(2.38)
November	3.22	23.28	18.19	67	18.91	16.27	16.35	(1.84)
December	2.12	18.06	14.11	67	15.17	13.04	13.08	(1.03)

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

The decrease in the temperature may not be for the longer distance as it is in low land. It could prevail to some distance but not throughout 34 Km stretch.

The magnitude, extent and duration of this impact are rated low, local and long-term respectively.

(v) Tunnel-induced impact on water source

The tunnel excavation may come across the ground water flow. This might affect the spring sources at the top. As TBM will be used for tunnel construction, instead of blasting, it is most likely that water source, if exist along the tunnel, may be affected and channeled to tunnel. If so, community water source will be affected and would be quite critical. Due to lack of impact evidences in similar projects, impact is considered indirect, low in magnitude, local in extent and long-term in duration.

(vi) Leakage of oil, grease and other chemicals

During the operation phase leakage of chemicals, oils, grease is most likely in powerhouse area during the maintenance of powerhouse mechanical components. Due to the chemicals leakage Marin Khola is most likely to be polluted. The magnitude of the predicted impact will be low, extent is site-specific and duration will be of short-term, only maintenance period.

(vii) Downstream sedimentation

The flushing of the sediments from the desilting basin will increase the turbidity of the river at the downstream area of the Sunkoshi River. It will likely deteriorate the physical quality of water and aquatic ecosystem of the downstream. The period will be critical for few days if the desilting is carried out in the lean period when the majority of the flow is diverted. Once sedimentation took place, aquatic life will adapt to and build resilience as well. The predicted impact is direct, low in magnitude, site-specific in extent and short- terming duration (desilting time and few more days only).

(viii) Scouring of river bed and river bank erosion from tailrace outlet

The tail race discharge will add 67 cumecs of water in the Marin Khola. Addition of this discharge could have significant impact on the river bed, banks, cropland, and downstream settlements lying on the bank of Marin Khola. The increase in the discharge is presented in Table 5.5a.

The predicted impact is direct, high in magnitude and local in extent and long-term in duration. Hence the impact would be significant.

(ix) Slope instability

Water level fluctuation in the reservoir may erode immediate uphill soil and drag down the weak slope which may induce slope instability, landslide and deposition of soil and landslide debries in the reservoir, including adverse impacts in number of houses and agricultural land at the immediate uphill of the pond level. Considering similar

impacts in other projects, magnitude of the impact has been predicted high, extent is site-specific and duration will be long-term.

(x) Noise and vibration in powerhouse area

The operation of the turbines and other electrical equipment generate constant noise and vibration, and will reduce 'hearing ability' of operation workers and staff working inside the powerhouse.

As experienced in other powerhouses, this this identified impact will be of direct nature, medium magnitude, site-specific extent and long-term duration, requiring urgent action to maintain or improve hearing.

6.2.2 Biological Environment

6.2.2.1 Construction Stage

(i) Use of Government Land for project facilities

The project will require 252.68 ha of government land (that includes 4.48 ha of forest area, 3.4 ha of community forest, 11.5 ha bush, 50.67 ha river course and 182.63 ha flood plains). Additional 6.39 ha of government land will be temporarily required. Please refer Table 2.6.

The impact will be direct in nature, high in magnitude, site-specific in extent and long-term in duration.

(ii) Loss of Forest Product

(a) Inundation Area/headworks

Development and maintenance of inundation level at 476 m will submerge vegetation of 312 ha of land comprising of 2.94 ha of forest area (mostly degraded), 180.81 ha of flood plain land and 78.91 ha of private land. A total of 364 trees and 1751 pole-sized tree species, including bushes and grasses will be inundated in the proposed inundation area (Table 6-3). This will also submerge about 7 thousand ft^3 of wood and nearly 20 chatter of firewood. Khari and small are use regulated species in Nepal.

Table 6-3 : Detail of the vegetation loss in the inundated area

SN	Tree Species	Number of tree	Number of pole	Wood volume (Cuff.)	Wood volume (M^3)	Firewood Chatter	Remarks
1	Bothayero (Lagerstroemia parviflora)	10	24	16.05	0.455	0.33	
2	Jamun (*Syzgium cumini*)	14	84	128.98	3.655	0.44	
3	Karma (*Adina cordifolia*)	3	4	0.00		0.11	
4	Khair (*Acacia catechu*)	33	289	401.95	11.391	0.32	
5	Simal (*Bombex ceiba*)	113	14	4552.96	129.025	5.07	
6	Siris (*Albizia lebbeck*)	2	740	0.00		0.08	
7	Sissoo (*Dalbergia sissoo*)	68	2	725.21	20.551	1.32	
8	Miscellaneous spp	121	594	1330.16	37.695	12.09	
	Total	**364**	**1751**	**7155.32**	202.772	**19.76**	

Source: Field Survey 2019

(b) Dam site

The construction of dam will be affecting 4 trees and 16 pole-sized tree species (Table 6-

Table 6-4 : Detail of the vegetation losses due to construction of Dam

SN	Tree/pole species	No of trees	No of Poles	Wood volume (Cu. ft.)	Wood volume (M^3)	Firewood chatta	Remarks
1	Simal (*Bambox ceiba*)	3	1	200.80	5.690	0.107	High khair seedlings (more than 1000)
2	Khair (*Acacia catechu*)		10	28.31	0.802		
3	Sissoo (*Dalbergia sissoo*)		2	3.14	0.089	.004	Second highest sissoo ≥500/ha
4	Miscellaneous	1	3	35.23	0.998	0.05	
	Total	**4**	**16**	**267.48**	7.580	**0.161**	

Source: Field Survey 2019

(c) Settling basin

The construction of settling basin will be affect 8 trees and 39 pole-sized plants (Table 6-5).

Table 6-5 : Detail of the vegetation losses due to construction of the Settling Basin

SN	Tree/pole species	No of trees	No of Poles	Wood volume (Cu. ft.)	Wood volume (M^3)	Firewood chatta	Remarks
1	Khair (*Acacia catechu*)	0	27	111.29	3.154	0.06	
2	Siris (*Albizia lebbeck*)	2	8		-	0.18	
3	Sissoo (*Dalbergia sissoo*)	2			-	0.03	
4	Simal (*Bombax ceiba*)	1	1	3.85	0.109	0.05	
5	Jamun (*Syzgium cumini*)	1			-	0.02	
6	Miscellaneous	2	3	75.96	2.153	0.11	
	Total	**8**	**39**	**191.10**	5.416	**0.46**	

Source: Field Survey 2019

(d) Surge tank and penstock

The construction of surge tank and installation of the penstock pipes will be affecting 17 trees and 55 pole-sized vegetation (Table 6-6).

Table 6-6 : Detail of the vegetation losses due to the construction Surge tank and installation of the penstock pipes

SN	Tree/pole species	No of trees	No of Poles	Volume (Cu.ft)	Wood volume (M^3)	Firewood chatta	Remarks
1	Sal (*Shorea robusta*)		5	46.4	1.315	0.03	Protected
2	Siris (*Albizia lebbeck*)	1	2	7.71	0.218	0.03	
3	Karma (*Adina cordifolia*)	1	1	108.28	3.069	0.15	
4	Botadheyaro (*Lagerstroemia parviflora*)	2	1	28.0	0.793	0.20	

5	Jamun (*Syzygium cumini*)	2		25.45	0.721	0.05	
6	Chilaune (*Schima wallichii*)	1		13.82	0.392	0.02	
7	Tooni (*Toona ciliata*)		1		-		
8	Miscellaneous	10	45	231.50	6.560	0.85	
	Total	**17**	**55**	**461.16**	13.069	**1.32**	

Source: Field Survey 2019

(e) Access raod from powerhouse to surge tank

The construction of project road from powerhouse to surge tank will be affecting 13 trees and 47 pole-sized vegetation (Table 6-7).

Table 6-7 : Detail of the vegetation losses due to the construction of project road from powerhouse to surge tank

SN	Tree/pole species	No of trees	No of Poles	Volume (Cu.ft)	Wood volume (M^3)	Firewood chatta	Remarks
1	Botadheyaro (*Lagerstroemia parviflora*)	2	2	28.00	0.793	2.18	
2	Chilaune (*Schima wallichii*)	1	1	13.82	0.392	0.02	
3	Jamun (*Syzygium cumini*)	2		25.45	0.721	0.05	
4	Karma (*Adina cordifolia*)	1	7	108.26	3.068	0.15	
5	Miscellaneous	5	27	231.50	6.560	0.84	
6	Tooni (*Toona ciliata*)		1	0.00	-	0.00	
7	Sal (*Shorea robusta*)		9	46.42	1.315	0.03	Protected
8	Siris (*Albizia lebbeck*)	2		7.71	0.218	0.01	
	Total	**13**	**47**	**461.17**	13.069	**3.29**	

Source: Field Survey 2019

(f) Powerhouse, construction yards and work camp

The area required for these infrastructures are located mainly in the private land. The proposed private land has also pole-sized and tree size plants. A total of 5 trees and 12 pole size plants were recorded in the land (Table 6-8).

Table 6-8 : Detail of the vegetation located in the powerhouse site

SN	Species	No of trees	No of poles	Volume (cu. ft.)	Wood volume (M^3)	Firewood in chatta	Remarks
1	Simal (*Bombax ceiba*)	1	10	12.16	0.345	0.02	
2	Chilaune (*Schema wallichii*)	0	1	0	-		
3	Sal (*Shorea robusta*)	0	1	0	-		Protected

4	Miscellaneous spp	4		52.74	1.495	0.37	
	Total	**5**	**12**	**64.9**	1.839	**0.39**	

Source: Field Survey 2019

(g) Disposal Sites

The enumerated vegetation in the disposal sites is summarized in Table 6-9. In total, 5 trees and 21 pole-sized tree species of Simal, Sissoo, Siris, Tooni, Karma etc. were enumerated during the field study.

Table 6-9 : Detail of the vegetation located in the disposal sites

SN	Tree/pole species	Disposal Site 1		Disposal Site 2		Disposal Site 3		Total	
		No of trees	No of Poles	No of trees	No of Poles	No of trees	No of Poles	No of trees	No of Poles
1	Bothayero (Lagerstroemia parviflora)						1	0	1
2	Simal (*Bombex ceiba*)				1		4	0	5
3	Sissoo (Dalbergia sissoo)		6					0	6
4	Siris (Albizia lebbeck)		2		1			0	3
5	Tooni (*Toona ciliata*)				1			0	1
6	Karma (*Adina cardifolia*)						3	0	3
7	Other			5	2			5	2
	Total	**0**	**8**	**5**	**5**	**0**	**8**	**5**	**21**

Source: Field Survey 2019

(h) Total vegetation loss by area and species in the whole project sites

Largest part of the project sites is situated in the private land which are mostly either left over parts of flooded khetland along with some newly river bank parts which are being left over after slight diversion of river. Total loss of vegetation is summarized in Table 6-9 (A).

Poles of all species are being put together since they are sold as a pole except Sal pole (total 15 pole-sized) whose market price is different than other poles. Similarly, Khair poles (326) are also being used to extract catechu and thus, both poles and trees are being calculated together in a form of cft which is then converted into Kg. (one cft of khair is equivalent to 30 Kg).

However, very small area lies within national forest and community forest, the Kusumtar community forest. There are altogether 416 trees above 30 cm dbh and 1939 poles totaling to 2355 trees to be felled during the project operation. A total of 2115 trees (above and below 30 cm dbh) are in inundation area. High number of Simal (119) having woods and pole-sized Siris (750), followed by 326 poles of Khair should be felled down as a part of site clearance in the project area (Table 6-9A).Magnitude, extent and duration of these identified impacts, related to site clearance, is high, site-specific and long-term.

Table 6-9 (A): Total loss of vegetation

Sl	Species	Inudation area		Dam site		Settling Basin, approach canal, acess road		Surge Tank and Penstock		Powerhouse and work camp		Project road from powerhouse to surge tank		Disposal Site 1		Disposal Site 2		Disposal Site 3		Total	
		312		1.44		1.41		4.71		4.21		1.3		3.65		1.16		1.58		Area in ha	
		Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles	Tree	Poles
1	Bothayero (Lagerstroemia parviflora)	10	24					2	1			2	2						1	14	28
2	Jamun (*Syzgium cumini*)	14	84			1		2				2								19	84
3	Karma (*Adina cardifolia*)	3	4					1	1			1	7						3	5	15
4	Khair (*Acacia catechu*)	33	289		10		27													33	326
5	Miscellaneous spp	121	594	1	3	2	3	10	45	4		5	27			2	2			145	674
6	Simal (*Bombex ceiba*)	113	14	3	1	1	1			1	10					1			4	119	30
7	Siris (*Albizia lebbeck*)	2	740			2	8					2			2	1				7	750
8	Sissoo (*Dalbergia sissoo*)	68	2		2	2		1	2						6					71	12
9	Sal (*Shorea robusta*)								5		1		9							0	15
10	Chilaune (*Schema wallichii*)							1			1	1	1							2	2
1	Tooni (*Cedrella toona*)								1		1		1			1				1	3
	Total	364	1751	4	16	8	39	17	55	5	13	13	47	0	8	5	2	0	8	416	1939

Source: Field Survey 2019

(iii) Firewood collection

As the project area and its vicinity do not have any potential site for firewood collection, local forest will not be affected due to collection of firewood by the construction labour. Moreover, the construction workers will be residing in the labour camp operated by the Contractor where the LPG would the main source of cooking. There will be large number of construction workers residing the in the labour camps. Hence, local forests will not be impacted by the construction workers from firewood collection or impact is insignificant as its maginitude, extent and duration is considered low, local and short-term respectively.

(iv) Increased pressure on surrounding forests

The project would need large quantities of the forest products such as timber and logs for construction works. The experiences of construction in other hydroelectric projects show that need of forest products to the Project are fulfilled from nearby forests and products of felled trees as a part of site clearance.

The impact will be indirect in nature, lowing magnitude, local in extent and short-term in duration.

(v) Disposal of spoils and muck

The spoil and muck disposal has been proposed at the bank of Marin Kholat. This will neither affect the aquatic ecosystem nor disturb the spawning ground of fish species. It means, disposal of mucks and spoils will not increase pressure on aquatic ecosystems.

(vi) Disturbances to wildlife habitat and movement

The project area is neither a good habitat of wildlife nor has any dense forests in the vicinity which could function as wildlife habitat. Hence this impact does not exit

(vii) Impact on endangered and protected species and their habitats

The biological survey reported to have few species of legally use regulated or protected plant and animal species. Chituwa is listed as threatened species. Simal, Khair and Sal are protected plant species. They require government approval before felling and use. This is related to site clearance

The impact will be direct in nature, high in magnitude, site-specific in extent and long-term in duration.

(viii) Impact of temporary diversion of water on aquatic life

The diverted flow will be from a confined channel during intake construction, and water is released in the Sunkoshi River itself. There could be tendency to catch the fish in the confined channel. Since the confined channel will be within the control area of project, fishing activities will be strictly prohibited. Hence impact is considered at low magnitude, local in extent and short-term in duration.

(ix) Disturbance to the aquatic habitat

Various construction activities at the headworks at and powerhouse site could pollute the Sunkoshi River and Marin Khola respectively both chemically and physically. Activities like excavation, grading, filling, extraction of construction materials, disposal of construction spoils, wastewater, oils and grease could change water quality chemically, which might have negative impact on fish population in the river. In addition, fishing will go high due to the growing demand. Extensive use of DC current and poising has been reported for fishing in the Sunkoshi River, resulting to less number of fish population. Exiting baseline showed decline in fish production also due to sand and gravel mining. The project activities, including demand for fish from workers and staff may induce fishing or collecting more fishes by any means.

As the fish population is declining and project activities may affect fish habitat physically and chemically, magnitude of the impact is considered medium, extent is local and duration is short-term.

(x) Reduction of grazing and forest land

Local people have used flood plains and river banks for grazing purposes. The vegetation at these locations is the source of fodder and firewood for the local communities. Grazing lands and areas having scattered trees will be inundated causing direct and irreversible impact from project activities.

Hence, the impact will be direct in nature, medium in magnitude, site-specific in extent and long-term in duration.

6.2.2.2 Operation Stage

(i) Disturbance to the Wildlife Habitat

None of the project sites is the core habitat for any wild animal and animals are occasional visitors in the project area vicinity. The project will inundate 312 ha of land and they are mostly river flood plain, bushes and cultivated land. It means, project activities will not disturb wildlife and its habitat and the impact has been predicted insignificant.

The magnitude, extent and duration of the impact will be low, site-specific and long-term respectively.

(ii) Aquatic life

As the project will be constructing barrage across the river, there will be a barrier for the movement of the aquatic life, particularly the fish species.

a) Barrier Effect

The construction of 12 m high (from riverbed to crest level) barrage across the Sunkoshi River will obstruct long-range and mid-range migratory species. Out of 19 fish species reported in the Sunkoshi River during the field study, 5 species (Raj bam, Conch, Jalkapoor, and 2 species of Sahar) are long-distance migratory species. Simialry, 4 species (Gardi, Katle, Chuchche Asala and Buchche Asala) are reported mid-distance migratory species. These fish species may be isolated by construction of barrage and its upstream-downstream movement will be obstructed.

Considering the existence of 9 migratory species identified impacts from the barrier have been considered of high magnitude, local extent, and of long-term duration in the Sunkoshi River.

b) Inter-basin transfer (Water diversion)

During the operational stage, 67.00 m^3/s of water will be diverted from the Sunkoshi River to the Marin Khola. This will leave minimum 23 % discharge in the river. This is more than minimum requirement, as per the Hydropower Development Policy (2001) proposed for the environmental release for the maintenance of the aquatic life in the river. The mean monthly balance flow in the Sunkoshi River is presented in Table 6-10

Table 6-10 : Balance Remaining Discharge

Month	Averagre monthly flow in m^3/s	Diversion in m^3/s	Balance remianing in m^3/s	Percentage of minimum monthly natural flow
January	111.20	67.00	44.20	40%
February	93.70	67.00	26.70	28%
March	87.00	67.00	20.00	23%
April	96.40	67.00	29.40	30%
May	150.90	67.00	83.90	56%
June	462.30	67.00	395.30	86%
July	1287.70	67.00	1220.70	95%
August	1675.80	67.00	1608.80	96%
September	1035.00	67.00	968.00	94%
October	463.20	67.00	396.20	86%
November	221.70	67.00	154.70	70%
December	143.00	67.00	76.00	53%

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

In Nepal there is no study of minimum water requirements for survival of fish in nursery pools during the dry season. Nepal has little experience and learning on the potential impacts of inter-basin water transfer. Publication of environmental monitoring report of Mai Khola HEP and Bheri-Babai multipurpose project may provide practical impacts and corresponding mitigation measures but this is not the case now. Knowledge and information on the

physical factors such as flow characteristics, temperature and water quality which influences the migration and spawning of these fish species, is poor and non-documented.

Numbers of method are available to assess the riparian release of water to maintain the aquatic life at the downstream. They are In-stream Flow Incremental Methodology (IFIM, Bovee 1982), the Tenant Method (1976), the NGRP Method (Northern Great Plains Resource Program 1974) and the Wetted Perimeter Method using outputs of HEC II simulations. To predict the impact of regulated flow, the Tenant Method (Tenant 1976) has been used worldwide. This method has been adopted in the Kali Gandaki A HEP also for the EIA study. Flow conditions with different regulated flows based on Tenanat Mehod is presented in Table 6.11.

Table 6-11 : In-Stream Flow Regimes for Fish, Wildlife, Recreation and Related Environmental Resources Based on the Modified Tenant Method (Kali Gandaki EIA Study).

Description	Monthly Average Flow	Rating or Score
Flushing or Maximum	200%	100
OptimumRange	60-100%	100
Outstanding	40-59%	90
Excellent	30-39%	80
Good	20-29%	70
Fair	10-19%	26-50
Minimum	10%	25
Severe Degradation	0-9%	0-20

Sources: Detailed Feasibility Study Sunkoshi Marin Diversion Multipurpose Project, 2019

Considering the balance flow in the river, the river will still have more than 23 % during the driest month of March, hence diversion effect has been considered of low magnitude, local extent, but of long-term duration.

(iii) Impact on the Fishes of Marin Khola

Mixing of cold water of Sunkoshi River to warm water of Marin Khola may have cold shock to the fishes of the Marin Khola. The cold shock and high flow is expected in the water mixing zone of about 500 m. Within this zone there will be water currents showing temperature of Sunkoshi River and Marin Khola flowing side by side in initial 100m to 150 m with a middle zone of mixed water and temperature little lower than the Marin Khola and higher than Sunkoshi River. The water temperature after mixing zone could have adverse effects (cold shock) to the fish population especially in the low flow season. On the other hand there could be positive impact in the fish population as the Marin khola will have substantially more water. Magnitude of impact is predicted as moderate, local in extent and of long-term duration.

