Survey Department
Ministry of Land Management, Cooperatives and Poverty Alleviation (MLMCPA)
Federal Democratic Republic of Nepal

THE PREPARATORY SURVEY REPORT FOR THE PROJECT FOR THE DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO IN THE FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

MARCH 2020

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

AERO ASAHI CORPORATION
YACHIYO ENGINEERING CO., LTD.
PASCO CORPORATION

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Preface

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to a joint venture which consist of AERO ASAHI CORPORATION and YACHIYO ENGINEERING CO., LTD. and PASCO CORPORATION.

The survey team held a series of discussions with the officials concerned of the Government of the Federal Democratic Republic of Nepal, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Federal Democratic Republic of Nepal for their close cooperation extended to the survey team.

March, 2020

Itsu ADACHI
Director General,
Infrastructure and Peacebuilding Department
Japan International Cooperation Agency

Summary

1. Outline of the Country

The Federal Democratic Republic of Nepal (hereinafter referred to as “Nepal”) had a population of 26.49 million people in 2011 (Population Census of 2011). The population increased at the rate of 1.14 %/year between 2001 (the year of the previous census) and 2011. Nepal has an area of approx. 147,000 km^2, approx. 1.8 times the area of Hokkaido in Japan. Terai Region in the south, in which the Project site of the Project is located, occupies 17 % of the total land area of Nepal and approx. half of its people live in this region.

Although Nepal had been politically unstable after the Maoists began armed struggle in 1996, the government and Maoist concluded a comprehensive peace agreement in 2006 and the general election for the Constituent Assembly was held in April 2008. The First Constituent Assembly held in May 2008 declared the transition of Nepal from a monarchy to a federal republic. Following the declaration, the drafting of a new constitution began. However, the deadlock among political parties delayed the drafting process significantly. However, following the earthquake in May 2015, major political parties recognized the importance of the establishment of a constitution for the reconstruction of the country from the earthquake disaster and accelerated the establishment process. A new constitution was promulgated in September 2015. The Chairman of the Communist Party of Nepal (Unified Marxist-Leninist) (CPN-UML), KP Sharma Oli, was elected as Prime Minister in a parliamentary vote on October 11, 2015 and a new government was formed on the following day. Nepal is in the period of transition from the centralized government to decentralized federalism.

GDP and the per capita GDP of Nepal are approx. USD 28.8 billion and USD 1,004, respectively (Fiscal 2017/2018). Because of this figure of per capita GDP, Nepal is classified as a least developed country (LLDC). Its main industries are agriculture and forestry, which accounts for approx. 28.9 % of its GDP. Approx. two-thirds of the working population are engaged in agriculture. The other main industries include trade, retail, transport and telecommunications industries.

The economy of Nepal has grown steadily. Looking at the change in GDP growth rate during the past 10 years, despite the growth rate dropped to 0.6 % in Fiscal 2015/2016 due to the damage caused by the earthquake, it increased in the following years, 8.2 % in Fiscal 2016/17 and 6.7 % in Fiscal 2017/18, which are higher than the average growth rate before the earthquake of approx. 4.6 %. This fact is regarded as a sign of economic growth.

2. Background and Outline of the Project

Nepal is regarded not only as a country with many natural disasters, including floods, earthquakes and landslides, but also as a disaster-vulnerable country because its people are likely to be affected by natural disasters due to the lack of appropriate infrastructure for disaster prevention. A study of the characteristics of past natural disasters reveals that floods have affected the largest number of people among all types of natural disasters, which have occurred most frequently second to fire. In the rainy

season, torrential rain occurs in a large area and the rain has always caused serious flood damage in the southern plains at low altitude (hereinafter generically referred to as “Terai Region”). The heavy rainfall in 2017 caused particularly large floods in the entire Terai Region and more than 200 people were killed or went missing in the floods. The floods also caused economic damage worth USD 584 million.

The Government of Nepal enacted the Disaster Management Act in October 2017 as a goal to strengthen its disaster prevention administration and to facilitate the formulation and implementation of relevant policies and plans. The government formulated the Disaster Risk Reduction Policy and Disaster Risk Reduction Strategy in June 2018 in accordance with the purpose of the act. As one of its purposes, the policy holds up the reduction of disaster risk with the improvement of the accuracy of weather forecast, establishment of a flood forecast and warning system and creation of flood hazard maps. Based on this policy. The Government of Nepal is installing weather radars and establishing a flood early forecast and warning system.

Under these circumstances, in 2019 the Government of Nepal requested the Japanese government for grant aid assistance for the project to develop digital elevation model and orthophoto (hereinafter related to as “the Project”). The objective of the Project is to improve the accuracy of planning required for countermeasures against flooding in the Terai Region and to contribute to reduction of flood damage, by developing a high accuracy digital elevation model.

3. Outline of the Preparatory Survey and Contents of the Project

At the request of the Nepal government, the Japan International Cooperation Agency (JICA) has decided to conduct a survey for a project to develop a digital elevation model and orthophotos in Nepal. The 1st field survey was conducted from 8th September, 2019 to 10th October. The 2nd field survey was conducted from 1st December, 2019 to 10th December. In the outline design of the Project, the optimal plan was formulated as a result of repeated discussions with the Nepali side on various aspects such as technical aspects, cost aspects, maintenance capability, etc., based on the results of various studies from scoping implemented in the first field survey and other detailed surveys implemented in the second field survey. The outline of the Project components is shown below.

Outline of the Project Components

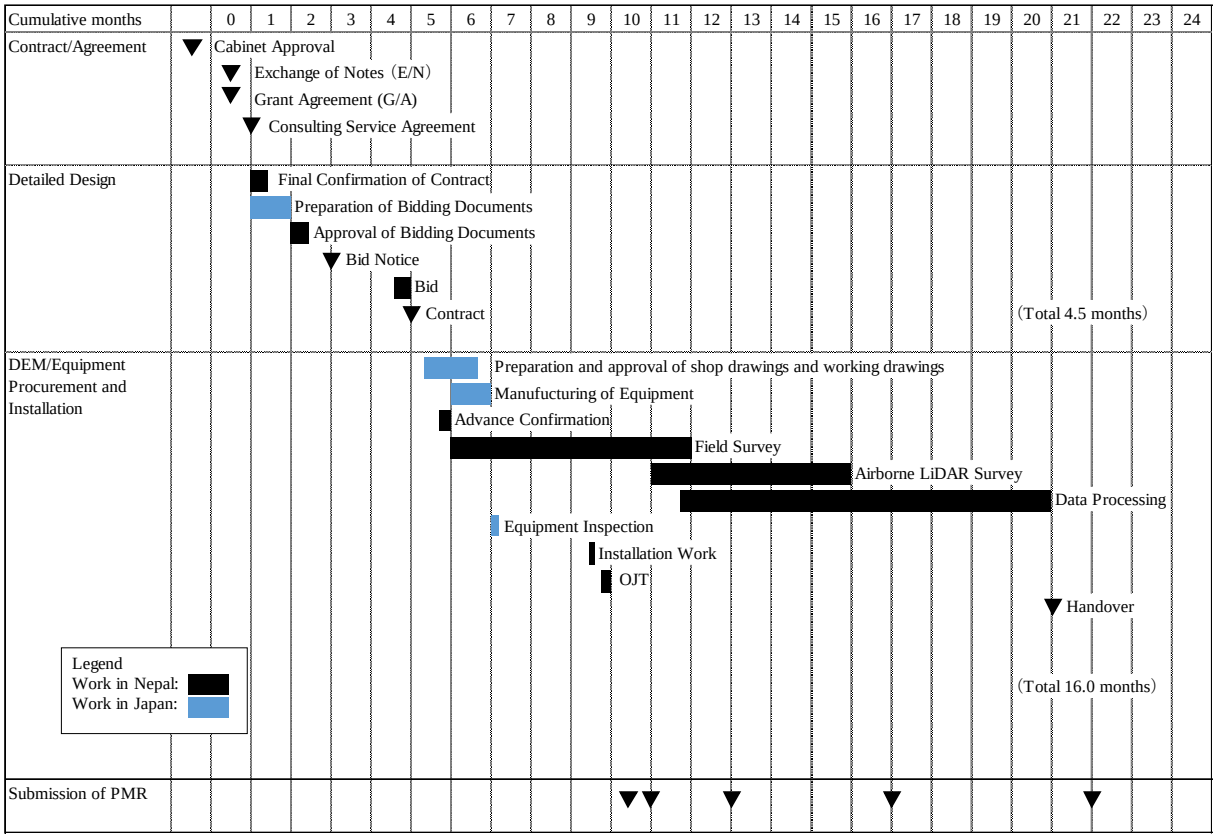
Item	Details
Contents of Procurement	1. DEM 1 set (of an approx. 15,000 km² area, mesh spacing 1 m) 2. Orthophotos (of an approx. about 15,000 km² area, GSD: 15 cm) 3. Computers for data processing and viewing 4. Software for the computers 5. Drones for photogrammetry
Contents of the consulting services / soft components	Detailed design, tendering assistance, supervision of procurement / establishment of DEM maintenance capacity, strengthening the system for use of DEM

Source: JICA Project Team

4. Implementation Schedule

The project implementation schedule prepared based on Japan's Grant Aid Guidelines is shown below. The required construction period of the Project is about 4.5 months for detailed design, about 16 months for digital elevation model / equipment procurement and installation, and about 20.5 months in total. The total project cost in Nepali side is about 5,445 thousand NRP. These mainly includes bank transaction fees and tax exemptions / refunds, equipment storage warehouse costs, temporary office costs, and soft component seminar venue costs.

Project Implementation Schedule



Source: JICA Project Team

5. Project Evaluation

(1) Relevance

By producing a high accuracy DEM in the Terai Region of Nepal, the Project will contribute to development of new large-scale topographical maps, and updating of existing topographical maps that will be used as basic data for disaster risk management represented by hazard maps and/or infrastructure development. Therefore, it is expected to contribute to the expansion of economic growth which will provide benefits for the people of the Terai Region.

This project is considered to be a precursor to a seven-year plan for the creation of a DEM for the whole national land of Nepal that is currently being planned, so it is expected to contribute to the long-term plan for the national land of Nepal.

(2) Effectiveness

Implementation of the Project is expected to generate the effects shown below. The reference value is the value in 2018 before the implementation of the Outline Design Study, and the target value is three years after the completion of the Project.

Quantitative Effects obtained by Implementation of the Project

Indicator	Standard value (recorded value of 2018)	Target value (2025)
DEM grid spacing (m) (or, contour interval (m))	50 (10)	1 (0.5)
Vertical accuracy (m)	5	0.25
Total area covered by large-scale maps (km^2)	0	300
Number of times of distribution of DEM data	0	15
Number of times of distribution of orthophoto data	0	15
Total area covered by hazard maps (km^2)	0	500

Source: JICA Project Team

The qualitative effects expected to be realized by the implementation of the Project are as follows.

- Updating of Existing Topographic Map Data.

  For the Terai Region, a 1: 25,000 topographic map is expected to be updated in parallel with the 1: 5,000 topographic map creation. Also, in addition to the modifications accompanying development, etc., floods, landslides, and other changes also involve terrain changes, so continuous updating of topographic map data is required. Since the photogrammetry technology using drones is acquired in the Project, it is expected that existing topographic map data can be updated not only in the Terai Region but also throughout the country.

- Improved Disaster Awareness of Relevant Organization and People

  A seminar for approx. 60 staff members of potential user organizations shall be held and the teaching materials and pamphlets of the seminar shall be prepared in the “Soft Component” of the Project. Through these, public relations education activities are expected to spread from the Survey Department to the relevant ministries and agencies, local governments, and even the residents, thereby raising awareness of disaster prevention.

- Improvement the Accuracy of Identification of Expected Flood Area

  By using a detailed DEM, inundation simulation and calculation of area to inundate and inundation depth are possible, consequently, reflecting this, it is expected that the accuracy of hazard maps will be improved and appropriate evacuation plans will be formulated.

- Flood control candidate sites such as embankment strengthening points and flood control reservoirs can be narrowed down

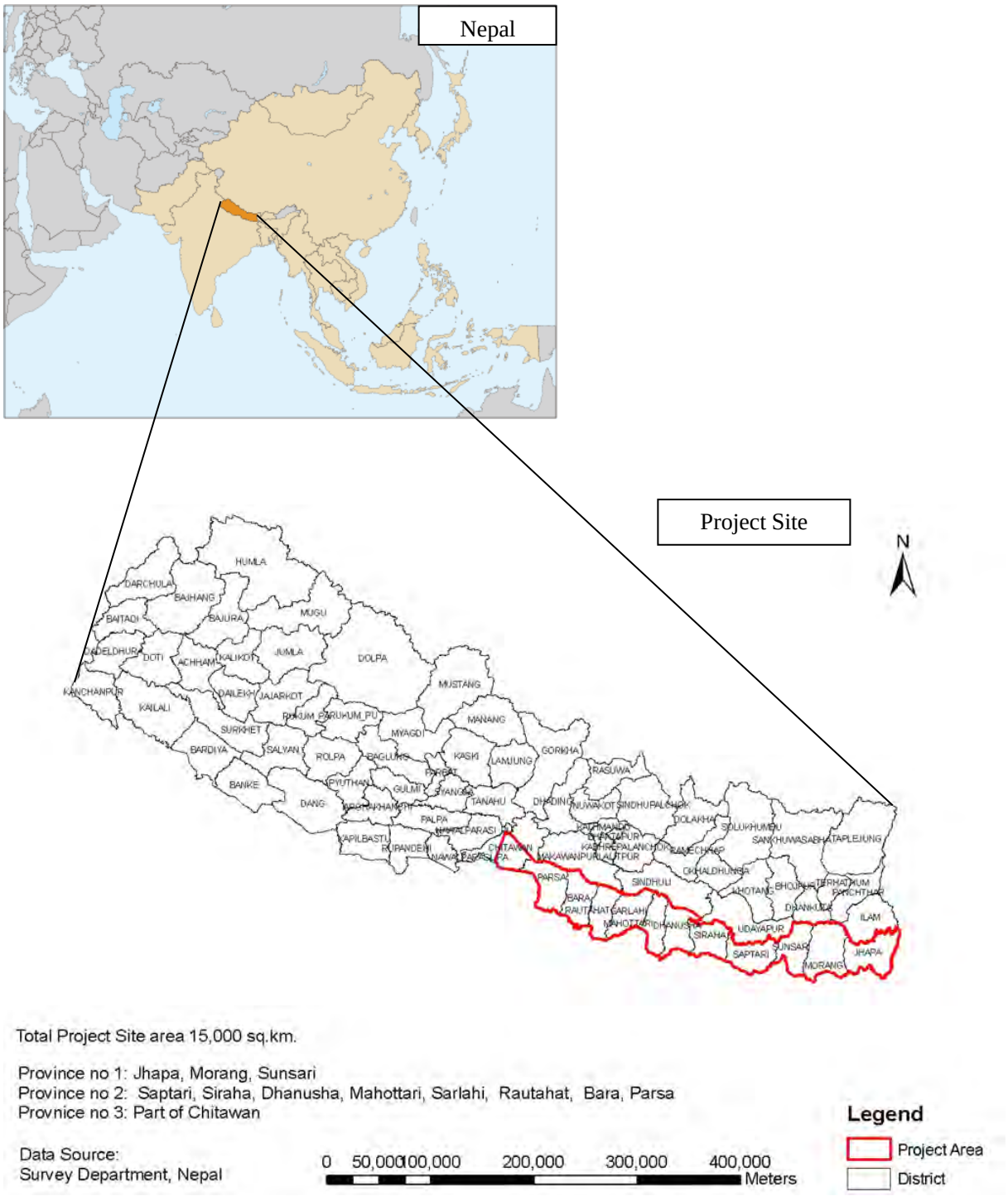
  It is expected to be used for disaster prevention measures, such as identification of danger of breach of levees, prioritization of countermeasure work, selection of candidate sites such as flood control reservoirs, etc. based on flow simulations during river flooding and detailed

topography such as levees.

- Use in Plans for Infrastructure Development (roads, railways, irrigation canals, etc.)
  The detailed topographic data and orthophotos to be created in the Project and the 1/5,000 topographic map data to be created consequently from them are essential for the preparation and implementation of infrastructure development plans and the provision of such data is expected to facilitate the infrastructure development in the Terai Region.

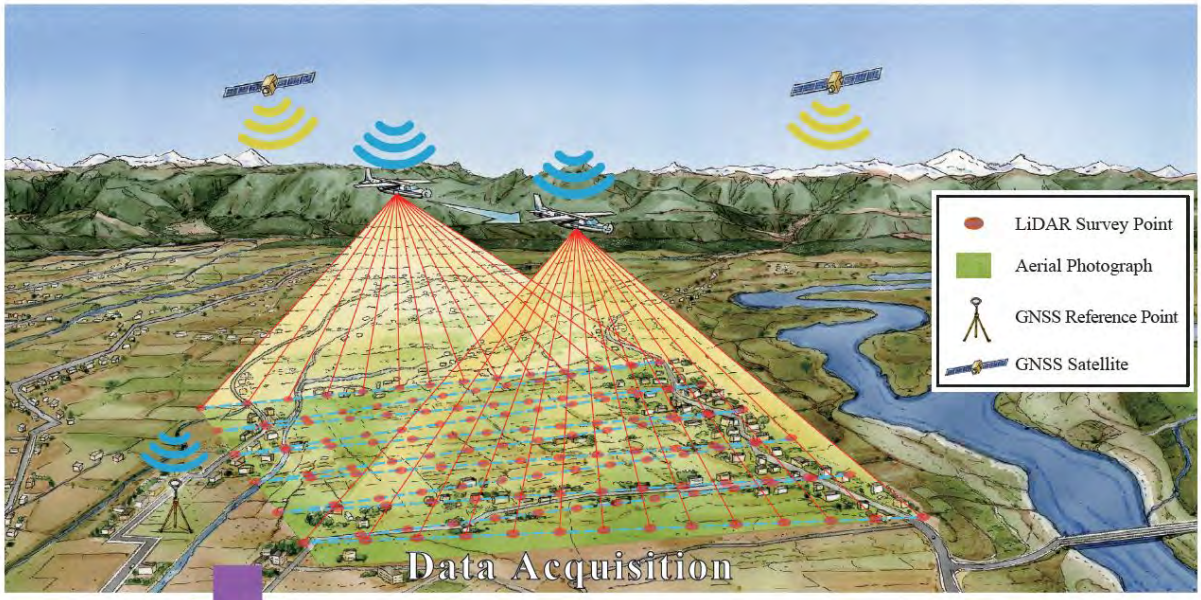
Contents

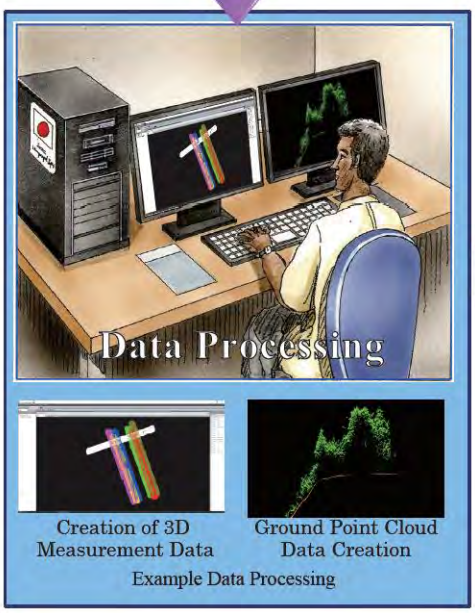
Location Map

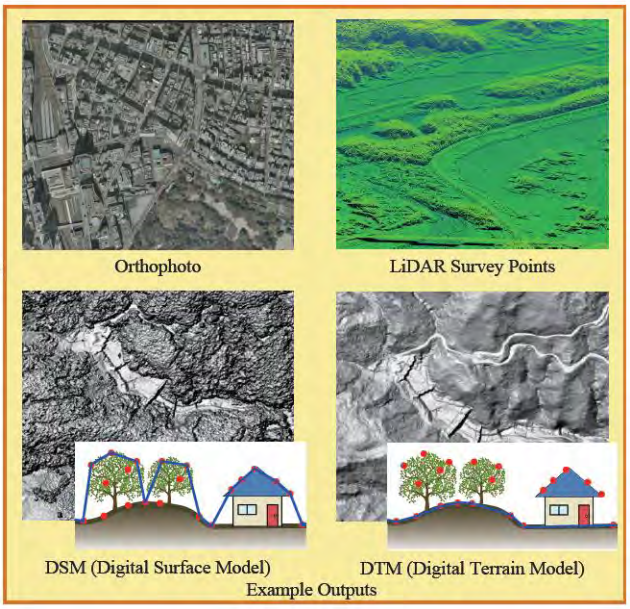


Source: Prepared by JICA Project Team based on data published by MLMCPA

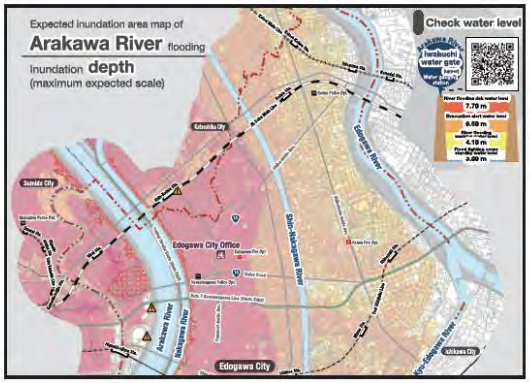
Perspective



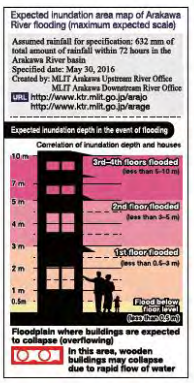




Examples of Utilization



Flood Hazard Map[1]



Cross Section View[2]

[1] Source：Edogawa City Flood Damage Hazard Map：https://www.city.edogawa.tokyo.jp/e007/bosaianzen/bosai/kanrenmap/n_hazardmap.html

[2] Source：Geospatial Information Authority Of Japan (GSI)

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Abbreviations

A/P	Authorization to Pay
ADB	Asian Development Bank
AGB	Above Ground Biomass
B/A	Banking Arrangement
B/L	Bill of Lading
CPU	Central Processing Unit
DAC	Development Assistance Committee
DHM	Department of Hydrology and Meteorology
DMD	Disaster Management Division
DMG	Department of Mines and Geology
DOR	Department of Road
DSM	Digital Surface Model
DTM	Digital Terrain Model
DWRI	Department of Water Resource & Irrigations
E/N	Exchange of Note
EIAJ	Electronic Industries Association of Japan
FDS	Flight Data Storage
G/A	Grant Agreement
GIID	Geographical Information Infrastructure Division
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GSD	Ground Sample Distance
ICIMOD	International Centre for Integrated Mountain Development
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITU	International Telecommunication Union
IMU	Inertial Measurement Unit
JCS	Japanese Cable Makers' Association Standard
JEAC	Japan Electric Association Code
JEC	Japanese Electrotechnical Committee
JEM	Japan Electrical Manufacturers’
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JPY	Japanese Yen
M/M	Man Month
MLMCPA	Ministry of Land Management, Cooperatives and Poverty Alleviation

NDRRMA	National Disaster Risk Reduction and Management Authority
NWRRDC	National Water Resource Research and Development Center
NEA	Nepal Electricity Authority
NPR	Nepali Rupee
PC	Personal Computer
PDOP	Position Dilution of Precision
PSP	Permanent Sample Plot
TIN	Triangulated Irregular Network
TV	Television
USD	United States Dollar
UTM	Universal Transverse Mercator
VAT	Value Added Tax
WECS	Water and Energy Commission Secretariat

Chapter 1 Background of the Project

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1-1 Background and Outline of Grant Aid Assistance

The Federal Democratic Republic of Nepal (hereinafter referred to as "Nepal") is sandwiched between India and China. The establishment and stability of democracy, as well as peacebuilding in Nepal are important in ensuring the stability of the entire southern Asia, an area which is politically and economically important. Therefore, Japan has long been assisting Nepal as a major donor.

Nepal is regarded not only as a country with many natural disasters, including floods, earthquakes and landslides, but also as a disaster-vulnerable country because its people are likely to be affected by natural disasters due to the lack of appropriate infrastructure for disaster prevention. A study of the characteristics of past natural disasters reveals that floods have affected the largest number of people among all types of natural disasters, which have occurred most frequently second to fire. In the rainy season, torrential rain occurs in a large area and the rain has always caused serious flood damage in the southern plains at low altitude (hereinafter generically referred to as "Terai Region"). The heavy rainfall in 2017 caused particularly large floods in the entire Terai Region and more than 200 people were killed or went missing in the floods. The floods also caused economic damage worth USD 584 million[1].

The Government of Nepal enacted the Disaster Management Act in October 2017 as a goal to strengthen its disaster prevention administration and to facilitate the formulation and implementation of relevant policies and plans. The government formulated the Disaster Risk Reduction Policy and Disaster Risk Reduction Strategy in June 2018 in accordance with the purpose of the act. As one of its purposes, the policy holds up the reduction of disaster risk with the improvement of the accuracy of weather forecast, establishment of a flood forecast and warning system and creation of flood hazard maps. Based on this policy, the Government of Nepal is installing weather radars and establishing a flood early forecast and warning system.

The Terai Region is the contact area of transportation and logistics with India and an industrial area where factory construction is concentrated. Even though the region is particularly prone to flood disasters, an accurate flood hazard map of the region has not been created. To create such a map and promote its use for flood damage mitigation and development of the early warning system, the Government of Nepal urgently needs to introduce a high-accuracy digital elevation model (DEM) of the region, which can be the base of such hazard map for identification of detail flood risk areas. Being able to understand flood risks more accurately will enable effective prevention of floods and flood damage, and be expected to contribute to the economic prosperity and the improvement of economic connectivity in the region.

Under these circumstances, in 2019 the Government of Nepal requested the Japanese government for grant aid assistance for the project for the development of digital elevation model and orthophoto

[1] National Planning Commission (2018), Post Flood Recovery Needs Assessment 2017 : https://www.npc.gov.np/images/category/PFRNA_Report_Final.pdf

(hereinafter referred to as “the Project”). The objective of the Project is to improve the accuracy of planning required for countermeasures against flooding in the Terai Region and to contribute to reduction of flood damage, by developing a high accuracy digital elevation model.

In the outline design of the Project, the optimal plan was formulated as a result of repeated discussions between a survey team (hereinafter referred to as “JICA Project Team”) and the Nepali side on various aspects such as technical aspects, cost aspects, maintenance capability, etc., based on the results of various studies from scoping implemented in the first field survey and other detailed surveys implemented in the second field survey. Table 1-1 shows the outline of the Project components.

Table 1-1 Outline of the Project Components

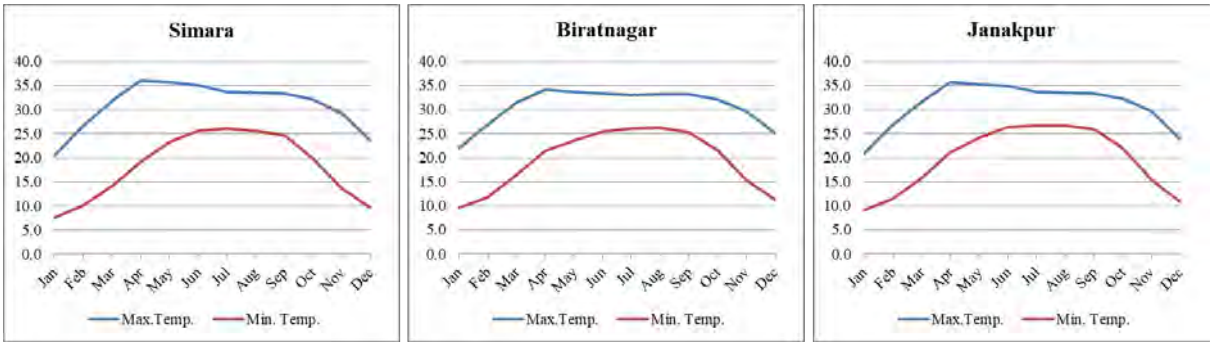
Item	Details
Contents of Procurement	1. DEM 1 set (of an approx. 15,000 km² area, mesh spacing 1 m) 2. Orthophotos (of an approx. about 15,000 km² area, GSD: 15 cm) 3. Computers for data processing and viewing 4. Software for the computers 5. Drones for photogrammetry
Contents of the consulting services / soft components	Detailed design, tendering assistance, supervision of procurement / establishment of DEM maintenance capacity, strengthening the system for use of DEM

Source: JICA Project Team

1-2 Natural Conditions

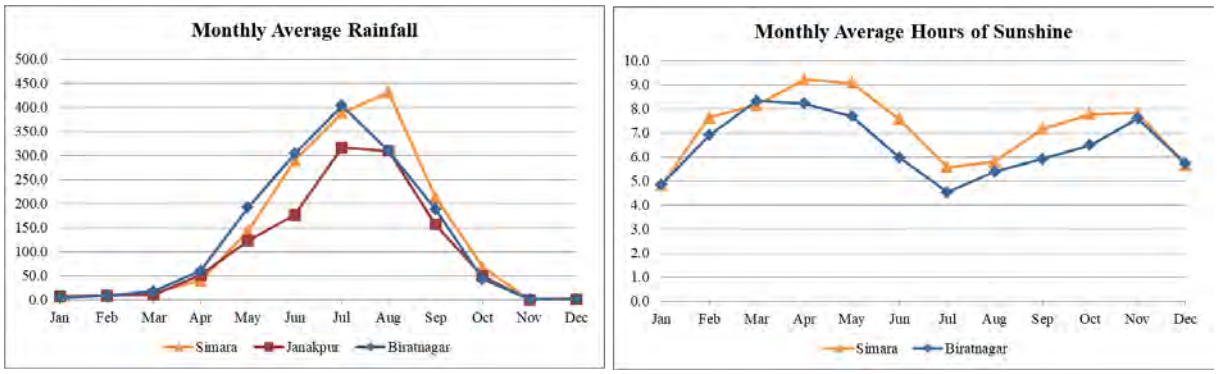
(1) Climate

Figure 1-1 and Figure 1-2 are graphs showing the climate throughout the year at the local airports in the Terai Region. From the monthly average precipitation and the average sunshine hours, the amount of precipitation in dry season is low from October to May. Sunshine hours in the dry season are shorter in December and January. Also, the period when there are few leaves on the trees and little vegetation on the cultivated land that would obstruct the measurement of the topography is around December to June. Therefore, based on weather and vegetation conditions, the suitable period for measurement was assumed to be around February to June.



Source: Prepared by the JICA Project Team based on data from the Department of Hydrology and Meteorology

Figure 1-1 Monthly Maximum and Minimum Temperatures (in the past 10 years) in the Terai Region (Simara, Janakpur, Biratnagar)



Source: Prepared by the JICA Project Team based on data from the Department of Hydrology and Meteorology

Figure 1-2 Monthly Average Rainfall and Hours of Sunshine (in the past 10 years) in the Terai Region (Simara, Janakpur, Biratnagar)

(2) Topography

The national land of Nepal is 885 km long in the east-west direction and 193 km in the north-south direction, and within this area the topography is complex and changes rapidly from the Himalayan peaks to plains at an elevation of 70 m above sea level. The plains in the Terai Region in the southern part of Nepal[2], which is the target area for the Project, comprises about 17% of the national land area. And, the majority of the Terai Region consists of Quaternary alluvial strata, which is soft ground containing gravel, sand, clay, etc.

(3) Flooding

During the rainy season from June to September, monsoons developed in the Bay of Bengal have caused heavy rainfall in Nepal. Flooding occurs in the Terai Region almost every two years, which greatly changed the riverbed each time. In July 2019 flooding was caused by the monsoon torrential rains, and according to the Nepal Ministry of Home Affairs, 117 people were killed and 38 left missing by floods and landslides. Particularly the Terai Region was badly damaged. It has been reported that farmlands and towns and villages have been damaged by flooding, roads and cars have been submerged, houses have been flooded and so on[3].

1-3 Environmental and Social Considerations

(1) Environmental Impact Assessment

The content of the Project is airborne LiDAR surveying including aerial photography, and the laser light used for airborne LiDAR surveying does not adversely affect humans, animals, etc. And, ground reference stations and control points are surveyed in the field work, but there is no effect given to the natural and social environment at and around the target site.

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[2] Central Bureau of Statistics (CBS), Nepal in Figures 2019：
https://cbs.gov.np/wp-content/upLoads/2019/07/Nepal-in-Figures-2019.pdf

[3] United Nations, Nepal: Monsoon Update (as of 28 July 2019):
https://floodresilience.net/resources/item/july-2019-nepal-floods-need-assessment-report

(2) Land Acquisition and Resettlement of Residents

The content of the Project is as described above, therefore, there is no need for land acquisition and resettlement.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

The purpose of the Project is to improve relevance of a flood prevention plan in the Terai Region, which is the part of Nepal that is most vulnerable to flood damage, with the development of a high accuracy DEM and orthophotos by airborne LiDAR survey, and to contribute to constructing a disaster prevention system for the mitigation of flood disaster.

The overall goal of the Project is consistent with the development issues and policies of Nepal as well as the development assistance (ODA) policy of Japan with respect to Nepal. It is considered that the Project will contribute to SDG goal 9 (to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation) and goal 11 (to make cities and human settlements inclusive, safe, resilient and sustainable), so the necessity for implementation of the Project is high.

Table 2-1 presents an overview of the Project as confirmed with Nepal in the Project.

Table 2-1 Overview of the Project

Contents of request	
Request Year	2019
Requested Implementation years	April 2020 to March 2022
Project Title	Project for creating high-resolution orthophotos and digital models enabling planning of infrastructure development and development of disaster resilience in Province No.2 in the Federal Democratic Republic of Nepal
Project Outline	
1. Project Type	Grant aid assistance
2. Overall Goal	Reduction of flooding damage in the Terai Region of southern Nepal
3. Project Purpose	Development of high accuracy digital elevation model and orthophotos
4. Project Site	Eastern Terai Plains in Nepal
5. Deliverables	➢ Digital elevation model (DSM, DTM） (approx. 15,000 km^2 area) ➢ Raw LiDAR data (approx. 15,000 km^2 area): ➢ Contour data (0.5m interval, approx. 15,000 km^2 area) ➢ Aerial photography data (Red, Green, Blue, IR） ➢ Orthorectified aerial photography data (15 cm GSD, Red, Green, Blue, IR) ➢ Orthophotos (15 cm GSD, Red, Green, Blue, IR） ➢ Reports ➢ Flight plan ➢ Index map
6. Project Components	➢ DEM creation (for High resolution DEM and orthophotos) ・ Field Survey ・ Airborne LiDAR Survey ・ Data Processing ➢ Procurement of the Equipment ・ Personal computer and monitor ・ Drone for Photogrammetry ・ Software ・ UPS ➢ Installation works of the Equipment ➢ Initial operation and maintenance trainings by the Supplier ➢ Consulting Service ・ Detailed Design, Bedding and Supervision ・ Assistance in the start-up or operation and maintenance (Soft components) - Data maintenance/management and updating DEM for natural and/or artificial

	change of topography - Promotion of data utilization

Source: JICA Project Team

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

The JICA Project Team prepared the contents of the assistance in accordance with the policies mentioned below in consultation with the Survey Department.

① The Project area shall be Eastern Terai Region, adjacent to the area in Western Terai Region where the Survey Department is to create DEM and orthophotos.

② There is demand for digital elevation models (DEM) for the mitigation of flood damage and the operation of early warning systems. As the detailed information of estimated inundation areas is required to satisfy the demand, 1 m x 1 m grid DEM, on which micro-topography can represented, shall be created.

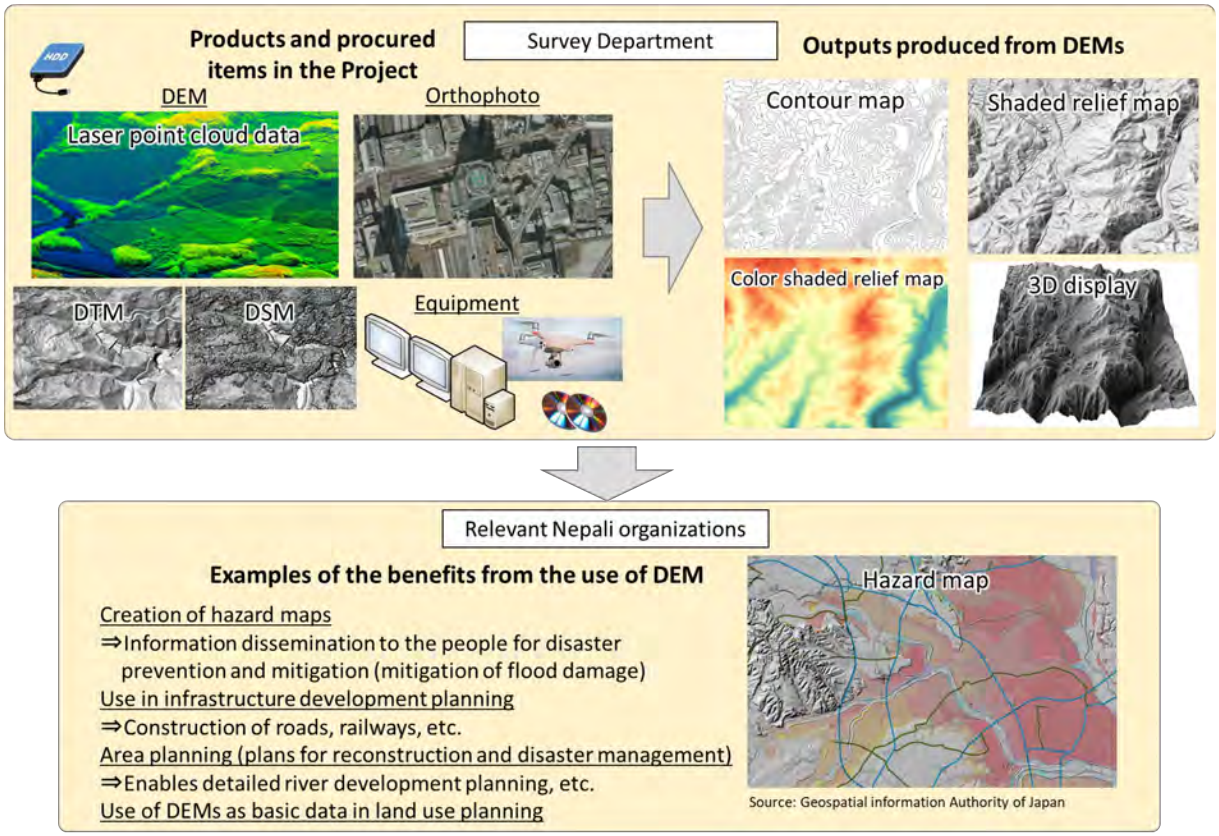
③ The airborne LiDAR survey shall be conducted with a point density of 4 points/m^2, which is necessary and sufficient to create 1 m x 1 m grid DEM and able to capture ground laser reflection without failure mostly.

④ As large-scale topographic maps required for the creation of hazard maps are not available, orthophotos with GSD of 15 cm shall be created and be used instead of the maps. As for the equipment procurement plan, in view of improving efficiency of the work, the equipment that can be used for both LiDAR and aerial photography has been selected. The created orthophotos are expected to be used for the creation of large-scale topographic maps in future.

⑤ Because there are not many continuously operating reference stations (CORS) in the Project site, ground GNSS reference stations shall be established for airborne LiDAR Survey. These stations shall be used for the kinematic positioning, which shall ensure the accuracy of coordinate data (latitude, longitude and height) captured by a GNSS/IMU system mounted on an aircraft. A height obtained in the GNSS observation is an ellipsoidal height and, to convert it into an elevation, the height must be corrected by a geoid height. A geoid model of Nepal required for the correction has not been developed. Therefore, leveling shall be conducted in the Project to create a simple geoid model of the Project site.

⑥ In order to promote the use of the created DEM, it is supposed that if the Survey Department, the implementing agency of the Project, does not have enough knowledge how to use them, the use of the model is not likely to be extended to other organizations. To prepare an environment in which staff of the department can use DEM, for example, for the production of thematic maps, by

themselves, equipment for and technical training on the use of DEM shall be provided to the department. As the models need to be revised for topographic changes over the years, equipment for and training on data analysis and processing required for partial modification of DEM shall also be provided to the department.



Source: JICA Project Team

Figure 2-1 Schematic Diagram of Outline Design of the Project

(2) Policies with respect to Natural Conditions

1) Meteorological Conditions

In Terai Region, the rainy season is between June and September and the dry season is between October and May. The time with small precipitation and a long sunshine duration, *i.e.*, the dry season, is a good time to conduct airborne LiDAR Survey and aerial photography. In addition, the time after leaf-fall and harvest is optimal for LiDAR Survey because the laser ray is more likely to reach the ground surface when trees have no leaves and there is no crop in fields. With the fact that haze (mist and fog) rises more often between December and February than the other months in the Terai Region and the time of leaf-fall and harvest in the region taken into consideration, the period between March and May is considered the best time for airborne LiDAR Survey and aerial photography. As bad weather could reduce the opportunities of LiDAR Survey and photography, the flight period shall be extended forward and backward by a month to ensure that the planned work can be completed. Therefore, the survey flight shall be conducted in the period between February and June.

2) Floods

In the rainy season between June and September, the monsoon developed over the Bay of Bengal brings a large quantity of rainfall to Nepal and the heavy rain causes floods in the Terai Region almost every other year. Approx. 80% of the floods and landslides occurred since 1998 have been concentrated in July and August. Therefore, field survey work shall not be implemented in these months to assure safety. As floods change the topography of riverbeds, revision of DEM after the Project might be considered.

(3) Policy with respect to Social Conditions

Public offices and banks in Nepal are closed on Saturdays because Saturdays are non-working days in Nepal. As the Vikram Samvat (calendar) is used in Nepal, a Nepali holiday falls on different days on the Gregorian calendar in different years. As Nepal has long holiday seasons, such as Dashain and Tihar, such holiday seasons shall be considered when a work schedule is planned.

(4) Policy with respect to Survey Work and Quality Control

To make DEM, the main outputs of the Project, used effectively in disaster management, the accuracy and quality of the output data must be assured. As a DEM is numerical data consisting of arrays of elevation values, it is not possible to evaluate its accuracy only by looking at it. Therefore, a method to guarantee the accuracy and quality of the final outputs by stipulating the work methods and equipment to be used in each process and evaluating the accuracy in a verification survey and inspection of the quality control sheets shall be used in the Project. The Contractor shall perform the prescribed accuracy and quality control by performing the work in accordance with the work rules that stipulate these work methods and the accuracy standards. The Consultant shall inspect the accuracy and quality of the outputs as required. As Nepal does not have its own LiDAR survey standards, the relevant provisions of “Standards for Operating Specifications for Public Surveying” (Notification Number 413 of March 31, 2008, the Ministry of Land, Infrastructure, Transport and Tourism, Japan) which are used in the public survey in Japan, shall be followed in the Project.

(5) Policy with respect to Airborne LiDAR Survey

Airborne LiDAR survey shall be conducted in the five-month long period between February and June based on the meteorological conditions in the Project site.

The sunshine hours in the Terai Region in the five-month period between February and June is similar to that in the Kanto region of Japan in January. For example, the average sunshine hours in January in Tokyo in the Kanto region (over the period between 2009 and 2019) is 6.7 hours/day. Table 2-2 shows the monthly average sunshine hours (over the period between 2009 and 2017) at two airports in the Project site, Simara and Biratnagar Airports, between February and June. The values in the table indicate that the average sunshine hours at Simara and Biratnagar Airports in the period are 8.34 hours/day and 7.42 hours/day, respectively. Because these average sunshine hours are longer than that

in Tokyo in January, it is reasonable to assume that LiDAR survey and aerial photography can be performed in the Terai Region in the five-month period at least at the same rate as in Tokyo in January.

The number of days on which LiDAR data acquisition can be performed in Tokyo in January is 15, according to the "Table of Numbers of Days on which LiDAR data acquisition can be Performed" in the "Standard Man-Days in Survey Work" of the "Design Cost Estimation Standards" edited by the Ministry of Land, Infrastructure, Transport and Tourism of Japan. Based on this number and the discussion in the previous paragraph, the assumption that LiDAR data acquisition can be conducted every other day on average shall be used in the planning of LiDAR survey in the Project.

On the assumption that LiDAR data acquisition is conducted four hours a day and an area of 150 km^2 can be surveyed in a day, the net number of flight days required to survey the entire project site of 15,000 km^2 is estimated at 100 days (= (area of the Project site): 15,000 km^2 / 150 km^2/day). As LiDAR data acquisition is to be performed every other day, the gross work period will be 200 days, or 6.6 months. As the period between February and June was shorter than 200 days, it was decided to use two aircrafts in LiDAR survey.

Table 2-2 Monthly Average Sunshine hours per Day in Project Site

Unit: Hour

Location	Feb.	March	April	May	June
Simara Airport	7.6	8.2	9.2	9.1	7.6
Biratnagar Airport	6.9	8.3	8.2	7.7	6.0

Source: JICA Project Team

(6) Policy with respect to Employment of Local Subcontractors

As some Nepali survey companies had experience in working in the field survey associated with airborne LiDAR survey projects and the capacity to conduct LiDAR survey related field survey, it was decided to employ one of such company in the field survey in the Project. However, as it is necessary to survey a very broad area in a limited time, a Japanese manager or a manager from a third country shall be assigned to the site to supervise the safety management, schedule control and quality control of the subcontractor.

A law (Land Act (Survey and Measurement), 2019 (1963)[4], see References 6-1 for details) in Nepal stipulates that it is required to get permission for the export of topographic map data outside Nepal. As topographic data of national border areas were to be captured in the Project, the Survey Department did not approve the data export. Therefore, it was decided to process the captured data in Nepal. As some Nepali companies have experience in processing LiDAR data, one of them shall be employed to conduct data processing. However, as data of a large area have to be processed in the Project, a Japanese manager or a manager from a third country shall be appointed to supervise the local subcontractor to ensure appropriate performance of the work process management, quality control and

[4] Land（Survey and Measurement）Act, 2019（1963）: http://www.lawcommission.gov.np/en/archives/category/documents/prevailing-law/statutes-acts/land-survey-and-measurement-act-2019-1963

accuracy control by the subcontractor.

The operating structures mentioned above are shown in “Figure 2-129 Organizational Structure for DEM Creation” below.

(7) Policy with respect to Transport of Equipment including Aircrafts

As aircrafts and equipment required for LiDAR survey is not available in Nepal, they shall be temporarily imported into Nepal from a third country for the implementation of the survey in the Project. All the other equipment, including personal computers and UAVs for aerial photography, shall be procured in Nepal.

(8) Policy with respect to Equipment Selection

All the equipment to be procured in the Project is expected to be consumer products commercially available in Nepal, not custom-made ones. The specifications for the personal computers for the creation and operation of DEM include high-performance CPU, memory, built-in graphic board and hard disk in order to satisfy the specifications required by the software. A UAV for aerial photography shall be procured for the maintenance of DEM.

(9) Policy with respect to Software Selection

The software procured in the Project will be selected as a product considered necessary from the viewpoint of maintenance and utilization of the DEM.

(10) Policy with respect to Equipment Transportation

All the Equipment for the Project is assumed to be locally procured. The Supplier will order the Equipment to a local vendor in Kathmandu and request delivery to the Survey Department in the city.

(11) Policy with respect to Power Supply

The Equipment procured in the Project will be installed in the Survey Department building. The commercial power supply supplied there is a single-phase two-wire AC 220 V/50 Hz. There is a power outage for 10 minutes about once every two to three days in the building, however there is no standby power supply such as an emergency generator. For this reason, an uninterruptible power supply is planned to be installed between the personal computer and the commercial power supply for the purpose of supplying power until the personal computer or software is safely shut down when power outage occurs.

2-2-2 Basic Plan

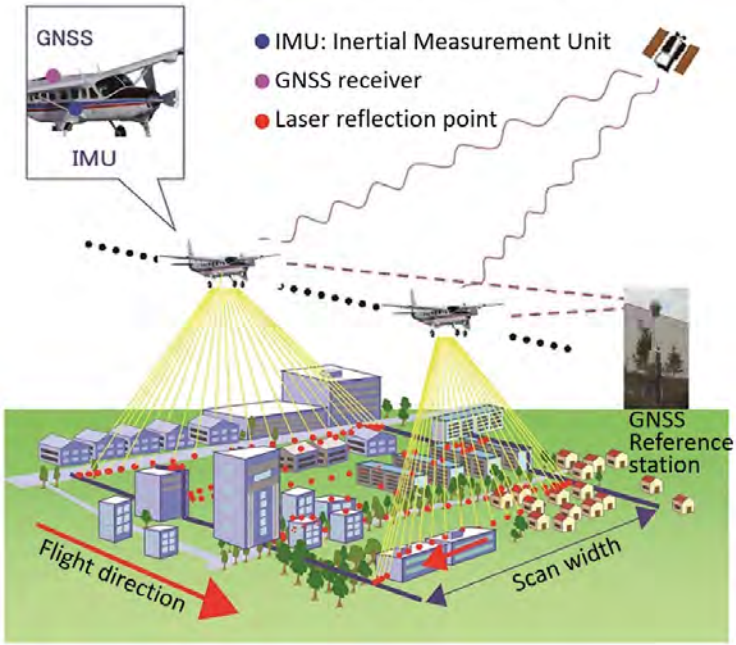
The LiDAR technology shall be used for the creation of high-density and detailed DEM in the Project. Airborne LiDAR survey is a survey method in which pulsed laser is emitted from a laser rangefinder

mounted on an aircraft to a point on the ground surface. The distance between the rangefinder and the point is calculated from the time required for the laser to travel from the rangefinder to the point and back. The three dimensional (3D) coordinates of the point are determined from the distance and the positional and attitude information of the aircraft captured by a GNSS receiver and IMU (inertial measurement unit) mounted on it. Aerial photography shall also be conducted at the same time as LiDAR Survey.

The position of the point of the emission of pulsed laser shall be determined accurately with kinematic positioning using a GNSS reference stations established on the ground and a GNSS receiver on an aircraft. To ensure the accuracy of the coordinates of an reflected point on the ground, reference control points shall be established for 3D coordinate adjustment.

To convert ellipsoidal height to elevation data, leveling shall be conducted at GNSS reference stations and the reference control points to obtain the elevations at the points. The geoid height at a reference control point shall be obtained as the difference between the elevation obtained in the leveling and the ellipsoidal height obtained in GNSS survey. From the geoid heights at reference control points, a simple geoid model of the Project site with appropriate grid spacing shall be created.

Figure 2-2 shows a conceptual diagram of airborne LiDAR survey.



Source: Website of the Geospatial Information Authority of Japan[5]

Figure 2-2 Conceptual Diagram of Airborne LiDAR Survey

[5] Geospatial Information Authority of Japan website: https://www.gsi.go.jp/kankyochiri/Laser_senmon.html

(1) Conditions for DEM Creation

1) Applicable Standards

In the ongoing project in western Terai Region, the specifications for DEM approved by the National Mapping Committee are used as the standards for DEM creation. The same specifications shall be used in the Project. The applicable provisions on the survey methods and accuracy verification methods of "Standards for Operating Specifications for Public Surveying" shall be followed.

2) Survey Standard (Reference Coordinate System) and Measurement Unit

Table 2-3 shows the survey standards, including the reference coordinate system, used in Nepal. In the Project, a world geodetic system, WGS84, in addition to the standards mentioned in the table, shall be used for output production. The metric system shall be used for the distance measurement.

Table 2-3 Survey Standards of Nepal

Item	Name	Definitions
Projected coordinate system	MUTM (Modified Universal Transverse Mercator)	・Number of zones: 3 (central meridians at 81°E, 84°E and 87°E) ・Origins of coordinate system: x-coordinate - the equator (latitude 0°) y-coordinates - 81°E, 84°E and 87°E False Easting X=0.000m, False Northing Y=500,000m ・Scale factor on the central meridian: 0.9999
Reference ellipsoid	Everest 1830	・Semi-major axis: 6,377,276.345m ・Semi-minor axis: 6,356,075.413m
Vertical datum		Mean sea level of India
Geoid		Undefined
Unit of distance		meter (m)

Source: JICA Project Team

3) Specifications for DEM Creation

Table 2-4 shows the specifications for the DEM creation agreed in the discussion with the Survey Department.