6.2.3 Socio-economic and Cultural Environment

6.2.3.1 Construction Stage

(i) Loss of Farmland, other Categories of Lands and Agricultural Products

A total of 69.47 ha of private cultivated land and 18.37 ha of cultivated land without land ownership certificate will affected by the project. In addition, project will affect total of 252.68 ha of government land of different categories. Detail break down of the land at different location is presented in Table 2.6. Details of land loss with the parcel numbers is presented in Annex 3.2. Estimated Loss of agricultural product is presented in Table 6.12. In proposed inundation area, high loss of paddy and maize-grown area correspond to the loss of high amount of total production.

Table 6-12 : Estimated Loss of Agriculture Products

Headworks	Area in ha	Total Production	Yeild/ ha in Mt	Area in ha	Total Production in Mt
Headworks/Inundation					
Paddy	5.34	17.5	3.28	32.63	106.95
Wheat	2.62	5.5	2.10	15.99	33.61
Maize	11.74	25.83	2.20	46.18	101.60
Millet	0.53	0.60	1.10	2.08	2.29
Pulse	0.70	0.75	0.82	2.75	2.26
Vegetable	0.87	14.20	12.50	0.05	4.01
Powerhouse				-	
Paddy	3.36	8.53	2.54	6.74	17.12
Wheat	1.83	3.02	1.65	3.68	6.07
Maize	0.71	1.49	2.10	2.17	4.57

Source: Field Survey 2019

The level of impacts on them might vary with proportion of loss of their land and its effects in overall household income.

The loss of land area is a direct loss of income to the PAFs, Hence the magnitude of impact would be high, extent is site-specific and the duration is long-term.

(ii) Temporary Acquisition of Land

The project wills acquisit 6.39 ha of the government land for temporary use. Out of which 4.35 ha area is covered by cultivation without land ownership certificate, and 2.04 ha is flood plain located at the left bank of Marin Khola. The proposed sites for the temporary acquisition of the land do not have thick vegetation. (Pls refer Table 6-9). Hence the magnitude of impact would not be low, extent is site-specific and the duration is short-term.

(iii) Demolition of Permanent Structures

The project will be affecting number of infrastructures such as parts of road and irrigation canal, suspension bridges, and transmission line poles. Structures like private houses and sheds will also be directly affected in the project area. Details of affected structures are presented in Table 6-1.

The nature of the impact is direct and irreversible. Magnitude, extent and duration of the impact is high, site-specific and long-term respectively as in 6.2.1.1.xi).

(iv) Social Service Facilities

The operation of the labour camps and work camp will require facilities such as drinking water, electricity and waste management. As these facilities are available in limited numbers at the local level, the Project will make own provision for labour and work camps as a part of the project component.

The magnitude of the impact is rated low and of short-term duration (throughout the construction period), site-specific extent.

(v) Health and Sanitation

During construction large number of people will be concentrated at the project site which would generate large volume of solid and liquid wastes. If not managed properly, they could contaminate the water source and may spread communicable diseases such as cholera, dysentery, diarrhea and other parasitic diseases etc. The mobilization of large numbers of outside workers might also raise danger of spreading of communicable diseases.

Taking note of the present health and sanitation condition in the project area, the magnitude, extent and duration of the impacts is predicted medium, site-specific and short-term respectively.

(vi) Occupational Health and Safety

In spite of precautions while drilling, blasting and other construction activities occurrence of accidents, particularly to workers, may not be ruled out. In addition, movements of local people at the construction sites may also be impacted from accident, if any. Hence construction activities pose safety concerns to the local people and workers as well. Drilling, blasting and plying of vehicles in the earthen road will increase dust and gaseous emissions which may threat to the health condition of the local people and workers.

Occupational health and safety will be the major concerns during the construction stage, and hence, magnitude of the impacts has been evaluated as low since provisions of health and safety measures are mandatory in any of the construction contract. The extent will be site-specific and duration will be short-term.

(vii) Gender and Vulnerable Group

Majority of men of the project area are likely to be involved in the construction activities creating shortage of labor required for agricultural and other household activities. The shortage may have to be fulfilled by women and children. The project area is dominated by Majhi community. In terms of population, Chhetri and Dalit may be considered vulnerable group. In terms of food sufficiency, 30 households produce food only for 3 months. This will give them additional burden of workload such as collection of fuel wood, fetching water and purchase of essential household consumption goods and additional work in farmland.

The magnitude of the impact will be low, extent will be local and duration will be short-term.

(viii) Law and Order

The concentration of large number of people with varied social and cultural backgrounds and cash in their hands may lead to anti-social activities such as use of more alcohol, gambling and prostitution. The influx of outside workers with varied socio-cultural backgrounds may also disturb existing local socio-cultural practices. This may bring uneasiness to the local people resulting conflicts. The conflicts may deteriorate the law and order situation. Such conflicts may eventually lead to work stoppage. At the headworks site being at the close proximity of Khurkot the floating population is comparatively higher. Hence, impact of influx outside workers may be insignificant but at the powerhouse site, where the large work camp and labour camp will be established, this impact could be significant.

Considering the seriousness of work stoppage and experience in other similar projects, the magnitude of the impact is considered to be high, extent will be local and duration will be short-term.

(ix) Cash Flow

The cash compensation and labor wage will increase cash flow in the project area. The sudden inflow of cash in the hands of the local people with limited experience in cash transactions and investments may feel themselves cash rich. This may lead to development of extravagant habit among them and start purchasing commodities of little use by paying more prices. Experiences from other hydroelectric projects showed that local people do not make proper use of cash and fall into economic crisis after the cash spent, and in particular the operational stage of the project.

The magnitude of this impact is medium, extent is local and duration would be short-term.

(x) Historical, Religious and Archeological sites

The execution of project activities will not disturb any historical, archaeological and/or religious sites within the project areas.

(xi) Social-Cultural and Religious Practices

Large number of construction workers from outside the project area will be required. The presence of outside workers might introduce host of alien socio-cultural and religious practices in the local area thus disturbing existing local social-cultural and religious practices.

As construction workers will stay at labour camps, magnitude of the impact has been predicted as low, extent is local and duration will be short-term.

(xii) Effect of tunneling

The tunnel excavation may possibly affect the spring sources of the vicinity. But the level difference of the tunnel alignment and settlement at the top is more than 200 m. spring water sources have not been reported in the vicinity of the tunnel portals. Furthermore, geology is considered good. Hence, adverse impact of tunnel on spring sources may not occur.

6.2.3.2 Operation Stage

(i) Withdrawal of economic activities and employment opportunities

When construction works are completed almost all workers will leave the area except few staffs required for the operation of the project. This sudden fall in the number of people will decrease demands for commodities dramatically. Market for local products will also be lost. Many local people will be out of work. All these will affect incomes of local people due to loss of business, and jobs. The sudden decline in income may lead to depressions among local people. As it is a natural phenomenon, impact is considered to be of low magnitude, local extent and of long-term duration.

(ii) Reduced agricultural activities

The project will be acquiring 37.7 ha of khet and 50.10 ha of bari/pakha land affecting agricultural production (PIs refer Table 6-13). There will be reduction of agricultural land and it will adversely affect production. So the private land owners especially the family which depend mainly on agriculture will suffer. Hathitar agricultural land is one of the most fertile lands in Ramechap District belonging to the majhi community will be greatly affected. Considering the importance of the land and its conversion to other land uses, decline in agri-production and foods habit as well, the impact is of high in magnitude, local in extent and long-term in duration.

(iii) Existing water use in downstream

Sunkoshi river water has not been used for the irrigation or other purpose at the downstream of the proposed headworks site. But the Marin Khola water has been used for the irrigation purpose. The addition of Sunkoshi river water will avail more water in the Marin Khola. Large volume of water in Marin Khola will affect the existing farmers managed irrigation systems and other irrigation projects if flood protection plan is not implemented timely and effectively

With the assumption of effective implementation of a separate flood protection plan, before the release of water from tailrace to Marin Khola, magnitude, extent and duration of impact of inter-basin transfer is rated as low, site-specific and short-term respectively.

(iv) Other planned hydropower projects in Sun Koshi River

The impact on Sunkoshi 2 project has been discussed in section 5.2.2. The SMDMP has been declared as one of the national pride projects of the Government of Nepal. The proposed project will be implemented as early as possible. Hence the dam height of Sunkoshi II will have to be reduced substantially and it is advised to redesign Sunkoshi II project.

The magnitude, extent and duration of the identified impact are rated high, regional and long-term respectively.

(v) Recession due to Withdrawal of Construction Works

When construction works are completed almost all workers will leave the area except few staffs required for the operation of the project. This sudden fall in the number of people will decrease demands for commodities dramatically. Market for local products will also be lost. Many local people will be out of work. All these will affect incomes of local people due to loss of business, and jobs. The sudden decline in income may lead to depressions among local people. As it is a natural phenomenon, impact is considered to be of low magnitude, local extent and of long-term duration.

(vi) Possible flooding of lands and houses

The flow in the river at the downstream of the headworks will be low during the operation of the project particularly in the drier months. People may have tendency to walk along or across the river bed during the period. When the water is suddenly released from the headworks for the maintenance of the project or other event without any prior information or warning, people may be washed away. Magnitude of predicted impact is high, extent is site-specific and duration is long-term.

(vii) Impact on cremation place

The cremation at the confluence of Sunkoshi River and Tamakoshi River will be inundated. Magnitude of this identified impact is high, extent is site-specific and duration is long-term. This is unavoidable as is located in the intake area.

6.3 EVALUATION OF THE IMPACTS

The above impacts are of two categories – identified and predicted. Those impacts which 'will happen' are categorized as 'identified' and those which 'may happen' are considered 'predicted' impacts. These impacts have been evaluated (Tables 6.13 and 6.14) to know their environmental significance taking into consideration the location of the project, nature of impact - direct or indirect, reversibility and irreversibility of the impacts, and more importantly the national policies, laws and standards. Furthermore, they have been grouped into identified and predicted impacts for easy understanding.

In general, direct impacts are identified, and indirect impacts predicted. The significance of the impacts has been evaluated using the words significant, moderately significant and insignificant. Assumption has also been made to evaluate the significant impacts. For example, the direct impacts or direct loss of land and property, forests and demolition of infrastructures as a part of site clearance are categorized as significant impacts; the project induced impacts are considered moderately significant; and impact that may occur outside the project area, and/or which is not directly related with the project activity is considered insignificant for this project.

As also mentioned in # 3.4.7 (assessment method), direct impacts having total score of over 75 are considered significant; impacts having 50 to 75 score are considered moderately significant; and impacts having total score of less than equal to 50 are considered insignificant for this project. However, some of the impacts whose total score exceeds 50 may not be significant in view of the nature of the predicted impacts. Some impacts having less than 50 score could also be considered significant. The logical base for such ranking has been given in the remarks. It has been done so, as impacts are related to the subjective judgment on its magnitude, extent and duration (Table 6.13 and 6.14). For example, impacts likely to occur outside the project's direct impact zone and of indirect nature may not be significant although the total score exceeds 50. This ranking has provided a basis to select and propose environmental protection measures, i.e., beneficial impacts augmentation measures, and adverse impacts mitigation measures.

Table 6-13: Evaluation of Beneficial Impacts

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
1. Construction Stage										
1.1	Increase in job opportunity for local people	D	√		H (60)	R (60)	ST (05)	125	Significant	
1.2	Increase in trade and business local economy	IN		√	H (60)	R (60)	ST (05)	125	Significant	
1.3	Skill enhancement of local people	D	√		H (60)	L (20)	LT (20)	100	Significant	
1.4	Induced development in the project area	ID		√	L (10)	L (20)	ST (05)	35	Insignificant	
1.5	Local area development through community support programme	D	√		H (60)	L (20)	LT (20)	100	Significant	
2. Operational Stage										
2.1	Availability of clean energy	D	√		H (60)	R (60)	LT (20)	140	Significant	
2.2	Increase in job opportunities for the	ID	√		L (10)	L (20)	LT (20)	50	Insignificant	

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
	local people									
2.3	Irrigation of 122,000 ha of land	D	√		H (60)	R (60)	LT (20)	140	Significant	
2.4	Increase in revenue and local development activities	D	√		H (60)	L (20)	LT (20)	100	Significant	
2.5	Increase in tourism development	ID		√	M (20)	L (20)	LT (20)	60	Moderately Significant	
2.6	Fish farming in the inundation area	ID		√	H (60)	L (20)	LT (20)	100	Significant	
2.7	Inter-province impacts and benefits	IN		√	L (10)	R (60)	LT (20)	90	Significant	
2.8	Induced development	D	√		H (60)	L (20)	LT (20)	100	Significant	

Note: Nature of Impact: D=Direct; IN = Indirect; R = Reversible; IR = Irreversible at site-specific level
Magnitude, H = High (60); M = Medium (20); and L = Low (10)
Extent, R = Regional (60), L = Local (20); and SS = Site-specific (10)
Duration, LT = Long-term (20), MT = Medium-term (10); and ST = Short-term (05)
The points in the parenthesis are taken from the National EIA Guidelines, 1993. As score for national level impact is not mentioned in the Guideline, 60 have been used for magnitude (as regional impact).

Table 6-14: **Evaluation of Adverse Impacts**

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
1. Physical Environment										
1.1 Construction Stage										
1.1.1	Change in topography and land use	D	√		L (10)	SS (10)	LT (20)	40	Insignificant	
1.1.2	Potential landslide and soil erosion	IN		√	L (10)	SS (10)	ST (05)	25	Insignificant	Good geology and mostly flat land
1.1.3	Air quality	D		√	L (10)	L (20)	ST (05)	35	Insignificant	
1.1.4	Water quality	IN		√	M	L	ST	45	Moderately	As it is related

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
					(20)	(20)	(05)		Significant	to human health
1.1.5	Noise level	D	√		M (20)	SS (10)	ST (05)	35	Insignificant	
1.1.6	Stockpiling of construction materials	D	√		M (20)	SS (10)	ST (05)	35	Insignificant	
1.1.7	Disposal of spoils	D	√		M (20)	SS (10)	ST (05)	35	Insignificant	
1.1.8	Operation of borrow areas / quarry sites	D	√		M (20)	SS (10)	ST (05)	50	Insignificant	
1.1.9	Change in river morphology	IN		√	L (10)	SS (10)	ST (05)	25	Insignificant	
1.1.10	Leakage of oil, grease and other liquid materials	IN		√	L (10)	SS (10)	ST (05)	25	Insignificant	
1.1.10	Impact on the local infrastructures	D	√		H (60)	SS (10)	LT (20)	90	Significant	
1.1.11	Loss of top soil	D	√		H (60)	SS (10)	LT (20)	90	Insignificant	No option as related to site clearance
1.1.12	Pressure on social sector facilities	D	√		M (20)	SS (10)	ST (05)	35	Insignificant	
1.1.13	Scarp dumping	D	√		M (20)	SS (10)	LT (20)	50	Moderately Significant	
1.1.14	Seismicity	ID		√	L (10)	SS (10)	LT (20)	40	Insignificant	
1.2. Operational Stage										
1.2.1	Change in hydrology and sedimentation	D	√		L (10)	L (20)	LT (20)	50	Moderately Significant	
1.2.2	Decrease in water volume due to diversion in Sunkoshi river									
a	Micro climate	D	√		L (10)	L (20)	LT (20)	50	Moderately Significant	Since the impact is irreversible, it is considered as significant impact

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
b	Water quality	ID		√	L (10)	L (20)	LT (20)	50	Insignificant	Over 20 % of river water will be released
c	River morphology and drainage	D	√		L (10)	SS (10)	LT (20)	40	Insignificant	
1.2.3	Increase in water volume in Marin Khola (due to Diversion of 67.0 m^3/s water from Sunkoshi River	D	√		H (60)	L (20)	LT (20)	100	Significant	
1.2.4	Decrease in water temperature in the Marin Khola	D	√		L (10)	L (20)	LT (20)	50	Moderately Significant	
1.2.5	Tunnel-induced impact on water source	ID		√	L (10)	L (20)	LT (20)	50	Moderately Significant	Insignificant impact due to good geology
1.2.6	Leakage of oil, grease and other chemicals	D	√		L (10)	SS (10)	ST (05)	25	Insignificant	
1.2.7	Downstream deposition	D	√		L (10)	SS (10)	ST (05)	25	Insignificant	
1.2.8	Scouring of river bed and river bank erosion from tailrace outlet	D	√		H (60)	L (20)	LT (20)	100	Significant	About 67m^3/s more water may induce scouring
1.2.9	Slope instability	D	√		H (60)	L (20)	LT (20)	100	Significant	
1.2.10	Noise and vibration in powerhouse area	D	√		M (20)	SS (10)	LT (20)	50	Moderately significant	
2. Biological Environment										
Adverse Impacts										
2.1. Construction Stage										
2.1.1	Use of government land for project facilities	D	√		H (60)	SS (10)	LT (20)	90	Significant	
2.1.2	Loss of forest in inundation area, dam site settling basin and other structures	D	√		H (60)	SS (10)	LT (20)	90	Significant	
2.1.3	Firewood collection			√	L	L	ST	35	Insignificant	will be

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
					(10)	(20)	(05)			provided to workers
2.1.4	Increased pressure on surrounding forests	ID		√	L (20)	L (20)	ST (05)	455	Insignificant	
2.1.5	Impact on endangered and protected species and their habitats	D	√		H (60)	SS (10)	LT (20)	90	Significant	Simal, Khair and Sal – use regulated species will be felled down
2.1.6	Impact of temporary diversion of water on aquatic life	D		√	L (10)	L (20)	ST (05)	35	Insignificant	
2.1.7	Disturbance to the aquatic habitat during the construction stage	D		√	M (20)	L (20)	ST (05)	45	Insignificant	
2.1.8	Reduction in grazing and forest lands	D	√		M (20)	SS (10)	LT (20)	50	Moderately Significant	Related with site clearance
2.2. Operational Stage										
2.2.1	Disturbance to aquatic habitat	IN	√		L (10)	SS (10)	LT (20)	40	Insignificant	
2.2.2	Aquatic life of Sunkoshi river due to barrier effect and inter-basin transfer	D, IR	√		H (60)	L (20)	LT (20)	100	Significant	
2.2.3	Impact on the Fishes of Marin Khola	D, IR		√	M (20)	L (20)	LT (20)	60	Moderately significant	
3. Socio economic and Cultural Environment										
Adverse Impacts										
3.1. Construction Stage										
3.1.1	Loss of farm land, other categories of lands and agricultural products	D	√		H (60)	SS (10)	LT (20)	90	Significant	
3.1.2	Temporary		√		L	SS	ST	25	Insignificant	

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
	acquisition of land	R			(10)	(10)	(05)			
3.1.3	Demolition of 44 houses, 1.27 km of transmission line, nearly 4 km road, 15 well and 2 solar panels and other permanent structures	D	√		H (60)	SS (10)	LT (20)	90	Significant	
3.1.4	Social service facilities	IN		√	L (10)	SS (10)	ST (05)	25	Insignificant	
3.1.5	Health and sanitation	IN		√	M (20)	SS (10)	ST (05)	35	Insignificant	
3.1.6	Occupational health and safety	D	√		L (10)	SS (10)	ST (05)	25	Insignificant	Provision of health and safety measures will be in place.
3.1.7	Gender and vulnerable group	IN		√	L (10)	L (20)	ST (05)	35	Insignificant	
3.1.8	Law and order	IN		√	H (60)	L (20)	ST (05)	85	Significant	Considering seriousness of the work stoppage
3.1.9	Cash flow	D	√		M (20)	L (20)	ST (05)	45	Insignificant	
3.1.10	Socio- cultural and religious practices	IN		√	L (10)	L (20)	ST (05)	35	Insignificant	
3.2. Operational and Maintenance Stage										
3.2.1	Withdrawal of economic activities and employment opportunities	D	√		L (10)	L (10)	LT (20)	40	Insignificant	
3,2,2	Reduced agricultural activities	D	√		H (60)	L (10)	LT (20)	90	Significant	
3.2.3	Existing water use in downstream	D	√		H (60)	L (10)	LT (20)	90	Significant	
3.2.4	Other planned hydropower projects in Sun Koshi River	D	√		H (60)	R (60)	LT (20)	140	Significant	
3.2.5	Recession of local economy due to	IN		√	L	L	LT	40	insignificant	

SN	Likely Impacts	Environmental Impacts						Total Score	Significance of Impacts	Remark
		Nature	Identified	Predicted	Magnitude	Extent	Duration			
	withdrawal of construction works				(10)	(10)	(20)			
3.2.6	Possible flooding of lands and houses due to sudden release of water downstream	D		√	H (60)	SS (10)	LT (20)	70	Significant	
3.2.7	Impact on cremation sites	D	√		H (60)	SS (10)	LT (20)	90	Significant	

Note: Nature of Impact: D=Direct; IN = Indirect; R = Reversible; IR = Irreversible at site-specific level
Magnitude, H = High (60); M = Medium (20); and L = Low (10)
Extent, R = Regional (60), L = Local (20); and SS = Site-specific (10)
Duration, LT = Long-term (20), MT = Medium-term (10); and ST = Short-term (05)
The points in the parenthesis are based on the National EIA Guidelines, 1993

CHAPTER – 7

7 ALTERNATIVE ANALYSIS

Alternative analysis is an integral part of project feasibility study and impact assessment. Alternative analysis is primarily governed by the factors like technical feasibility, economic viability and environmental acceptability. Ongoing detailed feasibility study has made the alternative analysis of project for different capacities. The purpose of alternative analysis in EIA study is to assess the environmental impacts of different alternatives, taking into consideration the aspects as included in the approved Terms of reference and the feasibility study.