Table 2-4 Specifications for DEM Creation

Item		Standards
Airborne LiDAR Survey	Measuring points density	4 points/m^2 or more
	Distance from reference station	25 km or less
	Overwrap ratio between courses	15 % or more
	Scanning area	DEM creation area and area outside of it up to 150 m
	Vertical accuracy	within ±0.25m (root mean square error)
Aerial Photography	Digital camera	Medium frame camera
	Ground pixel size	15 cm (at the nadir)
	Overwrap ratio within a course	15 % or more
	Overwrap ratio between courses	15 % or more
Orthophotos	Ground Sample Distance	15 cm
	Horizontal accuracy	±0.10 m
Deliverables	DEM	Types of elevation models: DTM (Digital Terrain Model) and DSM (Digital Surface Model) Grid spacing: 1 m x 1m

Item		Standards
	Original data	Including all pulse data and reflection intensity data Elevation precision: within ±0.25m (root mean square error)
	Contour data	contour interval: 50 cm
	Data of aerial photographs	4-band (red, green, blue and infrared) imagery, including external orientation elements
	Data of ortho-rectified aerial photographs	4-band (red, green, blue and infrared) imagery Ground pixel size: 15 cm
	Orthophotos	4-band (red, green, blue and infrared) imagery Ground pixel size: 15 cm
	Report	Including the results of field survey, airborne LiDAR survey and aerial photography and flight data storage (FDS)
	Flight plan for airborne LiDAR survey and aerial photography	
	Index map	
Output format	DEM	Any of the following file format: img, tiff or geotiff
	Original data	las (ver1.1)
	Contour data	shp
	Data of aerial photographs	Any of the following file format: img, tiff or geotiff
	Data of ortho-rectified aerial photographs	Any of the followings file format: img, tiff or geotiff
	Orthophotos	Any of the following file format: img, tiff or geotiff
	Report	Either of the following file format: doc or pdf
	Flight plan for airborne LiDAR survey and aerial photography	shp format
	Index map	shp format

Source: JICA Project Team

4) Project Site

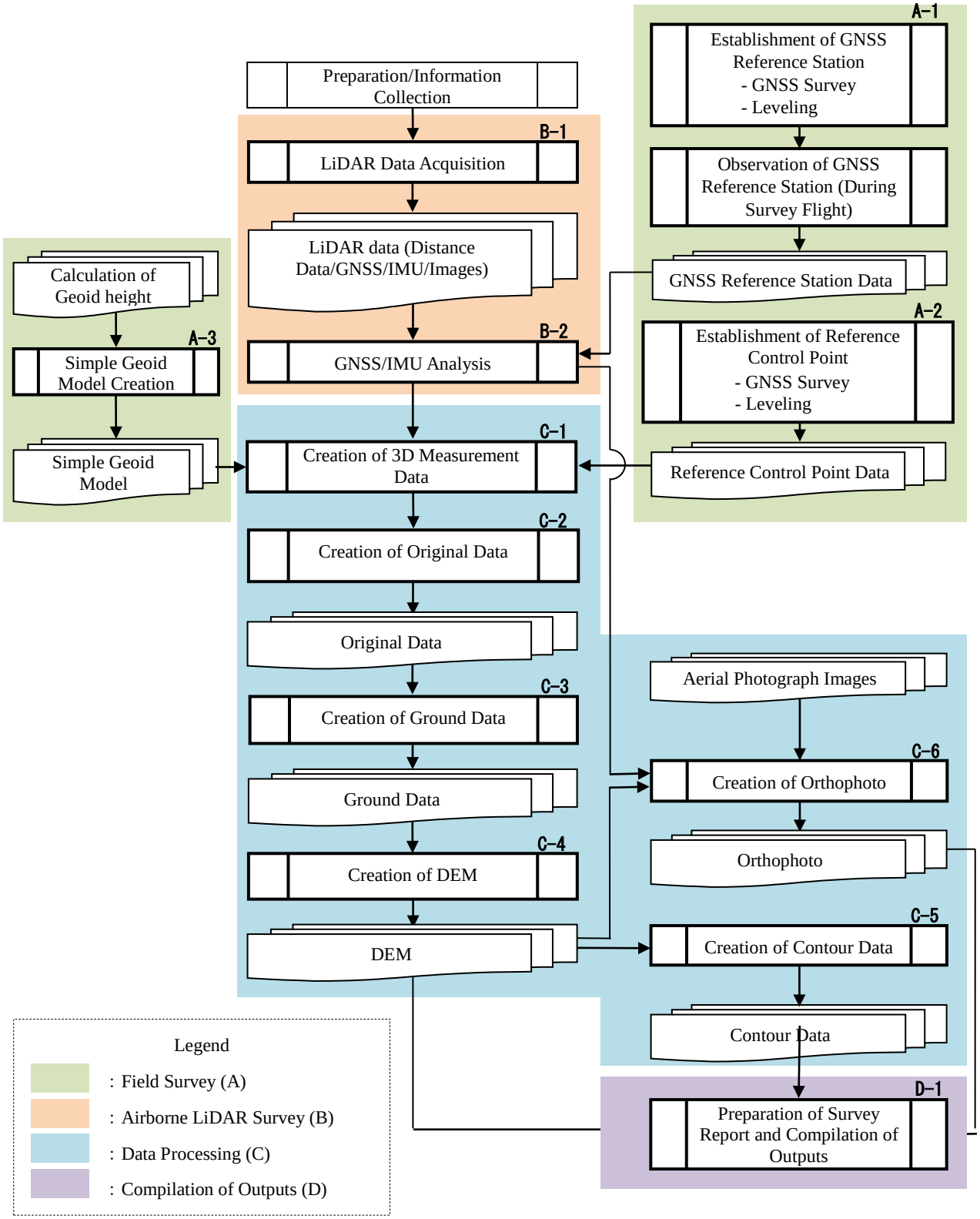
The Project site is Eastern Terai Region in Southeast Nepal along the border with India. The original plan was to create DEM of the entire Province 2 and three districts in Province 1 (Sunsari, Morang and Jhapa Districts). However, Survey Department requested that the Project site should be connected to the site of the ongoing DEM creation project in Western Terai Region. The JICA Project Team and Survey department agreed on the westward extension of the Project site and the creation of DEM of a total area of approx. 15,000 km^2. Figure 2-3 shows the Project site.

Source: JICA Project Team

Figure 2-3 Project Site (DEM of the area within the red line shall be created)

(2) Plan for DEM Creation

Figure 2-4 shows the flow of the work of the Contractor in the DEM creation. As seen in the figure, the DEM creation consists of three parts, (A) field survey, (B) airborne LiDAR survey and (C) data processing. The field survey (A) is GNSS survey and leveling of GNSS reference stations and reference control points, so as to obtain the positional information of those points required for the conversion of the coordinates of point cloud data obtained in LiDAR survey to those of a geodetic coordinate system. In airborne LiDAR survey (B), elevation data and photographs are taken from an aircraft that flies over the entire Project site. The data processing (C) is a process to produce tangible outputs of the Project, *i.e.* DEM and orthophotos, by analyzing and compiling the point cloud data obtained in LiDAR survey, data of aerial photographs and output of the field survey with designated software.



Source: JICA Project Team

Figure 2-4 DEM Design Workflow in the Project

A Field Survey

A-1 Establishment of GNSS Reference Stations

To identify the position of a LiDAR mounted on an aircraft with kinematic GNSS survey, ground reference stations shall be established in the Project site. The station shall be established at locations evenly distributed in the Project site in such a way that a base line length between a flight line and a GNSS reference station shall not exceed 25 km. In principle, they shall be established in public land, including roadsides and premises of central and local government buildings. Locations with broad upper view shall be selected for the establishment to ensure constant reception of the GNSS signals at the stations. A reference station shall not be established at a location near a high-rise building or tall trees. The locations of the establishment shall be decided with consent of the Survey Department. The application for the permit for the establishment shall be submitted to relevant authorities. The Survey Department shall provide its support in order to facilitate application procedures.

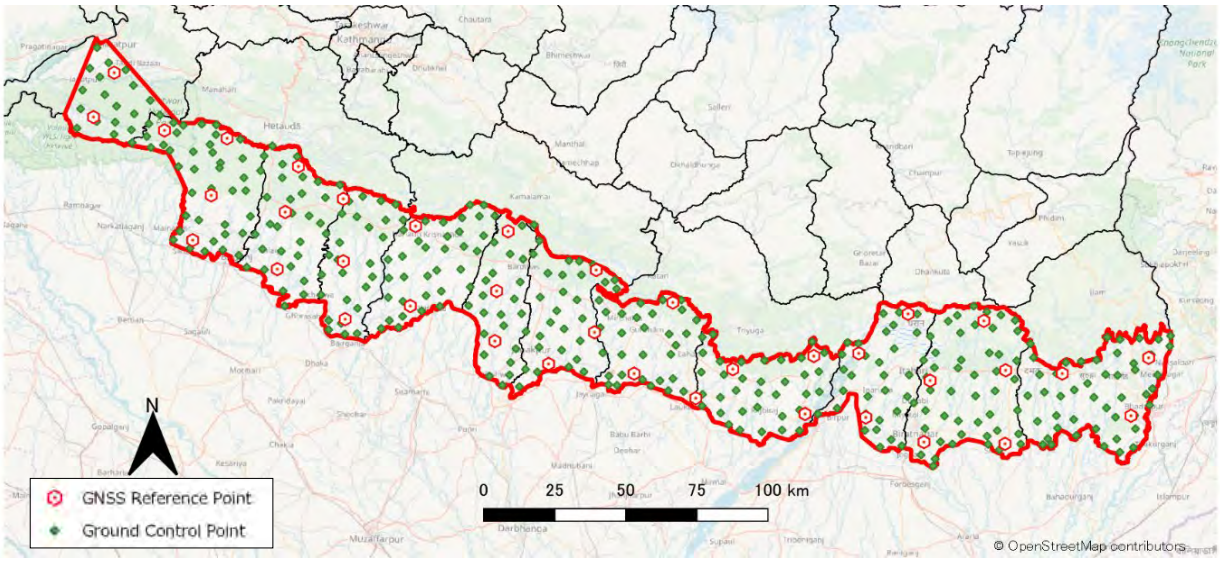
GNSS survey and leveling shall be conducted in the field survey to determine the coordinates (latitude and longitude as planimetric coordinates and elevation) of the GNSS reference stations. As the existing national control points and benchmarks are to be used as reference points for the determination of coordinates, deliberate preparation, such as inspection of the existing national control points for their usability, shall be made before the survey.

A GNSS receiver shall be installed on a GNSS reference station when survey flight is conducted. While an aircraft is conducting survey flight, GNSS observation shall be conducted constantly and the observation data shall be recorded. The GNSS observation data taken at the same time on the aircraft and at the reference station shall be used in a subsequence process of GNSS/IMU data analysis, which reveals the track of the aircraft with high accuracy.

A-2 Establishment of Reference Control Points

Reference control points shall be established for the inspection and correction of 3D measurement data taken in LiDAR survey as well as orthophotos. The points shall be established at a density of one in an area of 7 km x 7 km on flat surface, including playgrounds of public facilities, vacant lots, roads and roof tops. They shall be evenly distributed in the Project site. GNSS survey and leveling shall be conducted to determine the coordinates of reference control points as in the case of GNSS reference stations.

Figure 2-5 shows a map of the sample locations of GNSS reference stations and reference control points.

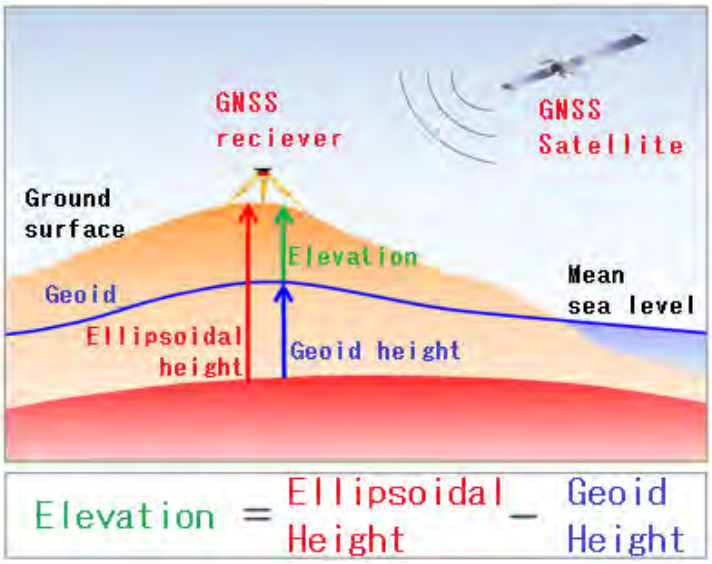


Source: JICA Project Team

Figure 2-5 Planned Locations of GNSS Reference Stations and Reference Control Points

A-3 Simple Geoid Model Creation

A survey with GNSS measuring instruments produces ellipsoidal heights. As LiDAR survey to be conducted in the Project produces measurement data based on the positional information obtained in a GNSS survey, it also produces ellipsoidal heights. As ellipsoidal heights have little real-world application, elevations (heights above the mean sea level) must be generated from ellipsoidal heights. As shown in Figure 2-6, an elevation at a point is given by subtracting the geoid height at the point from the ellipsoidal height. Therefore, a geoid model that gives a geoid height at a certain point is required for generating the elevation at the point. However, as mentioned in 2-2-1 (1) ⑤, a geoid model of Nepal has not been developed. Therefore, the GNSS survey and leveling shall be conducted at all GNSS reference stations and reference control points to obtain geoid heights and elevations at the reference stations and control points and a geoid height at each reference station or control point is obtained as a difference between the ellipsoidal height and elevation. In the Project, geoid heights at grid points placed at appropriate spacing shall be obtained from the interpolation of the geoid heights at the reference stations and control points and a geoid model required for the geoid height correction in the Project site shall be created in a simple form from the geoid heights at the grid points.



Source: Website of the Geospatial Information Authority of Japan[6]

Figure 2-6 Ellipsoid Height, Geoid Height and Elevation

B Airborne LiDAR Survey

B-1 LiDAR Data Acquisition

The aircraft shall be installed with a LiDAR sensor, GNNS receiver, IMU (inertial measurement unit: an instrument to measure the acceleration and attitude of an aircraft in the three directions, the roll, pitch and heading) and digital camera. LiDAR data acquisition shall be conducted in accordance with the plan based on the specifications for LiDAR survey.

In the planning of LiDAR survey, equipment that satisfies the specifications of the Project, *e.g.*, those for the LiDAR point density, ground sample distance of aerial photographs, etc., shall be selected and the specifications for LiDAR survey, including those for flight lines and altitude, shall be determined.

In principle, survey flight shall be conducted in a stable weather day and in such a period when the spatial arrangement of GNSS satellites are appropriate for the positioning. When the attitude of the aircraft seems to have changed significantly while the survey flight is in progress, because of change in air flow or deceleration of the aircraft, the survey flight shall be conducted again for the part of such a change occurred.

① Examples of Equipment to be used

<Aircraft>

It is assumed that fixed-wing aircrafts are to be used in LiDAR survey in the Project. Table 2-5 and Figure 2-7 show the specifications and a photograph, respectively, of an aircraft that has been used in many aerial surveys.

[6] Geospatial Information Authority of Japan website：https://www.gsi.go.jp/buturisokuchi/grageo_geoid.html

Table 2-5 Reference Specifications of an Aircraft for Aerial Survey

No.	Item	Specification
1	Model	Cessna 208 Caravan
2	Registration number	Not known
3	Payload	250 kg - 450 kg
4	Cruising speed (operating)	296 km/h
5	Seating capacity	10 people max.
6	Maximum flight duration	7.0 h
7	Engine	Turboprop engine: 1 unit

Source: JICA Project Team

Source: JICA Project Team

Figure 2-7 Fixed-wing Aircraft Installed with LiDAR System (Cessna 208 Caravan)

<Measuring Equipment>

Table 2-6 shows the specifications of the LiDAR system and Image Sensor as an example. Figure 2-8 shows photographs of the system and camera.

Table 2-6 Reference Specifications of LiDAR System

No.	Item	Specification
1	LiDAR sensor	
1-1	Model	ALTM Orion M300
1-2	Manufacturer	Optech
1-3	Operating flight height above the ground	100 - 2,500 m
1-4	Pulse frequency	Max. 300,000 Hz
1-5	Laser wavelength	1064 nm
1-6	Field of view	Max. 50 degrees
1-7	Beam divergence	0.25 mrad
1-8	Number of recorded echoes per pulse	Max. 4 (1st, 2nd, 3rd and last)
1-9	Elevation precision	0.10 m (1 s)
1-10	Horizontal accuracy	Flight height above the ground/5,500 m
1-11	Type of GNSS/IMU system	POS AV AP50
2	Image Sensor	
2-1	Model	Phase One IXU-RS-1000 (for RGB applications) Phase One IXU-RS-1000-NIR (for NIR applications)
2-2	Manufacturer	Phase One Industrial
2-3	Resolution (No. of pixels)	11,608 pixels × 8,708 pixels

No.	Item	Specification
2-4	Pixel size	4.6 μm
2-5	Focal distance	50 mm
2-6	Shutter speed	Max. 1/2,500 second
2-7	ISO light sensitivity	50 - 6400
2-8	Capture rate	0.6 s

Source: JICA Project Team

Source: JICA Project Team

Figure 2-8 LiDAR (ALTM Orion M300) (left) and Image Sensor (Phase One IXU-RS-1000) (right)

② Acquisition of Permits

Before the survey flight mission begins, applications for a flight permit in Nepal and permits for take-off, landing and parking of the aircraft at the five airports shall be made to relevant Nepali authorities and an application for a permit for flight along the Nepal-India border to the Embassy of India in Nepal. Survey flight shall be commenced after preliminary consultation with those relevant authorities. The daily flight schedule of the LiDAR aircraft shall be coordinated with the schedules of other aircrafts at the Civil Aviation Authority of Nepal.

③ Aircraft Operation

The airport closest to a survey site shall be used for the efficient implementation of LiDAR survey. Five airports in the Project site (Simara, Janakpur, Rajbiraj, Biratnagar and Bhadrapur Airports) that can be used for LiDAR survey shall be used as the bases of LiDAR survey. Figure 2-9 shows the locations of the five airports

Source: JICA Project Team

Figure 2-9 Locations of Airports in Project Site

④ Safety Control in Aircraft Operation

i) The pilot shall follow the "safety control rules" of the operator to ensure safety of the flight.

ii) The pilot shall confirm the site conditions and flight plan and follow the civil aviation laws to ensure safety of the flight.

iii) The mechanic shall inspect the aircraft carefully during the flight preparation and after the flight to ensure safety of the flight.

iv) The pilot shall confirm the local weather condition and meteorological information published by the Meteorological Forecasting Division and private weather forecasters on a day of flight, notify the manager of airborne LiDAR survey of her/his decision on the safety of flight and begin the flight in accordance with manager's instruction. Meanwhile, when the weather has changed while the aircraft is in the air, the pilot shall decide whether to land it or continue flying it with the safety of the flight taken into consideration.

v) The crew shall always take good care of themselves and, when they feel tired, inform the manager of their health conditions.

vi) When an accident occurs, aid the injured immediately, alert the relevant organizations and the local police of the accident quickly and take other required measures in accordance with the flight rules.

⑤ Criteria for Flight Suspension/Cancellation

When relevant Nepali authorities, such as the Department of Hydrology and Meteorology, have issued a warning against heavy rainfall, flooding, storm wind or high waves, a decision shall be made on whether to suspend/cancel the flight with the progress of the work and expected change of weather taken into consideration. Table 2-7 shows the criteria for flight suspension and cancellation used in Japan as reference.

Table 2-7 Standards of Visibility for Survey Flight in Japan

Weather factor	Condition	Criterion
Visibility	Condition for suspension and cancellation (before the flight)	5 km or less, the condition under which visual flight is not allowed
	Condition for suspension and cancellation (during the flight)	5 km or less, the condition under which visual flight is not allowed
	Condition for resumption	5 km or more, the condition under which visual flight is allowed

※ Visibility: the maximum distance at which an object can be clearly discerned
Source: JICA Project Team

The safety of flight is the first priority of the Project. When the pilot finds a risk, he/she shall decide to cancel the flight, if the aircraft is on the ground, or suspend the flight and take a safety measure (return to the nearest or a base airport) immediately, if the aircraft is in the air.

⑥ Safety Measures for Survey Flight

i) Use a LiDAR with a fail-safe mechanism (which controls the laser to be always operated on the safe side even in case of erroneous operation or abnormal behavior). Confirm the normal functioning of the LiDAR every time before the flight begins.
ii) Maintain the required flight height and do not fly at a lower height without a reasonable reason.
iii) Stop laser irradiation when it is inevitable to lower the flight height.

B-2 GNSS/IMU Data Analysis

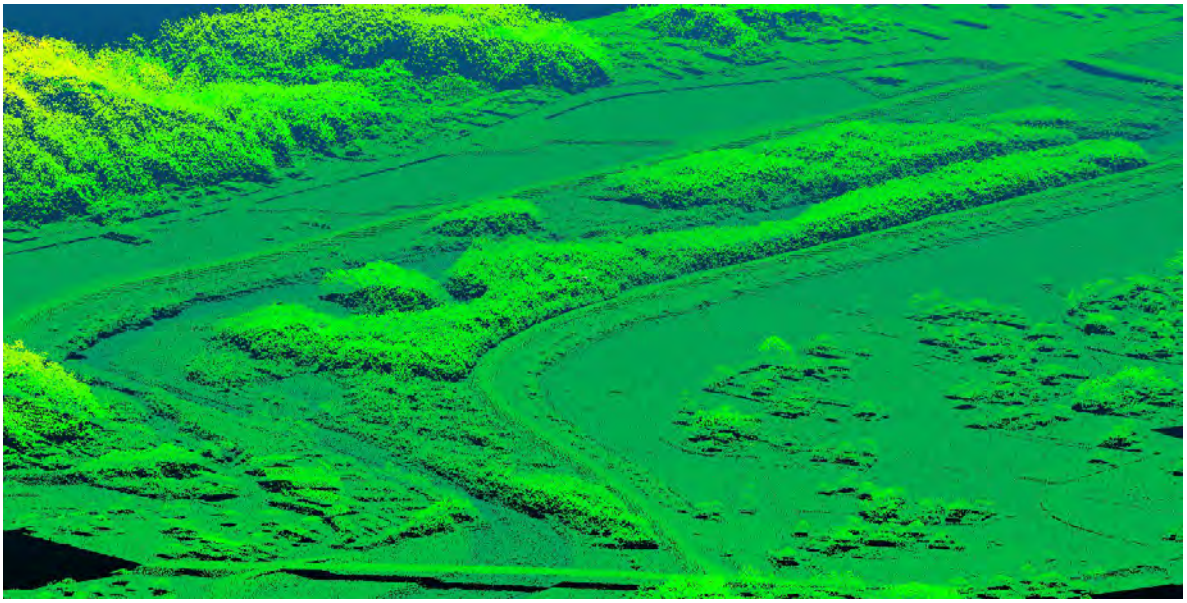
The position and attitude of an aircraft at the time of laser scanning shall be calculated by analyzing the data observed with a GNSS/IMU system mounted on the aircraft and the data observed at a GNSS reference station with a correction factor obtained in the calibration implemented before LiDAR survey. Kinematic analysis software that can be used for the analysis of baseline vectors and displaying evaluation of the analysis result shall be used in the analysis. The operation of the GNSS/IMU system is synchronized with that of a LiDAR and digital camera. The data obtained in the GNSS/IMU data analysis shall be used as external orientation elements at the time of the laser emission and photographing in the creation of 3D measurement data and orthophotos.

C Data Processing

C-1 Creation of 3D Measurement Data

Three-dimensional coordinates of each reflection point shall be calculated from the external orientation elements obtained in B-2 and the data of the direction of laser emission and travelling distance of laser. Three-dimensional measurement data shall be produced by deleting data erroneously measured because of noise, etc. from the 3D coordinate data. Figure 2-10 show examples of 3D measurement data. The data shall be inspected by comparing elevation values of reference control points in the 3D measurement data and those obtained in the leveling, by comparing elevation values of a point calculated from the data taken on adjacent flight lines and by calculating the ratio of missing

data. If the standard measuring point density is not satisfied or there are missing data, re-survey shall be conducted. If the discrepancy between the 3D measurement data and data measured at reference control points is large, the cause(s) of the discrepancy shall be identified and re-survey shall be conducted, if necessary.



Source: JICA Project Team

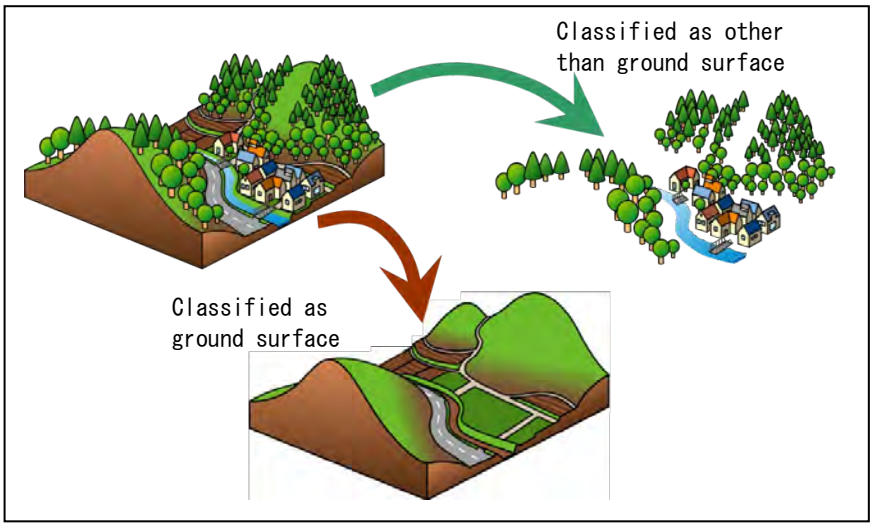
Figure 2-10 Example of 3D Measurement Data

C-2 Creation of Original Data

If the absolute value of the mean of the differences between evaluation values of the reference control points in the 3D measurement data inspected in C-1 and those obtained in the leveling is larger than tolerance of error, all the elevation values in the 3D data shall be shifted by a fixed value. After the correction, the absolute value of the mean of the differences shall be calculated to confirm whether it is within tolerance of error.

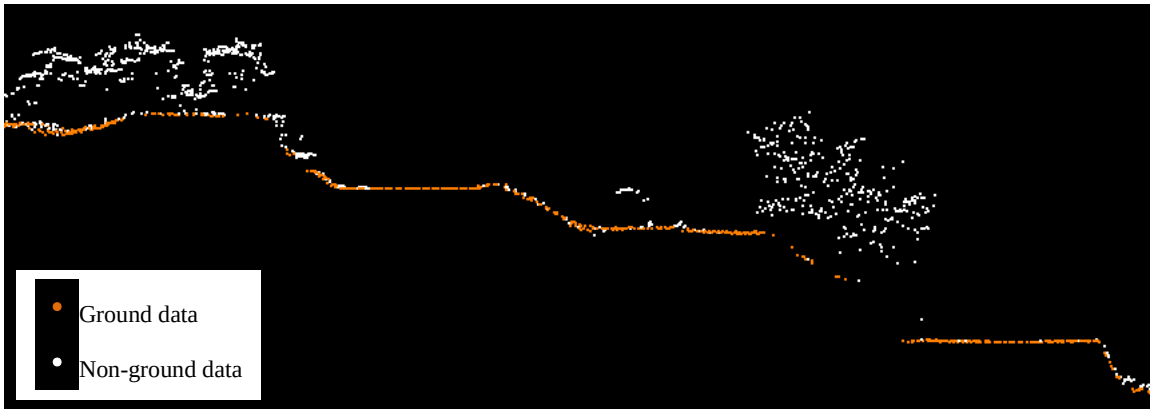
C-3 Creation of Ground Data

The original data created in Section C-2 shall be transformed into ground data with the removal of sensor noise, movable objects, such as vehicles, and objects other than ground surface, such as tree crowns, bridges, buildings and other major artificial features. The produced ground data shall be inspected for whether the filtering has been conducted appropriately and whether there are abnormal data in them. Figure 2-11 and Figure 2-12 show a conceptual diagram of the filtering and a cross section after filtering, respectively.