During alternative analysis in EIA, the first step is to know what will be the impacts of 'with' and 'without' project on environmental ground.

7.1 DESIGN ALTERNATIVES

The main design alternative of the project was on tunnel construction. In addition, key parameters of do nothing alternative has also been considered in this section.

- Do nothing
- No forest options
- Implementation of the proposed project

Apart from that possible alternative for the different installed capacity was also considered.

7.2 DO NOTHING ALTERNATIVE

Nepal has theoretical hydroelectric potential of about 83,000 MW and technical potential of about 42,000 MW, has faced power shortage and meeting her demand from import from India. According to the power forecast of NEA, annual increment of the power demand is about 100 MW. Though large number of survey licenses has been issued for feasibility study of hydroelectric projects, they are confined on the studies only. Limited projects are under construction stage. Besides, number of private entrepreneurs have initiated development of the hydroelectric projects and acquired the survey license from Government of Nepal. But most of them are under the study stage. Hence do-nothing scenario will be against the government's plan and/or national commitment. If hydroelectric generation is not continued, power shortage will continue and hamper the overall socio-economic development of the country. People of Nepal have not forgotten the trade embargo from India.

Do nothing scenario means the non-use of available potential for power generation and loss of job opportunity. In a country where unemployment is very high, and energy is in shortage, do nothing scenario, particularly in respect of clean energy like Hydroelectricity development, is a regressive approach and it will accelerate environmental destruction. Hydroelectric development will replace the requirement of fossil fuel burning and will reduce the emission of greenhouse gases - the main man-made cause - affecting climate change. Furthermore, people may switch to use hydroelectricity instead of using LPG and firewood or coal or biomass or cow-dung for cooking purposes.

The project's main objectives are to generate hydroelectricity and to supplement 67 m^3/s of water to Bagamati Irrigation Project extension of command area of 122,000 ha in Bara, Sarlahi, Rautahat and Mahottari districts. Do nothing scenario would cease this potential irrigation prospects.

7.3 COMPARISON OF ALTERNATIVES

Nepal has accorded high priority for the development of hydro-electricity project(s) both at the public and private sectors. The project will generate environment-friendly clean energy and will contribute to the socio-economic development of the country.

The potential environmental impacts of those four alternatives (do-noting, implementation of the proposed project, relocation of Headwork site and relocation of Powerhouse) have been predicted and are given below in the Table-7.1.

Table 7-1: Potential Environmental Impacts of the Alternatives

SN	Alternatives	Environmental Impacts		Remark
		Beneficial Impacts	***Adverse Impacts***	

SN	Alternatives	Environmental Impacts		Remark
		Beneficial Impacts	***Adverse Impacts***	
1	Do Nothing Alternative	No disturbance to the natural environment due to the construction activities	No addition in hydroelectric power leading to further load shedding Irrigation facilities to 122000 ha is lost Loss of employment opportunities due to non-implementation of the project Loss of socio-economic development opportunities. Inadequate electricity, continuation of use of forest products to meet the energy demand, thereby depleting the forest resource	More adverse impacts than beneficial impacts
2	Implementation of the proposed project	A basis for economic development of the project area as well as nation. Generation of 28.62 MW of hydroelectric power Irrigation facility to 122000 ha command area Increase in per capita income due to project-related employment and increased socio-economic activities	Disturbance to topography Loss of agricultural land and other category of the land, particularly in inundation area Impact on aquatic habitat due to reduced flow in a stretch of few km.	Long-term beneficial impacts are higher than adverse impacts Increased availability of electricity becomes the gateway for socio-economic development.

The above qualitative judgments indicate that implementation of the project will also improve the environmental conditions of the area during the operational stage of the project by promoting the use of clean energy as the local people has strong desire to switch over on electric energy for household consumption. In addition, alternative to hydropower project has also been considered (elaborated in # 7.10).

7.4 NO FOREST OPTION

Section 42 of the Forest Act 2076 (1993) obliges the proponent to explore alternative site (area), other than forest area, to construct and implement the project. It should also ensure that there is no alternative to forest area and environmental impacts will not be significant on forest.

The no forest option helps to conserve and protect some forest areas for optimal option selected for the project. It will obviously provide ecosystem services, soil and nutrient conservation, habitat for wildlife, source of fuel wood, forage and fodder to local people and other forest based raw materials but it will seriously undermine the development of proposed option that is renewable and clean source of energy. The long-term operation of the project far outweighs the economic benefits provided by the forest to be impacted by project activities. It will provide continuous source of clean energy that will displace existing use of fossils fuels and fuel woods, helps to conserve more forest area that will obviously degraded in the future that has negative impact on forest and human health on long run.

The project location and baseline information confirms that the proposed project area is basically riverbank and flood prone with little or no productive and dense forest. Few 'use regulated or protected species' occur in the area. There are no appropriate sites for intake and powerhouse to generate electricity as proposed, and also divert water from Sunkoshi River to Marin Khola for irrigation of maximum land.

The project's layout option is such that minimal forest area is required. The forest loss will be compensated as per Procedures for the Use of National Forests for National Priority Project, 2074 (2017) and other mitigation programs as proposed in Chapter 8.

Taking into consideration, multiple economic, social and environmental benefits of implementing the project, and Government commitment of providing irrigation facility to a large area in Province 2, generate about 28.62 MW hydro-electricity as a by-product of this multipurpose project, and lack of 'no forest option' but low impact flood plain area, 'with project' (implementation of the project) alternative has been selected for further alternative analysis 'within' project. The following elements have been considered to select 'best alternative' within the project.

7.5 ALTERNATIVE TO THE QUARRY SITES

Considering the availability of construction materials there are three alternatives for the project. The first is to mine the required materials from the bed rocks and second is to use the muck of the tunnel and third is aggregates from the flood plain of Sunkoshi and Marin Khola. The first alternatives involves direct impacts on land use and accelerate slope instability whereas the quality of the material is not yet confirmed in the second alternative and third alternative will avoid such impacts on the land resource of public use. The Sunkoshi river bed materials are being extensively used as the construction material. More than 10 quarry plants are running at present at the river bed of Sunkoshi River. These sites will have limitations on the mine operation in the rainy season. The Detailed feasibility study of the project has also identified the Sunkoshi River bed as the potential source of the local construction materials. Based on the assessment, this option three (use of aggregates from the flood plain of Sunkoshi River and Marin Khola) is the best alternative from the environmental and social stand point with a few measures to be implemented for the protection of the river water quality.

7.6 CONSTRUCTION METHOD ALTERNATIVES

Due to the geological conditions of the project area, double shields, also referred to as telescopic shields are selected for tunnel excavation. A double shield TBM is considered more versatile and can be used in rocks that are likely to be heterogeneous (not uniform throughout). When boring in competent rocks, the double shield TBM grips the sidewalls like a main beam TBM, which enables it to achieve similar rates of advance. For the lining, its dual thrust systems allow a double shield to bore and install the lining, simultaneously.

The main reasons for the choice of Double Shield machines are as follows:

- Possibility of erection of segment lining simultaneously with excavation
- Majority of the tunnels lies in poor rock condition
- No temporary support required
- Concrete lining after excavation or in parallel with excavation eliminated
- Optimum program with no delay in follow-on concrete lining
- Various fault and shear zones expected
- Hydraulic design requiring a lining

Construction methodology will be based on intensive technologies of construction equipment and maximum utilization of local resources to the extent possible. This is to ensure lowest possible cost for project development and ensure quality in the works undertaken. Due priority will be given for the recruitment of local people which will minimize the requirement of temporary camp, reduce fuel wood, timber requirement, enhance local skill, economy to develop better relationship between the project and local people. The surface construction work will be scheduled in day and night construction will be limited to underground work.

Tunnel construction is proposed to be carried out by TBM and no blasting will be required. But limited blasting will be required at the headworks and powerhouse. Controlled blasting will be practiced at all times while excavating the underground area to have a minimum vibration impact on the house structures located close to the tunnel alignment. Use of TBM will minimize adverse impacts on local topography, structural damages in nearby settlement and unnecessary disturbances to local community and hence, this technology is selected.

7.7 CONSTRUCTION MATERIAL ALTERNATIVE

Physical resources are consumed for the construction of proposed project. The materials to be used are boulders (stones) for gabion and walls, gabion wires, masonry wall, brick or concrete block, aggregates for concreting. Other local resources will be quarry and burrow used from the area. Reinforcement bars and cement will also need to be transported from other places of the country or outside of country. Electro-mechanical equipment's should to be imported from overseas manufacturers. There are no other cost-effective alternatives for the above materials in construction works of the project.

The construction is intended to be carried out by conventional method, whereas earthwork, construction of simple structure such as drains, gabion walls, bio-engineering works etc. will be carried out manually. In view of availability, good quality construction materials will be used.

7.8 CONSTRUCTION SCHEDULE ALTERNATIVES

The estimated project construction period is 5 years (60 months) from the date of commencement of the work. The construction works are mainly of two types – surface construction works and underground construction works. The surface construction works is to be carried out only in dry season. But the underground structures such as desander, tunnel, surge tank, powerhouse and other structures can be constructed throughout the year irrespective of weather and climatic conditions. All surface work will be scheduled in day time.

7.9 INSTALLED CAPACITY ALTERNATIVES

The terms of reference of the EIA study was approved for the installed capacity of 43.6 MW with the design discharge of 87m^3/s. It was based on the draft detailed feasibility study. However, final detailed feasibility study concluded the installed capacity as 28.62 MW with design discharge of 67m^3/sec. The reason for reducing installed capacity of the project is mainly to accommodate the downstream project in the Sunkoshi River mainly Sunkoshi II.

7.10 ALTERNATIVES FOR HYDROPOWER PROJECT

7.10.1 Hydropower Development Considering Small/Mini/Micros

Nepal does have potential for the small, mini and macro hydropower development. These plants are mostly in isolated rural areas. Numbers of studies are being carried out for the development of the small hydropower projects.

Similarly, mini/micro (>100 KW) hydropower projects are becoming popular and are extensively being constructed in appropriate areas. However, the limited number of technically feasible sites, equipment transportation difficulties in hills, lack of trained personnel and high cost of mini/micro hydropower projects are some of the restraining factors for faster implementation of mini/micro hydropower projects. Furthermore, small and mini/micro hydropower projects are no alternative of to-be-grid connected medium size hydropower projects of 50 MW capacities. Rather, they are complementary to each other.

7.10.2 Solar Power/Wind Power Option

Solar and wind power are other sources of energy. Some studies have also shown the potential of both solar and wind power in the particular areas where the sunshine hour and wind velocity is high. This prospect provides opportunity for solar power development in Nepal. Solar power is mostly used for the individual households. Recently, it is being used for the drinking water and irrigation projects also to lift the water. Study is being made for connecting the solar power to the national transmission grid line. But it cannot compete or replace the hydropower. However, the following are the problems associated with solar power plants.

- Imported solar panels and complex technology for spare parts.
- Costly maintenance.
- No power generation in wet weather.
- Lack of trained manpower.

Regarding the wind power, studies have shown that Nepal has potential of more than 500 MW mostly in hilltops, river valleys and so on. NEA developed the first pilot project of wind power in Kagbeni of Mustang district. Since this 20 KW project failed there has been a gloom in the wind power sector. The main problems associated with wind power project area:

- Lack of time series data of wind.
- Lack of trained manpower.
- Battery charging problems
- Problems associated with design of wind turbines.
- Unavailability of wind at certain time of the day.

7.10.3 Thermal Power Option

Some amount of low-grade coal is produced in Dang Valley. But this amount is not sufficient for commercial power generation. Furthermore experience in the 39 MW Duhabi Multi-fuel power plant and 10 MW Hetauda Diesel power plants have shown that there are serious environmental problems like air pollution, sludge handling, high noise, high temperature and fire hazard. Besides, since the petroleum products are imported from abroad, there is also a problem of spare parts and their high cost. Last but not the least, the reliability of a thermal power plant is less than 20% of the installed capacity.

In the present context of the global environmental concern, the CO_2 emission from a thermal plant of 50 MW capacities could save more than 100 thousand tons annually. It is, therefore, concluded that thermal option is not viable for power generation in Nepal.

Qualitative assumptions, baseline condition and existing resources, potential social, economic and environmental impacts of water diversion from the Sunkoshi River in the said location and use of above mentioned technologies to generate 28.62 MW of hydroelectricity, release of diverted water to Marin Khola from the tailrace of the hydropower project, and use of tailrace water to irrigate 122,000 ha of farmland in four districts of Province 2 is selected as the 'best alternative'.

CHAPTER – 8

8 ENHANCEMENT AND MITIGATION MEASURES

In order to address the beneficial and adverse environmental impacts as listed in Chapter 6 (summarized in Tables 6.13 and 6.14), this chapter presents the feasible and practical environmental protection measures for implementation.

The project will implement all mitigation and enhancement measures mentioned in this chapter of the report at its own cost. Apart from that the project will also compensate the affected parties for losses of lives or properties occurred during implementation of the project as per prevailing Acts, and Rules of the country. Implementation of all enhancement and mitigation measures will be coordinated through the Local Coordination Committee, as appropriate and related to local people. The Committee will be formed with the representation from the affected wards of the Rural Municipalities, Municipality and PAFs.

Apart from that the Government has made provision of making 0.75 % of the total project cost for the community support programme of the affected area.

8.1 ENHANCEMENT MEASURES

8.1.1 Construction Stage

The likely beneficial impacts of the project during its construction stage are:

(i) Increase in job opportunity for local people

The project will give first priority to PAFs and local people who want to work in the project. The project will maintain the roster of the PAFs and at least a member of PAF, willing to work, will be employed during the project construction period. The employment will increase the income level of that family. The project will provide necessary training to the PAFs, if necessary, depending upon the nature of the work offered.

The project will include a binding clause in the contractor's agreement to give first priority to PAFs while hiring both skilled and unskilled labor forces and to give daily wages or monthly wages not less than the district approved rates. The wage rate will not be less than respective local government rate. The next priority will be given to local people for employment. The employment to the local people will be coordinated through the Local Coordination Committee.

(ii) Increase in trade and business

The project staffs and its workers would require local products such as vegetables, rice, pulses, eggs, milks, ghee, chicken, mutton etc. and other consumption goods such as groceries, edible oil etc. They could be fulfilled by the local vendors.

Apart from that the project will allocate budget for training to one person each PAFs willing to enhance skills in modern techniques of cash crop and livestock farming, tourism activities for example homestay trekking, or the enhancement of the technical skills and know–how. Assuming Rs 90,000.00 per person for a training of CTVT level II, an amount of Rs 47,880,000.00 has been allocated for 532 PAFs.

The project will encourage its staff members and construction workers to purchase local products in order to uplift the economic condition of local farmers.

(iii) Skill enhancement of locals

The project will launch training programs in specialized area such as electro–mechanical works of hydroelectricity, house wiring and maintenance, road slope stabilization, spoil handling, fodder values etc. At least one member from PAF will be covered in the training depending on their interest and need. The cost of training is covered in above estimate [# 8.1.1 (ii)].

(iv) Induced development in the project area

The project will use the local products to the extent possible and encourage its staff to buy the local products.

(v) Local area development through Community Support Programme (CSP)

Proposed budget of Rs 1.00 crore per year for the construction period of 5 years will be channeled through Local Coordination Committee that would be formed for the Project with the participation of the local people representing

the affected local GPs/MP. The Committee will be encouraged to select activities that support to make the project activities environment-friendly and sustainable.

8.1.2 Operation Stage

No mitigation measure is proposed for the availability of clean energy and irrigation of 122,000 ha of farmland which is the main objective of this project. Furthermore, induced development such as increase in tourism has been evaluated as significant impact, and local people may wish to promote such activities.

(i) Increase in job opportunities for the local people

The project will employ the local people for the operation of the power plant to the extent possible depending on the qualification, preference, skill and willingness of the people. Preference will be given to the project affected families.

(ii) Increase in revenue and Local Development Activities

The local government will be receiving funds for local area development from two different sources due to the implementation of the project. (i) part of CSP budget (part of 0.75 % of the project cost equivalent to Rs 346.750 million) and 25 % of royalty of hydroelectric power generation. It is recommended that CSP budget should be used entirely for the project affected areas (development activities of the project affected wards) whereas the amount received from the royalty of hydroelectric power could be shared and used for the overall development activities in the project affected Rural Minicipalities and/or Municipalities. The sharing of these funds will have to be worked out by the local governments.

(iii) Fish farming in the inundation area

As the Sunkoshi River could rare the high value fish species such as Asla, Sahar etc, it is recommended to promote fish farming of such high value fishes in the inundation area. The project will release 100,000 fingerlings every year for the period at least 5 years in the inundation area. The project will support the fishermen community in raring the fingerlings. This will revive the traditional practice of fishermen community. An amount of Rs 10,000,000.00 per year has been budgeted for 5 years for this enhancement programme for the operational stage. The majhi community will be benefitted by (i) fish stocking for five years and (ii) fishing in the inundation area and it will greatly improve their livelihoods. This is also considered the means of compensating the affected Majhi community.

(iv) Inter-Province impacts and benefits

At present the benefit sharing of the royalty is 50 % to the central government and 50 % is shared by the Provincial government and local government. The modality of the benefit sharing could be different in the projects like this where the one province bears most of the adverse impact whereas the major benefits are at the national level and other province. As inter-basin and inter-Province adverse impacts and benefits is new to Nepal, it is proposed to develop an appropriate mechanism through extensive consultative process, where necessary policy and legal instrument, in sharing benefits by realizing the impacts. This mechanism may also be a basis for future projects of similar nature.

8.2 ADVERSE IMPACTS

Effort has been made to evaluate the environmental impacts in Chapter-6 of this report. In order to reduce or compensate adverse significant impacts, mitigation measures have been proposed for each impact. Although this report is based on the systematic process of impact identification and prediction, there might yet be unforeseen environmental impacts which may be encountered during the project construction and operational stages. If there are additional impacts or damages to the environment due to the project activities, they will be mitigated and/or compensated according to the rules and regulation of the country.

8.2.1 Physical Environment

8.2.1.1 Construction Phase

(i) Change in topography and land use

Permanent land and property acquisition will be minimized to the extent possible. Land acquisition will be made for the inundation area and structures like headworks, surge tank, powerhouse, permanent work camp and the project road. Land and property acquired for project activities will be compensate as fixed by the Compensation Fixation Committee and/or paid to other in market price through negotiation. Area required for other activities such as temporary work camp, borrow areas, spoil disposal area, and stockpile area for the construction materials, etc. will be taken on lease or rent. The leased land will be returned to the owner after proper treatment/rehabilitation. The site will be vegetated with local plant species and stabilized after be developed as

picnic spot as appropriate. Rehabilitation of the land and re-vegetating of the disturbed land will be the part of the civil works which will be specified in the specification.

(ii) Potential landslide and soil erosion

All possible and active landslide areas, including landslide triggered from excavation works will be identified, and treated as it will affect the project structures and shorten their life. Budget for such landslide prevention and control will be in-built in the project structures.

(iii) Degradation of air and water quality and increase in noise level

(a) Air quality

In order to mitigate the possible change in air quality, the following mitigation measures will be implemented:

- Water spraying will be carried out in all gravel and earthen roads at least two times a day during dry period of 4 months (February –May) in one year;
- All vehicles belonging to the project i.e. consultants, owner, contractors, vendors will comply with the national emission standards and regular (monthly) check-up for maintenance of all vehicles will be carried out every 3000 km;
- Use of breathing mask by the construction workers in the dust-prone areas such as crushing plant, batching plant, rock drilling areas etc. will be made compulsory; and Maintenance of air quality is a part of project activity and use of personal protective equipment (PPE) will be made compulsory for construction workers as a part of occupational health and safety (OHS) measure.