Source: JICA Project Team

Figure 2-11 Conceptual Diagram of Filtering

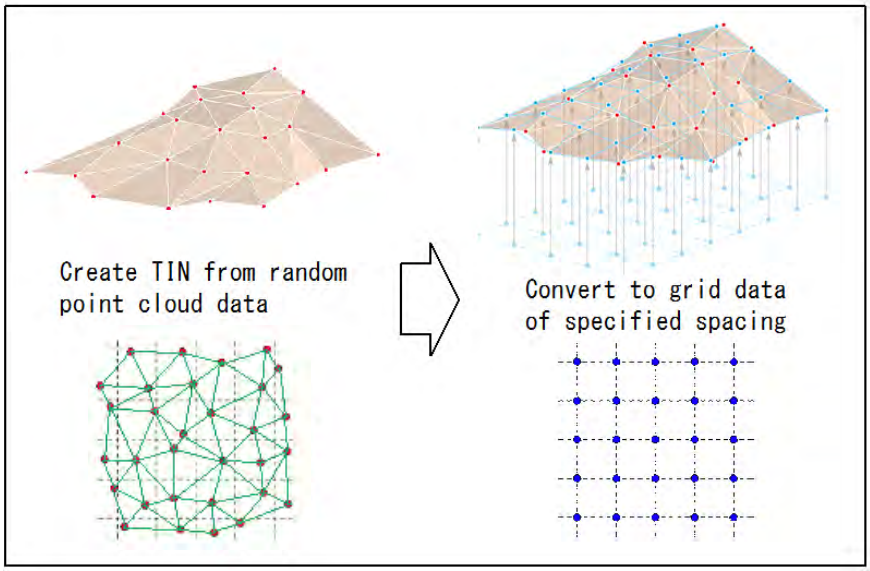


Source: JICA Project Team

Figure 2-12 Cross Section after Filtering

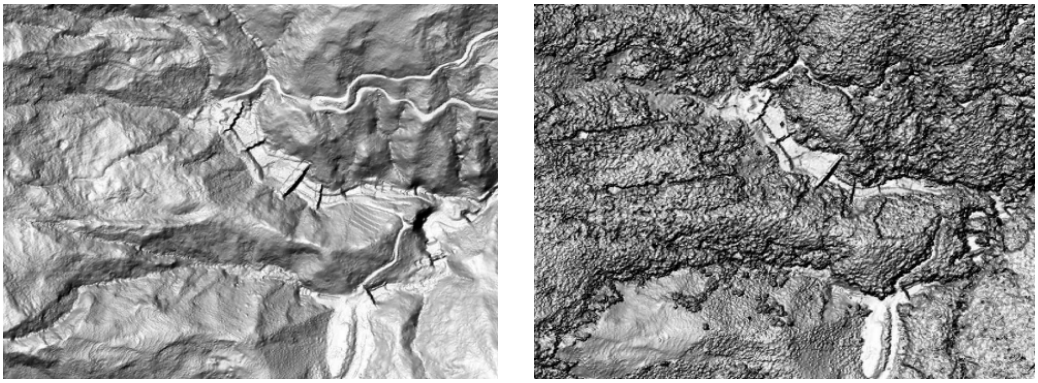
C-4 Creation of DEM (DTM and DSM)

Interpolation such as a triangular irregular network (TIN) method shall be used for the creation of digital terrain model (DTM) data with 1 m grid spacing from the ground data created in Section C-3. Also digital surface model (DSM) data with 1 m grid spacing, including the data of objects other than ground surface, such as trees, buildings and other artificial features, shall be created from the original data. The conceptual method to convert random data into gridded data is shown in Figure 2-13. A DTM and a DSM expressed with shaded relief are compared in Figure 2-14.



Source: JICA Project Team

Figure 2-13 Method to Convert Random Data into Gridded Data

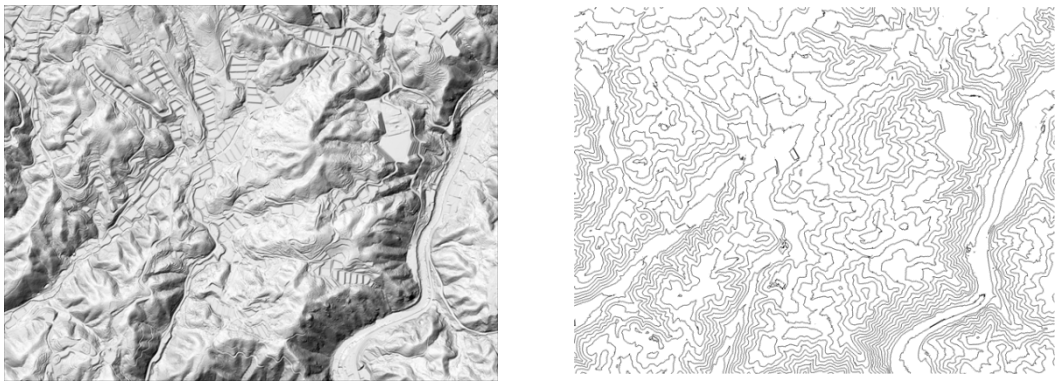


Source: JICA Project Team

Figure 2-14 Comparison between DTM (left) and DSM (right)

C-5 Creation of Contour Data

Contour data with an interval of 50 cm shall be created from the DTM data. The automatic contour generation function of the software may be used for the contour data creation. In such a case, automatically generated contour data shall be inspected for anomaly. A DTM and contour map are compared in Figure 2-15.

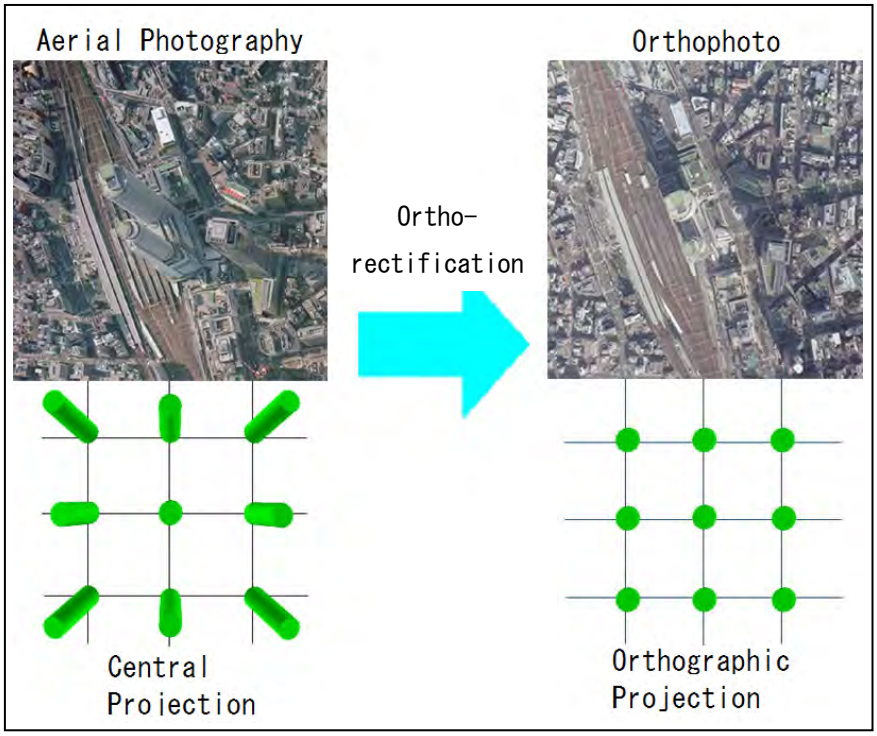


Source: JICA Project Team

Figure 2-15 Comparison between DTM (left) and Contour Map (right)

C-6 Creation of Orthophotos

Orthophotos with a ground pixel size of 15 cm shall be created by ortho-rectification of aerial photographs taken at the same time as LiDAR survey using the positional and attitude data of an aircraft (external orientation elements) produced in B-2 and a DEM. Adjacent orthophotos shall be mosaicked in such a way to keep positional and tonal consistency between them. Figure 2-16 shows an example of the ortho-rectification of an aerial photograph.



Source: Geospatial Information Authority of Japan website[7]

Figure 2-16 Ortho-rectification of an Aerial Photograph

[7] Geospatial Information Authority of Japan website：https://www.gsi.go.jp/gazochosa/gazochosa40002.html

D Compilation of Outputs

D-1 Preparation of Survey Report and Compilation of Outputs

A report including the results of the field survey, airborne LiDAR survey, data processing, accuracy control, etc. shall be prepared. Table 2-8 shows the DEM and accompanying tangible outputs to be created in the Project.

Table 2-8 DEM and Accompanying Tangible Outputs

No.	Output	File format	Note
1	Original data	las（ver1.1）	Whole pulse data and reflection intensity data
2	DEM (DSM)	img/tiff/geotiff	Grid spacing: 1 m
3	DEM (DTM)	img/tiff/geotiff	Grid spacing: 1 m
4	Contour data	shp	Contour interval: 0.5 m
5	Data of aerial photographs	img/tiff/geotiff	4-band (red, green, blue and infrared) imagery, including external orientation elements
6	Data of orthorectified aerial photographs	img/tiff/geotiff	4-band (red, green, blue and infrared) imagery Ground pixel size: 15 cm
7	Digital orthophotos	img/tiff/geotiff	4-band (red, green, blue and infrared) imagery Ground pixel size: 15 cm
8	Report	doc/pdf	Including the results of field survey, airborne LiDAR survey and aerial photography and flight data storage (FDS)
9	Flight plan for airborne LiDAR survey and aerial photography	shp	
10	Index map	shp	

Source: JICA Project Team

(3) Plan for Designing Equipment to be Procured

1) Design Conditions

① Applicable Standards and Measurement Units

The standards and units shown in Table 2-9 shall be applied to the equipment to be procured in the Project.

Table 2-9 List of Applicable Standards

	Name of Standard	Application
(a)	International Electro technical Commission (IEC)	Overall electronic products
(b)	International Organization for Standardization (ISO)	Overall industrial products
(c)	Japanese Industrial Standards (JIS)	Overall industrial products
(d)	Japanese Electro technical Committee (JEC)	Overall electronic products
(e)	The Japan Electrical Manufacturers' Association (JEM)	Overall electronic products
(f)	Japan Electric Association Code (JEAC)	Overall electronic products
(g)	The Japanese Cable Makers' Association Standard (JCS)	Electrical cables
(h)	Electronic Industries Association of Japan (EIAJ)	Overall electronic products
(i)	International Telecommunication Union (ITU)	Overall electronic products

Source: JICA Project Team

② Condition of Project Site

a. Installation Location of the Equipment: Inside Room in the Survey Department building (Environment where room temperature and humidity are kept constant by air conditioning equipment)

b. Power Supply: AC 220 V (single-phase), 50 Hz

2) Equipment Planning

Table 2-10 shows the quantity and usage of the Equipment procured in the Project.

Table 2-10 Equipment Configuration and Usage

No.	Item	Q'ty	Unit	Usage/Function
1.	DEM data	1	lot	Basic data for the creation of hazard maps and planning of infrastructure development
2.	Personal Computer and Monitor	3	set	Used to create a thematic map from DEM
3.	Drone for Aerial Photography	2	pc	Used to create DEM in photogrammetry.
4.	Software	1	lot	-
4-1	Pix4Dmapper	3	set	Software for creating DEM and orthophoto from drone images
4-2	Microstation	3	set	CAD software required to use the following Terra series
4-3	Terra Scan	3	set	Point cloud processing software add-in to Microstation
4-4	Terra Modeler	3	set	Software used with Terra Scan during point cloud processing
4-5	ArcGIS Desktop (ArcMap) Basic	3	set	Software for creating various thematic maps from DEM data
4-6	ArcGIS 3D Analyst Extension	3	set	Extension for DEM processing that runs on ArcGIS
4-7	WebTool	1	set	Tool to search a DEM datafile that includes the data of a user-defined area
5	Uninterruptible Power Supply (UPS)	3	pc	Equipment for protecting PCs from voltage fluctuations and momentary power interruptions

Source: JICA Project Team

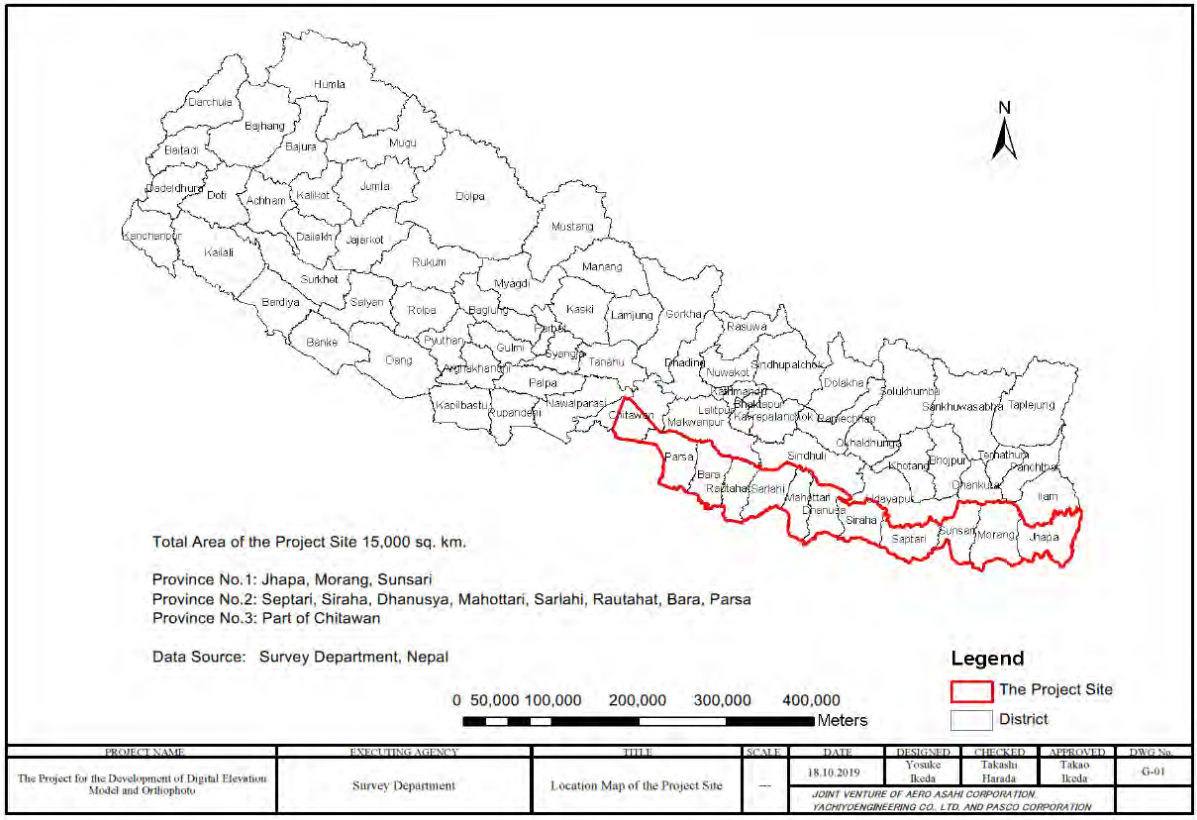
2-2-3 Outline Design Drawings

Table 2-11 shows the list of the outline design drawings of the Project.

Table 2-11 Outline Design Drawings

Drawing No.	Title
G-01	Project Site Location Map
FP-01	Flight Plan and Control Point Map

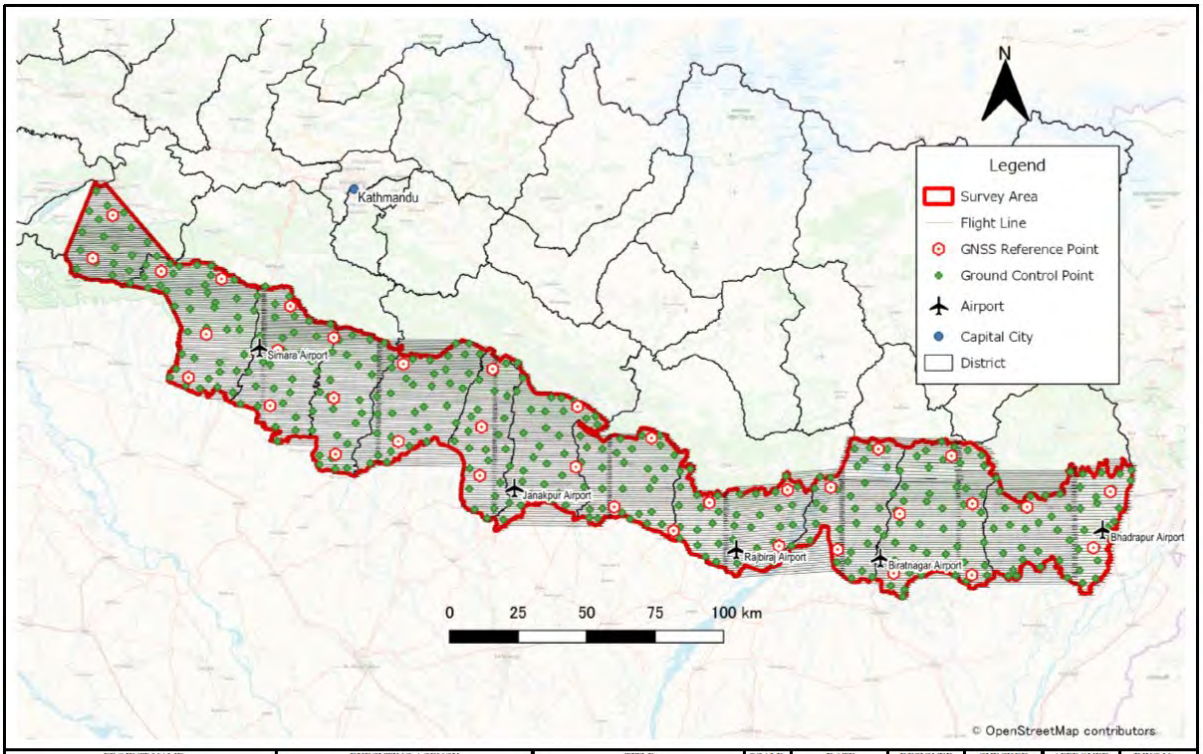
Source: JICA Project Team



PROJECT NAME	EXECUTING AGENCY	TITLE	SCALE	DATE	DESIGNED	CHECKED	APPROVED	DWG No.
The Project for the Development of Digital Elevation Model and Orthophoto	Survey Department	Location Map of the Project Site	---	18.10.2019	Yosuke Ikeda	Takashi Harada	Takao Ikeda	G-01
				JOINT VENTURE OF AERO ASAHI CORPORATION, YACHIYOENGINEERING CO., LTD. AND PASCO CORPORATION				

Source: JICA Project Team

Figure 2-17 Project Site Location Map (Drawing No. G-01)



PROJECT NAME	EXECUTING AGENCY	TITLE	SCALE	DATE	DESIGNED	CHECKED	APPROVED	DWG No.
The Project for the Development of Digital Elevation Model and Orthophoto	Survey Department	Flight Plan and Control Point Distribution Map	---	18.10.2019	Shinjiro Tomizawa	Takashi Harada	Takao Ikeda	FP-01
				JOINT VENTURE OF AERO ASAHI CORPORATION, YACHIYOENGINEERING CO., LTD. AND PASCO CORPORATION				

Source: JICA Project Team

Figure 2-18 Flight Plan and Control Point Map (Drawing No. FP-01)

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The Project will be implemented based on Japan's grant aid scheme. Therefore, it will be implemented after approval is granted by the Government of Japan and the Exchange of Notes (E/N) and the Grant Agreement (G/A) are signed by the Government of Nepal and the Government of Japan. The following paragraphs describe the basic items and points that require particular consideration when implementing the Project.

(1) Project Implementing Agency

The Project implementing agency on the Nepali side is the Survey Department, while the Ministry of Land Management, Cooperatives and Poverty Alleviation is the Project responsible agency. The Survey Department will implement the Project, and to operate and maintain the DEM and Equipment, it will be necessary for the Survey Department to conduct close liaison and discussions with the Japanese consultant (hereinafter referred to as "the Consultant") and Japanese supplier (hereinafter referred to as "the Supplier") and appoint its personnel in charge of the Project.

(2) Consultant

In order to procure the DEM and Equipment in the Project smoothly, the Consultant will conclude a design supervision contract with the Survey Department and implement the implementation design and execution supervision. Then the Consultant will prepare bidding documents and conduct the bid on behalf of the Survey Department. The Consultant shall also supervise the Contractor's work by dispatching supervising engineers to the Project site before the commencement and at the completion of the DEM creation (from the field survey to the data processing) and by confirming appropriately the progress of each work item and quality control in Japan. During the equipment installation work period, a procurement supervision engineer is dispatched in accordance with the progress of the Installation Work, adjustment/testing, initial guidance, operating guidance and On-The-Job trainings, etc., and the Supplier is instructed and supervised to implement safety management.

(3) Japanese Supplier

In accordance with the framework of Japan's grant aid scheme, the Supplier that has been selected by the Nepali side in competitive bid will implement the Equipment procurement, installation works, initial guidance, operating guidance and On-The-Job trainings of the Project. Since it will be necessary to continue maintenance of the DEM and conducting post-installation service to resolve breakdowns and so on after the completion of the Project, it will be significant for the Supplier to establish a liaison with the Survey Department after the handover of the DEM and Equipment.

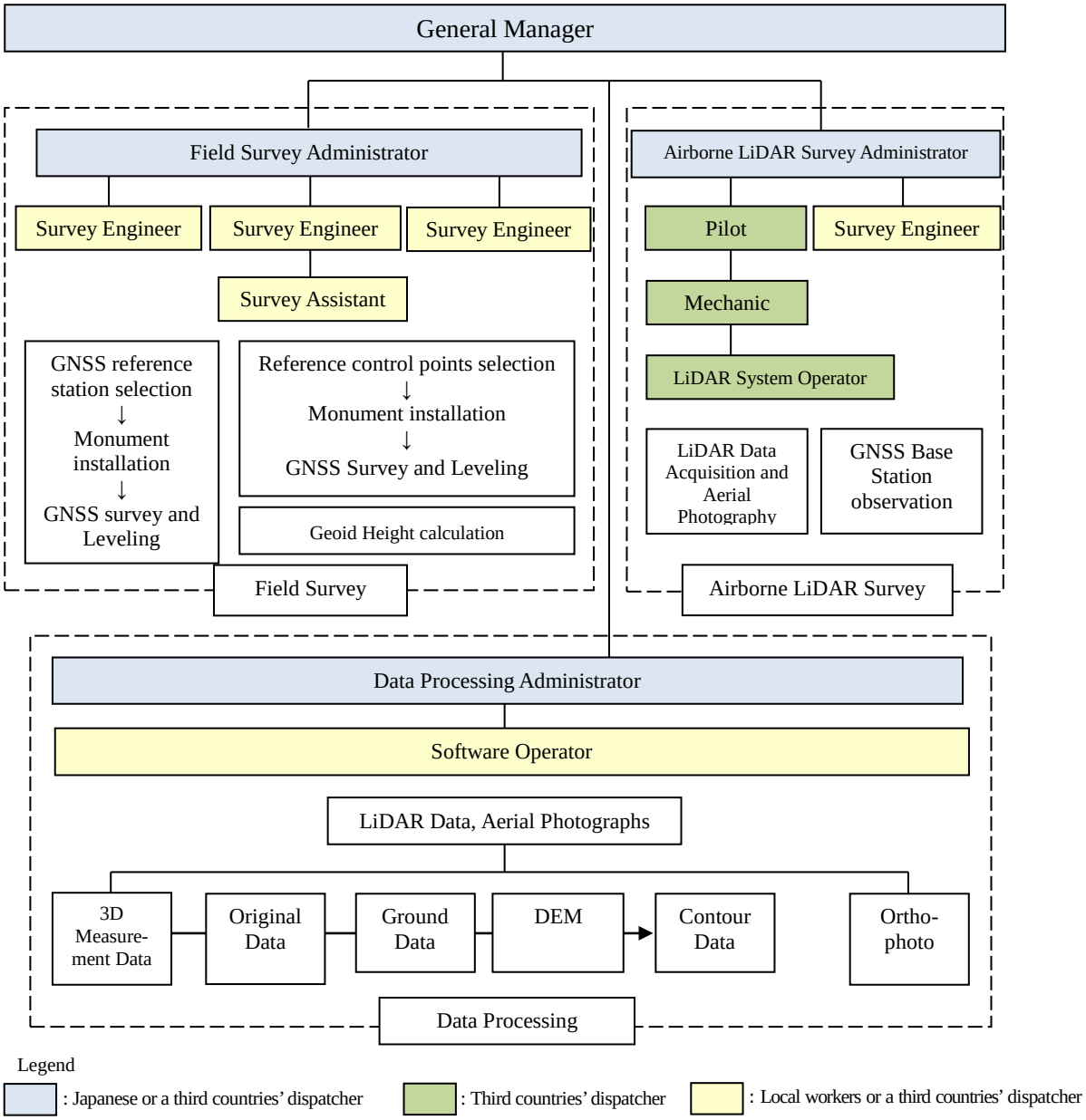
(4) Necessity for Dispatch of Engineers

The Japanese contractor shall operate aircrafts and use professional survey equipment and software to produce high precision survey results for the creation of DEM in the Project. As advanced technology will be required to conduct a series of work in the DEM creation (field survey, airborne LiDAR survey and data processing), it shall be conducted under the guidance and supervision of an engineer dispatched from Japan or a third country.

As no company in Nepal can operate an aircraft mounted with a LiDAR system, LiDAR survey shall be conducted by engineers dispatched from a company in a third country with the aircrafts and scanners of the company. Because the Project site is bordered with India, the application for the permits for cross-border flights and survey flight must be made with relevant authorities. The survey company, implementing agency and other relevant organizations shall have to maintain close communication and frequent information exchange among them on issues, such as decision on whether to conduct a survey flight on a day. To maintain the communication and information exchange, a Japanese engineer or an engineer of a third country shall be dispatched to the Project site. LiDAR survey shall be conducted with appropriate information exchange under the supervision of the engineer.

Local workers (survey engineers and assistants) shall conduct comprehensive quality control and work process management in the field work, including selection of control points, survey and data analysis, under the guidance and supervision of a Japanese engineer or an engineer from a third country. Local workers (software operators) shall also conduct comprehensive quality control and work process management in the data processing, from the data reception to the creation of outputs to be delivered, under the guidance and supervision of a Japanese engineer.

Figure 2-19 shows the organizational structure for DEM creation in the Project.



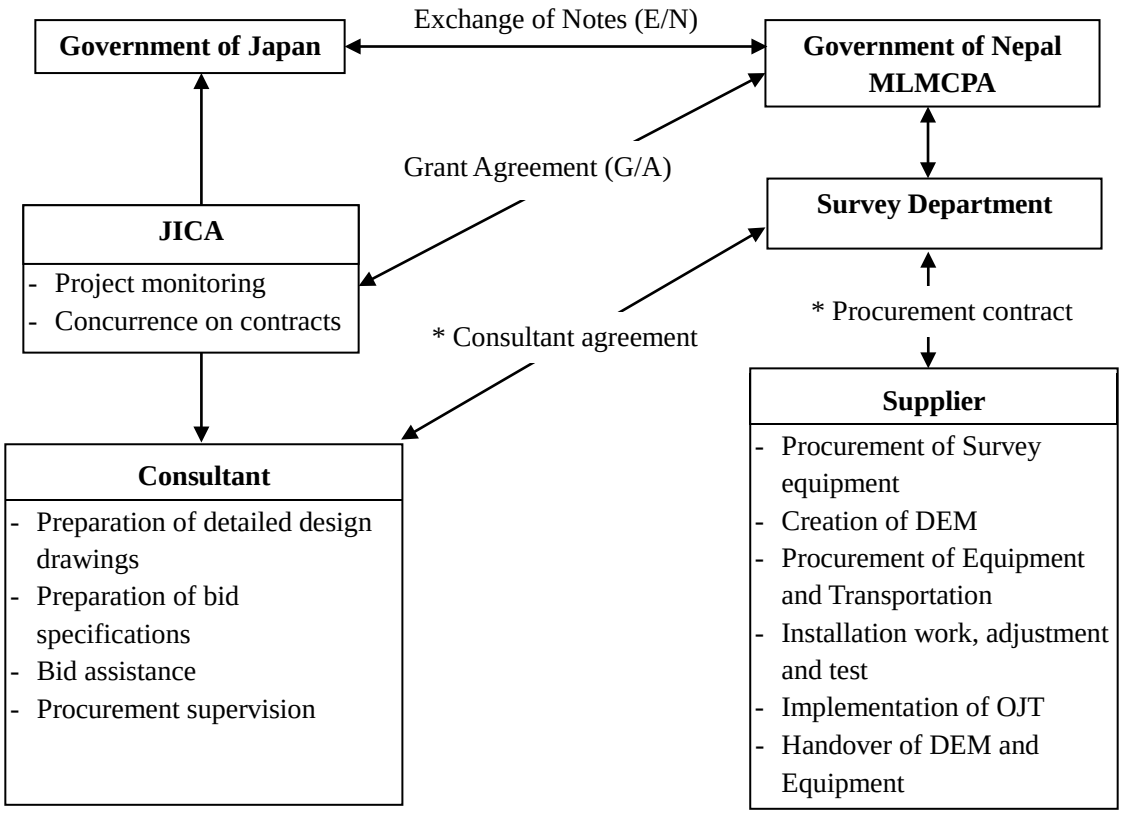
Source: JICA Project Team

Figure 2-19 Organizational Structure for DEM Creation

The equipment installation work in this Project (hereinafter referred to as "Installation Work") is a small-scale work such as installation of personal computer, UPS, software, etc.. Therefore, the Installation Work will be implemented by one Japanese engineer and one local common labor.

(5) Overall Relationship regarding Project Implementation

Figure 2-20 shows the overall relationship diagram of the stakeholder in the Project.



*Note: The Consultant agreement and the procurement contract require concurrence by JICA
Source: JICA Project Team

Figure 2-20 Project Implementation Relationships

2-2-4-2 Implementation Conditions

①In Nepal, it is possible to secure engineers and workers involved in surveying work related to the creation of the DEM, equipment installation work, etc., however, there are not many engineers with specialized skills in process, quality, safety management, etc. Accordingly, it is necessary for the Supplier to dispatch engineers or skilled workers from Japan or third countries to Nepal.

②Although the Equipment for the Project can be procured locally, survey equipment (aircraft, LiDAR sensor, aerial cameras, etc.) used for LiDAR survey cannot be locally procured. Therefore, it is assumed that they will be procured from a third country. When carrying out LiDAR survey, it is necessary to process import procedures, flight permits, data acquisition permits, etc. of the relevant measurement equipment without delay, and to carry out procedures for permitting parking and aviation fuel when entering the field.

③The number of standby days in LiDAR survey shall be based on the “Cost Estimation Standards in Design Work” of the Ministry of Land, Infrastructure, Transport and Tourism of Japan. They are to be calculated according to the formula provided with the surveying parameters such as altitude, overlaps between flight lines, scanning frequency, etc., flight plans on map and various conditions of target area and periods.

Then, based on available meteorological conditions in the survey area, the policy for LiDAR survey was studied, and it was turned out that the sunshine hours in the survey area would be equal to or longer than in Tokyo. Therefore, it can be considered that the standby days calculated based on the "Cost Estimation Standards in Design Work" is reasonable.

As the LiDAR survey contracts made in Japan consider no settlement of contract price, the lump-sum contract, which does not consider adjustment of the contract price by actual standby days, will be applied to the contractor in the Project.

2-2-4-3 Scope of Works

Table 2-12 shows the work and cost demarcation of the Project between Japan and Nepal. The JICA Project Team will confirm with the Survey Department that the Nepali items will be implemented at an appropriate time and necessary budget for that will be secured.

Table 2-12 The Work and Cost Demarcation of the Project (draft)

(1) Before the Bid

No.	Undertaking	To be covered by			Notes
		Japan	Nepal		
			MOF	SD	
1	Opening bank account by Banking Arrangement (B/A)		●		Complete within 1 month after G/A
2	Bearing the following commissions to a bank in Japan for banking services based upon the B/A				
	(1) Advising commission of Authorization to Pay (A/P)		●		For the consulting services
	(2) Payment commission		●		Advance payment for consulting services
3	Securing of lands (hereinafter referred to as "the Project site") for the installation of the Equipment			●	Complete before bid notice
4	Submitting Project Monitoring Report			●	Reflect the result of the Detail Design

Remark: ● denotes the side responsible for the work, MOF: Ministry of Finance, SD: Survey Department

(2) During the Project Implementation

No.	Undertaking	To be covered by			Notes
		Japan	Nepal		
			MOF	SD	
1	According to Japanese nationals and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work			●	
2	Bearing the following commissions to a bank in Japan for banking services based upon the B/A				
	(1) Advising commission of Authorization to Pay (A/P)		●		For the works undertaken by the Supplier
	(2) Payment commission		●		For the contract for consulting service and Supplier's works
3	Assuring the security of personnel at the Project site,			●	

No.	Undertaking	To be covered by			Notes
		Japan	Nepal		
			MOF	SD	
	when necessary				
4	Submitting Project Monitoring Report at fixed times			●	In accordance with G/A
5	Obtaining the following permission regarding airborne LiDAR survey: (1) Permission for parking of aircraft used for the survey (2) Domestic flight permission (3) Permission to fly on the Indian border (4) Data acquisition permission			●	Complete before the commencement of airborne LiDAR survey
6	Providing of information of existing control point and bench marks			●	
7	Procurement of the DEM	●			
8	Procurement of the Equipment	●			"the Equipment" is defined as the equipment and materials to be provided by the Japanese side under the Project.
9	Securing the following storage spaces, facilities, sites, yards, etc.: (1) Storage spaces for the Equipment (2) Space for temporary offices for the Consultant and the Supplier (3) Space for parking aircraft for LiDAR survey (4) Space for storage of material (5) Space for a seminar of Soft Component (Max. 60 persons)			●	
10	Ensuring that custom duties, internal taxes and other fiscal levies which may be imposed in the country of the recipient with respect to the purchase of the products and/or the services be exempted, such as, (1) Corporate Tax, (2) Personal Income Tax, (3) Withholding Tax, (4) Consumption Tax (VAT), (5) Excise Tax, (6) Import Duties, (7) Other duties, taxes or levies, if any		●	●	
11	Transporting of the Equipment and LiDAR equipment, customs procedures and tax procedures				
	(1) Air transportation of air craft for LiDAR survey to Kathmandu airport	●			
	(2) Procedures for tax exemption and customs clearance at Kathmandu airport			●	
	(3) Air transportation of the air craft from Kathmandu airport to the airport in Terai Region.	●			
	(4) Inland transportation inside Kathmandu city to the Project site.	●			
12	Obtaining a confirmation letter for: (1) Permission to undertake the Installation work at the Project site (2) Permission to enter the Project site			●	
13	Providing electricity for the Equipment at the Project site			●	
14	Field survey, airborne LiDAR survey and data processing for the DEM	●			
15	Installing the Equipment, adjusting and testing the equipment	●			

No.	Undertaking	To be covered by			Notes
		Japan	Nepal		
			MOF	SD	
16	Providing security at the Project site during the implementation of the following works. (1) Field survey regarding the DEM (2) Airborne LiDAR survey regarding the DEM (3) Installation work for the Equipment	●			
17	Operation and maintenance training for the DEM and Equipment	●			
18	Bearing all expenses other than those covered by the Grant Aid, necessary for the implementation of the Project			●	

Remark: ● denotes the side responsible for the work, MOF: Ministry of Finance, SD: Survey Department

(3) After the Project

No.	Undertaking	To be covered by			Notes
		Japan	Nepal		
			MOF	SD	
1	Providing security to the DEM and Equipment after handover			●	
2	Establishing structure for implementing operations and maintenance for the DEM and Equipment			●	
3	Allocating necessary staff and budget to establish proper operations and maintenance structures, including routine checks/periodic inspections and cleaning.			●	

Remark: ● denotes the side responsible for the work, MOF: Ministry of Finance, SD: Survey Department
Source: JICA Project Team

2-2-4-4 Consultant Supervision

(1) Basic Policy of Consultant Supervision

The Consultant has the obligation to organize a project team in charge of the Project affairs and to smoothly execute the detail design and the supervision work in accordance with the contents of the Guideline of Japan's grant aid and the outline design. The Consultant will dispatch specialist engineers according to the progress of the DEM creation (field survey, airborne LiDAR survey and data processing), installation works of the Equipment, onsite test and adjustment works, etc., and he/she will guide and supervise the Supplier and strive to control the schedule, quality, progress and safety based on the plan.

(2) Process Management

The Consultant will compare the progress of the work with the implementation schedule decided by the Supplier in the contract every month or every week in order to adhere to the delivery deadline given in the contract. In cases where delays are predicted, the procurement agent will warn the Supplier and demand the submission and implementation of a plan of countermeasures. Comparison of the planned schedule and actual progress will mainly be based on the following items:

① Confirmation of the commencement of the work
② Confirmation of the quantity of completed work (quantities of equipment manufactured at plants and shipped from the plants)
③ Confirmation of the quantity of completed work (DEM)
④ Confirmation of the Equipment delivery
⑤ Supervision of the process according to the implementation schedule

(3) Safety Control

Discussions will be held and cooperation will be sought with responsible officers of the Supplier, and safety control will be exercised during the work period in order to prevent the occurrence of industrial accidents on the Project site, injuries to third parties or any other accidents. Important points to consider in safety management on the ground are as follows:

① Establishment of safety control regulations and assignment of safety manager
② Planning of the work vehicles and transporting machines operating routes and thorough enforcement of safe driving
③ Encouragement of workers to utilize welfare measures and vacations
④ Security measures during the stay

(4) Supervisors

The Consultant shall supervise the Project implementation with a team of the personnel mentioned below (Table 2-13).

Table 2-13 Supervisors of the Consultant

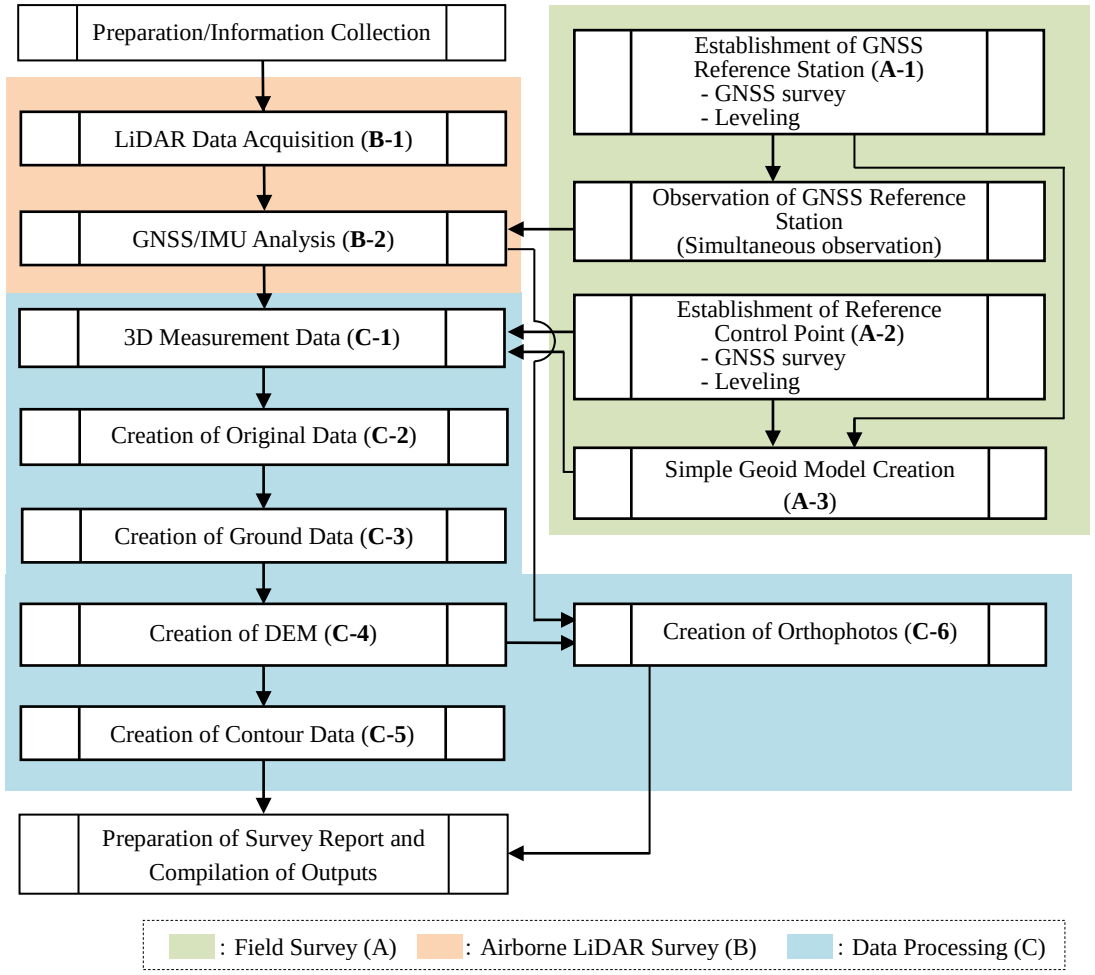
Member	Place of supervision (country)	Responsibility
Chief Engineer/Supervising Engineer 4 (acceptance inspection and handover)	Nepal and Japan	Implementation of the quality control meeting before the commencement of the field survey, confirmation of the results of the final inspection, acceptance inspection and handover of the outputs
Supervising Engineer 1 (airborne LiDAR survey)	Japan	Confirmation of the progress of airborne LiDAR survey and inspection of its results
Supervising Engineer 2 (Equipment)	Nepal	Supervision of the equipment installation
Supervising Engineer 3 (Field Survey)	Japan	Confirmation of the progress of the field survey and inspection of its results
Inspection Engineer 1 (Verification, collation and inspection of shop drawings)	Japan	Verification, collation and inspection of shop drawings
Inspection Engineer 2 (Data Processing)	Japan	Confirmation of the progress of the data processing and inspection of its results
Inspection Engineer 3 (Data Processing)	Japan	Confirmation of the progress of the data processing by the Project owner and inspection of its results
Inspection Engineer 4 (Data Processing)	Japan	ditto

Source: JICA Project Team

2-2-4-5 Quality Control Plan

(1) DEM

To confirm whether the created DEM satisfy the specifications on accuracy and functions, the quality of the models shall be inspected. The accuracy control to be performed by a contractor is provided in detail in “Standards for Operating Specifications for Public Surveying” (hereinafter referred to as “the Standards”). The method of examining the accuracy by conducting verification survey and inspecting the quality control sheets in each process of the work shall be used in the Project. Figure 2-21 shows the processes to be inspected in the workflow of the DEM creation. Table 2-14 shows the names of the documents for quality control, including quality control sheets to be prepared in each process and the articles of the Standards that stipulate the details of the inspection (See References 6-2 for details). The Consultant shall confirm whether the work is implemented appropriately by checking various record books and quality control sheets prepared by the Contractor. If the inspection reveals a possibility that the quality may not be satisfactory, the Consultant shall instruct the Contractor to take necessary measures, such as conducting a re-survey, immediately. The Consultant shall inform the Owner of the inspection result immediately and obtain Owner’s consent to the result. Table 2-15 shows the responsibilities of the Contractor, Consultant and Owner in the quality control during the Project implementation.



Source: JICA Project Team

Figure 2-21 Processes in which Accuracy Control and Inspection shall be Conducted (Note: The numbers in the parentheses are the same as those in Table 2-4.)

Table 2-14 Documents for Quality Control, Including Quality Control Sheets to be Prepared in Each Process of the Work and the Relevant Articles of the Standards

No.	Process	Document for Quality control	Article of Standards
A-1 A-2	GNSS survey (Establishment of GNSS reference stations) (Establishment of reference control points)	GNSS Observation Sheet	Article 38
		GNSS Observation Record	Article 41
		GNSS Computation Sheet	Articles 40-43
		GNSS Net-Adjustment Diagram	Article 26
		GNSS Control Point Survey Result Table	Article 43
		Description of Control Points	Article 33
		Distribution Map of Control Points	Article 43
		Ground Photographs of Survey Markers	Article 32
		GNSS Verification Survey Sheet	Article 13
		GNSS Observation Diagram	Article 37
		Quality Control Sheet for Control Point	Articles 42-43
		GNSS Observation Record	Article 37
A-1 A-2	Leveling (Establishment of GNSS reference stations) (Establishment of reference control points)	Leveling Observation Sheet	Article 64
		Leveling Observation Result Table	Article 64
		Leveling Network Adjustment Table	Article 70
		Leveling Routes	Article 70
		Leveling Computation Sheet	Articles 67-70
		Leveling Net-Adjustment Diagram	Article 57

No.	Process	Document for Quality control	Article of Standards
		Description of Benchmarks	Article 60
		Ground Photographs of Benchmarks	Article 60
		Leveling Verification Survey Sheet	Article 13
		Quality Control Sheet for Leveling	Article 69, 70
A-3	Simple geoid model creation	Result table of Check for Geoid Model at Check points	*1
B-1	LiDAR data acquisition	Airborne LiDAR Survey System Calibration Sheet	Article 319
		Flight Plan for Airborne LiDAR Survey and Aerial Photography	Article 315
		Specification Table for Airborne LiDAR Survey and Aerial Photography	Article 315
		Flight Operation Sheet of Airborne LiDAR Survey	Article 322
		Flight Daily Report of Airborne LiDAR Survey	Article 322
		Inspection Map of LiDAR Survey Coverage	Article 322
		Quality Control Sheet for Aerial Photography	*2
B-2	GNSS/IMU data analysis	Number of Satellites and PDOP Diagram	Article 322
		Flight Trajectory Chart	Article 322
		Quality Control Sheet for GNSS/IMU Analysis	Article 322
		Observation Record at GNSS Reference Station	Article 322
C-1	Creation of 3D measurement data	Distribution Map of Reference Control Points and Inspection Points Between Flight Lines	Articles 327, 328
		Inspection Sheet of 3D Measurement Data	Article 326
		Inspection Result of 3D Measurement Data	Article 326
		Residuals Between Flight Lines	Article 327
		Inspection Result of Data Void Rate	Article 331
C-2	Creation of original data	Inspection Result of Original Data	Article 334
C-3	Creation of ground data	Filtering Inspection Map	Article 338
		Quality Control Sheet of Ground Data	Article 339
		Inspection Result of Existing Data	Article 336
C-4	Creation of DEM	Quality Control Sheet of Grid Data	Article 342
		Quality Control Sheet of Geospatial Data	Article 345
C-5	Creation of contour data	Quality Control Sheet of Contour Data	Article 344*2
C-6	Creation of orthophotos	Quality Control Sheet of Orthophoto	*3
		Inspection Result of Orthophoto Position Accuracy	*3

※1 GNSS survey and leveling shall be conducted at 12 points evenly distributed in the Project site and the actual geoid height and geoid height obtained from the geoid model at each of these points shall be compared.
※2 Contour data shall be inspected for erroneous and missing data entry and shapes of contours
※3 The Standards assume the use of a large-frame camera for aerial survey in the description of the work procedure. Therefore, the description and check items of the accuracy check sheet in the Standards shall be modified to make it appropriate for the use in the Project.

Source: JICA Project Team

Table 2-15 Responsibility Sharing in Quality Control of DEM at Different Time in the Project

No.	Time	Contractor	Consultant	Owner
1	After the conclusion of the contract until the commencement of project activities	To prepare and inspect Flight Plan for Airborne LiDAR Survey and Aerial Photography	To verify and approve (all) the flight plan	To confirm the verification result
2	At the beginning and middle of the field survey	To prepare and inspect the following accuracy check sheets ・Description of Control Points and Benchmarks ・Verification Survey Sheet ・Quality Control Sheet	・To verify and approve the result of the verification survey of the existing control points ・To verify and approve (all) the quality control sheets prepared by the Contractor	ditto

No.	Time	Contractor	Consultant	Owner
3	At the completion of the field survey	To prepare and inspect the following accuracy check sheets ・Description of Control Points and Benchmarks ・Verification Survey Sheet ・Quality Control Sheet ・Result table of check for Geoid Model at Check points	・To verify and approve (all) the quality control sheets prepared by the Contractor ・To verify and approve the result of geoid model verification survey	ditto
4	In the middle and at the completion of airborne LiDAR survey	To prepare and inspect the following accuracy check sheets ・Flight Operation Sheet of Airborne LiDAR Survey ・Inspection Map of LiDAR Survey Coverage ・Quality Control Sheet for Aerial Photography ・Flight Trajectory Chart	To verify and approve (5 % of) the quality control sheets prepared by the Contractor	ditto
5	During the data processing	To prepare and inspect the following accuracy check sheets ・Inspection Sheet of 3D Measurement Data ・Inspection Result of Data Void Rate ・Inspection Result of Original Data ・Filtering Inspection Map ・Quality Control Sheet of Ground Data ・Quality Control Sheet of Grid Data ・Quality Control Sheet of Contour Data ・Quality Control Sheet of Orthophoto ・Inspection Result of Orthophoto Position Accuracy	To verify and approve (5 % of) the quality control sheets prepared by the Contractor	ditto
6	At the completion of the data processing	ditto	ditto	To witness the verification To confirm the verification results
7	After the completion of output compilation	To produce a survey report and implement the following inspections ・Self-inspection ・Acceptance inspection To prepare the final report	・To witness the acceptance inspection ・To verify and approve the survey report and final report prepared by the Contractor	To witness the acceptance inspection To confirm the verification results

Source: JICA Project Team

(2) Equipment Procurement

The Consultant shall perform quality control of the procurement of equipment (including PCs, software and UPSs) so that the equipment shall satisfy the quality specified in the contract document. Table 2-16 shows the major activities in the quality control of the equipment procurement.

Table 2-16 Responsibility Sharing in Quality Control of Equipment Procurement at Different Time in the Project

No.	Time	Contractor	Consultant	Owner
1	After the conclusion of the contract until placing orders of equipment	To prepare the following documents for approval ・Specifications ・Shop drawings of equipment ・Working drawings	To verify and approve the documents prepared by the Contractor	To confirm the documents for approval
2	Until the equipment delivery	To prepare the following documents for approval ・Equipment inspection guidelines ・Result of delivery inspection ・Installation manual	ditto	ditto
3	During the installation	To install the procured equipment following the installation manual	To witness the installation and confirm that it is implemented as provide in the manual	To witness the installation, as required.
4	After the installation	To conduct the following inspections after the adjustment and trial runs. ・Self-inspection ・Acceptance inspection To prepare the following document for approval ・Acceptance inspection report ・Completion drawings	To witness the acceptance inspection To verify and approve the documents prepared by the Contractor	To witness the acceptance inspection To confirm the documents for approval

Source: JICA Project Team

If the confirmation and verification of a document for approval by the Consultant have revealed a potential quality risk, the Consultant shall immediately ask the Contractor to correct, revise and/or eliminate defects.

2-2-4-6 Procurement Plan

(1) Countries as Equipment Procurement Sources

The Equipment in the Project will basically be procured locally in Nepal. Table 2-17 shows Equipment Procurement Sources.

Table 2-17 Equipment Procurement Sources

No.	Item	Qty	Country of Origin
1	DEM data	1 lot	Japan
2	Personal Computer and Monitor	3 sets	China, Malaysia
3	Drone for Aerial Photogrammetry	2 pcs	China
4	Software	1 lot	
4-1	Pix4Dmapper	3 sets	Switzerland
4-2	Microstation	3 sets	USA
4-3	Terra Scan	3 sets	Finland
4-4	Terra Modeler	3 sets	Finland
4-5	ArcGIS Desktop (ArcMap) Basic	3 sets	USA
4-6	ArcGIS 3D Analyst Extension	3 sets	USA
4-7	WebTool	1 set	Nepal
5	Uninterruptible Power Supply (UPS)	3 pcs	China, Turkey

Source: JICA Project Team

(2) Equipment and Survey Equipment Transportation Plan

The transportation plan for the Equipment and survey equipment of the Project is shown in Figure 2-22 and Figure 2-23.

[■Procurement in Nepal]

Transportation time required from purchase order to the Project site delivery: 2weeks – 1month

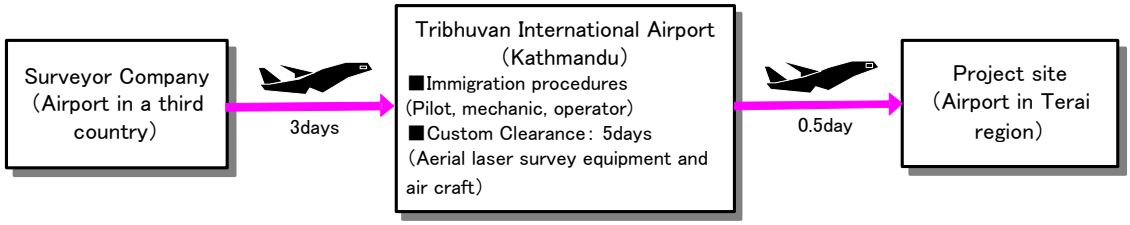
Source: JICA Project Team

Figure 2-22 Equipment Transportation Plan

As described in Figure 2-22, the procured equipment can be ready about two weeks after ordering from a local vendor in Kathmandu. The vendor and the Project site (Survey Department) are both located in Kathmandu, and the transportation time is expected to be about 30 minutes by truck.