(b) Water quality and solid wastes

In order to provide safe drinking water and to maintain water quality, the following activities will be implemented:

Water supplies to work camps for human use will be disinfected through the process of filtration and chlorination. Water, thus, supplied will meet National Drinking Water Quality Standards (NDWQS), 2005.

All discharges from the batching plant and other sources will be collected in the settling ponds and provide biological treatment before discharging into the stream or other water source.

All solid wastes generated in the project, in particular labour work and labour camps, will be recycled to the extent possible and biodegradable wastes will be disposed of safely in the ditch to make compost. In the case of night soil and bio degradable wastes, a biogas plant will be constructed and energy will be supplied to the canteen.

Maintenance of air quality and water quality is a part of construction cost.

(c) Noise level

Although noise level increase has been evaluated as insignificant, several equipments in operation will have high noise level and the project will make effort to reduce noise level during its construction period.

- Use of explosives will be limited to the extent possible;
- The construction area will be fenced by thick plywood;
- Ear gears will be provided to the construction workers in the noise-prone areas such as blasting for hard rock excavation;
- Noise producing engines such as air compressors will be fitted with noise reducing equipment; and
- All vehicles plying in the construction area will be maintained regularly as per the manufacturer's recommendations and drivers will be instructed not to use 'pressure horn'.

Bringing the noise level to the acceptable level and minimize its impact on human beings is a part of construction cost.

(iv) Stockpiling of construction materials

Stockpiling of construction materials and spoil disposal will be carried out in leased or rented land and/or with the consent from the land owner. The economic loss and the physical inconvenience will be negotiated and compensated. This provision will be made in the contract agreement. Cost implication for this mitigation measure is part of construction cost.

(v) Muck/ spoil disposal

The required land for the spoil disposal will be taken on lease at suitable location and following activities will be complied with:

- The spoil will not be disposed in the stream and it will be safely deposited in the designated area away from water bodies such as drinking water source. This area will be reclaimed using bio-engineering treatments and made appropriate for gardening and picnic spot;
- Construction of drainage ditch will be connected up to the permanent water bodies. To safely discharge the high intensity rainfall, the size of the ditch will not be less than 2ft. wide and 1.5 ft. deep all around the area;
- The leased area will be properly leveled and reclaimed for reuse and restored to original shape as far as possible and support will be made available for its other use. e.g. garden;
- Generated spoil and/or muck will be used as back fill material as far as possible. For this, if required, spoil disposal will be stored safely. Water will be sprinkled on stored spoil and covered by plastic sheet for reuse.

To minimize the impacts generated from stockpiling of construction materials and disposal of spoil is a part of the construction cost.

(vi) Operation of borrow areas/quarry sites

The quarry sites will be taken on lease and following precautionary measures will be taken:

- Retaining structures will be constructed if necessary while taking out the construction materials;
- Masonry wall will be constructed to maintain the aesthetic beauty from the main access road;
- Use of gelatin quantity will be minimized to the extent possible to lower slope instability and explosion noise from blasting;
- Preferably less than 45^0 slope will be maintained at the quarry sites; and
- Both vertical and horizontal drains will be constructed to drain water where required.

The construction materials will be extracted guidelines set by the Government of Nepal.

The cost for rehabilitation of quarry site is already a part of the construction cost.

(vii) Change in fiver morphology

The activities within the river bed such as construction of headworks, extraction of river bed materials etc. will have some impact on river morphology. Extraction of the river bed material if any will be planned in such a way that river morphology does not change after the removal of the materials. Similarly the construction of the barrage will be planned in a way so that concentrated flow or the diverted flow does not make bank erosion as such. The construction debris from the demolition of the coffer dam will be planned and disposed off at the designated locations. As it is related to planning, no budget will be required for mitigating this impact.

(viii) Effect on springs along Tunnel Alignment

Though it has not been foreseen at present, if any impact is occurred during the construction stage it will have to compensated or mitigated under the provisional sum.

(ix) Leakage of oil, grease and other liquid materials

The effective mitigation for this impact is to construct double wall of concrete to regulate leakage of oil, grease and other toxic liquids around the oil and grease holding structure. Since this is a part of the project activity, no separate fund has been allocated for this purpose.

(x) Impact on local infrastructures

All the affected infrastructures will be relocated or compensated at the market value. Estimated cost for the relocation of the affected infrastructure is presented in Table 8.1.

Table 8-1: Relocation Cost of the Affected Infrastructures

Categories	Unit	Sindhuli Quantity(No.)	Ramechap Quantity(No.)	Total	Rate in Nrs	Amount
Road						
BP Highway	KM	2.3		2.30	14,671,161.00	33,743,670.30
Local rural roads	Km		1.59	1.59	700,000.00	1,111,250.00
Suspension bridges	no	2	1.00	3.00	10,000,000.00	30,000,000.00
Dharan Chatra Road	Km	0.8		0.80	14,671,161.00	11,736,928.80
Transmission line/Pole	KM		1.27	1.27	2,000,000.00	2,540,000.00
Well	no	3	12.00	15.00	50,000.00	750,000.00
Irrigation Canal	m	–	794.00	794.00	3,500.00	2,779,000.00
Solar						-
Solar 1	no		1.00	1.00	20,000,000.00	20,000,000.00
Solar 2	no	1	1.00	2.00	150,000.00	300,000.00
Maintenance of the existing road for 5 years	Km	8.5	6.50	15.00	1,000,000.00	15,000,000.00
Relocation of the cremation place	no	1		1.00	5,000,000.00	5,000,000.00
					Total	**122,960,849.10**

* pump house is temporary use so no cost is included

Source: Field survey and Disrict Rate

The building cost is not included in this section.

(xi) Loss of top soils

The top soil estimated quantity of 263490 m^3 will be stored and reused. Assuming Rs 500.00 per m^3 of as the management of top soil including transportation, the required cost for the management of top soil would be Rs 131,745,000.00

(xii) Pressure on social sector facilities

The project will make own provision of required health and sanitation facilities including water, waste management for the construction camps. Provisions of these facilities are within the construction cost.

(xiii) Scarp dumping

Haphazard scrap dumping will be strictly prohibited. Scrap will be reused to the extent possible. Rest will be disposed of safely or metal scrap will be stored and sold. Safe disposal of the construction wastes is one of good construction practice.

(xiv) Seismicity

The structural design of the infrastructures has adequately considered possible impact of seismicity on structures in the project area.

8.2.1.2 Operation Stage

After construction, the project enters into operation and maintenance stage and electricity is regularly generated from the powerhouse. During this stage, the following mitigation measures will be implemented to mitigate the adverse impacts.

(i) Change in hydrology and sedimentation

Sediment flushing will be carried out as per the operation plan. No separate cost is required.

(ii) Decrease in water volume due to diversion in Sunkoshi River

Over 20 percent of the total discharge in the Sunkoshi River will be released to reduce adverse impacts in downstream aquatic ecosystem. This release is double than mentioned in the Hydropower Development Policy (2001). Change in micro-climate may be addressed from water release. However, impacts related to change in

water quality and river morphology are insignificant and necessary precautionary measures will be taken, as and when required.

(iii) Increase in water volume in Marin Khola

Adverse impacts related to bank cutting and erosion, change in river morphology, and scouring etc. from high discharge of water from tailrace in Marin Khola will be addressed through the effective implementation of the Flood Protection Plan of Marin Khola. The following paragraphs inform highlights of the Flood Protection Plan.

The Project has carried out detailed study for the Preparation of Flood Protection Plan of Marin Khola. The mapping of the affected area was carried out by the Drone Survey and verified by the walk through along the Marin Khola. Based on this detailed study a flood protection plan has been prepared. It proposed structural protection measures based on the simulation of flood both without levee and with levee conditions. Most of the existing agricultural land will be protected through 34 km long dikes along the banks of Marin Khola on both sides at priority locations. A total of 18 spurs have been proposed for protection of infrastructures and adjacent agricultural land by controlling bank erosion. Sixteen drain outlets have been proposed in the newly proposed dikes to let the drainage water to pass safely to river.

The flood map without levee for 50 year return period flood is presented in Figure 8-1 and. the flood map with levee for 50 years return period is presented in Figure 8-2.

Figure 8-1: Flood map for flood with 50 years return period without levee.

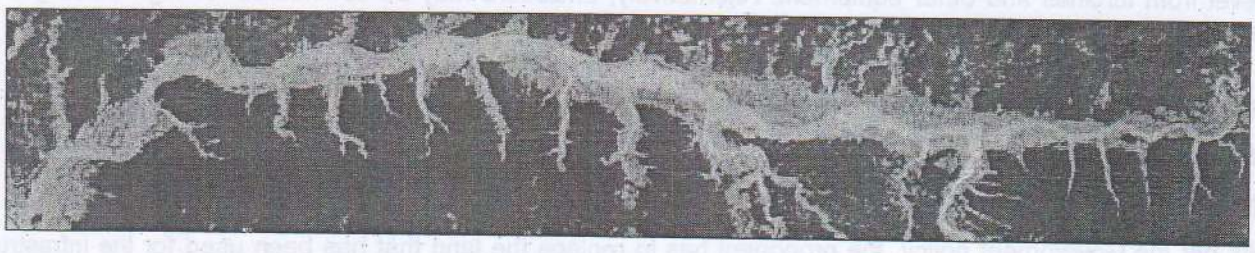


Figure 8-2: Flood map for flood with 50 years return period with levee.

The locations for proposed dikes were selected based on limiting the expanse of flood and protection of erosion and inundation of agricultural land. The dikes have been proposed to protect most of the agricultural land from erosion and inundation in combination with protection of other areas with spurs. Most of the existing agricultural land will be protected through 34 km long dikes along the banks of the Marin Khola on both sides at priority locations.

The total cost of the flood protection work is NRs. 810,584,191.27 including contingencies and VAT for the structures proposed which are irrigation intakes, spurs and dikes.

The study concluded that:

- The proposed structural measures will be to protect the adjacent land and property during high flood in combination with water diverted from Sunkoshi River to Marin Khola
- Only the structural measures for flood protection cannot be successful unless proper management of the construction works is done for which it is recommended to mobilize the community from the beginning of implementation to operation and maintenance of the structures through Users' Associations,
- In addition to structural measures, non-structural measures such as awareness raising, capacity development, early warning system, coordination of various implementation agencies with coordinated action on master plan etc. are needed,
- Bio-engineering measures of protection with the use of local varieties of protective vegetation and local materials with active community mobilization is highly recommended for exploration and need to be implemented along with the structures recommended here.
- Flood protection embankments (Dikes) – mainly to prevent inundation to the agricultural land and prevent erosion along the banks of Marin River and

- Spurs – mainly to prevent erosion to protect infrastructures or adjacent lands to facilitate local sedimentation and push the main river current away from the banks.

(iv) Tunnel-induced impact on water source

Drainage flow in the tunnel will be dealt in the construction phase itself. It is expected that geological condition of the area and use of TBM in tunnel construction will reduce this impact.

(v) Leakage of oil, grease and other chemicals

Leakage of the oil, grease and other chemicals will not be an issue in the operation of powerhouse. It will be properly taken take in the operational plan.

(vi) Downstream deposition

The flushing of the sediments will be carried out during the high flow period so that the sediment is flushed away along with flow.

(vii) Scouring of river bed and river bank erosion from tailrace outlet

As mentioned above [# 8.2.1.2 (iii)], this significant impact will be reduced through the effective implementation of the Preparation of Flood Protection Plan of Marin Khola.

(viii) Slope instability

The retaining structure such as stone masonry rip rap of 2.0 m is proposed along the critical part of the periphery of the reservoir for the protection of the cultivated land and settlement. Total length of 16.25 km of the boulder pitching (equivalent to 48,750$m^{3)}$ would be required. Assuming the cost per m^3 of boulder @ of Rs 3435.00, estimated cost for this measure would be Rs 167,602,500.00.

(ix) Noise and vibration in powerhouse area

Staffs and workers in powerhouse will be provided with ear plug regularly to reduce 'hearing ability' from high noise level from turbines and other equipment. Alternatively, enclosure may be considered for high noise generating equipment.

8.2.2 Biological Environment

8.2.2.1 Construction Stage

(i) Use of government land for project facilities

As per the Government policy, the proponent has to replace the land that has been used for the infrastructures development. In case the land cannot be replaced, the Proponent has to pay cash compensation for buying the land elsewhere which is applicable for the Government projects also.

With this in perspective, loss of the forest area in this project for infrastructure development is the permanent loss which will be compensated.

The compensatory measures for the loss of the forest area are

- Replacement of the lost land or equivalent cash compensation
- Compensatory plantation for the lost vegetation of size > 10 cm dbh

This loss is inevitable as it is a part of site clearance. This direct and significant impact could neither be prevented nor corrected, and hence, will be compensated. As the Directives with standard for the Use of National Forest for the National Priority Project 2076, the project will have to provide the land compensation for the loss of forest land and compensatory plantation for the loss of vegetation. Annex 1 of the Directives also presents the rate of compensation for the different categories of the forest land. The required compensation cost for the use of the government land is presented in Table 8.2 A.

Table-8-2A: Estimate for the Compensation of the Government Land

Type of land	Area in ha	Rate/ha in Nrs	Amount in Nrs
Forest	4.48	1,200,000.00	5,376,000.00
Community Forest	3.4	1,200,000.00	4,080,000.00
Bush	11.5	1,150,000.00	13,225,000.00
River course	50.67	1,000,000.00	50,670,000.00
Sand bar	182.63	1,000,000.00	182,630,000.00
Total	252.68		255,981,000.00

The required cost for 252.68 ha of land would be Rs 255,981,000.00

Total loss of trees and pole size vegetation is 2355. Considering 1:10 compensatory plantation for the loss required number of plantation sampling would be 23550 nos. and considering 1600 plants/ ha, the required area for the plantation would be 14.72 ha. In addition, plantation will be carried out in the area temporarily acquired (2.04 ha.). Hence the planation will be carried out in 16.76 ha in total. The project will seek the assistance of the forest and soil conservation office in the district in carrying out the compensatory plantation, preferably with selection of appropriate plant species.

Cost for the Compensatory Plantation

Cost of planting including plantation management could be divided into four phases.

For plantation in 16.76 ha

- Phase I. Plantation including – site clearance, digging pits, planting seedling with seedling cost plus Barbed wire fencing costs – NRs. 100,000/ha
- Phase II. Watchman to protect plantation NRs. 18,000/ha/year up to 5 year minimum
- Phase III. Casualty beating/replacement of dead plants (25% of total planted) cost 35 labor/ha/year up to 5 years minimum
- Phase IV. Weeding/soil works cost 35 labor/ha/year up to 5 years minimum

The plantation area will be maintained for 5 years. The cost of compensatory plantation in 16.76 ha is presented in Table-8.2. The required cost for the compensatory plantation in 16.76 ha is NRs 10,558,800.00

Table-8-3: Estimate for the Compensatory Plantation for Area 16.76 ha

Plantation Area	16.76	ha		
Description of Works	Rate in NRs	Unit	Amount in NRs	Remarks
Phase I: Plantation	100,000	per ha	1,676,000	
Phase II: Heralu Cost	36,000	per/ha/year	3,016,800	For the period of 5 Years
Phase III: Casuaty beating.replacement of dead plants	35	Labour/ha/year	2,933,000	For the period of 5 Years, cost of Labour Rs 1000/manday
Phase IV: Weeding/soil works	35	Labour/ha/year	2,933,000	
Total			10,558,800	

Source: Field Survey and District Rate

The cost is for the estimation purpose only. .

(ii) Firewood collection

The project will be operating labour camp. Kerosene and LPG will be used for cooking purpose.

(iii) Increased pressure on surrounding forests

The project will procure required forest products for the project activities from the authorized suppliers. Residential workers will not be engaged in firewood and timber collection. Strict supervision will be in place to regulate workers activities in forests, including NTFPs collection, if any. If anybody is found guilty, forest organization will be informed for necessary action.

(iv) Impact on endangered and protected species and their habitats

Felling of' use regulated' plant species, as a part of site clearance, is inevitable. Any form of collection of the endangered and threatened species of flora and fauna will be strictly prohibited and if occurred, will be immediately reported to the forestry organization.

(v) Impact of temporary diversion of river on aquatic life

The fishing, if any, will be strictly prohibited in the diversion channel.

(vi) Disturbance to the aquatic habitat during construction stage

Fishing by DC current and fish poisoning will be punishable activities and will be strictly prohibited. If such event occurred, the project will inform the Government for necessary action.

(vii) Reduction of grazing and forest lands

The flood plains and the river banks are grazing land for the local community. These areas will be inundated. Though the compensatory plantation has been proposed for the loss of such areas, but they may not be accessible for the affected settlements. The project will provide fodder species for plantation to provide nutritious food for livestock and to improve livelihood of the local people.

8.2.2.2 Operation Stage

(i) Disturbance to aquatic life

As the project will be constructing barrage across the river, there will be a barrier for the movement of the aquatic life. The project will be releasing minimum of 18.6m3/s discharge in the river as the environmental release for the maintenance of the aquatic life in the river. This quantity of the discharge would be good enough to maintain the minimum aquatic life in the river.

a) Barrier Effect

Being the barrier 12m high, the Project will release about 100000 fingerlings of the local specie fish in the inundation area of Sunkosi River for at least 5 years after the construction of the barrage. Cost of stocking would be Rs 10,000,000.00 per year. Total cost for 5 years would Rs 50,000.000.00

b) Water diversion

The project will be diverting only 67 m 3/s of water which is 77 % of the flow in the driest month March.

(ii) Impact on the fishes of Marin Khola

Increase in amount of water in the Marin Khola from tailrace onwards will reduce temperature and increase fish production. If necessary, local fingerlings will be added to increase fish production and improve the livelihood of the local communities.

8.2.3 Socio-economic and Cultural Environment

8.2.3.1 Construction Stage

(i) Loss of farmland, other Category of lands and agricultural products

Compensation will be provided for all lost assets, including all types of land. Replacement values of the lands which reflect real market rates will be used to determine the prices of land and to estimate the compensation amount. This will be decided by the Compensation Fixation Committee that would be formed under the legal provision. A reasonable rate has been used for compensation estimation. Table 8-3 presents the suggested rate for the land located in different places. Estimated cost for compensation of the private land located at the different locations is presented in Table 8-4. The compensation rate will be the market value at the time of land acquisition.

Table 8-4: **Proposed rates for the private land**

Sl	Location	District Rate	Market Rate	Suggested Rate
Ramechap				
1	Hathitar	400,000.00	1,400,000.00	800,000.00
2	Hathitar			500,000.00
3	Seleghat	300,000.00	800,000.00	800,000.00
4	Simladi	150,000.00	600,000.00	500,000.00
5	Puchighat	200,000.00	750,000.00	700,000.00
6	Rajgaun	150,000.00	600,000.00	500,000.00
7	Masantar 1	400,000.00	1,400,000.00	1,000,000.00
8	Khosai 1	150,000.00	600,000.00	500,000.00
9	Khosai 2	150,000.00	600,000.00	500,000.00
10	Khalleri	150,000.00	600,000.00	500,000.00
Sindhuli				
	Sitalpati 1 kha	300,000.00	1,600,000.00	1,000,000.00
	Sitalpati 2 ga	300,000.00	1,600,000.00	1,000,000.00
	Sitalpati 9 ka	300,000.00	1,600,000.00	1,000,000.00
	Sitalpati 9 gha	300,000.00	1,600,000.00	1,000,000.00
	Powehouse	300,000.00	1,600,000.00	1,000,000.00

Source: Field survey and District Rate

Table8-5: Estimate for Land Compensation

Location	Area	Total Area		Rate in Nrs	Amount in NRs
Inudation Area/Headworks		in m 2	in Ropani		
Along Tamakoshi River	Hattitar 1	91,653.95	180.16	800,000.00	144,127,850.00
	Hattitar 2	183,654.06	361.00	500,000.00	180,500,026.00
	Seleghat	34,199.09	67.22	800,000.00	53,778,825.00
	Simladi	94,758.30	186.26	500,000.00	93,130,943.00
	Puchighat	32,400.87	63.69	700,000.00	44,582,191.00
	Rajgaun	44,938.46	88.33	500,000.00	44,166,698.00
	Masantar	22,569.68	44.36	1,000,000.00	44,364,140.00
	Khosai 1	76,085.38	149.56	500,000.00	74,778,712.00
	Khosai 2	19,324.41	37.99	500,000.00	18,992,540.00
	Khalleri	24,552.84	48.26	500,000.00	24,131,176.00
Along Sunkoshi River	Sitalpati 1 kha	66,961.86	131.62	1,000,000.00	131,623,746.00
	Sitalpati 2 ga	13,839.20	27.20	1,000,000.00	27,203,058.00
	Sitalpati 9 ka	15,013.41	29.51	1,000,000.00	29,511,147.00
	Sitalpati 9 gha	69,107.97	135.84	1,000,000.00	135,842,253.00
Powerhouse	Mashantar, Kamala Mai Municipality	89,629.44	176.18	1,000,000.00	176,180,331.00
	Total		1,727.20		1,222,913,636.00

Source: Field survey and District Rate

The Land Acquisition Act obliges the proponent to provide compensation for one time equivalent to total value of annual production of crops from the land to be acquired. Based on current prices of different crops total compensation cost for crops are estimated at Rs.7,123,442. Detail breakdowns are shown in Table 8.5. For the purpose of estimate the deregistered land of Hattitar 2 also has been considered for the compensation. It would need special decision of the Government for paying the compensation to such land.