[■Procurement from a third country] (in case of aerial laser survey equipment)

Transportation time reqired from a third country to the Project site: about 9days



Source: JICA Project Team

Figure 2-23 Survey Equipment Transportation Plan

As shown in Figure 2-23, the survey equipment (including a Cessna for LiDAR survey) shall be transported from an airport in a third country to the Tribhuvan International Airport. After the custom clearance at the airport has been completed, the equipment shall be transported from the Tribhuvan International Airport to an airport in the Project site in the Terai Region. The time required for transporting the equipment from the third country to the Project site in Nepal (a local airport in Terai), including time for the custom clearance, will be around nine days or less.

2-2-4-7 Plan for Initial Operations Guidance and Management Guidance, etc.

The staffs of the Survey Department have no experience in the creation of DEM from LiDAR data, a planned activity of the Project. They have no experience in the use of the equipment to be procured in the Project either. Therefore, the procurement contractor shall have to dispatch its engineer to the Project site to provide them with technical guidance on the use of the equipment in the form of on-the-job training. Table 2-18 shows the planned subjects, contents and participants (trainees) of the guidance.

Table 2-18 Planned Subjects of Technical Guidance

Type of guidance	Equipment	Content	Duration	Trainees
Initial Operational Guidance	Microstation	・Guidance on the use of software ・Preparation and verification of working files	1 day	SD staff: 6 persons
	Terra Scan	・Import of laser scanning data	1 day	
	Terra Modeler	・Creation of surface models	1 day	
	ArcMap	・Creation of new files ・Introduction to coordinate systems and project methods	1 day	
	Pix4Dmapper	・Photographic data ・Camera data ・GNSS data at the time of photo-taking	1 day	
	Drone for aerial photography	・Inspection of drone ・Inspection of battery	1 day	
	Web Tool	・Method to search a specific DEM	1 day	
How-to-Use Guidance	Terra Scan	・Creation of project files	1 day	
	Drone for aerial photograph	・Calibration of drone ・GCP	1 day	

Source: JICA Project Team

The procurement contractor shall submit a report on the operational guidance to the consultant after completing the initial operational guidance and how-to-use guidance mentioned above. After the owner and the consultant have confirmed the sufficiency of the contents of the report, the consultant shall issue a certificate of completion of technical guidance to the contractor, with approval from the owner.

2-2-4-8 Soft Component (Technical Assistance) Plan

In the Project, it will be necessary to disseminate to the Nepali side information about the products and services to be realized in the future such as water resource measures other than flood countermeasures, urban planning, etc., using the DEM. In addition, it will be necessary to construct a system for maintenance and updating of the DEM created in the Project. Under this background, technical guidance will be provided to the members of staff of the Survey Department that will operate and maintain the DEM, to promote efficient utilization of the DEM. The objectives of the soft components of the Project are as follows.

(1) Objectives

Output 1: Continuation of appropriate maintenance of the DEM

The staff of the Survey Department will understand the basic and applied technologies regarding the functions of the equipment procured and the methods of operation and maintenance, and will effectively and continuously utilize the equipment procured in the future. Also, they will be able to continuously maintain the DEM utilizing the equipment procured. In particular, the capabilities of appropriately updating and maintaining the DEM will be strengthened in the field of flood countermeasures.

Output 2: Facilitation of the Utilization of the DEM

The Nepali people will be widely informed of the potential use of the DEM, and an environment will be constructed to enable people to easily obtain and use the detailed DEM. Also, the staff of the Survey Department will understand the methods of using the DEM, and will be capable of preparing various types of thematic maps using the equipment procured. In addition, the relevant organizations involved in flood countermeasures will recognize the importance of their feedback to the Survey Department of information relating to topographical changes.

(2) Soft Component Activities (Input Plan)

Table 2-19 and Table 2-20 show the soft component activity plan. Note that the details of the soft component plan are as shown in the "Soft Component Plan" in the attached document.

Table 2-19 Soft Component Activity Plan (Establishment of the DEM maintenance capabilities)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
First term First on-site training (classroom lectures, guidance for preparation of plans and procedures, hands-on training using the equipment)			
Output 1-1 Creation and update of the DEM by drone photogrammetry Target personnel and its number			
(1) Staff of the Survey Department are able to perform appropriate operation and maintenance of the procured equipment. Survey Department (6 persons): Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Overall lecture on drone photogrammetry (principle, workflow, etc.) ▪ Lecture and hands-on training on drone photogrammetry planning (photography planning, control point positioning), on-site operations (driving, safety measures) and analysis method of acquired data ▪ Lecture and hands-on training on the management method of the old and new DEM	Survey results of the hands-on training area 1) Adjustment calculation result 2) Point cloud data 3) Orthophotos	0.53 M/M (16 days) Including trip [Haneda→Kathmandu]
(2) Staff of the Survey Department maintains procedures, develops operation plans according to the objectives and continually updates the DEM using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Attendees complete the following procedures under the guidance of the instructor based on the learnings from the lectures and hands-on training. - Procedure for operation of drones (driving, maintenance, safety measures, etc.) - Procedure for creating DEM by drone photogrammetry - Procedure for maintaining and updating DEM by drone photogrammetry (Updating a part of the existing digital elevation models by drone photogrammetry) - DEM maintenance procedure	1) Procedure for operation of drones (driving, maintenance, safety measures, etc.) 2) Procedure for creating DEM by drone photogrammetry 3) Procedure for maintaining and updating DEM by drone photogrammetry 4) DEM maintenance procedure	0.13 M/M (4 days)
Output 1-2 Processing of point cloud data Target personnel and its number			

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
(1) Ground data can be extracted by processing the original Airborne LiDAR data. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Classroom lecture on point cloud data acquisition principle and workflow for each surveying method (drone photogrammetry、ALS, terrestrial laser survey, etc.) ▪ Hands-on training in ground data extraction (filtering) by automated and manual processing ▪ Lecture and hands-on training on creation of grid data ▪ Lecture and hands-on training on creation of contour data	Data from the hands-on training area 1) Ground data 2) Grid data 3) Contour data	0.30M/M (9 days)
(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment. Survey Department (6 persons): Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Attendees complete the following procedures under the guidance of the instructor based on the learnings from the lectures and hands-on training. - Procedure for extraction of ground data - Procedure for creation of grid data - Procedure for creation of contour data	1) Procedure for extraction of ground data 2) Procedure for creation of grid data 3) Procedure for creation of contour data	0.17M/M (5 days) Including trip [Kathmandu→ Haneda]
Second term　Second on-site training (Verification, evaluation and review of the outputs of the first term)			
Output 1-1 Creation and update of DEM by drone photogrammetry Target personnel and its number	After implementing the first on-site training (in about one months after the training), perform measurement of the outputs produced in the first term and take necessary improvement measures.		
(1) Staff of the Survey Department are able to perform appropriate operation and maintenance of the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Staff of the Survey Department are assigned to perform planning, photographing, analysis and product creation by themselves for a pre-determined area. ▪ Confirmation of implementation status and issues to be tackled ▪ Confirmation of failure occurrence and repair status as well as issues to be tackled	Survey results of the assigned area 1) Adjustment calculation result 2) Point cloud data 3) Orthophotos	0.50 M/M (15 days) Including trip [Haneda→Kathmandu]
(2) Staff of the Survey Department maintains procedures, develop operation plans according to the objectives and continually updates the DEM using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure	▪ Guidance for reflection of issues on the procedures ▪ Guidance for reflection of failure occurrence and repairs on the procedures	Revised procedures	0.06 M/M (2 days)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Division (GIID)"			
Output 1-2 Processing of point cloud data Target personnel and its number	After implementing the first on-site training (in about 1 month after the training), perform measurement of the outputs produced in the first term and take necessary improvement measures.		
(1) Ground data can be extracted by processing the original Airborne LiDAR data. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	Staff of the Survey Department are assigned to perform data processing and product creation by themselves for a pre-determined area. ▪ Confirmation of implementation status and issues to be tackled	Survey results of the assigned area 1) Ground data 2) Grid data 3) Contour data	0.17 M/M (5 days)
(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Guidance for reflection of issues on the procedures	Revised procedures	0.13 M/M (4 days) Including trip [Kathmandu→ Haneda]

Source: JICA Project Team

Table 2-20 Soft Component Activity Plan (strengthening of the DEM utilization structure)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
First term First on-site training (preparations for holding a seminar, classroom lectures, guidance for creation of procedures) Target personnel and its number			
(1) Specifications and usability of the detailed DEM are acknowledged by many agencies and people. Survey Department (3 persons): Sales Staff of "Geographic Information Infrastructure Division (GIID)"	▪ Prepare for holding a seminar to introduce the specifications and usage examples of the detailed DEM. ▪ Create a pamphlet (draft) about the detailed DEM.	Pamphlet (draft)	0.20M/M (6 days) Including trip [Haneda→Kathmandu]
(2) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management	▪ Lectures and hands-on training on creation of thematic maps ▪ Attendees complete procedures for creating the following thematic maps under the guidance of the instructor based on the learnings from lectures and hands-on training. - Profile and cross section - Shading map - Contour map - Elevation tints map - Bird's eye view	Procedures for creating the following thematic maps 1) Profile and cross section 2) Shading map 3) Contour map 4) Elevation tints map 5) Bird's eye view 6) Slope classification map 7) Difference map	0.10M/M (3 days)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Division" and "Geographic Information Infrastructure Division (GIID)"	- Slope classification map - Difference map		
(3) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lectures and hands-on training on analysis of sediment changes ▪ Attendees complete the procedure for analyzing sediment changes under the guidance of the instructor based on the learnings from lectures and hands-on training.	Procedure for analyzing sediment changes	0.13 M/M (4 days) Including trip [Kathmandu→ Haneda]
(4) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lectures on the current situation of riverbed rise, riverbank erosion and flooding caused by road embankment in the eastern Tarai region. ▪ Lectures on that the DEM enables precise flood analysis and to create an accurate hazard map, then appropriate flood countermeasures can be implemented based on the analysis and the map. ▪ Under the guidance of the trainer, prepare a draft pamphlet explaining the use of DEM for flood control.	1) Instruction on "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using DEM " 2) Pamphlet (draft) of the above.	0.17 M/M (5 days) Including trip [Haneda→Kathmandu]
(5) The importance of feedback on topographical changes information from the organizations related to flood control field to the Survey Department will be recognized. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lecture on the below. ▪ In order to conduct appropriate flood control projects and river management, it is necessary to update the DEM information of the location when there is a change in topography or land use in the river area. Therefore, it is important to obtain feedback on the topographical and geographical changes from the related agency responsible for river management and infrastructure construction to the Survey Department, and it is necessary for this to be recognized by flood control organizations. ▪ Preparing a pamphlet (draft) under the guidance of the trainer to explain at the seminar. (The seminar is targeted at flood control organizations.)	1) Sorting out of the importance feedback information on topographical changes from the organizations related to flood control field 2) Pamphlet (draft) of the above.	0.23M/M (7 days) Including trip [Kathmandu→ Haneda]
Second term Second on-site training (verification, evaluation and review of technology transfer outputs) Target personnel and its number			
(1) Specifications and usability of the detailed DEM are acknowledged by many agencies and people. Survey Department, Department of Road, Forest Research and Training Centre, Department of Hydrology and Meteorology, Department of	▪ Hold a seminar to introduce the specifications and usage examples of the detailed DEM by inviting about 60 persons from potential user agencies. ▪ Capture the effectiveness of the seminar based on questionnaires and media reports. ▪ Prepare a pamphlet.	1) Results of questionnaire survey on recognition by relevant agencies 2) Results of survey on the content and frequency of reports by newspaper and TV.	0.27 M/M (9 days) Including trip [Haneda→Kathmandu]

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Water Resources and Irrigation, Department of Mines and Geology, International Center for Integrated Mountain Development (ICIMOD), donors, etc. (60 persons)		3) Pamphlet about the detailed DEM	
(2) Personnel in charge of provision are able to explain the specifications and usage examples of the detailed elevation model. Survey Department (5 persons) : Sales Staff of "Geographic Information Infrastructure Division (GIID)"	▪ Provide guidance to personnel in charge of provision of detailed DEM at the Survey Department on the specifications and usage examples of the models. ▪ The personnel summarize the outcome as user manual.	User manual explaining the detailed DEM.	0.10 M/M (3 days)
(3) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Guidance to reflect issues on procedures, etc.	Revised procedures	0.10 M/M (3 days)
(4) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Guidance to reflect issues on procedures, etc.	Revised procedures	0.17 M/M (5 days) Including trip [Kathmandu→ Haneda]
(5) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood. Same number to (1) (60 persons)	▪ Under the guidance of the trainer, a pamphlet explaining the use of DEM for flood control will be created and its contents will be explained at the seminar.	Pamphlet of "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using digital elevation models"	0.13M/M (4 days) Including trip [Haneda→Kathmandu]
(6) The importance of feedback on topographical changes information for flood control field from the related organizations to the Survey Department will be recognized.	▪ Pamphlet on the feedback information on topographical changes for flood control field from the related organizations will be prepared and its contents will be explained at the seminar.	Pamphlet of the feedback information on topographical changes for flood control field from the related organizations	0.17 M/M (5 days) Including trip [Kathmandu→ Haneda]

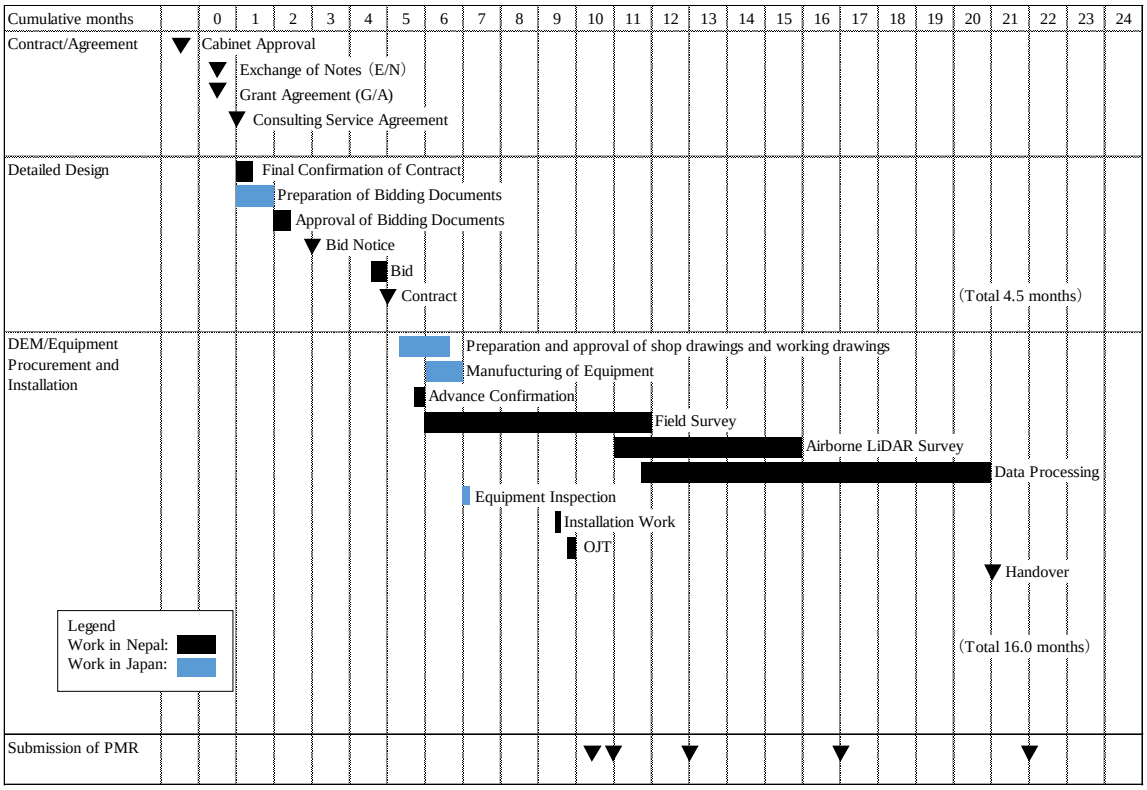
Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Same number to (1) (60 persons)			

Source: JICA Project Team

2-2-4-9 Implementation Schedule

Based on Japan's Guidelines for Grant Aid, the Project implementation schedule is as shown in Table 2-21. The required work period for the Project is approximately 20.5 months, including implementation design and DEM/Equipment procurement, completion of the Installation Work, etc.

Table 2-21 Project Implementation Schedule



Source: JICA Project Team

2-2-5 Security Plan

(1) Security situation in the Project Site

In the Terai Region, the site of the Project, the people led by a group of ethnic Southern Nepali organize general strikes called *bandas* against the draft Constitution (and the draft demarcation of the provincial boundaries, in particular). Some strikers have even attacked vehicles of non-strikers. The protest group attack government offices, police stations and police posts and violent confrontations between the group and security force occur frequently. People on both sides have been killed and injured in the confrontation. The security force sometimes uses tear gas and live bullets to calm the

situation.

(2) Security Measures in the Project Site

Because of the state of security of the site described in (1), the Japanese nationals and/or physical persons of third countries involved in the Project shall avoid going out unless it is essential and urgently required or going out at night as much as possible and always carry mobile phones so that they can be reached at any time. Note that together with the staff of the Survey Department participating in surveying the existing control points and benchmarks, and the work of selecting the newly installed GNSS reference stations and reference control points, sufficient care will be given to the following points in the work.

- A team member who is planning to stay in Nepal for three months or longer shall submit a residence report to the Embassy of Japan in Nepal after arriving in Nepal without delay.
- Obtain the latest security information.
- Use safe means of transport.
- Do not go near dangerous places and suspicious objects.
- Do not go near places where people demonstrate or gather.
- Manage valuables carefully not to be stolen.
- Do not be involved in drug cases.
- Subscribe to overseas travel insurance policy.

2-3 Obligations of Recipient Country

When the Project is implemented, the Japanese side will be responsible for the DEM and Equipment procurement, and the Nepali side will be responsible for obtaining the permission for the implementation of airborne LiDAR survey before the start of the survey work. The main items to be done by the Nepali side are as follows.

(1) Payment for Nepali bank based on B/A

The Ministry of Finance will bear the following fees arising during the Project.

- A/P notification fee
- Fees paid to banks in connection with payments for the Consulting Agreement and Construction Contract

(2) Securing of space for the installation of the Equipment and lands for GNSS reference stations and reference control points

The location of the installation of Equipment to be procured by the Project is decided in the Survey Department building. There are already the existing servers in the building, and air conditioning and power supplies are supplied relatively stable.

Before the start of field survey, a Japanese consultant engineer in charge of procurement management of the Project, confirms the progress of each of operations with the staff of the Survey Department. In this way, a detailed process plan will be formulated, and necessary work will be discussed before the start of surveying, then a system will be established as the survey can be started at a specified schedule.

(3) Providing electricity for the Equipment

The Survey Department will secure the power supply for the Equipment in the Project. If it is necessary to add the power capacity or install a power cable additionally, the installation work will be carried out by the Survey Department before the Installation Work of the commencement of the Project.

(4) Provision of necessary conveniences for Project stakeholders (Japanese / third country engineer, consultant, etc.) to enter and stay in Nepal

It is envisaged that Japanese engineers as well as engineers from third countries will be involved in the various work of field survey, airborne LiDAR survey, and data processing on the Project. Therefore, the Survey Department will perform the necessary procedures, permits, etc. (entry visa, residence visa) for them to enter and remain in the country. With the normal tourist visa it is possible to stay up to a maximum of 90 days in Nepal, but for work on the Project it is desirable that a work permit be obtained. It is possible to apply for a working visa (or a residence visa) in accordance with the time period involved in the work.

(5) Obtaining permission for the implementation of airborne LiDAR survey

Before the contractor commences LiDAR survey, the Survey Department must complete obtaining the following permits from the Civil Aviation Authority of Nepal, the Ministry of Defense, the Police, and the Indian authorities.

- Permission for parking of aircraft used for the survey
- Domestic flight permission
- Permission to fly on the Indian border
- Data acquisition permission

(6) Transportation of survey equipment, customs clearance and tax exemption procedures

As stated in Section 2-2-4-6 (2), the procured equipment can be delivered about two weeks after placing the order with a local supplier within Kathmandu City. The supplier and the Project site (Survey Department) are both within Kathmandu City, so it is envisaged that about 30 minutes will be required for transport by truck.

Likewise surveying equipment (Cessna aircraft for LiDAR survey, etc.) will be transported from an airport in a third country to Tribhuvan International Airport, and after completing the customs

procedures at that airport, it will be transported to an airport in the Terai Region that is the Project site. The time required for transport from the third country to the Project site within Nepal (airport in the Terai Region) will be a maximum of about 9 days, including the customs procedures. The Survey Department will perform the procedures relating to customs, tax exemption, etc., for this equipment.

(7) Securing the storage spaces, facilities, sites, yards, etc.

The Survey Department will secure the following warehouses, temporary offices, and material storage areas.

- Equipment storage
- Temporary offices of the Consultant and Supplier
- Parking space for LiDAR survey aircraft
- Material storage
- Space for a seminar of Soft Component (Max. 60 persons)

(8) Tax Exemption Procedures

Table 2-22 shows the taxes, tax exemption/refund, and procedures for the Project.

Table 2-22 Taxes and Levies on Project Equipment

Type of Taxes and Levies	Taxes and Levies related to the Project*		Rate (%)	Law/ Regulation	How to exempt/ refund	Remarks
Corporate Tax	①	Corporate tax for Japanese nationals	-	Income Tax Act 2002 (2059) Chapter 4.10	Exempt (Advance)	It is necessary to mention the exemption on E/N and G/A.
	②	Corporate tax for third countries nationals	20-30	Income Tax Act 2002 (2059) Chapter 2	Not Exempted	-
	③	Corporate tax for Nepali nationals	20-30	Income Tax Act 2002 (2059) Chapter 2	Not Exempted	-
Personal Income Tax	④	Personal income tax for Japanese staff	-	Income Tax Act 2002 (2059) Chapter 4.10	Exempt (Advance)	It is necessary to mention the exemption on E/N and G/A.
	⑤	Personal income tax for third country's staff	-	Income Tax Act 2002 (2059) Chapter 4.10	Exempt (Advance)	Ditto
	⑥	Personal income tax for local staff	5-25	Income Tax Act 2002 (2059) Chapter 2	Not Exempted	-
	⑦	Withholding tax for Japanese staff		Income Tax Act 2002 (2059) Chapter 4.10	Exempt (Advance)	It is necessary to mention the exemption on E/N and G/A.
	⑧	Withholding tax for third country's staff		Income Tax Act 2002 (2059) Chapter 4.10	Exempt (Advance)	Ditto
	⑨	Withholding tax for local staff	5-15	Income Tax Act 2002 (2059) Chapter 17	Not Exempted	-
Indirect Tax	⑩	VAT	13	Value Added Tax Act, 1996 (2052) Section 25	Refund	■ Application destination: Inland Revenue Office (IRO) ■ Procedure to apply W-PAN approximately (approximately 2 weeks): 1. The Supplier will submit a request tax registration letter (the designated application form, Contract, passport and Power of attorney) to IRO. 2. IRO will issue W-PAN to the Supplier. ■ Procedure for tax refund (approximately 2-3 months after the application): 1. The Supplier will register W-PAN. 2. The Supplier will obtain ID and PW for the web refund application. 3. The Supplier will input necessary information on Web site of IRO for online application. 4. The Supplier will submit the request recommendation letter for refund to MLMCPA.

Type of Taxes and Levies	Taxes and Levies related to the Project*		Rate (%)	Law/ Regulation	How to exempt/ refund	Remarks
						5. MLMCPA will issue the recommendation letter for refund to the Supplier. 6. The Supplier will submit the letter to IRO with INVOICE and the printed out online application document. 7. IRO will review the submitted documents. 8. IRO will refund by check.
	⑪	Excise duty	Setting for each item	Excise Act2001 (2058)	Refund	Ditto
Duty	⑫	Import duty	0-80	Custom Act, 2064 (2007)	Exempt (Advance)	■ Application destination: Survey Department, MLMCPA, Department of Customs ■ Procedure for Master list approval (approximately 2-3 months): 1. The Supplier will submit a request letter for master list approval to Survey Department and MLMCPA. 2. The Supplier will obtain approval from Survey Department and MLMCPA will for the master list. 3. MLMCPA will approve the master list. 4. After the approval, MLMCPA will ask Ministry of Finance (MOF) with a request letter with the master list to approve import duty/VAT exemption. 5. MOF will approve the exemption and inform it to MLMCPA and Department of Customs by an approval letter. ■ Procedure for tax exemption (approximately 30 days): 1. The Supplier will submit a tax exemption request documents (copy of INVOICE, copy of Packing List, copy of B/L, Certificate of origin and copy of Transportation insurance policy) to MLMCPA each shipping. 2. Survey Department will issue a tax exemption letter to Department of Customs. 3. Department of Customs will review the request documents with the approval master list and approval. 4. Department of Customs will issue a tax exemption letter to the related Custom Office.
Other Fiscal Levies and Taxes	⑬	VAT on Fuel	See remark	Nepal Oil co-operation's tentative price list	Refund	Procedure is as same as ⑪
		Government Tax on Fuel			Not Exempted	Government Tax consists of the following items: 1. Custom tax 2. Road maintenance tax 3. Government infrastructure tax 4. Pollution charge 5. Price fixation fund 6. Nepal Civil Aviation's Air fuel charge

Source: JICA Project Team

2-4 Operation and Maintenance System of this Project

(1) Operation and Maintenance Structure

It is expected that the DEM and orthophotos created in the Project will be utilized in the future for flood countermeasures and infrastructure development plans, etc., by the relevant organizations in Nepal. After implementation of the Project, the Survey Department will carry out activities so that the outputs are widely known about and utilized within Nepal. GIID, the section responsible for implementation of the Project, will undertake the publication and distribution of the data. GIID is responsible for providing the existing digital data, so it will not be necessary to increase the number of staff in order to provide the outputs from the Project. On the other hand, this is the first time that the Survey Department will deal with DEM from LiDAR data, so they wish to acquire the data processing technology, technology for use of the DEM, and maintenance technology. In the Project, the soft components including technical trainings will be implemented to strengthen capabilities of the staff of the Survey Department. Thorough these trainings, the staff of the Survey Department will acquire the skills for operation of the DEM using the procured equipment such as the personal computers for data processing and viewing, software, etc., and updating data for changes in topography and rivers over time, for maintenance of the DEM. As a result of this equipment procurement and the technical training, an appropriate structure for operation and maintenance of the DEM will be constructed.

(2) Updating and Maintenance of the DEM

The DEM is data that models the elevation of the ground of the region, so normally updating is not necessary as long as there is no large-scale modification of topography. However, raising of the level of riverbeds and changes in the course of rivers occur occasionally in the Terai Region, so it will be necessary to update the DEM to the extent that changes in topography are envisaged. There is little vegetation in these rivers, so it will be possible to prepare the DEM by the photogrammetry method. Technical guidance on the preparation of DEM using the drones for aerial photography procured in the Project shall be provided in the soft components, so that the Survey Department will be capable of continuously implementing, updating and maintaining the DEM.

(3) Maintenance of the Procured Equipment

The Equipment such as personal computers and UPSs of the Project does not include consumables and spare parts as it will be needed replacing frequently. Since the Equipment will be installed indoors and used, an operation and maintenance plan will be formulated with taking into account the following points.

- To keep the room clean to prevent that dust get inside the Equipment.
- To prevent overheating of the personal computer, air conditioning will be used when the room temperature is high as during summer.

In addition, since the Equipment can be procured locally, if a failure occurs after the warranty period, a

replacement will be procured from a local vendor. Also, the procurement of spare parts and consumables, including propellers and batteries, shall be included in the procurement of an UAV (drone for aerial photography) to be used for the maintenance of the DEM. Therefore, the procurement plan shall include the procurement of required numbers of the spare parts and consumables from a local supplier.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) Estimation of Cost Borne by the Government of Nepal

Table 2-23 Budget Estimation of Tasks Undertaken by MOF

No.	Item	Estimated Cost (NPR)	Remark
Before the Bid			
1	Open a Bank Account by Banking Arrangement (B/A)	0	To be completed within one month after G/A
2	Bearing the following commissions to a bank in Japan for banking services based upon the Banking Arrangement (B/A)		
	(1) Advising commission of Authorization to Pay (A/P)	5,000	For the Consultant Service Agreement 5,000 NPR /time x 1 time = 5,000 NPR
	(2) Payment commission	1,180,000	Securing of the budget for the Consulting Service Agreement and the Contract before the Bid
During Implementation of the Project			
3	Bearing the following commissions to a bank in Japan for banking services based upon the Banking Arrangement (B/A)		For the Consultant and the Supplier's work
	(1) Advising commission of Authorization to Pay (A/P)	5,000	5,000 NPR /time x 1 time = 5,000 NPR
	(2) Payment commission	-	Included in 2 (2) above
4	Ensuring that custom duties, internal taxes and other fiscal levies which may be imposed in the country of the recipient with respect to the purchase of the products and/or the services be exempted, such as, (1) Corporate Tax, (2) Personal Income Tax, (3) Withholding Tax, (4) Consumption Tax (VAT), (5) Excise Tax, (6) Import Duties,	2,370,000 1,410,000 320,000	■ VAT for the Equipment (local procurement) 160,940 USD x 13% = 20,922.2 USD ≒ 2,370,000 NPR ■ VAT for Aviation Fuel 10,425,700 JPY x 13% = 1,355,344 JPY ≒ 1,410,000 NPR ■ VAT for Aviation Oil 2,391,350 JPY x 13% = 310,876 JPY ≒ 320,000 NPR
	Total amount:	**5,290,000**	

Source: JICA Project Team

Table 2-24 Budget Estimation of Tasks Undertaken by SD

No.	Item	Estimated Cost (NPR)	Remark
Before the Bid			
1	Securing of lands (hereinafter referred to as "the Project site") for the installation of the Equipment	0	

No.	Item	Estimated Cost (NPR)	Remark
2	Submitting Project Monitoring Report	0	
During the Project Implementation			
3	According to Japanese nationals and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work	0	
4	Assuring the security of personnel at the Project site, when necessary	0	
5	Submitting Project Monitoring Report at fixed times	0	
6	Obtaining the following permission regarding airborne LiDAR survey: (1) Permission for parking of aircraft used for the survey (2) Domestic flight permission (3) Permission to fly on the Indian border (4) Data acquisition permission	0	
7	Securing the following storage spaces, facilities, sites, yards, etc.: (1) Storage spaces for the Equipment (2) Space for temporary offices for the Consultant and the Supplier (3) Space for parking aircraft for LiDAR survey (4) Space for storage of material (5) Space for a seminar of Soft Component (Max. 60 persons)	155,000	■ Cost for seminar venue: 60 persons (including the cost of PA, and protector)
8	Ensuring that custom duties, internal taxes and other fiscal levies which may be imposed in the country of the recipient with respect to the purchase of the products and/or the services be exempted, such as, (1) Corporate Tax, (2) Personal Income Tax, (3) Withholding Tax, (4) Consumption Tax (VAT), (5) Excise Tax, (6) Import Duties, (7) Other duties, taxes or levies, if any	0	
9	Transporting of the LiDAR equipment and tax exemption and customs clearance at Kathmandu airport	0	
10	Obtaining a confirmation letter for: (1) Permission to undertake the Installation work at the Project site (2) Permission to enter the Project site	0	
11	Providing electricity for the Equipment at the Project site	0	
12	Bearing all expenses other than those covered by the Grant Aid, necessary for the implementation of the Project	0	
	Total amount:	**155,000**	

Source: JICA Project Team

(2) Estimation Conditions

① Estimation date: October 2019

② Exchange rates: 1 US$＝108.36 JPY

1 NPR＝0.95602 JPY Nepal

2-5-2 Operation and Maintenance Costs

(1) Operation and Maintenance Costs

The DEM procured in the Project will be operated and maintained by the implementation systemdescribed in Section 2-4. There will be no additional personnel costs due to the implementation of the Project, because the existing staff will operate and maintain. However, the costs shown in Table 2-25 will increase, such as electricity costs, replacement parts and consumables costs for the Equipment.

Table 2-25 Operation and Maintenance Costs after the Project (increased)

Category	Objective Equipment	Unit Price (NPR)	Remark
1. Electricity Cost	Personal Computer and Monitor	17,300	Hours of operation per year: 6 hours/day x 24 days/month x 12 months = 1,728 hours Power Consumption: Personal Computer x 3 sets (300 W x 3) + Monitor x 3 sets (110 W x 3) = 1,230 W Electricity Cost: (Hours of operation per year) x (Power Consumption) x (Average Electricity Rate) = 1,728 h x 1,230 W x 8.14 NPR/kWh* = 17,301 NPR
	Uninterrupted Power Supply (UPS)	6,500	Hours of operation per year: 6 hours/day x 24 days/month x 12 months = 1,728 hours Power Consumption: 155 W x 3 sets = 465 W Electricity Cost: (Hours of operation per year) x (Power Consumption) x (Average Electricity Rate) =1,728 h x 465 W x 8.14 NPR/kWh* = 6,540 NPR
2. Spare Parts and Consumable Parts	Drone for Aerial photography (propeller)	2,100	Spare Parts Cost: Propeller (1 set for 4 blades) 150 NPR x 14 sets = 2,100 NPR ※The frequency of exchange is assumed to be once every 20 flights, and 14 exchanges per year.
	Drone for Aerial photography (battery)	31,400	Spare Parts Cost: Battery 31,380 NPR x 1 pc = 31,380 NPR ※Assumed usable period is 1 to 2 years and the number of charging is about 100 times.
	Total	57,300	

* The average electricity price of 8.14 NPR/kWh was obtained from the Nepal Electricity Authority (NEA) annual report
Source: JICA Project Team

(2) Operation and Maintenance Costs

In the Project, the life time of the main equipment to be procured is expected to be as shown in Table 2-26. Therefore, in order to operate and maintain the Equipment properly, it is necessary to take into account of the life time (update time) of each equipment and secure a budget for that equipment.

Table 2-26 Renewal Period of the Equipment in the Project

No.	Item	Renewal Period (Year)
1	Personal Computer and Monitor	4
2	Drone for Aerial Photography	5
3	Software	3
4	Uninterrupted Power Supply (UPS)	5

Source: JICA Project Team

2-6 Warranty Period of DEM Products

Warranty period shall be one year after the date of delivery of the products. The warranty covers the case where the products are not created based on the specifications. In this case, the supplier will correct them. However, the warranty does not apply to places where the laser cannot physically reach the ground and data cannot be acquired, such as water areas and under bridges, even if the data do not match to the actual condition due to secular changes of topography. As a result, this warranty does not apply to topographic changes due to natural disaster or other event after data acquisition.

2-7 Utilization plan of Digital Elevation Model (DEM)

2-7-1 Utilization plan of DEM (other than hazard mapping)

(1) Utilization plan of DEM

Considering the specifications of DEM developed in the Project, the utilization plans in the Table 2-27 are expected in governmental and other organizations.

Table 2-27 Utilization of the DEM to be Developed in the Project in Various Organizations

Organization	Utilization of DEM
Irrigation section, DWRI	Generation of contour lines and spot heights of the 1:5,000 scale topographic maps for the planning of irrigation projects
DOR	One layer expressing detailed topography in the GIS for road management
FRTC	Digital Surface Model (or raw data) with point density of 4 pt/m^2 for Above Ground Biomass (AGB) measurement of forest
DMG	Development of geological maps required for the projects in Terai plains
Central Department of Geography, Tribhuvan University	Research activities on various themes (land use and residential area planning considering flood risk due to topography, irrigation planning, flood analysis, flood forecast and flood resistant agriculture, etc)
ICIMOD	- Practical realization of various analysis such as those for flood inundation and sediment disaster - Digital Surface Model (or raw data) with point density of 4 pt/m^2 for Above Ground Biomass (AGB) measurement of forest
Private Sector	More labor-saving and accurate development of large scale orthophoto and topographic map
Donors	- Planning and designing of infrastructure development in road and railroad constructions - Water resource development

Source: JICA Project team

(2) Measures enhancing utilization of DEM

DEM which is the result of the Project is only digital data, consequently it does not bring any benefit to Nepal if it remains as it is. DEM becomes significant data only after utilized for various purposes such as flood hazard mapping, irrigation planning and other infrastructure development planning.

In this regard, it is necessary to disseminate usefulness of DEM widely in Nepal and to make it the data easily accessible and handled. In addition, as DEM is not something immobile and visible, it is necessary to ensure the visibility of the DEM being developed by the support of Japan, and to make the issues of copyright of DEM clear. From these points of view, the following activities shall be implemented.

1) Dissemination through Web site

To provide the information of DEM using photos and figures which answers various questions such as "What exactly are DEM data?" and "What purposes are DEM expected to be used for?"

2) Distribution of products in various specifications

DEM is just a collection of height data. The target area of the Project is about 15,000 km^2, which is very wide, so if all the data is recorded in single file, it becomes huge file, which makes it very difficult to handle. Therefore, whole DEM shall be divided into many files, and the size of each file shall be set so that users can handle the data easily.

The coordinate system of topographic maps provided by Survey Department is based on the geodetic reference system and the map projection which were defined locally in Nepal. However, the use of WGS84 as geodetic reference system and UTM as map projection is common in the Projects of developing geospatial information by ICIMOD and donors such as World Bank. Therefore, DEM shall be provided based on both Nepal geodetic standard and world geodetic standard.

Furthermore, in order to estimate AGB of forest, it is necessary original laser survey data for developing Canopy Height Model in addition to DEM. Therefore, the provision of the original data shall be considered depending on users' needs.

3) Distribution of products easy to access

From the point of enhancing the utilization of DEM, it is ideal to distribute DEM free of charge. Even in the charging case, the price of DEM should be cheap as much as possible. This brings high expectation of the active utilizations of DEM in universities, which has least budget to purchase data, and consultants which mainly depend on the works ordered from government organizations.

In addition, in order to shorten the time required from visiting Survey Department to actual acquisition of requested DEM data, some tool shall be developed.

4) Holding the seminar

In order to introduce the specifications, access and expected uses of DEM for many organizations and users including potential ones, the seminar shall be held inviting stakeholders who are expected to use

DEM.

5) Issues on copyright and ensuring visibility of the support by Japan

While the copyright of DEM to be developed by the Project shall belong to Survey Department, Japan shall have the right to use the DEM freely. DEM is supposed to be distributed with some kind of explanatory document. In such a document, the effort such as putting the description showing DEM has developed by the support of Japan with the logo of Japan's ODA shall be made to increase the visibility of Japan's support.

2-7-2 Use of Digital Elevation Model for Flood Alleviation

Since the topography of the Terai Region is flat, the 10m contour line of the existing 1: 25,000 topographic map is not enough for flood alleviation activities. A digital elevation model with an error of 50 cm or less are required by organizations in the fields shown in Table 2-28. The problems that can be solved by the digital elevation model are as follows.

- The condition of the riverbed at the time of the DEM survey can be used as a reference for future riverbed rise.
- Appropriate structural measures can be planned based on theriver topographic change by DEM.
- The risk of levee failure can be assessed by grasping erosion of riverbanks and sedimentation of riverbeds on DEM.
- The risk of road embankment failure due to flood can be analyzed.
- Flood analysis based on precise topographic information is possible, and detailed hazard maps are created. Based on the detailed hazard maps, accurate forecasts, warnings, evacuation activities, rescue activities, and other non-structural measures can be implemented.

In order to carry out appropriate flood alleviation projects and river management, it is necessary to update the DEM information of the locations of river areas where topographical or geographical changes occur. For this reason, it is important to provide feedback to the DOS about changes in topography and geography from the administrative organizations responsible for river management, infrastructure construction etc. This includes river channel changes due to floods and sedimentation, river repair and improvement, construction of dams and weirs, bridge construction, construction of embankment structures for railways / roads, and increase in flood-risk areas through urban and agricultural development.

Table 2-28 Use of DEM by Related Organizations

Organization	Areas of application for DEM
WECS	Formulation of policies for flood risk reduction
WIDRMD and local river management offices	Grasp of riverbed rise, hydraulic and hydrological calculations, sediment flow analysis, structure planning and design
WRRDC	Grasp of riverbed rise, hydraulic and hydrological calculations, sediment flow analysis, structure design research and development

Organization	Areas of application for DEM
DHM	Creating a hazard map: If a detailed hazard map is created by the digital elevation model, 1) accurate forecast warning, 2) safe evacuation activities, 3) efficient emergency response, and 4) excellent BBB plan will be possible. Hazard maps are used by emergency response centers and other disaster prevention organizations.
Department of Road, Ministry of Physical Infrastructure and Transport	Grasping and hydraulic analysis of flood obstruction caused by road embankment and bridge-approach road embankment
Universities	Researches on flood analysis, sediment flow analysis, river channel characteristics

Source: JICA Project Team

The organizations shown in Table 2-29 may carry out activities related to flood risk reduction using hazard maps. The department in charge of creating and providing DEM is DOS while creation of the hazard map using DEM is DHM. As such, the users of DEM are diverse with government agencies, NGOs and private organizations, mutual information sharing and collaboration are essential for updating and maintaining DEM.

Table 2-29 Flood Alleviation Activities Using Hazard Maps

Organization	Areas of use for hazard maps
National Disaster Risk Reduction and Management Council	Approval of policies and plans for disaster prevention
Executive Committee	Policy / plan instructions approved by the council
DMD	Formulation of disaster prevention policy
National emergency operation center	Integration of flood emergency measures and restoration business
Emergency operation centers of states, districts, cities and local communities	Implement flood emergency measures and restoration projects at each administrative level
NDRRMA	Integration of reparation, emergency measures, restoration, and reconstruction
Disaster management committees of states, districts, cities and local communities	Integration of preparation, emergency measures, restoration and reconstruction at each administrative level
DHM	Issuance of flood forecasts and warnings, notification to the media, etc.
NGOs	Evacuation activities
National Red Cross	Emergency medical activities
TV, Radio, Newspaper	Publicize flood forecasts and warnings, and disseminate flood information

Source: JICA Project Team

2-8 Copyright and publication plan of DEM

Based on the points noted in Section 2-6-1(2), the copyright and the publication of DEM developed by the grant aid project are proposed as follows.

(1) Copyright of DEM

The copyright of DEM developed by the grant aid project belongs to Survey Department, and Japan is vested to have right of using DEM.

(2) Target of publication of DEM

All the DEM of the target area of the Project shall be open. DEM shall be open not only Nepal people but also foreigners. When someone requests the original data of the laser survey, it shall be open if the purpose of use is appropriate.

(3) Distribution of DEM

The DEM shall be distributed at the office in charge of data sales in GIID. The flow of sales for existing digital products shall be applied to the distribution of the DEM. The turnaround time from order to receipt in the office should be reduced using the Web tools such as the one developed in the soft component in the Project.

In near future, it is desirable to establish an environment enabling data order through Internet even though the receipt of the data is made in Survey Department as it is.

(4) Price of DEM Products

Variety of DEM products shall be as follows.

1) Coordinate system

a. Based on geodetic reference system and map projection defined in Nepal
b. Based on WGS84 and UTM projection

2) File unit

The extent of 10 km x 10 km shall be one file. Several file formats which are appropriate considering user needs should be prepared.

The price should be free of charge ideally, but if it is difficult, it should be affordable, for instance about following price so that anyone who wants DEM can get it.

Set 300 NRP as the price of DEM for the extent of one sheet of 1:25,000 scale topographic maps, and calculate unit price per area. Data price shall be area of data to be provided multiplied by unit price. Three hundred NRP corresponds to the highest price of layer data among 8 layers of 1:25,000 digital topographic map. In the case of distributing original laser survey data, it shall be free of charge.

(5) Description about the assistance by Japan

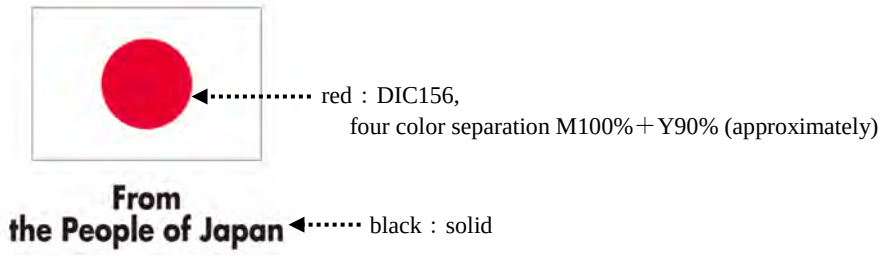
Procured products are data form, therefore not easy to express on the products directly as a “visibility”, such as a Japanese flag mark, in procured products themselves. In order to indicate that the products are prepared by assistance of Japan, the logo of Japanese ODA and the description that they are "Created with Japanese Grant Aid" should be stated in materials accompanying the data listed below. Figure 2 24 shows Japanese flag mark.

- Specification file attached to the products in providing for users
- Pamphlet to be distributed at the seminar

- Data search sites such as geoportal
- Secondary use maps such as hazard maps, topographic maps, etc.
- others (if any)

There are the laws and regulations as listed below for providing data to third parties in Nepal, a system is available for providing data that is the copyrighted work of Survey Department to third parties. Therefore, it is considered that enable to describe the above-mentioned contents in the secondary use maps.

- The Copyright Act, 2059 (2002)[8]
- Copyright Rules, 2016 (2004)[9]
- Directive of Distribution, Use and Regulation, 2069[10]



Source：Guideline of consulting work in the grant aid project (reference 13)[11]

Figure 2-24 Japanese Flag Sticker

2-9 Proposal of New Cooperation for Flood Alleviation Using DEM

Using the DEM, the following new cooperation menu is proposed. It is important to realize the actual effects with financial cooperation. In future cooperation with Nepal, it is necessary to pay attention to investment in disaster prevention mentioned in the Sendai framework, with structural measures in mind. Non-structural measures save lives but do not protect assets. Structural measures are indispensable in order to secure public safety and accumulate public / private capital from disasters.

Table 2-30 shows a proposal for JICA's new cooperation projects using DEM.

Table 2-30 Proposal for JICA's New Cooperation

No.	Field of Cooperation	Details of Cooperation
1	Countermeasures for sedimentation and flood	(1) Implementing organizations
		NWRRDC, DWRI
		(2) Input fields
		hydrological analysis, sediment runoff analysis, sabo planning, sabo facility design, digital elevation model
		(3) Cooperation scheme

[8] The Copyright Act, 2059 (2002) : http://www.lawcommission.gov.np/en/archives/category/documents/prevailing-law/statutes-acts/the-copyright-act-2059-2002

[9] Copyright Rules, 2016 (2004) : http://www.lawcommission.gov.np/en/archives/4220

[10] Directive of Distribution, Use and Regulation, 2069 : http://dos.gov.np/old/?medias=डिजिटल-डाटाको-वितरण-प्रय

[11] Guideline of consulting work in the grant aid project (reference 13) : https://www.jica.go.jp/activities/schemes/grant_aid/guideline/ku57pq0000050ovv-att/13.pdf

No.	Field of Cooperation	Details of Cooperation
		Development study and subsequent financial cooperation for structural measures
		(4) Contents of the project
		Facilities to control sediment production and runoff control in the eastern Terai Region are planned and designed by development study. DEM is used to understand sediment run off mechanism. In fact, NWRRDC is researching and developing countermeasures on the Baklaha River, where sedimentation has become severe. The effect will be practical if this project is targeted. In addition to creating topographic maps and river cross sections using digital elevation models, riverbed gradients, water depths at typical discharges, etc. are also surveyed, and sabo plans are formulated based on these data. After the completion of this development study, sabo facilities are constructed with financial assistance. Rivers in the eastern Terai Region flowing from north to the south can be regarded as having similar river fauna due to their topographical and geological characteristics, so it is highly likely that the results of surveys of typical rivers can be applied to other rivers. The officials will be transferred technology on the creation of topographic maps and river cross-sections using DEM so that the technology can be applied to sediment control of other rivers.
		(5) Reference: Projects planned at NWRRDC
		There is a problem of sedimentation through Bakraha River in the Eastern Terai Region. According to locals, the riverbed has risen 10 meters. As a result, the height of the riverbed and the surrounding land became the same, and floods began to occur frequently. The Sediment monitoring system is started to formulate countermeasures. Observation equipment will be installed on the hillside where sediment production takes place. The needs of controlling sediment production and runoff is urgent as and it is required to build sabo dams.
2	Flood Alleviation	(1) Implementing organization
		DWRI and its local river management offices
		(2) Input fields
		Flood control plan, hydrological analysis, sediment / hydraulic analysis, structure planning, facility design, DEM
		(3) Cooperation scheme
		Development study and subsequent financial cooperation for structural measures Cooperation contents
		(4) Contents of the project
		Using digital elevation models, the flood risk of rivers with elevated riverbeds are identified, and structural measures such as revetment, revetment and embankment strengthening are formulated. ADB has already developed flood countermeasures in the eastern Terai Region for the Bilin, Mawa-Ratouwa and Lakhandei rivers. India manages the Koshi River, and also cooperates with the Bagmati River for structural measures. It is necessary for Japan to select the project rivers so that they do not overlap with these. It is also conceivable to select the project rivers based on the following criteria. - Rivers that were severely damaged by a flood in July 2019 (such as the Lal-Bakaiya River). - Rivers that have not yet been rehabilitated, such as embankments (Domush-Baklaha River, Hoandra River, etc.) - These are under the jurisdiction of the Koshi and Baklaha River Management Offices visited during the first field survey on 2019.
3	Flood hazard map creation	(1) Implementing organization
		DHM
		(2) Input fields
		Development Study
		(3) Cooperation scheme

No.	Field of Cooperation	Details of Cooperation
		Hydrological analysis, flood calculation, hazard map creation, digital elevation model, flood disaster prevention
		(4) Contents of the project
		Hazard maps are created for major rivers in the East Terai Region. In parallel, guidelines will be created for hazard map creation by flood analysis using digital elevation models. The DHM issues flood forecast warnings by matching weather observation data with hazard maps. In addition, various organizations related to disaster prevention carry out various activities using the hazard maps. Therefore, by cooperating with the creation of the hazard map of DHM, the capacity of the related organizations for disaster prevention in emergency response activities can be strengthened.
4	Countermeasures against flood by road embankment	(1) Implementing organization
		Department of Road
		(2) Input fields
		DEM, flood calculation, flood facility planning, flood facility design
		(3) Cooperation scheme
		Development study, followed by financial cooperation
		(4) Contents of the project
		The flood obstruction caused by road embankment will be analyzed using a DEM, and structural measures such as drainage facilities, bridges and causeways will be planned. Guidelines required for this purpose are prepared and technical cooperation is implemented for strengthening the disaster management capacity of the Highway Department. The facilities are constructed with financial assistance based on the results of the development study.
5	Higher education in rivers and sabo engineering	(1) Implementing organization
		Tribhuvan University
		(2) Input fields
		Sabo planning, river planning, facility design, use of digital elevation models
		(3) Cooperation scheme
		Dispatch of experts
		(4) Contents of the project
		Cooperation is implemented in opening and running courses at the university, dispatching lecturers, and conducting research activities. Until now, JICA cooperation on this field has been on human resource development and capacity building of government agencies. By teaching and researching this theme at the university, continually fostering engineers and researchers in the river and sabo fields by using DEM, these human resources can work in government, private and academic organizations. This will enable human resources work on river and sabo aspects through-out the country. Education and research activities such as sediment and hydraulic analysis using DEM will be promoted to enhance river and sabo engineering in the nation.

Source: JICA Project Team

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Precondition

For the implementation of the Project, it is necessary that the Nepali side undertakes the items described in Section 2-2-4-3 and in Table 2-12 at the appropriate timing.

3-2 Necessary Inputs by Nepali Side

(1) Development of Operation and Maintenance System (budget allocation and personnel assignment)

To realize and sustain the effects of the Project, the Nepali side needs to maintain the operation and maintenance system. Therefore, after the Project is completed, the budget and staff necessary to continue using the DEM and procured equipment will be secured.

In addition, since the Survey Department has no experience in DEM processing, it is necessary to appropriately assign personnel after the completion of the Project so that the skills learned with soft components etc. can be continued or expanded.

(2) Extension and Promotion of Use and Recruitment of New Users

It is necessary to hold a seminar to promote the utilization of the DEM at the time of the soft component even after the end of the Project, to disseminate and promote the use, and to cultivate users.

3-3 Important Assumptions

(1) Important Assumptions for Achievement of Overall Goal and Long-term Objective

The long-term objective and overall goal of the Project are:

- Reduction of flood damage in the Terai Region of southern Nepal

The important assumptions for the achievement of the goal and objective are that:

- There should be no change in the policies regarding the Disaster Management Act, the Disaster Risk Reduction Policy, and the Disaster Risk Reduction Strategy adopted by Nepal.
- Nepali economic growth should continue, such as infrastructure development, etc.

(2) Important Assumptions Concerning Direct Effects of Project Outputs

The direct effects expected from the outputs of the Project are as follows.

- The outputs of the Project will improve the accuracy of topographic data of the Terai Region greatly and enable the identification of flood-risk areas and selection of the areas for the

implementation of flood prevention measures. The outputs can be used for the preparation and implementation of various plans, including those for infrastructure development for disaster prevention.