Table 8-6: **Estimation of the Annual Crop Loss**

Headworks	Area in ha	Total Production	Yeild/ ha in Mt	Area in ha	Total Production in Mt	Value in NRs
Headworks/Inundation						
Paddy	5.34	17.5	3.28	32.63	106.95	2,459,788.27
Wheat	2.62	5.5	2.10	15.99	33.61	1,008,360.41
Maize	11.74	25.83	2.20	46.18	101.60	2,438,436.60
Millet	0.53	0.60	1.10	2.08	2.29	59,628.15
Pulse	0.70	0.75	0.82	2.75	2.26	270,958.38
Vegetable	0.87	14.20	12.50	0.05	4.01	200,733.45
Powerhouse				-		
Paddy	3.36	8.53	2.54	6.74	17.12	393,860.93
Wheat	1.83	3.02	1.65	3.68	6.07	182,060.99
Maize	0.71	1.49	2.10	2.17	4.57	109,614.93
					Total	7,123,442.12

Source: Field survey and District Rate

The experience of the other projects showed that male members of the family tend to spend money in unproductive means. Hence it is recommended that the compensation money be paid through the nearest commercial bank in the knowledge of the senior female member of the family.

The project will provide counseling service to PAFs for the effective utilization of the compensation money. For this, the project will develop and implement necessary activities such as counseling during the construction stage. The project will allocate Rs.300,000.00 for counseling services.

Land that will be acquired for temporary use will be either leased or rented in market price, through negotiation.

(ii) Demolition of Permanent and Temporary Structures as a part of Site Clearance

(a) Affected houses/sheds

Each and every affected structure will be compensated at the market rate. A complete list of the affected house/shed is presented in Annex 3.2. Based on the plinth areas value of the house and shed are estimated. The total of compensation cost for the house and other structures is estimated to be NRs. 106,501,128.53. Detail of the individual house including the measurement is presented in Annex 11 and summarized in Table 8.6 and Table 8.7.

Table 8-6: Estimated cost for the affected buildings at the Inundation Area

s.no	Description	Total in sindhuli	Total in Ramechap	Total	Total in sqf	Rate per sq.	Total amount
1	House	0	24	24.00	34,688.22	2500	**86,720,544.38**
2	Shed	4	15	19.00	5,793.56	1300	7,531,630.00
3	Generator house	1	2	3.00	1,262.24	600	757,343.70
	Total amount						**95,009,518.07**

Source: Field survey and District Rate

Table 8-7: Estimated cost for the affected buildings at the Powerhouse Site

s.no	Description	Total in sindhuli	Total in sq	Rate per s	Total amount
1	House	20	3,930.47	2500	**9,826,175.00**
2	Shed	18	1,281.10	1300	**1,665,435.46**
	Total amount				**11,491,610.46**

Source: Field survey and District Rate

(b) Cost for the Transportation Facilities

Apart from the compensation, house owners will be allowed to take away reusable materials of the demolished structures. Rs.20,000.00 for a single storied house and Rs 30,000.00 for double storied and more will be provided as the transportation facilities. Total transportation facilities for 31 single storey and 13 double storey builds are estimated to be Rs.1,010,000.00

(c) Hardship and Displacement Cost

Similarly a monthly hardship and displacement cost (rental) of Rs.10,000.00 per household per month will be provided to each household for 6 months period. Total hardship and displacement cost for 44 houses is estimated to be Rs. 2,640,000.00

(d) Infrastructures

The affected road will be relocated at the project cost. Estimated cost for affected roads is presented in Table 8.10.

Table 8-8: Reconstruction cost for the affected roads

s.no	Discription	Length in km	Rate / km	Total
1	B.P highway	2.3	14,671,161.50	33,743,671.45
2	Rural Road	1.59	700,000.00	1,111,250.00
	Total			**34,854,921.45**

Source: Field survey and District Rate

(e) Transmission Line

Affected length of the transmission line of 1.27 km will be relocated. Estimated cost for the relocations is NRs 2,539,840.00

(f) Affected wells

All 15 affected wells will be compensated to the developer. An amount of Rs 750,000.00 has been allocated for the compensation of the wells.

(g) Solar Panel

Two small solar panels one each at Sindhuli District and Ramechap District will be compensated at the cost of Rs 100,000.00 each whereas the large solar used for the lifting the water for the purpose of drinking water supply will be relocated at the convenient location. It was reported that the estimated cost of the project NRs 24 crores. The solar panels and submersible pumps could be reused. But the well development, reservoir, pump house and other related structures will have to rebuild. An amount of Rs 2.00 crore has been budgeted for the relocation of the well and pump house. Total compensation for the solar panels is estimated to be NRs 20,300,000.00

(iii) Occupational health and safety

All construction workers and staffs will be covered with accident insurance. In order to minimize the unwanted accidents and possible effects of dust and gaseous emission to construction workers, the project will ensure adequate PPE and safety measures such as helmets, masks, air plugs, road signs, warning signals etc. To minimize effects of dust to local people provision of water spraying will be made two times a day during the dry season.

The workforce will be made aware of the likely occurrence of accidents during construction works and teach them precautionary measures to be taken for avoiding such accidents. Safety measures for the local people around the area will also be carefully dealt with. The safety measures and cost for accident insurance will be included under the construction cost of the project during the preparation of the detail design. Construction yards and premises will be well fenced.

(iv) Pressure on social service facilities

The project will make own arrangement of water supply, health and sanitation facilities which will the part of the construction cost. The project will be using the existing roads during the construction period. It will be the responsibility of the contractor to maintain the existing roads during the construction period. This provision will be included in the contractor's contract agreement.

(v) Law and order

In case of malpractices and disturbances by the construction workers and staffs, local authority will be informed and requested to impose restrictions. Late night operation of hotels, restaurant and bars will be regulated. Regular surveillance will be made.

In order to encourage discipline among the workers, a cash prize of Rs. 25,000.00 per person will be awarded to five diligent and disciplined workers every year. With the construction period of 5 years, Rs. 625,000.00 has been allocated for this purpose.

(vi) Gender and Vulnerable Group

Weekly working hours will be fixed to the construction workers so that they could help women in household works, shopping of essential consumer goods and other works. The project will make effort to maintain gender balance during the employment and will not employ any child for construction works. Project will give priority to vulnerable groups while providing employment in the project activities. The project will make necessary arrangement for general health check-up of spouse and children of workers employed by the project during construction period.

(vii) Cash Flow

Significant amount of cash flow is expected in the project area due to cash compensation for the lost assets, payment for leased or rented facilities, and salaries and remunerations. The project will run an awareness programs to inform the local people on the effective and timely use of the newly available cash and prioritizing needs. They will also be made aware of the investment opportunities likely to be generated due to the project and also encourage them to exploit opportunities for long-term income sources. It will be the part of counseling service to PAFs.

(viii) Historical, Religious and Archeological sites

The execution of project activities will not disturb any archaeological and/or religious sites of the project affected areas rural municipality's

(ix) Social-Cultural and Religious Practices

Outside workers will be kept in the separate labor camps. Counseling service will be provided to the outside workers regularly for the harmony with the local community

8.2.3.2 Operation Stage

(i) Withdrawal of economic activities and employment opportunities

(ii) The project proposed to carry out the counseling services to the PAFs for the effective use of the cash received from the project. Few PAFs and skilled people may also be employed. Impacts related to recession of local economy may be revived from fish release and fishing.

In order to compensate the loss of agricultural products due to loss of agricultural land, use of improved variety seeds and technology could be practiced in the agricultural land. Local people may revive agriculture practices

and the project will provide necessary skill development training to PAFs and local people on demand basis from the allocated budget for public awareness.

(iii) Possible flooding of lands due to increase in flow in the Marin Khola

The project has prepared a master plan for Marin Khola training works. Flood protection plan has been prepared based on the hydraulic simulation of flood. Most of the existing agricultural land will be protected through 34 km long dikes along the banks of Marin Khola on both sides at priority locations. Construction of l 18 spurs and 16 drain outlets will help to reduce impacts from floods. Existing FMISs will be rehabilitated. Total cost has been estimated at NRS 810,584,191.27. The project will support in the construction of suspension bridges across the Marin Khola at the different locations.

(iv) Possible flooding of lands and houses due to sudden release of water downstream

The water from the barrage will be released as per the planned schedule. Local people will made aware on possible impacts of sudden release of water in Sunkoshi River.

(v) Impact on cremation sites

As the cremation site will be inundated, the project will develop the site in consultation with the local people above or on the side or below the inundation area. Necessary budget will be a part of project administration.

CHAPTER – 9

9 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management Plan (EMP) is an important component of the EIA report and will be an integral part of SMDMP to set out the procedural framework to ensure the implementation of mitigation measures, monitoring and auditing requirements. The plan specifies the environmental responsibilities of all parties involved in the project, and detail environmental management requirements for the project during the pre-construction, construction and operation phases. The plan also specifies the coordination mechanism with various line agencies, project participants and schedule. The monitoring component likewise defines the monitoring mechanism, reporting etc. Similarly impact audit define the auditing parameters and responsibility.

The project proponent will be responsible for the implementation of the EMP. The plan will apply adaptive management to accommodate changes in project design. The POSDCORB approach is being followed to prepare EMP for this report (Uprety, 2003; MoEST, 2006 and DoED, 2001). It focuses on the inclusion of planning, organization, staffing, directives, co-ordination, reporting and budgeting. Within this broad framework, the following sections describe to address 5W's (what, why/how, where, when and who) for the implementation of benefit augmentation and mitigation measures, environmental monitoring and auditing works. The EMP will be updated during the detail design to cover the likely changes in project design, likely changes in policy and regulatory mechanism and stakeholder concerns.

Furthermore, EMP refers to the documentation pertaining to the project management, monitoring and examination of the implementation of the mitigation measures and verification of the predicted impacts during EIA process and project cycle. EMP becomes an important management tool to ensure the proper project implementation of the mitigation measures for minimizing the adverse impacts and maximizing the beneficial impacts.

EMP is prepared for effective implementation of proposed augmentation and mitigation measures, monitoring and auditing for assessing the effectiveness of mitigation measures and the institutional arrangement for the implementation of the EMP.

9.1 OBJECTIVES OF EMP

The EMP is an environmental operation manual for use by management and staff employed on the project, and will serve as an informative document to regulatory authorities such as, Ministry of Forest and Environment (MoFE) and Ministry of Energy, Water Resources and Irrigation (MoEWRI). The EMP has five primary objectives and they are:

a. define environmental management principles and guidelines for the design, construction and operation of the project
b. describe mitigation measures that shall be implemented to avoid or mitigate adverse environmental impacts
c. formulate environment management framework to ensure the implementation of mitigation measures and monitoring programs
d. establishment of supervision, monitoring, auditing and reporting framework
e. establish the roles and responsibilities of all parties involved in project environmental management

The EMP has been prepared for the Sunkoshi Marin Diversion Multipurpose Project (SMDMP) to set out environmental management requirements and to develop procedures to ensure that all mitigation measures and monitoring requirements specified in this EIA study report will be carried out in subsequent stages of project development. This plan covers structures of the Environmental and Social Management Unit (ESMU) of the Project Management Office (PMO) and main roles and responsibilities of the parties involved in all phases of project viz., pre-construction, construction and operation.

9.2 STATUTORY REQUIREMENT

EPR (1997) requires EMP to be included in the EIA report. This EMP is based on the experiences of constructed hydroelectric projects of similar nature, findings of the EIA study, and review of other EMPs. Guidelines and Manuals relevant to the hydropower projects particularly "Manual for Preparing Environmental Management Plan of Hydropower Projects" published by DoED and MoEST issued 'A Guide to EMP of Hydropower Projects' has been best utilized to prepare an EMP.

9.3 ENVIRONMENTAL PERMIT AND APPROVAL

The overall responsibility of environmental management of Sunkoshi Marin Diversion Multipurpose Project (SMDMP) is of Project Management Office (PMO). Key stakeholders including the project, to be involved for project environmental management in hierarchal order is listed below:

- Ministry of Forests and Environment, (MoFE)
- Ministry of Energy, Water Resources and Irrigation (MoEWRI)
- Department of Water Resources and Irrigation
- Department of Forests and Soil Conservation
- Rastrapati Chure Terai Madhesh Conservation Committee (RCTMCC)
- Division forest and soil conservation office and its sector offices and posts
- Construction contractor (CC)
- EIA experts
- Supervising engineers (SE)
- The Proponent and its line offices
- Sunkoshi Rural Municipality, Khadadevi Rural Municipality, Kamalamai Municipality and Manthali Municipality
- Non-government organizations, community-based organizations

The roles and responsibilities of the key stakeholders have been described in the Table 9-1.

Table 9-1: Roles and responsibilities of the stakeholders

SN	Stakeholder	Roles and responsibilities	Time schedule
1	MoFE	Final approval of the EIA report as per the provisions of Act and Rules	Prior to proposal implementation phase
		Review of project monitoring reports during construction and operation phases and give comments for corrective actions	As and when required during construction and operation phases
		Carry out environmental auditing of project's general performance during operation phase	After two years of operation phase
		Review of EIA prior its approval	Prior to EIA approval
		Give approval and permission for forest clearance of the national forest land	After approval of EIA pre-construction phase
		Assist proponent in pegging, measuring and evaluation of the forest resources of the affected forest stretch	Before project construction starts
		Review of monitoring reports of project construction and operation and give guidance or instruction for corrective actions related to forest and ecology	As and when required construction and operation phases
		Assist the proponent in identification of compensatory afforestation areas	As and when required construction and operation phases
		Advise and assist the proponent in the forestry awareness programs	As and when required construction and operation phases
2	MoEWRI/ DoWRI	Send with review comments on EIA report to MoFE for approval	Prior to EIA approval
		Review project design and contract documents, against approved EIA report and national environmental standards and guide for corrective actions	Before contract bidding
		Carry out environmental monitoring and/or review of monitoring reports of project construction and operation and instruct for corrective actions	As and when required construction and operation phases
4	RCTMCC	Guidance to implement in an environment-friendly and sustainable manner	During project construction
5	Proponent and its institutional line offices	Prespare project-specific EIA report and submit for its approval	Prior to EIA report approval
		Ensure that the EIA measures are incorporated in the final project design and tender documents of project construction and operation	Prior to contract award
		Acquire necessary permits and approval for project construction and operation	Before construction phase
		Ensure that the project construction and operation activities are in accordance with EIA and other GoN legislative requirements as well as international standards	During construction and operation phases
		Monitoring and record keeping regarding environmental measures and impacts	During construction and operation phases
		Ensure public participation and involvement in project implementation and operation	During construction and operation phases
		Compilation of environmental monitoring and performance report and dispatch for review through proponent to stakeholders	Every 2 month during construction phase
		Compilation of environmental monitoring and performance report of construction activity and dispatch to stakeholders for review	Once within 3 months of construction completion
		Compilation of Environmental monitoring and performance report of operation activity and dispatch for review to stakeholders	Once in 3 months for the first two years of operation

SN	Stakeholder	Roles and responsibilities	Time schedule
6	Department of Forests and Soil Conservation	Facilitate in process for forest area clearance Instruct forest office in district to coordinate tree felling, storage of timber and firewood and selling Provide technical support and know-how to the proponent for compensatory plantation and soil and water conservation activities	Before construction starts After tree felling and storage of woods Before and during compensatory plantation and soil conservation works
7	Department of Water Resources and Irrigation Project Management Office Environmental and Social management Unit	Supervision, baseline, compliance and impact monitoring of construction contractor's activities as per responsibilities in the contract document and advise the proponent and Supervising engineers for needed actions at the site in regular environmental management meetings.	Monthly and three monthly
		Monitoring of implementation of the socioeconomic physical, cultural, chemical and biological environmental responsibilities of the proponent not included in the contract document and advise the proponent for needed actions	Regularly during construction phase
		Provide needed corrective action as per the field requirements to minimize the impacts	Regularly during construction phase
		Prepare environmental monitoring report of the project construction and forward to the proponent for review to the stakeholder	Bi-monthly during construction and after three months of the project construction completion
8	Construction Supervising Engineers	Supervise the construction works as per the provisions of EIA and direct construction contractor in consultation with the environmental engineers for the environmental improvement Instruct and supervise contractors' work in line with EIA report's mitigation measures	Regularly during construction phase
		Preside monthly Environmental Management and Health and Safety Meetings of the supervising engineers, contractors and Environmental Engineers and maintain the records for implementation status and needed corrective actions	Monthly during construction phase
9	Construction Contractor	Implement mitigation measures as specified in EIA report and/or as instructed by supervising engineer	Daily during construction phase
		First hand monitoring and record keeping of environmental mitigation measures implemented and their performance	Regularly during construction phase
		Implement any corrective actions specified by supervising engineers within specified time	Regularly during construction phase
		Provide training to operator and others as mentioned in the EIA report	First year of operation phase
10	Local District Office	Provide recommendations to the proponent and assist proponent in project implementation	Prior to proposal implementation phase
		Assist in public consultation awareness building organized by the proponent	During construction and operation phases
		Assist and provide suggestions to the proponent in the matters related to community mobilization	During construction and operation phases
		Assist MoFE in the proposal audit	During operation phase
		Review of monitoring reports of project construction and operation and give comments for corrective actions	As and when required during construction and operation phases
		Ensure that transparency in the project activities are maintained by all the concerned	Regularly during construction and operation phase

SN	Stakeholder	Roles and responsibilities	Time schedule
		stakeholders as per EIA report and commitments	
11	Affected Municipality/ Rural Municipality(Sunkoshi RM, Khadadevi RM, Kamalamai M and Manthali M)	Provide recommendations to the proponent and assist proponent in the project implementation	Prior to proposal implementation phase
		Assist in public consultation awareness building organized by the proponent	During construction and operation phases
		Assist and provide suggestions to the proponent in matters related to community mobilization	During construction and operation phases
		Assist MoFE in the proposal audit	During operation phase
		Review of monitoring reports of project construction and operation and give comments for corrective actions	As and when required during construction & operation phases
		Form Stakeholder committees in each of the project affected ward through a public franchise process to select and assist to implement the programs of Environmental Enhancement Programs	Pre-construction and as and when required during construction and operation phases
		Ensure that transparency in the project activities are maintained by all concerned stakeholders as per EIA report and commitments	Regularly during construction and operation phases
12	NGOs, and CBOs	Provide recommendations to the proponent and assist proponent in the project implementation	Prior to proposal implementation phase
		Assist in public consultation awareness building organized by the proponent	During construction and operation phases
		Assist and provide suggestions to the proponent in the matters related to community mobilization	During construction and operation phases
		Review of monitoring reports of project construction and operation and give comments for corrective actions	As and when required construction and operation phases
		Assist project affected Rural Municipality to form Stakeholder committees in each of the project affected wards through a public franchise process to select and assist to implement the programs of Environmental enhancement	Pre-construction and as and when required during construction and operation phases
		Ensure that transparency in the project activities are maintained by all the concerned stakeholders as per EIA report and commitments	Pre-construction and as and when required during construction and operation and regularly during construction and operation phases

9.4 PROJECT ENVIRONMENTAL MANAGEMENT FRAMEWORK

As per Environment Protection Rules, environmental management of the project is the responsibility of the proponent. For the project, the proponent's PMO has the responsibility of Project's Environmental Management. To ensure that the EIA recommended mitigation and monitoring actions are duly implemented, monitored, analyzed and disseminated to the stakeholders for feedback and improvement, the PMO will establish a separate Environmental and Social Management Unit (ESMU) of its own. The proposed ESMU has four major roles to play. Firstly, it will implement and administer land and property acquisition, and compensation to project affected families or parties. Secondly, it will implement and administer the program in the project affected areas. Thirdly, it will disseminate information to the project's stakeholders and co-ordinate with the different line agencies. Lastly, it will monitor the environmental and social measures and its performance as per EMP.

The ESMU will be managed by the consultants with experience in environmental monitoring of the projects in the past. The project ESMU shall be established at least six months before project's civil construction award. This Unit shall function directly under the Project Manager and will have a responsibility to co-ordinate with the project's Supervising Consultant.

9.5 ENVIRONMENT ENHANCEMENT AND MITIGATION PLAN

Environmental management actions to be undertaken and to be adopted for the realization of environmental enhancement and environmental mitigation during construction and operation phases are presented in Chapter 8. This plan includes impact-based description of enhancement/mitigation action required, individual responsibility, national standard and guidelines, timing of action, individual or agency responsible and tentative financial requirements. Environmental enhancement and mitigation plan will actions to enhance beneficial impacts and mitigate adverse impacts, along with organization responsible for implementation of measures.

9.6 ENVIRONMENT MANAGEMENT DURING CONSTRUCTION AND OPERATION

9.6.1 Environmental Management and Execution Plan

The contractor is responsible for preparation of the site specific plans as stipulated in the EMP and its subsequent obligations under each plan. The plans will be inclusive in a broader Environmental Management and Execution Plan (EMEP) of contractor to be submitted by the contractor to the client.

The project management will include the above provisions in the contract documentation as a priority clause for compliance. The EMEP shall be approved prior to the implementation of contractor's mitigation obligations or as per deadline highlighted in the contract documentation.

The plans to be submitted by the contractor within EMEP include:

a. Permits and approvals plan
b. Compensation management plan
c. Project information management plan
d. Pollution abatement plan
e. Erosion abatement and muck/spoil management plan
f. Construction camps and traffic management plan
g. Terrestrial ecosystem management plan
h. Aquatic ecosystem management plan
i. Public health and occupational safety management plan
j. Rehabilitation/reinstatement management plan
k. Emergency management plan
l. Disaster Risk Management Plan
m. Decommissioning plan of temporary facilities

The implementation modality of above plans shall be clearly mentioned by the contractor in the EMEP. The implementation modality shall include the organizational structure of the EMEP implementers, timeframe, methods, monitoring and reporting mechanisms.

a) Permits and approvals plan

The objective of permits and approvals is to comply with the government legislative mechanism and to keep cordial relationships with the project stakeholders. There are a number of legislative provisions which require

prior permits and approvals from the concerned government agencies to commence the works. Besides, some activities would require general consensus of the project area communities or individuals for smooth operation of certain activities of construction and operation. In these cases, project management will obtain prior permits and approvals or consensus of the affected communities and general public before the start of activities. The permits and approval or consensus required for the project are presented in Table 9-2.

Table 9-2: Permit and approval plan

SN	Required permits and approvals	Authority	Timeline in project lifecycle	Responsibility
1	EIA approval	MoFE	Pre-construction	Proponent
3	Tree felling in Community forest	MoFE, DFO and CFUGs	Pre-construction	Proponent
4	Tree felling in Private forest	Land owner	Pre-construction	Proponent
5	Permanent land acquisition	Chief District Officer	Pre-construction	Proponent
6	Temporary land acquisition	Land owner	Pre-construction	Proponent
7	Entry and works on private land and property	Land owner	Construction	Proponent

All approvals and permits will be procured at least a week before the start of Pre-construction and construction works by the responsible stakeholders as listed in Table 9-2. The permits and approval will be documented and recorded at the EMSU at the site.

b) Compensation management plan

Prior to site clearance, compensation should be provided to the land and property owner. The proponent will prepare a detail plan related to providing compensation of lost resources (crop land, forests, infrastructures, social service facilities etc.) for smooth functioning of the compensation mechanism. Compensation of roads, bridges, transmission lines, irrigation canals, wells, and solar panels will be included in agreement with contractor. While compensatory plantation or case compensation for land and property acquisition should be dealt directly by the proponent.

c) Project information management plan

Project Management Office (PMO) has the responsibility of overall Project's Management. The PMO will establish a separate ESMU of its own. ESMU shall be responsible for maintenance of records by acquisition from the contractor and proponent, dissemination of information to the project stakeholders and co-ordinate with the different line agencies. A Public Information Center (PIC) will be established within the project office premise to maintain necessary records that could be of public interest.

d) Pollution abatement plan

The objective of the pollution abatement plan is to avoid or minimize the pollution streams (gaseous, liquid, solid and acoustic) from the project activities during pre-construction, construction and operation phase of the project, both preventive and remedial measures will be implemented by the project. The preventive measure focus on preventing pollution streams whereas the remedial measures will focus on the measures to minimize the effects of pollution through end of the pipe treatment technologies. A number of measures have been listed in the mitigation measures in Chapter 8 for air, water, land, and noise pollution. Table 9 3 highlights key features of the pollution abatement plan.

The contractor will prepare mitigation measures-based and site-specific pollution abatement plan incorporating the provisions listed above and in the mitigation section of Chapter 8. This plan will be submitted to the supervising engineers for a prior approval of a concerned environmental officer before the project construction starts. The approved pollution abatement plan of the contractor will be documented and placed in the public information center at the site office as a reference document.

e) Erosion abatement and muck/ spoil management plan

The SMDMP development works involves a number of activities that directly interact with the existing landform. The objective of this plan is to minimize the landform instabilities and reduce soil erosion and landslides to the extent possible. The second objective is to conserve the top soil, the lifeline for any vegetative productivity. The key elements of the management plan are presented in the Table 9 4.

The contractor will prepare a spoil disposal plan and topsoil saving and reuse plan in the designated areas provided by the project management at least a month before the actual excavation works and will take approval from the project environmental officer. The spoil disposal and top soil saving plan will incorporate the minimum provisions as stipulated in the mitigation section in Chapter 8. This document will be placed in the project information Centre as a reference document.

Table 9-3: Pollution (Air, water, land, and noise) abatement plan and solid waste management plan

S N	Activities/proposed measures	Timing of action	Location	Responsibilities
1	**Air pollution abatement**			
1.1	The earthen and graveled road corridors will be sprinkled regularly to minimize the fugitive dusts generated by construction related vehicles plying particularly in the winter, summer and dry season.	Construction phase	All active construction sites including access road Manthali to Headworks	Contractor and SMDMP
1.2	The aggregate crushing sites and active construction sites will be sprinkled regularly by water as to the requirement on the advice of supervising engineers.	Construction phase	Aggregate crushing site	Contractor and SMDMP
1.3	Use of breathing mask by the construction workers in the dust-prone areas such as crushing plant, batching plant, rock drilling areas etc. will be made compulsory.	Construction phase	All construction sites	Contractor and SMDMP
1.4	All vehicles belonging to the project i.e. consultants, owner, contractors, vendors will comply with the national emission standards and regular (monthly) check-up for maintenance of all vehicles will be carried out every 3,000 km.	Construction phase	Project area	Contractor and SMDMP
2	**Water and land pollution abatement**			
2.1	The water discharged from aggregate batching plant will be collected in settling tanks/ ponds at suitable location for sedimentation and treatment (minimum water retention time of the tanks is 2 hours)	Construction phase	Aggregate batching plants	Contractor and SMDMP
2.2	All spent grease and mobile and unused or date expired toxic chemicals will be collected separately in plastic drums and stored in a safe place under the shade	Pre-construction, Construction and Operation phase	All the project sites and facilities	Contractor and Operation Manager

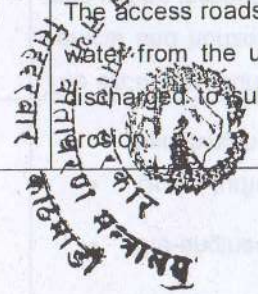
S N	Activities/proposed measures	Timing of action	Location	Responsibilities
2.3	Spent oil shall be collected and stored in suitable storage tank and returned to supplier/ manufacturer.	Pre-construction, Construction and Operation phase	All the project sites and facilities	Contractor and Operation Manager
2.4	The waste water from the mechanical yards will be collected in a separate area. The water will be treated for the oil and grease and then released into the water bodies.	Construction phase	Mechanical yard and waste discharge point	Contractor and SMDMP
2.5	Discharge of construction waste such as cement and concrete slurry will not be discharged to the river water.	Construction phase	Headworks and powerhouse	Contractor and SMDMP
2.6	Provision of toilets with septic tanks shall be made in all camps. Toilets shall be made at the rate of one toilet for 10 workers in temporary camps and one toilet for 25 workers at the work site.	Pre-construction and construction phase	All camps and active construction sites	Contractor and SMDMP
2.7	Open defecation will be prohibited in and around the construction sites, camp sites and in the river bank area. Hoarding sign boards will be placed in the construction camps, and active construction sites.	Pre-construction and construction phase	Areas surrounding construction sites	Contractor and SMDMP
2.8	A solid waste collection and storage system will be established in all the construction related camps and construction sites. The collected waste will be segregated as to the property of the waste as degradable, glass, metals, plastics, cloths and leather etc. and will be stored in separate bounded areas. These materials will be disposed as to the recommendations and approval of the project EMSU.	Pre-construction, construction and operation phase	All camps (construction and operation) and active construction sites	Contractor and SMDMP
2.9	Garbage containers of adequate size will be placed at critical places in the construction camps and construction sites. The collected garbage will be collected daily for segregation and storage as outlined above.	Pre-construction, construction and operation phases	Construction and operation camps and active construction sites	Contractor and SMDMP
2.10	The quarry operation will not be carried below the flowing water level of	Construction phase	Quarry site	Contractor and SMDMP

S N	Activities/proposed measures	Timing of action	Location	Responsibilities
	the river			
2.11	Excavation of the aggregates from wet river channels will be prohibited	Construction phase	Quarry site	Contractor and SMDMP
2.12	Stockpiling and storage of the construction materials will be only in designated sites and away from the water paths. Prohibition on the stockpiling of construction materials in other areas than designated area.	Construction phase	Stockpiling area	Contractor and SMDMP
2.13	Spoil disposal will be carried out in the designated sites only. Prohibition of spoil disposal in other non-designated areas	Construction phase	Spoil disposal site	Contractor and SMDMP
	Noise pollution abatement			
3.1	Operation of high noise generating construction activities will be only executed in the day time as far as possible	Pre-construction and construction phase	All camps and active construction sites	Contractor and SMDMP
3.2	Regular maintenance of the vehicles to reduce the mechanical and body noise during its operation	Pre-construction, construction and operation phase	All vehicle and machinery	Contractor and SMDMP
3.3	Prohibition of the horns use in critical stretches close to villages and near the school area	Pre-construction, construction and operation phase	Villages and school areas	Contractor and Operation Manager
3.4	Sound mufflers will be used to reduce sound pollution in the compressors and diesel generator sets	Pre-construction and construction phase	Compressors and diesel generator	Contractor and SMDMP
3.5	Ear plugs should be provided to labours operating with high noise producing construction equipment	Construction phase	Active construction sites	Contractor and SMDMP

Table 9-4: Erosion and muck/ spoil management plan

S N	Activities	Timing of action	Location	Responsibilities
1	All surface excavation above 3 m vertical height will be excavated through benching	Construction phase	All project sites	Supervising Engineer/ Contractor
2	Potential landslide and soil erosion will be controlled through: • Pegging and flagging on the boundary of the landslide area • Maintenance of slope less than the angle of response • Provision of proper drains • Bio-engineering measures on landslide • Grass turfing on gentle slope and concreting on the steep slope with benching height > 3 m & proper drainage	Pre-construction and construction phase	Project area	Contractor
3	The excavated surface will be protected against the water erosion by adequate vertical and horizontal drainages and the water collected from the excavation area will be discharged into safe area.	Construction phase	All project sites	Supervising Engineer/ Contractor
4	All excavated areas and spoil deposited areas will be stabilized by civil and bio-engineering works.	Construction phase	All project sites	Contractor and SMDMP
5	Stockpiling and storage of the construction materials will be done in designated sites only. Prohibition on the stockpiling of construction materials in other areas.	Construction phase	All project sites	Contractor
6	Muck disposal sites will be carried out in the designated sites only. Prohibition of muck disposal in other non-designated areas.	Construction phase	All project sites	Contractor
7	Prior to the start of spoil disposal, the contractor will make a plan for spoil disposal and get approval from the project environmental officer. The plan, among others, will have measures for toe protection from the monsoon washout.	Construction phase	Muck disposal area	EMSU and Contractor

S N	Activities	Timing of action	Location	Responsibilities
8	The muck deposited will be properly compacted and will be facilitated by surface runoff drainage facilities to avoid air pollution and run off erosion.	Construction phase	Muck disposal area	Contractor and SMDMP
9	The runoff discharge from the muck disposal areas will be collected through proper drainage arrangements and passed through sedimentation tanks to arrest the suspended sediments prior to discharge into receiving water bodies.	Construction phase	Muck disposal area	Contractor and SMDMP
10	All project facility sites (camps, mechanical yards, storage facilities, muck disposal sites etc.) will have drainage facilities to collect and discharge the runoff water safely to the natural water bodies	Construction phase	All project sites	ESMU and Contractor
11	The access roads of 1.5 km will have permanent side drain structures to collect water from the upslope area. The collected water of the side drains will be discharged to suitable natural waterways to avoid upstream and downstream erosion.	Construction phase	Access roads	Contractor



f) Construction camps and traffic management plan

Transportation of construction equipment and accessories and establishment of various camps for engineers, contractors, workers, storage yards, and mechanical yards are the first activities of the inception phase of SMDMP. The construction preparation activities at the site have a lasting consequence both environmentally and socially. Therefore, planning for traffic management (on site and along the road corridor) and management of construction camps and storage facilities (fuel and hazardous materials) are crucial for the overall EMP. A proper and sensible planning at this stage will avoid likely environmental and social adverse consequences in the future. The highlights of construction camps and Traffic management plan are presented in the Table 9-5.

g) Terrestrial ecosystem management plan

The objective is to ensure that the terrestrial resources such as forests/vegetation, and wildlife of the project site and surroundings will not face adverse impact due to the project implementation. However, project efforts will help to safeguard ecosystem and enhance its goods and services. The activities of the terrestrial ecosystem management plan are presented in Table that follows.

The contractor will be made contractually responsible for provisioning local employment, supply of kerosene and LPG at the labor camps, for prohibiting the use of local NTFP and wildlife and its product within the camp etc. The PMO will ensure that the above provisions are adequately covered in the bid documents. The ESMU will be responsible for drawing terrestrial resource management, particularly the public awareness and compensatory afforestation, based on the wider consultation with the local communities and concerned government line agencies.

h) Aquatic ecosystem management plan

One of the key impacts of proposed hydropower project will be on the aquatic ecology of the Sunkoshi River and Marin Khola. Though the impacts of the river diversion cannot be completely avoided, however, it could be minimized to the extent possible by implementing the activities listed in Table 9-7 as a part of the aquatic ecosystem management plan in the project life cycle.

i) Public health and occupational safety management plan

The project development site is in the rural setting (even the affected wards of Manthali Municipality and Kamalamai Municipality) are thinly populated and the population is not exposed to high pollution loads of diverse types. This increased pollution, in an infrastructure deficient area, becomes the primary cause of public health degradation. Apart from this, people from different places and with different diseases come in the area as project workers or economic opportunity seekers. They may also act as carriers of the communicable diseases which are otherwise alien to the local population of the project area.

As the construction work is associated with diverse types of risk prone activities. The workers involved in the construction works are exposed to these occupational risks. Sickness, injuries, and even fatal accidents cannot be ruled out. The increased traffic of construction vehicles and associated fugitive dust and noise are yet another source of direct imperative health effects, even fatal to both the project area people and occupational workers.
Taking the above mentioned probabilities into consideration, a site-specific plan on public health and occupational safety has been developed to minimize the risk on public health and construction related occupation of the workers. Table 9-9 highlights the key features of the Plan.

j) Rehabilitation and reinstatement management plan

The primary objective of the plan is to rehabilitate the affected land area, facilities, construction sites, muck/spoil disposal sites, quarry sites, storage and mechanical yards, temporary camp sites, solid and liquid waste storage and treatment sites etc. once the construction works and its utility for the construction period is over in the designated site. This activity is envisaged to clean up the pollution created by the construction activities on land, water and air and help to restore the general aesthetic of the area similar to pre-construction period. The key highlights of the plan are presented in Table 9-9.

The rehabilitation plan with the outlined provisions will be prepared by the contractor including the provisions listed in the mitigation section in Chapter 8 and agreement with the private parties by the contractor at least a year before the closure of the construction works. The environmental officer will review and approve the document with needed changes. This document will be placed in the public information center as a reference document for monitoring.

Table 9-5: Construction camps and traffic management plan

S.N	Activities	Timing of action	Location	Responsibilities
1	Pre-information to the local area people on the start date of project preparation works and the range of activities to be undertaken.	Pre-construction	Local Village	SMDMP
2	Preparation of elaborated plan for the construction camps (issue and site-based)	Pre-construction	All project sites	Contractor
3	Check landscape harmony, adequacy of space, room size, ventilation system, fire hazard equipment placements, toilets, water supply system, communication systems, medical facilities, drainage system, common cooking and dining space, sewage treatment system, recreational facilities, solid waste collection and storage facilities, top soil excavation, and storage area for later use, spoil placement site for later final disposal in spoil disposal sites, fencing, hoarding board placement sites etc.	Pre-construction	All project sites	Contractor and Supervising engineer of SMDMP
4	Identification and preparation of sites for the parking of the project vehicles (off the road site)	Pre-construction	Project site as required	Contractor and SMDMP
5	Identification and preparation of sites for material storage and staying facilities for the early construction workers/ contractors with adequate facilities of water supply, drainage, cooking, dining, toilets, solid waste collection and storage, place of disposal of various categories of wastes etc.	Pre-construction	All project sites as required	Contractor and SMDMP
6	Site clearance and construction plan for construction camps (engineer, contractor, labor force, mechanical yards, long term storage facilities for lubricants and fuel etc.) with plans to save top soil for later use.	Pre-construction	Plan documents	Contractor and SMDMP
7	Preparation of a Guideline for construction vehicle operation (speed, use of horn, parking on and off the road etc.) and maintenance to meet pollution criteria and green stickers, Transport Emergencies, timing of movement,	Pre-construction	Guideline document	Supervising engineer at SMDMP
8	Construction of camps and facilities including fuel storage yards, lubricant and other hazardous material storage yards etc.	Pre-construction	Construction area	Contractor and SMDMP
9	Operation management guideline for permanent operation camps, transport vehicle, code of conduct of the operation personnel, of sanitation facilities etc.	Start of operation	All project site	Project management team

Table 9-6: Terrestrial ecosystem (Forest loss) management plan

Activities	Timing of action	Location	Responsibilities
Find area for compensatory plantation for the loss of the forest area or pay the cost of for the land value	Before the construction	To be identified	SMDMP and DoF
Make agreement with Division Forest Office for the compensatory plantation as provisioned0 EIA report.	Construction and Operation phase	Area as designated by DFO	SMDMP and DoF
Prohibition on the sale and purchase of the local NTFP and fishes in the camps	Pre-construction, construction and operation phase	All project locations	Contractor
Prohibition in roaming in the local forest area by the outside workforce	Pre-construction, construction and operation phase	Surrounding project areas	Contractor and SMDMP
Clearing of the forest vegetation and stockpiling the vegetation products before handover to CFUGs	Construction phase	All permanently occupied forest areas	Contractor
Clearing of the forest vegetation as to the requirement of project structures and facilities only by pegging the area and numbering the trees	Construction phase	All permanently occupied forest areas	SMDMP and ESMU
Project will inform the local Rural Municipality, CFUG, Range post in the protection works of the forest areas close to the construction sites	Construction phase	Surrounding areas of the project site	SMDMP and ESMU
Hoarding/Arrow boards will be placed at critical location as needed	Construction phase	Surrounding areas of the project site	SMDMP and ESMU
Public awareness programs will be launched to prevent the forest fires in the local area	Construction phase	Surrounding areas of the project site	SMDMP and ESMU
Conservation awareness training to the workforce and project staff	Construction phase	Surrounding areas of the project site	SMDMP/ ESMU / Contractor

Table 9-7: Aquatic ecosystem management plan

Activities	Schedule	Location	Responsibility
Restriction on fishing activities by the construction workforce in the Sunkoshi River and Marin Khola	Construction and Operation phase	Sunkoshi, Marina Khola and their Tributaries in the project area	Contractor
Monitoring of fish along the reduced flow zone	Construction and operational phases	Reduced flow zone	Contractor
Implementation of the activities in water and land pollution abatement	Pre-construction and construction phase	All project sites	Contractor
Strict prohibition of muck/spoil disposal into the river bodies	Pre-construction and Construction phase	All construction sites	Contractor
Design the provision of releasing at least 10% of the minimum mean monthly flow as an inbuilt structure of the weir	Design phase	Intake	Design engineer and supervising engineer

Table 9-8: Public health and occupational safety management plan

Activities	Timing of action	Location	Responsibilities
Implement Pollution Abatement Plan	Construction phase	All project sites	Contractor
Preparation of occupational health and safety plan and submission to ESMU of SMDMP for approval	Pre-construction phase	All project sites and all workforce	Contractor
Provision of First aid facilities	Construction phase	All active construction sites and yards	Contractor
Medical check-up of the workforce before employment	Construction phase	All construction workers	Contractor
Regular medical check-up of the construction workers every 6 months	Construction phase	All construction workers	Contractor
Support to health facilities (intermittent health camps, strengthening health post nearby the project) to local public as per the CSP	Construction phase	People of project area	Contractor and SMDMP
Water supply facility with a treatment unit	Construction phase	All project camp	Contractor
Establishment of construction waste collection system and management	Construction phase	All active construction sites	Contractor
Fencing of all construction sites and restriction on entry of the outsiders others than authorized person	Construction phase	All active construction sites	Contractor
Appropriate signs boards in all active construction sites, and work areas as to the degree of risk in the site	Construction phase	All active construction sites	Contractor
Provision of Personal Protective Equipment (PPE) (such as boots, gloves, masks, ear plugs, helmets, safety goggles etc.) to the construction workers as appropriate to the requirement and risk of the working area and implement the use effectively	Construction phase	All construction workers	Contractor
Regular training as required to the construction workers and health and safety issues of the construction works	Before and during construction phase	All construction workers	Contractor
Regular training to operation staffs as required on occupation health and safety issues	Operation phase	All construction workers	Contractor
Insurance of workers	Pre-construction phase	All workers	Contractor

Table 9-9: Rehabilitation and reinstatement management plan

Activities	Schedule	Location	Responsibilities
Rehabilitate the excavated slopes of the construction areas using appropriate bioengineering measures	Post-construction phase	Access roads, headworks, adit and penstock area, powerhouse, tailrace and others facilities	Contractor
Rehabilitation the drainage networks as to the requirement (some area might need strengthening while in some it might have to demolish completely to give the land and drainage the natural condition)	Post-construction phase	Access roads, headworks, camps, storage area, powerhouse, spoil disposal sites etc.	Contractor
Demolition of all unnecessary structures, their foundations, clean up and reclaim the sites to pre-construction phase	Post-construction phase	Temporary residential camps, storage yards, mechanical yards, batching plant, aggregate crushers, aggregate washing plants, etc.	Contractor
Rehabilitation the muck disposal site with proper drainage facility as per approved plan. Use the saved top soil on the top of the spoil sites to develop the land in an usable land for afforestation or other purpose as per the recommendation of the ESMU	Post-construction phase	Muck disposal site	Contractor

Activities	Schedule	Location	Responsibilities
Rehabilitation of the quarry area in such that puddles and depressions are not left out	Post construction phase	Quarry area	Contractor
Rehabilitate the temporarily acquired cultivable land by tilling and spreading the top soil saved.	Post construction phase	Temporary camp and storage area	Contractor
Handover the temporary land acquired sites to the respective owners and get a certificate of handover	Post construction phase	Labour camps	Contractor

k) Emergency management plan

The emergency management will be prepared to handle unforeseen events during emergency operations is presented in Table 9-10. This emergency management plan highlights some key features of the emergency preparedness in the event of such unforeseen events.

Table 9.10: Emergency Management Plan

S.No	Activities	Schedule	Location	Responsibilities
1	Provision of sirens to inform the people of the emergencies (fire hazards, blasting operations, chemical hazard, traffic accidents, earthquake etc.) and drill operations.	Construction	Access roads, intakes, headrace, tunnel, adit, powerhouse, etc.	Contractor
2	A system will be developed for warning or informing people before sudden release of water downstream like siren. Awareness program will be conducted to educate local people about the importance of siren warning system, possibilities of accidents and other possible impacts.	Construction	Intake, penstock alignment, ad it, powerhouse, muck and spoil disposal sites, nearby settlements, etc.	Contractor
3	Siren network will be established in the dewatered zone and will be blown for 5 minutes continuously by the project staff and repeat if necessary as warning alarm before the release of water from the dam for maintenance.	Construction and Post Construction	Intake, penstock alignment, ad it, Powerhouse, muck and spoil disposal sites, nearby settlements, etc.	Contractor
4	Provision of stabilizing equipment and facilities to the injured before he could be moved to the nearest hospital with good facilities.	Construction	Intake, penstock alignment, ad it, powerhouse, muck and spoil disposal sites, etc.	Contractor

l) Disaster management plan

Table 9-11 presents disaster risk management plan for the projects

Table 9.11: Disaster Risk Management Plan

S.No	Activities	Schedule	Location	Responsibilities
1	Formulation of Disaster Risk Reduction and coping team in project	Construction	Access roads, headwork ad it portals, penstock area, powerhouse, tailrace	Contractor
2	Identification of Disaster prone areas such as landslide hazard zone, river flood plain areas, etc.	Construction	Access roads, head working including, camps, storage area, powerhouse. muck and spoil disposal sites etc.	Contractor
3	Regular maintenance of project components along the flood plain.	Post-Construction	head works including penstock alignment, powerhouse, muck and spoil disposal sites etc.	Contractor
4	Protection measures at the	Construction	head works including	Contractor

	landslide prone areas and areas with risk of floods and soil erosion.		penstock alignment, powerhouse, muck and spoil disposal sites etc.	
5	Engineering techniques like bioengineering, gabion wall s, retaining walls, drainage managements	Construction	head works including, camps, storage area, powerhouse, muck and spoil disposal sites etc.	Contractor
6	Alarming and training to task group will be given to cope with disasters and emergency	Post-Construction	head works including penstock alignment, powerhouse, muck and spoil disposal sites, nearby settlements, etc.	Contractor
7	Occupational Health Safety and Environmental Safety will be made strict for the implementation	Construction	Access roads, head works including camps, storage area, powerhouse, muck and spoil disposal sites etc.	Contractor

m) Decommissioning plan of temporary facilities

Table 9-12 presents the decommissioning plan of temporary facilities of the projects

Table 9.12: Decommissioning plan of temporary facilities

S.No	Activities	Schedule	Location	Responsibilities
1	Rehabilitation of the excavated slopes of the construction areas using appropriate bio-engineering measures/enrichment plantation /vegetative cover	Post-Construction	Access roads, headwork adit portals, penstock area, powerhouse, tailrace	Contractor
2	Rehabilitation of the drainage networks as to the requirement (some area might need strengthening while in some it might have to demolished completely to give the land and drainage to natural condition)	Post-Construction	Access roads, headworks, camps, storage area, powerhouse, muck and spoil disposal sites etc.	Contractor
3	Demolition of all unnecessary structures, their foundations and clean up and reclaim the sites to pre-construction phase	Post-Construction	Temporary residential camps, storage yards, mechanical yards, batching plant, aggregate crushers. aggregate washing plants, waste water treatment sites of Tunnel Roads	Contractor
4	Rehabilitation of the muck disposal site with proper drainage facility, leveling and compaction as per approved plan_ Use of the saved top soil on the top of the muck sites to develop the land in an usable land for plantation garden/picnic spot	Post-Construction	Muck deposal site	Contractor
5	Rehabilitation of the quarry area in such a way that puddles and depressions are not left out	Post-Construction	Quarry area	Contractor
6	Handover of the leased land sites to the respective owner and get a certificate of handover	Post-Construction	Quarry Area/Labor camps	Employer

9.7 ORGANIZATION AND STAFFING

The details of the organizational chart with necessary human resources are presented in Figure 9.1 The proponent will be responsible for the implementation of mitigation measures and monitoring plan. The proponent will establish a separate Environmental and Social Management Unit (ESMU) as an integral part of the project to ensure the proper implementation of mitigation measures and monitoring. The study team recommends an internal audit study shall be carried out by the proponent in order to examine the actual environmental impacts, accuracy of predictions and effectiveness of environmental impact mitigation, enhancement measures and functioning of monitoring mechanisms. The proponent will implement environment protection measures itself or through the involvement of the contractors, and its supervision will be done by supervising consultant. The ESMU will focus on compliance monitoring, record keeping and providing technical inputs to the contractors. The ESMU will also prepare a report on the impact monitoring. The proponent will conduct environmental monitoring through its ESMU or may hire an independent monitoring team for impact monitoring.

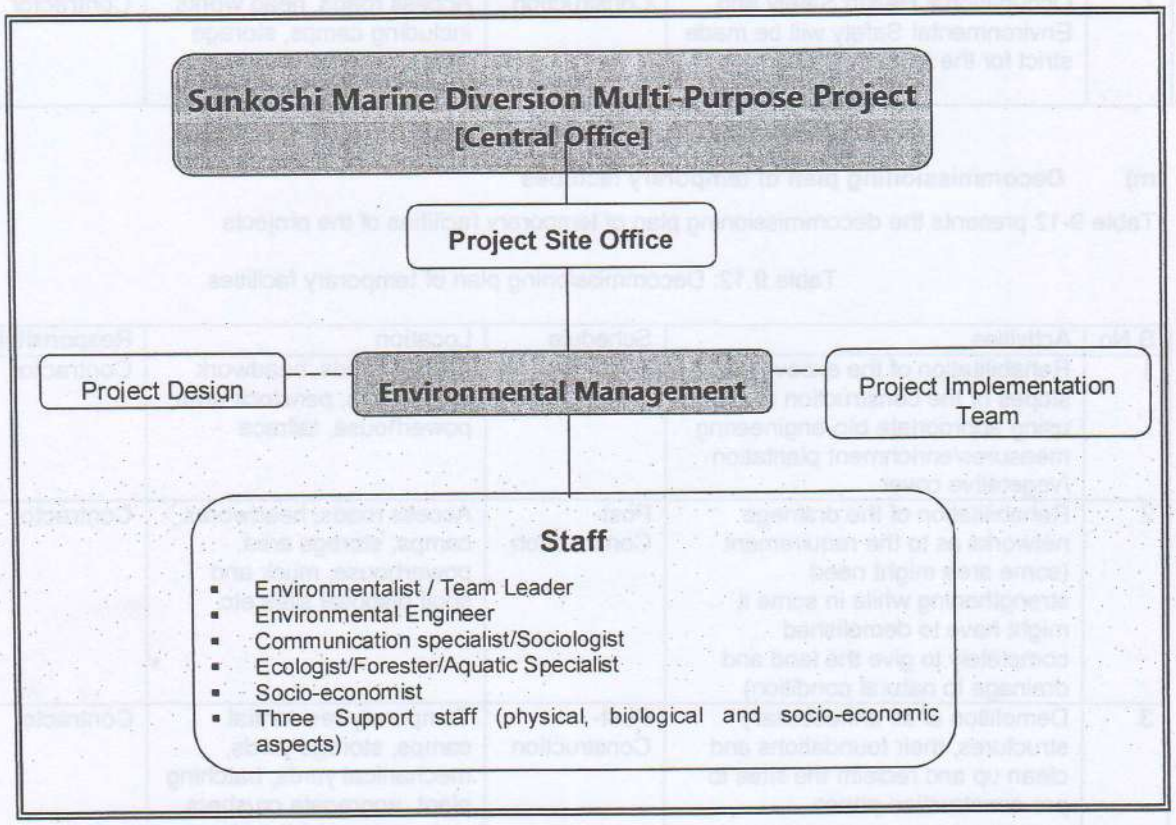


Figure 9-1 : Organogram of EIA Study of Upper Marshyangdi "A" (UM-O) Hydro-electric Project

9.8 DIRECTIVES AND COORDINATION

In order to ensure proper implementation of EMPs and carrying out environmental monitoring, MoFE may give some directives as required by the ESMU. Further the project may co-ordinate with project affected Municipality/Rural Municipality, DFO, NGOs and related stakeholders as necessary during the implementation of project. Besides, above mentioned stakeholders committee, the project will form Local Coordination Committee to co-ordinate and ensure proper implementation of the project in the project affected area.

9.9 REPORTING AND BUDGET FOR IMPLEMENTATION OF EMP

The effectiveness of EIA study relies particularly on the implementation of EMP. Further, the implementation of EMP directly depends upon the adequate budget allocated for mitigation/ enhancement measures, environmental monitoring and environmental auditing. The estimated EMP cost is included in the project cost so that the proponent can make an early plan for separating the budget during the implementation phase. Summary of the cost of mitigation and compensatory measures is presented in Table 9.11.

The proponent will make necessary arrangement to circulate the EMP implementation report annually and will ensure that all project related stakeholders receive it. In addition, the proponent will also explore avenues to make such report public.

Table 9-10: Emergency management plan

Activities	Schedule	Location	Responsibilities
Provision of helipad for emergency evacuation of injured or other people	Pre-construction phase	Construction site	Contractor and SMDMP
Provision of standby ambulance to evacuate the injured at the earliest to the nearest hospital	Construction phase	Powerhouse and Headwork's area	Contractor and SMDMP
Provision of medical stock particularly for water borne disease to tackle the epidemic in the camp or in the villages surrounding the project site	Construction phase	Health care facility at project site	Contractor
Provision of firefighting equipment and regular firefighting training as needed	Construction phase	Construction site	Contractor
Provision of sirens to inform people of the emergencies (fire hazards, blasting operations, chemical hazard, traffic accidents, earthquake etc.) and drill operations at least once in 6 months	Construction phase	Powerhouse, camp sites, headwork and adit portals	Contractor
Emergency preparedness training and on drill operation (floods, release of water from dam, epidemic outbreak, earthquake etc.) at least every 6 months	Operation phase	All project site/ powerhouse, headwork and dewatered stretch	Operation manager

Table 9-11: Summary of Environmental Benefits Augmentation, Mitigation and Compensation Cost

Mitigation Measures	Method	Amount in Nrs
Pre- Construction Stages		
Compensation Cost		
Land compensation	Pay cash	1,222,913,636
Crop compensation	Pay cash	7,123,442
Compensation to the building strcutures	Pay cash	106,501,129
Transportation facilities		1,010,000
Hardship allowance		2,640,000
Compensation to government land		255,981,000
Compensatory plantation		10,558,800
	Total Compensation Cost during pre construction stage	1,606,728,007
Construction Stage		
Benefits Augmentation Measures		
Income generation training and Enhancement in Technical Skills and Know-how to 532 people	Income generating training in modern techniques of cash crop and livestock productions and in enterprise development activities Construction skills training programs in specialized area such as electro–mechanical works of hydropower, road slope stabilization, spoil handling etc.	47,880,000
0.75 % of the project cost to the Community Support Programme of the project affected area for the entire project period which is equivalent to Rs 346.454 million..	Project will provide Rs 10,000,000.00 per year in health, education, sanitation and infrastructure sector for the period of 5 years. Balance amount will be provisioned for the operation phase.	50,000,000
	Benefit Augumentation Cost (Construction)	97,880,000
Mitigation Measures		
Relocation and reconstruction of the affected structures due inudation		122,960,849
Management of top soil	Mangement of 263490 m^3 of top soil	131,745,000
Slope protection works in the inudation area	Total length 16.25 km of the boulder pitching (equivalent to 48750 m 3)	167,602,500
Flood protection works in Marin Khola		810,584,191
Counselling to PAFs	Couselling meeting	300,000
Law and order	Award to diligent and discipline workers	625,000
	Mitigation Cost during construction	1,233,817,540
Mitigation Measures during operation		
Community support programme	Community support programme will be continued with budget of Rs 296.45. crore	296,454,740
Release of fingerling in Sunkoshi River for 5 years	release 100,000 fingerlings per year for 5 years period	50,000,000
	Mitigation Cost during construction	346,454,740
Total Compensation and Mitigation Cost		3,284,880,287

CHAPTER – 10

10 ENVIRONMENTAL MONITORING AND AUDITING

Environmental monitoring is an integral part of the EIA report and/or EMP. It is carried out to confirm the compliance and effectiveness of the proposed benefits augmentation and adverse impact mitigation measures. There are three types of monitoring namely baseline, compliance and impact monitoring. Baseline monitoring will not be required as the project intends to be starting the construction as early as possible. However the project will update the key basic data such as land to be acquired for the permanent and temporary acquisitions, along with ownership certificate, before the construction of the project. It will also make detailed inventory of the trees to be removed during the site clearance. This sub-section focuses on the compliance and impact monitoring. The impact monitoring will be carried out during and after the construction stage to evaluate the effectiveness of the proposed environment protection measures (EPMs). The project proponent will allocate adequate budget for carrying out all the proposed monitoring activities.

The project will elaborate the plan to monitor the compliance through its ESMU within the project. The proponent will seek technical assistance, if required, from the MoEWRI and DoWRI. In order to guide and supervise the compliance monitoring and an inter-ministerial monitoring team has been proposed. This monitoring team will comprise of the representatives each from MoEWRI, MoFE, DoWRI and the project. This team will make necessary site visit to oversee the compliance. Required budget for this monitoring team has been included in the monitoring budget.

10.1 MONITORING PARAMETERS

The monitoring parameters have been linked with the above EPMs. The following parameters will be monitored during the pre-construction, construction and operational stages of the project in accordance with the background of environmental information.

Monitoring of number of jobs created and PAFs and local people employed, skill training to PAFs, change in commodity prices, and nature and quality of community support programmes will be carried out during the construction stage. During the operational stage, number of job provided to PAFs/local people, total amount of revenue chanelled to the local governments, fish farming in inundation area and livelihood improvement, inter-basin and inter-Province benefits and impacts along with coordination will be monitored through the ESMU to better understand the implementation of measure to optimize beneficial impacts and their effectiveness.

For adverse impacts mitigation, following parameters will be taken into consideration for compliance and impact monitoring.

a) Physical Environment

During the construction stage, the project will monitor the air quality, noise level and water quality of the project area at regular intervals particularly in the construction areas. The air pollutants and noise level from the crusher will also be monitored. Similarly, quantity of muck extracted and disposed, amount of aggregates crushed and used, frequency of water sprinkling, total quantity of spoils (disposal materials) and their disposal, spoil bank reclamation activities, locations of natural slope disturbance, implementation of slope protection measures, provision for adequate drainage facility such as side drains will be monitored to know the compliance and effectiveness of the EPMs. Furthermore, the monitoring parameters such as the frequency of vehicle maintenance, water spraying on service roads; number of safety gears provided to the construction workers including mask, helmet, glove and ear plugs; establishment of sirens and other safety measures such as road sign boards at the road bends and no horn signs at settlements will also be monitored at regular intervals.

During the operational stage, slope failures, impact from decrease of water volume in Sunkoshi River and more water in Marin Khola, bed scouring, erosion and bank cutting in Marin Khola, and noise and vibration in powerhouse will be monitored.

b) Biological Environment

The project will monitor the actual number of felled trees (species-wise) and quantity of forest products and numbers of tea stalls and restaurants which use forest firewood and/or type of fuel used as energy source in the project area vicinity and construction workers. The ESMU will monitor forest products inundated, pressure on surrounding forests, and impact on endangered and 'use regulated' species, Fish and aquatic life monitoring will focus on fish population and migration status of long-distance migratory fish species, release of fingerlings in the

inundation area, and downstream fish species, fishing activities of the local people and construction workers and their dependents if any, amount of fish collection and sales within the project area.

During the operational stage, impact on aquatic life in the flow reduced zone in Sunkoshi River (up to 35 km), fish production in high volume of water in Marin Khola, number and type of fish species and average production of fish will be the key parameters for the monitoring.

c) Socio-economic and Cultural Environment

During the pre-construction stage, the project will monitor the rate and amount of compensation paid for acquired or damaged houses, land or other properties. The project will also record the use of received compensation if possible, number of counseling trainings and income generating activities during the construction stage. The project will monitor the number of construction workers in particular the PAFs and the local people according to the type of work, number of women employed, number of outside laborers and their dependents and will record the salaries or daily wages. The project will also monitor the number and type of tea stalls nearby the project area, health and sanitation facilities in the work camps and labor camps. Similarly, the project will monitor in-migration and out-migration in the project area. Frequency and types of illness of the construction workers and cases of construction-related respiratory diseases, type and number of accident, availability of first-aid and emergency services and awareness of the workers and roadside people on occupational health and safety will also be monitored. Furthermore, the project will monitor the events of social disharmony and related disputes, occupational safety, and change in price of commodities within the project area during the construction stage. The project will also monitor the award given to the best and disciplined workers.

After the completion of the project, the proponent will monitor the impact produced by the project, in particular, the socio-economic status of PAFs water use in the downstream and impact of flood or more water in the Marin Khola.

10.2 MONITORING LOCATIONS, SCHEDULES AND RESPONSIBILITIES

During the project construction and operation stages, two types of monitoring – compliance and impact monitoring– will be conducted, including the implementation status of all EPMs. Key baseline data will be updated prior to the construction stage which will be considered as the baseline monitoring. The compliance monitoring provides information on the status of project's performance on complying with the implementation of EPMs. Much focus will be given on impact monitoring in order to know the effectiveness on EPMs on improving the environmental condition, and making the project environment-friendly. Monitoring will be carried out at different locations during the pre-construction, construction and operational stages. In order to know the level of compliance and effectiveness of the EPMs, the monitoring parameters, indicators, location of monitoring, method of monitoring and responsible agencies have been identified for updating baseline data, compliance monitoring and impact monitoring and presented in Table 10.1, to Table 10.4 respectively.. The environmental monitoring will be done by the Environmental and Social Management Unit. A study on the impact of the project on the PAFs has been proposed towards the end of the construction phase. The purpose of this study is to assess the socio-economic status and changes in the life style of PAFs.

Table 10-1**Updating of Baseline Data**

Parameters	Indicators	Method	Location	Schedule
Pre-construction stage				
Physical Environment				
River hydrology	Flow rates of river Sunkoshi River and Marin Khola	Discharge measurement	Between the weir and tailrace outlet of DK-4.	Before the construction
Possible drying of springs above tunnel alignment	Flow rates of the Springs after blasting activities	Discharge measurement	Along Tunnel Alignment	During Construction
Water quality	Temperature, pH, turbidity, TSS, DSS, hardness, Nacl, Pb, oil, grease, coli form, DO, BOD, COD, P, S, chlorophyll, etc.	Sample collection and laboratory testing	Headworks site, powerhouse site, water bodies near camp site, Muck/spoil disposal site, and labour camps	Before the construction

Parameters	Indicators	Method	Location	Schedule
Air quality	Total suspended solid particulates, SO_2, CO_2, NO_2, PM 10, etc.	Inspection and measurement	In and around construction sites and along the access road / project road	Before the construction
Biological Environment				
Separate presentation of loss of poles and trees	Enumeration of poles and trees separately	Marking the trees and poles before feeling	Project site	Before the construction
Fisheries	Size and type of fish population, identification of spawning area	Fish sampling and discussion with local fishermen.	Headworks site its downstream in Sunkoshi river and d/s of the powerhouse site in Marin Khola	Before the construction
Socio-economic and Cultural Environment				
Land, Houses and other structures	Confirmation of PAFs	Survey with personal contact.	Project site and concerned wards of Rural Municipalitys and Municipality	Before the construction
Impacts on Settlements above the Tunnel Alignment.	Impact/cracks on houses above the tunnel alignment due to basting activities	Survey with personal contact or settlement community	Along tunnel alignment (Project site)	During Construction

Table 10-2 : **Compliance Monitoring during Pre-construction Stage**

Parameters	Indicators	Schedule	Method	Agency(s) to be Consulted
Implementation of EIA recommendations	Inclusion of EPMs in the design and tender document	During approval of project implementation	Assistance to tender document preparation and detailed design.	Design consultant
	Allocation of adequate budget for implementation of EMPs	During approval	Review on budget	Design review consultant
Construction logistics	Set up labor camp by the contractors, procurement and storage of materials and arrangement for construction activities	Beginning of construction as per schedule	Site visit and confirmation	Contractor
Incorporation of environmental consideration from the tender document into contractor's proposed work plan	Inclusion of environmental consideration in the contractors work plan	During approval	Review of proposed work plan and budget	Design review consultant
Land and other property	Land/property acquisition process	During the discussion with the local people and the project management	At the time of land/property acquisition	Compensation Fixation Committee
	Rate of compensation for land and property	Once	File record, inquiry	Proponent/Compensation Fixation Committee

Table 10-3: **Compliance Monitoring during Construction Stage**

Parameters	Indicators	Location	Schedule/ frequency	Method
Physical Environment				
Slope	Quantity of disposal materials	Project site	Once a week	Inspection of Truck movement record
	Spoil bank reclamation	Site specific	Once a year (pre-monsoon)	Observation

Parameters	Indicators	Location	Schedule/ frequency	Method
	Slope protection measure	Hill slope cutting on project site	After rainy season	Field observation
	Drainage facility	Project site	As and when needed	Observation, measurement
Water quality	Temperature, pH, turbidity, TSS, DS, hardness, chloride, sodium, oil, grease , coliform, DO, BOD, P, S, chlorophyll, etc.	At headpond, in between headpond and powerhouse and downstream of powerhouse	Once in a month	Water sampling and testing and comparison to ambient standards
Air quality	TSP	Project site	Once a month	HVAS/HACH DREL
	PM_{10}	Project site	Once a month	HVAS
	SO_2	Project site	Once a month	HVAS/HACH DREL
	NO_X	Project site	Once a month	HVAS/HACH DREL
	Noise level (dBA)	Project site	Once a month	Audiometer
	Water sprinkling	Project site	At least twice in a day during dry season	Observation, inquiry
	Vehicle maintenance	Work camp	1 in 6 months	Record inspection
Biological Environment				
Fisheries	Fishing activities by work force and their families	SunkoshiRiver and Marin Khola	Once in a year	Observation and enquiry
Forest and Vegetation	Actual number of trees felled	In the project area and its vicinity by the project activities	Before construction works	Site visit, Inquiry and record inspection
	Use of kerosene or LPG/month	Work camp	Twice a year	Record, inquiry
Socio economy and Cultural Environment				
Water supply/sanitation in the project area	Health and sanitation facilities in camp(s)	Project site	Twice a year	Site visit
	No. of labor force using public drinking water tap	Settlement area	Twice a year	Inquiry
Public health	First-aid and emergency services	Project site	Twice a year	Observation
	Number and type of safety equipment such as mask, helmet, glove and ear plugs (PPE)	Project site	Once a year	Record inspection, inquiry and observation
	Information dissemination, safety and no horn signs	settlements, road bends	1 in 6 months	Observation, inquiry, record inspection
Economy	Compensation for land and property	Project site	Once	Record

Note: HVAS = High Volume Air Sampler, Envirotech, India, Model APM 441

HACH DREL 2000/USA Spectrophotometer (calibrated in NBSM) for spectrophotometric analysis, SO_2 absorber is tetrachloromercurate solution, airflow rate is 2 L/min, and running time will be 24 hrs and OHAUS/USA Model AS 120 weighing balance will be used. For NOx, absorber will be 0.1N NAOH with sodium arsenite, with airflow rate of 1.5 L/min, and running time of 24 hrs. Noise level will be measures by Audiometer, Lutron, Model SL-4010 which is calibrated in factory.

Table 10-4: **Impact Monitoring during Construction Stage**

Parameters	Indicators	Location	Schedule/ frequency	Method
Physical Environment				
Slopes	Condition of project area slopes and muck fill site	Project site	Once in 2 year	Inspection/Observation
Spoil disposal site	Functioning of compaction and drainage facilities	Disposal site	Once in 3 year	Observation and study, if necessary
Biological Environment				

Parameters	Indicators	Location	Schedule/ frequency	Method
Fisheries	Fishing and local fish in market	Local market and camp site	Once in two year	Enquiry and observation
Forest products	Use of forest products by workers and Project	Project site	Once in two years	Interview and use record
	Numbers of tea stalls and restaurant, and type of energy used	Project site	Oncea year	Inquiry, record inspection
Socio-economic Environment				
Public health	No. of workers affected from local diseases	Camp	One a year	Inquiry, information materials
	Frequency of illness of the construction workers	Project site	Twice a year	Health record
	Cases of respiratory diseases	Project site	Thrice a year	Inquiry, file record
	Type and number of accident	Project site	Once a year	File record
Economy	Effectiveness of skill development training	Project area	Once in a year	Inquiry/ Observation
	Number of construction workers employed	Project site	Once a year	Record, inquiry and observation
	Percentage of local construction laborers	Project site	Once a year	Record, inquiry and observation
	Number of women employed	Project site	Once a year	Record, inquiry and observation
	No. of outside laborers and their dependents	Project site	Once a year	Record, inquiry and observation
	Loss of agri- products and business	Project site	Once a year	Inquiry
	Impact on socio-economic condition of SFAFs and PAFs	Project area	At the end of construction period	Study
Infrastructure	Impact on local infrastructures	Project area	Once in a year	Inquiry/ Observation

Table 10-5: Impact Monitoring during Operation and Maintenance Stage

Parameters	Indicators	Location	Schedule	Method
Physical Environment				
Slopes	Condition of the spoil filled banks	Project site	Twice a year	Inspection/Observation
	Effectiveness of slope protection measures	Project site	Twice a year	Inspection/Observation
	Effectiveness of drainage facilities	Project site	Twice a year	Inspection/Observation
	Impact of reduced flow	Sunkoshi River	Twice a year	Observation
	Impact of increased flow	From powerhouse to downstream in Marin Khola	Twice a year	Observation
Noise level	Number of staff affected or loosing hearing ability	Powerhouse	Twice a year	Enquiry
Biological Environment				
Fisheries	Fish population from release of fingerlings Fish migration downstream	Inundation area, Sunkoshi River	March and September	Observation, sampling and enquiry

10.3 ENVIRONMENTAL AUDITING

An audit implies some kind of testing and verification process. It will be carried out for those parameters, which are most significant. An environmental auditing will compare monitoring results with information generated during

the pre-project period. It helps to evaluate the accuracy of EIA predictions by relating actual impacts with predicted impacts. Audit will help to understand the effectiveness of mitigation measures and understand where actual impacts have exceeded norms. Although not a mandatory and legal requirement, an internal audit study shall be carried out by the proponent in order to examine the actual environmental impacts, accuracy of predictions, effectiveness of impact mitigation and enhancement measures and functioning of monitoring mechanisms. As per the legal provision (EPR, 1997), MoFE is responsible to carry out environmental audit study after two years of commencement of project. For this, data and information of internal audit would be very much useful.

Taking into consideration the objectives, nature and location of the project, and impacts evaluated and mitigation measures proposed, project impact auditing is proposed to carry out for the following selected indicators, this impact auditing will help to examine environmental changes arising out of project implementation. The detail of environmental auditing indicators and methods is given below Table 10.6.

Table 10-6: Indicators and Methods for environmental auditing

Parameter	Indicator	Location	Methods	Sources
Physical environment				
Air quality	Total suspended matter, dust accumulation on vegetation, houses and prevalence of air borne diseases	Intake, powerhouse site and access road	TSP and Dust quality monitoring using high volume sampler, visual inspection, measurement and comparison with ambient standard	Observation and sampling
Water quality	Turbidity, TSS, DO, BOD, COD, pH, prevalence of water borne diseases, fish status	Upstream and downstream of headworks, tailrace and spoil disposal site	Inspection and laboratory analysis	Observation, measurement and sampling
Noise quality	Hearing impairment, e	Project area and powerhouse	Measurement of noise level and comparison of standards	Inspection and measurement
Erosion and slope stability	Slope failure and water turbidity	Intake, powerhouse site and surge shaft	Observation and measurement	Photographs and geo-referencing
Muck and spoil disposal	Aesthetic value, landslide and erosion, impact on agriculture and vegetation	Disposal site	Observation and interview	Photographs and inspection
Stock piling and labor camp construction	Aesthetic value, air pollution and waste pollution	Stockpiling sites and camp site	Observation and interview	Records and observation
Increased water flow	River bed scouring and erosion and bank cutting	Marin Khola	Observation and measurement	Flood protection plan, Records and observation
Biological environment				
Forest status	Change in physical condition of forest	Project and surrounding areas	Observation and measurement	Records and observation
Fish diversity and population	Abundance of fish, fish type Status of long and medium distance migratory fishes Fish farming (release of fingerlings)	Upstream and downstream of the intake site and Marin Khola	Sampling and interview to the local fisher man	Records
Socio-economic and cultural environment				
Local employment	Number of local people employed and income generation	Project affected area	Discussion with workforce	Records from project management
	Number of women employed	Project affected area	Discussion with female workforce	Records from project management
Early warning system	Installation of siren and danger signal posted system	Intake, downstream and risky area	Direct observation and discussion with local people	Records from project management
Occupational health and safety	Type of accident occurred during construction, adequacy of occupational	Project area	Direct observation and discussion with workforce	Record from project management

Parameter	Indicator	Location	Methods	Sources
	health safety measure, facilities of first aid, emergency facilities, compensation to the loss and disabled			
Health and sanitation	Cases of communicable diseases	Project site/ health post	Observation and interview	Records
Trade and commerce	Increased number of shops and tea stall, establishment of industries during construction and their regularity	Project area	Observation and interview	Observation and records
Inflation	Rise in price in daily use goods	Project area	Interview with local people	Market center
Economic condition	Change in per capita income	Local market	Interview with local people	Survey in market
Land and property acquisition and compensation	Land holding status of affected parties Use of compensated amount	Project affected families	Interview with PAFs	Records from project management

Note: Auditing parameters and indicators may be revised to be more realistic while carrying out auditing study. Indicators should be selected based on impacts occurred as this EIA report is based on best possible science-based predictive tools.

10.4 REPORTING REQUIREMENT

The ESMU of SMDMP will prepare necessary reports; particularly the environment performance reports and submits to the project management and concerned agencies. The report will also be made available to the local public to ensure the process transparent. The ESMU will prepare and disseminate monitoring report twice a year during the construction stage, and annually during the operation stage. This report will include information on the implementation status of the EPMs and monitoring results including compliance status. The ESMU will also prepare impact monitoring report on the third year of the construction stage and will circulate to the concerned organizations. The ESMU will also prepare internal audit report and may provide the report as per the request of concerned organization. It will also assist the MoFE to prepare environmental audit report for legal purpose.

10.5 BUDGET FOR ENVIRONMENTAL MONITORING

The environmental monitoring as one of the project activities will be carried out through ESMU, to be located at the Project Management Office. All environmental monitoring works of the proponent will be performed from this ESMU. The estimated cost for ESMU operation is presented in Table 10.7.

10.6 BUDGET FOR ENVIRONMENTAL AUDITING

As per the EPR, Environmental Auditing is the responsibility of the MoFE. This study has identified the auditing parameters and indicative input as well as the cost for auditing Table 10.8. As the commitment on the environment safeguard, the Proponent has provisioned for environmental cost in the Project.

10.7 TOTAL ENVIRONMENTAL AND SOCIAL COST

Table 10-7 : Estimated Cost for Environmental and Social Management Unit

S. No.	Item	Unit	Qty.	Rate (NRs)	Amount (NRs)
1	**Personal Cost**				
	Environmental Coordinator/Team Leader	months	10	300,000	3,000,000
	Environmental Monitoring Officer	months	60	150,000	9,000,000
	Socio-economist	months	60	150,000	9,000,000
	Forester/Biologist	months	10	250,000	2,500,000
	Support Staff	months	60	30,000	1,800,000
2	Per diem	days	200	2,500	500,000
3	Subsistence/housing				
	- Professional	months	120	30,000	3,600,000
2	**Air Quality and Noise Level Measurement**				0
	High Volume Sampler	no.	1	500,000	500,000
	Sound Level Meter	no.	1	100,000	100,000
	Laboratory Analysis	sample	540	3,000	1,620,000
3	Water Quality Analysis	sample	540	4,000	2,160,000
4	Office Establishment				0
	Space		60	20,000	1,200,000
	Furniture				0
	Computer and other office equipment				0
5	Office Supplies	months	60	10,000	600,000
6	Transportation Facilities Including Operation C	months			0
	Motorbikes	no.	2	150,000	300,000
	Operation of Motorbikes	months	120	10,000	1,200,000
	4 WD Jeep vehicles hire including PoL	months	10	200,000	2,000,000
7	Report Preparation	Quarterly	20	5,000	100,000
8	Facilitation Cost for inter-agency supervisor tea	half yearly	10	100,000	1,000,000
9	Impact Monitoring at the end of the Construction				3,000,000
	Total				**43,180,000**
10	Impact monitoring during operation stage	half yearly	50	200,000	10,000,000
	Total cost of monitoring				53,180,000

Table 10-8: Indicative cost for Environmental Auditing

S. No.	Item	Unit	Quantity	Rate	Amount
1	**Personal Cost**				
	Environmentalist	1	4	300,000	1,200,000
	Hydropower Engineer	1	2	250,000	500,000
	Ecologist/Forester	1	2	200,000	400,000
	Fishery Specialist	1	2	200,000	400,000
	Communication Specialist/Sociologist	1	2	200,000	400,000
	Socio-economist	1	3	200,000	600,000
	Support Staff	3	2	50,000	100,000
2	Field Perdiem		L.S		175,000
3	Vehicles and Logistic		L.S		100,000
4	Office supplies and Consumable		L.S		100,000
5	Report Production		L.S		50,000
	Sub-Total				4,025,000
	Contingencies	15%			330,000
	Grand-total				4,355,000

Table 10-9: Summary of the Cost

S N	Item/ Description	Total cost (NRs.)
1	Total project cost	46,193,965,321
2	Compensation cost	1,606,728,007
3	Benefit augumentation measures ans Mitigation measures	1,331,697,540
4	Community support programme	346,450,000
5	Environmental monitoring	53,180,000
6	Environmental Auditing	4,355,000
	Total	**49,536,375,868**

10.8 COST BENEFIT ANALYSIS OF THE PROJECT

The financial analysis of the SMDMP has been carried out to ascertain the financial viability of the scheme. The technical feasibility of the scheme has been established through study carried out on the technical aspects.

Financial evaluation uses the real term monetary values of the cost and benefits and is inclusive of taxes, transfers, duties and escalation. The financial evaluation concerns with the developer of the project and its impact on its accounts. Hence, from the perspective of a private developer, financial evaluation is the most important aspect of the project to determine whether to finance it or not.

Wherever possible, the financial analysis has been carried out based on known information. Where financial parameters are not known they have been estimated by extrapolation from known data or reasonable assumptions have been made. These assumptions are, on the whole, conservative estimates and figures considered to be realistic and standard for analysis of this nature.

The financial analysis consists of a cash flow during the project life, a financial evaluation, which suggests the Net Present Value (NPV), a Benefit Cost (B/C) ratio and the Internal Rate of Return (IRR) on project and equity.

10.8.1 Assumptions

A financial analysis has been carried out based on following assumptions:

- Capital cost for project is NRs.46,193,965,321.00 with installed capacity 28.62 MW

- The project is expected to be completed within 5 years after commencing construction
- Project life is 35 years
- Annual operation and maintenance cost is estimated at 1.25% of the capital cost
- Average interest rate and discount rate are assumed 8% fixed
- Loan payment period will be 12 years from the time of generation and
- Tax and royalty has been allocated as per current electricity act

Table 10-10: Result of financial analysis

SN	Economic indicator	Value
1	Total Project cost	NRs. 46,193,965,321.00
2	B/C ratio	1.94
3	IRR in project percentage	17.05
4	NPV	NRs. 55,095,220,000.00

Based on this analysis, cost-benefit ratio is 1.94 with 17.06 percent of the internal rate of return. Hence, the project is financially beneficial and viable.

10.9 Public Grievance Redress Management Plan

The project will establish grievance redress mechanism to allow the project affected persons and community to appeal against any disagreeable decisions, practices and activities arising from compensation for land and assets, technical and general project-related disputes. The ESMU will be responsible for redressing general public grievance. Grievance recording register will be established at the SMDMP site offices and all grievances, filed orally or in writing, will be registered. At local level, a Grievance Redress Committee (GRC) will be formed with involvement of Environment and Social Officer and representatives from Concern Committee (CC), if any, Rural Municipality and Contractor in advance in order to address the grievances of local people. The central project level GRC will comprise of Project Manager, Chief District Officer (CDO) and Chairman of the Concern Committee. The CDO and the Chairman of CC will be the independent members of this Committee. It will look after the grievances that cannot be resolved at the site by ESMU or local level GRC.

CHAPTER – 11

11 CONCLUSIONS

The project will inundate 312 ha of different categories of land due to the construction of barrage and will have significant impacts on the private property and insignificant impact on public property. People have positive response for the project even by the affected people and communities. Cash compensation for the acquisition of land, property and crops, relocation and reconstruction has been proposed for the project-affected people and structures.

The project will generate 250.594 GWh of annual average energy, out of which 125.004 GWh would be generated in dry season and wet season energy would be 125.691 GWh. The project would be main means of providing irrigation water to 122,000.00 in five districts of Province 2 in terai. In the present context when the country is facing food decifit and importing the food grains, year-round irrigation facilities to the available cultivated land is the need of the country.

The hydropower component of the SMDMP is the secondary benefit of the project, Though the cost per MW is estimated to NRs 1,614,044,910.00, the detailed feasibility study of the project has concluded that the overall project is economically viable with EIRR of 17.04 % and B/C ration of 1.94. The Government of Nepal has declared the project as one of the national priority projects.

Taking into consideration the nature of project, its location, people's positive response, evaluated environmental impacts and practical mitigation measures, including existing policies and laws on water resources utilization and the environment, this project is recommended for implementation on environmental ground. No further environmental study will be required for project clearance and implement the project. The proponent commits to implement appropriate mitigation measures for all unforeseen environmental impacts identified, if any, during the construction and operational stages of this project to make the project environment-friendly and sustainable as well.

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