- The effect of the Project can be sustained in the future because it is possible to update the DEM for topographical changes due to flooding and landslide disasters by drone photogrammetry.

The important assumptions for the realization of these effects are as follows.

- A system and budget for operation and maintenance of the equipment that is planned in the Project must be provided.
- The data developed in the Project must be widely published and provided free of charge or at low cost.
- Equipment planned in the Project will not be lost or damaged due to intentional actions or natural disasters.

3-4 Project Evaluation

The evaluation of the Project is organized into the following sections, with particular emphasis on relevance and effectiveness, taking into account the five evaluation items of the Development Assistance Committee (DAC).

3-4-1 Relevance

(1) Project Beneficiaries

By producing a high accuracy DEM in the Terai Region of Nepal, the Project will contribute to development of new large-scale topographical maps, and updating of existing topographical maps that will be used as basic data for disaster risk management represented by hazard maps and/or infrastructure development. Therefore, it is expected to contribute to the expansion of economic growth which will provide benefits for the people of the Terai Region.

(2) Contribution to Upper Level Plan

This project is considered to be a precursor to a seven-year plan for the creation of a DEM for the whole national land of Nepal that is currently being planned, so it is expected to contribute to the long-term plan for the national land of Nepal.

3-4-2 Effectiveness

The effectiveness is evaluated by classifying it into (1) quantitative effects and (2) qualitative effects.

(1) Quantitative Effects

Implementation of the Project is expected to generate the effects shown in Table 3-1. The reference value is the value in 2018 before the implementation of the Outline Design Study, and the target value is three years after the completion of the Project.

Table 3-1 Quantitative Effects Obtained by Implementation of the Project

Indicator	Standard value (recorded value of 2018)	Target value (2025)
DEM grid spacing (m) (or, contour interval (m))	50 (10)	1 (0.5)
Vertical accuracy (m)	5	0.25
Total area covered by large-scale maps (km^2)	0	300
Number of times of distribution of DEM data	0	15
Number of times of distribution of orthophoto data	0	15
Total area covered by hazard maps (km^2)	0	500

Source: JICA Project Team

1) Improvement in the Accuracy of Topographical Information in the Terai Region

The development of the detailed DEM is the direct output of the Project, so at the time of completion of the Project (2022) this index will be reliably achieved.

The topographical information for the Terai Region before implementation of the Project contains contours at 10 m intervals drawn on 1:25,000 topographical maps only. This quantity of information is equivalent to a DEM with a grid size of approximately 50 m x 50 m (the DEM with a grid 50 m x 50 m published by the Geospatial Information Authority of Japan is prepared from 1:25,000 topographical maps with contours at 10 m intervals and spot heights). The DEM to be created in the Project will have a 1 m x 1m grid, of which the amount of information becomes about 2,500 times more. In addition, the accuracy of the elevation value will be improved by 20 times from 5m, which is half the interval between contour lines, and the accuracy of the digital elevation model will be 0.25m.

2) Production of 1:5,000 topographical maps of the eastern part of the Terai Region will be enabled

By mapping based on the orthophotos created in the Project, the Survey Department will be able to create 1:5,000 topographical maps. For contour lines, contour data, which is one of the results of the Project, can be used. However, some field surveying will be required for annotation, etc.

Taking into account the staff and capacity of the Survey Department, it was expected that 1: 5,000 topographic map of about 100 km^2 per year would be created, therefore, it has been set that 1: 5,000 topographic map will be prepared by the target year.

3) The number of users of the DEM will be increased

Using the DEM and orthophotos, the organizations involved in disaster prevention can produce hazard maps using the digital elevation data, formulate disaster prevention plans, etc. Also, it is expected that the DEM will be utilized in each of the organizations involved in infrastructure development, etc., for

producing infrastructure development plans such as urban planning, agricultural land development, roads, railways, plans for construction of watercourses for irrigation, etc.

As a result of interviews with organizations assuming use, there are about 11 organizations requesting the use of the DEM, and the number of requests from each organization is expected to be about 1-2 times by the target year. Therefore, the number of requests for DEM distribution is set to 15 times in total. Since it is assumed that there are many cases where the orthophoto is used integrally with the DEM, the number of distributions of the orthophoto is set to 15 similarly.

Since the processing technology of DEM is common in research institutions such as universities and private companies, it is expected that these institutions will utilize it after the implementation of the Project.

4) Area for production of hazard maps

There are 15 small and medium-sized rivers that require flood control measures within the Project site, of which 4 rivers require high priority flood control measures, for which ADB has produced hazard maps using DEM created from satellite images (vertical accuracy about 10 m).

After creation of the high accuracy DEM in the Project (vertical accuracy 0.25 m), it is expected that hazard maps [12] for the 15 rivers will be updated or produced. It is necessary that the hazard maps for the existing 4 rivers (about 500 km^2) are to be urgently updated, so the target has been set to update them by the target year.

(2) Qualitative Effects

The qualitative effects expected to be realized by the implementation of the Project are as follows.

- Updating of Existing Topographic Map Data.
  For the Terai Region, a 1: 25,000 topographic map is expected to be updated in parallel with the 1: 5,000 topographic map creation. Also, in addition to the modifications accompanying development, etc., floods, landslides, and other changes also involve terrain changes, so continuous updating of topographic map data is required. Since the photogrammetry technology using drones is acquired in the Project, it is expected that existing topographic map data can be updated not only in the Terai Region but also throughout the country.

- Improved Disaster Awareness of Relevant Organization and People
  A seminar for approx. 60 staff members of potential user organizations shall be held and the teaching materials and pamphlets of the seminar shall be prepared in the “Soft Component” of the Project. Through these, public relations education activities are expected to spread from the Survey Department to the relevant ministries and agencies, local governments, and even the residents, thereby raising awareness of disaster prevention.

[12] The hazard maps shall include all the maps produced in order to mitigate disaster risks.

- Improvement the Accuracy of Identification of Expected Flood Area
  By using a detailed DEM, inundation simulation and calculation of area to inundate and inundation depth are possible, consequently, reflecting this, it is expected that the accuracy of hazard maps will be improved and appropriate evacuation plans will be formulated.

- Flood control candidate sites such as embankment strengthening points and flood control reservoirs can be narrowed down
  It is expected to be used for disaster prevention measures, such as identification of danger of breach of levees, prioritization of countermeasure work, selection of candidate sites such as flood control reservoirs, etc. based on flow simulations during river flooding and detailed topography such as levees.

- Use in Plans for Infrastructure Development (roads, railways, irrigation canals, etc.)
  The detailed topographic data and orthophotos to be created in the Project and the 1/5,000 topographic map data to be created consequently from them are essential for the preparation and implementation of infrastructure development plans and the provision of such data is expected to facilitate the infrastructure development in the Terai Region.

Appendices

Appendices

Appendix 1

Member List of the Study Team

1 Member List of the Study Team

(JICA)

Name	Assignment	Organization
Mr. Hidenori Kumagai	Leader	Senior Assistant Director Urban and Regional Development Group & Office for Peacebuilding and Reconstruction Infrastructure and Peacebuilding Department **Japan International Cooperation Agency**

(Consultant)

Name	Assignment	Organization
Mr. Takashi Harada	Chief Consultant/ Consultation of Specifications 1	Aero Asahi Corporation
Mr. Takao Ikeda	Co-Chief Consultant/ Consultation of Specifications 2	Aero Asahi Corporation
Mr. Shinjiro Tomizawa	Airborne Lidar Survey Planning	Aero Asahi Corporation
Mr. Jun Hoshino	Procurement Planning/ Cost Estimation 2	Aero Asahi Corporation
Mr. Hiromichi Maruyama	Data Utilization Planning	Aero Asahi Corporation (Infrastructure Development Institude-Japan)
Mr. Yosuke Ikeda	Procurement Planning/ Cost Estimation 1	Yachiyo Engineering Co., Ltd.
Mr. Junji Yokokura	Disaster Risk Reduction Planning	Yachiyo Engineering Co., Ltd.
Mr. Sah Bhuwneshwar Prasad	Control Point and Field Survey Planning	Pasco Corporation

Appendix 2 Study Schedule

THE PROJECT FOR THE DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO IN THE FEDERAL DEMOCRATIC REPUBLIC OF NEPAL
Schedule for the 1st Field Survey

No.	Date	Day	Survey Content								Stay at
			JICA Mr. Hidenori Kumagai	AAC Mr. Takashi Harada	AAC Mr. Takao Ikeda	AAC Mr. Shinjiro Tomizawa	Pasco Mr. Sah Bhuwneshwar Prasad	AAC Mr. Hiromichi Maruyama	yec Mr. Yosuke ikeda	yec Mr. Junji Yokokura	
Person in charge			Leader	Chief Consultant / Consultation of Specifications 1	Co-Chief Consultant / Consultation of Specifications 2	Airborne Lidar Survey Planning	Control Point and Field Survey Planning	Data Utilization Planning	Procurement Planning / Cost Estimation	Disaster Risk Reduction Planning	
Number of days			8	29	25	15	21	14	17	17	
1	8-Sep	Sun	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting			Trip[Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Kathmandu
2	9-Sep	Mon	・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)	・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)	・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)			・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)	・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)	・Meeting with JICA Nepal Office ・Meeting with SD (Explanation of Inception Report)	Kathmandu
3	10-Sep	Tue	・Meeting with SD (Explanation of Inception Report) ・Preparation of M/D	・Meeting with SD (Explanation of Inception Report) ・Preparation of M/D	・Meeting with SD (Explanation of Inception Report) ・Preparation of M/D			・Meeting with WECS ・Meeting with Div. of DP, DWRI ・Meeting with Div. of irrigation, DWRI ・Meeting with SD	・Meeting with SD (Explanation of Inception Report) ・Preparation of M/D ・Request for Quotation of Rental-car and hotel	・Meeting with DWIDM ・Meeting with WECS ・Meeting with DWRI ・Meeting with SD (Explanation of Inception Report)	Kathmandu
4	11-Sep	Wed	・Internal Meeting ・Preparation of M/D	・Internal Meeting ・Preparation of M/D	・Internal Meeting ・Preparation of M/D			・Meeting with CDG, Tribhuvan Univ. ・Meeting with JICA Nepal Office ・Meeting with DHM	・Internal Meeting ・Preparation of M/D	・Meeting with CDG, Tribhuvan Univ. ・Meeting with JICA Nepal Office ・Meeting with DHM	Kathmandu
5	12-Sep	Thu	・Discussion on M/D with SD ・Conclusion of M/D (Sign)	・Discussion on M/D with SD ・Conclusion of M/D (Sign)	・Discussion on M/D with SD ・Conclusion of M/D (Sign)			・Meeting with DMG ・Meeting with WRRDC ・Meeting with ICIMOD	・Discussion on M/D with SD ・Conclusion of M/D (Sign)	・Meeting with Ministry of Interior (MOI) ・Meeting with National Reconstruction Authority(NRA) ・Meeting with ICIMOD	Kathmandu
6	13-Sep	Fri	・Internal Meeting ・Sorting information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data			・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Kathmandu
7	14-Sep	Sat	Trip [Kathmandu 13:30(TG320)→18:15 Bangkok 22:10(TG640)→Narita +1]	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data			・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Meeting with DoR staff	Kathmandu/ On flight
8	15-Sep	Sun	Trip [→06:20Narita]	・Meeting with SD ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	Trip [Haneda 00:20(TG661)→04:50 Bangkok 10:15(TG319)→12:25 Kathmandu] ・Internal Meeting	・Meeting with DoR ・Meeting with local survey company	Trip [Kathmandu→Simara] flight ・Meeting with DWIDM local office at Birganj ・Site survey on Bagmati River Basin	Trip [Kathmandu→Simara] flight ・Meeting with DWIDM local office at Birganj ・Site survey on Bagmati River Basin	Kathmandu/ Janakpur
9	16-Sep	Mon		・Meeting with SD ・Meeting with local survey company	Trip [Kathmandu→Bangkok] for engaged in another JICA project	・Meeting with SD ・Meeting with JICA Nepal Office	・Meeting with SD ・Meeting with JICA Nepal Office	・Meeting with FRTC ・Meeting with SD	Trip [Janakpur→Biratnagar]land ・Site survey on rivers in the Terai region	Trip [Janakpur→Biratnagar]land ・Site survey on rivers in the Terai region	Kathmandu/ Biratnagar
10	17-Sep	Tue		・Meeting with SD ・Meeting with CAAN	Engaged in another JICA project	・Meeting with SD ・Meeting with CAAN ・Meeting with local survey company	・Meeting with SD ・Meeting with CAAN ・Meeting with local survey company	・Meeting wth WB ・Meeting with local surveying company ・Meeting with ADB	・Site survey on Koshi River Basin ・Meeting with DWIDM local office Trip[Biratnagar→Kathmandu]flight	・Site survey on Koshi River Basin ・Meeting with DWIDM local office Trip[Biratnagar→Kathmandu]flight	Kathmandu
11	18-Sep	Wed		・Meeting with SD ・Meeting with local survey company	Engaged in another JICA project	・Meeting with local survey company ・Meeting with SD	・Meeting with local survey company ・Meeting with SD	・Meeting with local survey company ・Data Purchase at SD ・Meeting with SD	・Internal Meeting ・Organizing data and documents ・Collecting quotations of rental-car and hotel	・Meeting with SD	Kathmandu
12	19-Sep	Thu		・Meeting with SD ・Meeting with JICA Nepal Office ・Meeting with CAAN ・Meeting with MOF	Engaged in another JICA project	・Meeting with Softwel ・Meeting with SD ・Meeting with JICA Nepal Office ・Meeting with CAAN	・Meeting with Softwel ・Meeting with SD ・Meeting with JICA Nepal Office ・Meeting with CAAN	・Meeting with SD ・Meeting with JICA Nepal Office at hotel	・Meeting with MOF (Tax information) ・Meeting with IRO (Tax information) ・Meeting with JICA Nepal Office at hotel	・Meeting with JICA Nepal Office at hotel	Kathmandu
13	20-Sep	Fri		・Internal Meeting ・Sorting Information and Data	Trip [Bangkok→Kathmandu] for this project	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Trip[Kathmandu13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]	・Internal Meeting ・Organizing data and documents ・Procurement Survey (Local Company) and request for quotation of local workers	・Internal Meeting ・Sorting Information and Data	Kathmandu/ On flight
14	21-Sep	Sat		・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Trip[→06:55 Haneda]	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Kathmandu

A2-1

No.	Date	Day	Survey Content								Stay at
			JICA Mr. Hidenori Kumagai	AAC Mr. Takashi Harada	AAC Mr. Takao Ikeda	AAC Mr. Shinjiro Tomizawa	Pasco Mr. Sah Bhuwneshwar Prasad	AAC Mr. Hiromichi Maruyama	yec Mr. Yosuke ikeda	yec Mr. Junji Yokokura	
Person in charge			Leader	Chief Consultant / Consultation of Specifications 1	Co-Chief Consultant / Consultation of Specifications 2	Airborne Lidar Survey Planning	Control Point and Field Survey Planning	Data Utilization Planning	Procurement Planning / Cost Estimation	Disaster Risk Reduction Planning	
Number of days			8	29	25	15	21	14	17	17	
15	22-Sep	Sun		・Meeting with SD ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company	・Internal Meeting ・Meeting with SD ・Meeting with local survey company	・Internal Meeting ・Meeting with SD ・Meeting with local survey company		・Survey for the existing equipment/Environment for the Equipment ・Procurement Survey (Local Office of Japanese Construction Company) ・Meeting with MOF (Tax information) ・Meeting with local survey company	・Meeting with local survey company ・Procurement Survey (Local Office of Japanese Construction Company)	Kathmandu
16	23-Sep	Mon		・Meeting with SD ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company	・Internal Meeting ・Meeting with SD ・Meeting with local survey company	・Internal Meeting ・Meeting with SD ・Meeting with local survey company		Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]	Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]	Kathmandu/On flight
17	24-Sep	Tue		・Meeting with JICA Nepal Office ・Meeting with SD ・Meeting with local survey company	・Meeting with JICA Nepal Office ・Meeting with SD ・Meeting with local survey company	Trip [Kathmandu→Simara] flight ・Reference Point Survey around Simara Airport and Birgunj ・Meeting with DOS Bara Office and DOS Parsa Office	Trip [Kathmandu→Simara] flight ・Reference Point Survey around Simara Airport and Birgunj ・Meeting with DOS Bara Office and DOS Parsa Office		Trip [→06:55 Haneda]	Trip [→06:55 Haneda]	Kathmandu/ Birganj
18	25-Sep	Wed		・Sorting Information and Data	・Sorting Information and Data	Trip [Birgunj→Janakpur] land ・Reference Point Survey around Rautahat and Sarlahi ・Meeting with DOS Rautahat Office and DOS Sarlahi Office	Trip [Birgunj→Janakpur] land ・Reference Point Survey around Rautahat and Sarlahi ・Meeting with DOS Rautahat Office and DOS Sarlahi Office				Kathmandu/ Janakpur
19	26-Sep	Thu		・Meeting with local survey company ・Sorting Information and Data	・Meeting with local survey company ・Sorting Information and Data	・Meeting with DOS Janakpur Office ・Reference Point Survey in Janakpur Airport ・Meeting with Janakpur Airport Ofiice Trip [Janakpur→Kathmandu] flight	・Meeting with DOS Janakpur Office ・Reference Point Survey in Janakpur Airport ・Meeting with Janakpur Airport Ofiice Trip [Janakpur→Kathmandu] flight				Kathmandu
20	27-Sep	Fri		・Meeting with local survey company ・Internal Meeting	・Meeting with local survey company ・Internal Meeting	・Meeting with local survey company ・Internal Meeting	・Meeting with local survey company ・Internal Meeting				Kathmandu/On flight
21	28-Sep	Sat		・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]	Trip [Terai→Kathmandu]				Kathmandu/ On flight
22	29-Sep	Sun		・Meeting with local survey company ・Internal Meeting	・Meeting with local survey company ・Internal Meeting	Trip [→06:55 Haneda]	・Meeting with local survey company ・Internal Meeting				Kathmandu
23	30-Sep	Mon		・Meeting with SD ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company		・Meeting with SD ・Meeting with local survey company				Kathmandu
24	1-Oct	Tue		・Meeting with local survey company ・Meeting with JICA Nepal Office ・Internal Meeting	・Meeting with local survey company ・Meeting with JICA Nepal Office ・Internal Meeting		・Meeting with local survey company ・Meeting with JICA Nepal Office ・Internal Meeting				Kathmandu
25	2-Oct	Wed		・Meeting with MOF ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company		・Meeting with SD ・Meeting with local survey company ・Meeting with MOF				Kathmandu
26	3-Oct	Thu		・Meeting with SD ・Meeting with local survey company	・Meeting with SD ・Meeting with local survey company		・Meeting with SD ・Meeting with local survey company				Kathmandu
27	4-Oct	Fri		・Report to JICA Nepal Office ・Report to EOJ ・Meeting with local survey company	・Report to JICA Nepal Office ・Report to EOJ ・Meeting with local survey company		Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]				Kathmandu/ On flight
28	5-Oct	Sat		Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]	Trip [Kathmandu 13:30(TG320)→18:15 Bangkoku 22:45(TG682)→Haneda +1]		Trip [→06:55 Haneda]				Kathmandu/ On flight
29	6-Oct	Sun		Trip [→06:55 Haneda]	Trip [→06:55 Haneda]						-

SD: Survey Department, Ministry of Land Management, Cooperatives and Poverty Alleviation

THE PROJECT FOR THE DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO IN THE FEDERAL DEMOCRATIC REPUBLIC OF NEPAL
Schedule for the 2nd Field Survey

No.	Date	Day	Survey Content					Stay at
			JICA Mr. Hidenori Kumagai	AAC Mr. Takashi Harada	AAC Mr. Takao Ikeda	Pasco Mr. Sah Bhuwneshwar Prasad	yec Mr. Yosuke ikeda	
Person in charge			Leader	Chief Consultant / Consultation of Specifications 1	Co-Chief Consultant / Consultation of Specifications 2	Control Point and Field Survey Planning	Procurement Planning / Cost Estimation	
Number of days			8	10	6	10	8	
1	1-Dec	Sun	Trip[Haneda 00:20(TG661)→05:25 Bangkok 10:30(TG319)→12:45 Kathmandu] ・Internal Meeting		Trip[Narita→Bangkok] for engaged in another JICA project	Trip[Haneda 00:20(TG661)→05:25 Bangkok 10:30(TG319)→12:45 Kathmandu] ・Internal Meeting		Kathmandu
2	2-Dec	Mon	・Meeting with JICA Nepal Office ・Meeting with SD		Engaged in another JICA project	Same to the Leader		Kathmandu
3	3-Dec	Tue	・Preparation of M/D ・Internal Meeting		Engaged in another JICA project	Same to the Leader		Kathmandu
4	4-Dec	Wed	・Discussion on M/D with SD		Trip [Bangkok→Kathmandu] for this project	Same to the Leader		Kathmandu
5	5-Dec	Thu	・Discussion on M/D with SD ・Meeting with MOF		Same to the Leader			Kathmandu
6	6-Dec	Fri	・Conclusion of M/D (Sign) ・Report to EOJ/JICA Nepal Office ・Internal Meeting		・Conclusion of M/D (Sign) ・Internal Meeting			Kathmandu
7	7-Dec	Sat	Trip[Kathmandu 13:30(TG320)→18:15 Bangkok 22:10(TG640)→Narita +1]	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	・Internal Meeting ・Sorting Information and Data	Trip[Kathmandu 13:30(TG320)→18:15 Bangkok 22:45(TG682)→Haneda +1]	Kathmandu/ On flight
8	8-Dec	Sun	Trip[→06:20 Narita]	・Preparation of Final Report	・Preparation of Final Report	・Preparation of Final Report	Trip[→06:55Haneda]	Kathmandu
9	9-Dec	Mon		Trip[Kathmandu 13:30(TG320)→18:15 Bangkok 22:45(TG682)→Haneda +1]				Kathmandu
10	10-Dec	Tue		Trip[→06:55Haneda]				-

Appendix 3

List of Parties Concerned in the Recipient Country

3 List of Parties Concerned in the Recipient Country

Survey Department

Name	Position
Prakash Joshi	Director General
Kamal Ghimire	Director
Sushil Narsingh Rajbhandari	Chief Survey Officer Geographic Information Infrastructure Division
Susheel Dangol	Chief Survey Officer & Co-ordinator Mt. Everest Height Measurement Program
Abhash Joshi	Survey Officer Geomatics Engineer Geographic Information Infrastructure Division
Nirmal Kumar Acharya	Chief Survey Office Geodetic Survey Division

Civil Aviation Authority of Nepal

Name	Position
Er. Sanjeev Singh Kathayat	Deputy Director

Ministry of Finance

Name	Position
Krishna Chandra Kafley	Section Officer International Economic Cooperation Co-ordination Division

Inland Revenue Department

Name	Position
Puskar Neupane	Director

Department of Hydrology and Meteorology

Name	Position
Sarayu K. Baidya	Director General
Bikram Shrestha Zoowa	Senior Divisional Hydrologist, Flood Forecasting Section

Ministry of Energy, Water Resources and Irrigation

Name	Position
Dr. Rishi Sharma	Joint Secretary Water and Energy Commission Secretariat: WECS
Suresh Maskey	Senior Divisional Hydrologist Water and Energy Commission Secretariat: WECS
Er. Shishir Koirala,	Deputy Director General Dept. of Water Resources and Irrigation: DWRI
Dinesh Rajouria	Project Director Dept. of Water Resources and Irrigation: DWRI

Bagumati River and Lal Bakeya River Management Project Office

Name	Position
Manoranjan Kumar Singh	Project Manager
Er. Rajinand Prasad Chaudhary	Civil Engineer

Koshi and Bakraha River Management Project

Name	Position
Bilanand Dyadar	Project Manager
Mahesh Kumar Chaudhary	Engineer
Dhirary Kumar Karna	Sub Engineer

Water Resources Research and Development Center

Name	Position
Shiv Kumar Basnet	Joint Secretary/Chief of the Center
Ashok Raj Gautam	Engineer

Ministry of Home Affairs

Name	Position
Bamshi Kumar Acharrya	Under Secretary, Disaster Management Division
Shambhu Prasad Regmi	Under Secretary and Chief of NEO, National Emergency Operation Center

Department of Mines and Geology

Name	Position
Dr. Soma Nath Sapkota	Director General
Dr. Rajendra Prasad Bhandari	Deputy Director General

Department of Road

Name	Position
Keshab Kumar Sharma	Director General
Naresh Man Shakya	Senior Divisional Engineer
Binod Bhattarai	Senior Divisional Engineer
Salina Dangol	Computer Engineer

Forest Research and Training Centre

Name	Position
Raja Ram Aryal	
Ananda Khadka	
Dipak Mahatana	

Megharaj Poudel	

Central Department of Geography of Tribhuvan University

Name	Position
Dr. Hriday Lal Koirala	Professor and Head
Dr. Prem Sagar Chapagain	Professor
Gyanu Raja Maharjan	GIS Practitioner Head Office Assistant & Research Assistant

International Center for Integrated Mountain Development

Name	Position
Dr. Mir Matin	
Dr. Ghulam Rasul	
Karma Tsering	
Sudip Pradhan	

World Bank

Name	Position
Avani Mani Dixit	

Asian Development Bank

Name	Position
Naresh Pradhan	

Millennium Challenge Account Nepal

Name	Position
Biswal Dhoj Joshi	In charge of Electricity
Sudhan Shrestha	In charge of Road and Highway

Embassy of Japan in Nepal

Name	Position
Yoshiki Sando	Second Secretary

JICA Nepal Office

Name	Position
Kozo Nagami	Deputy Director
Yoji Toriumi	Representative
Ram Prasad Bhandari	Program Manager

Appendix 4 Minutes of Discussion

(1) 1st Field Survey 12th September 2019

(2) 2nd Field Survey 6th December 2019

(1) 1st Field Survey

Minutes of Discussions
on the Preparatory Survey for the Project for
DEVELOPMENT OF DIGITAL ELEVATION MODEL
ENABLING DISASTER RESILIENCE,
FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

Based on the several preliminary discussions between the Government of the Federal Democratic Republic of Nepal (hereinafter referred to as "Nepal") and JICA Nepal Office, Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") of the Project for DEVELOPMENT OF DIGITAL ELEVATION MODEL ENABLING DISASTER RESILIENCE, FEDERAL DEMOCRATIC REPUBLIC OF NEPAL (hereinafter referred to as "the Project") to Nepal. The Team held a series of discussions with the officials of the Government of Nepal and conducted a field survey. In the course of the discussions, the main items described are as in the attached sheets.

Kathmandu, 12 September, 2019

Mr. Hidenori KUMAGAI	Mr. Prakash JOSHI
Team Leader	Director General
Preparatory Survey Team	Department of Survey
Japan International Cooperation Agency	Ministry of Land Management, Cooperatives and Poverty Alleviation
Japan	Government of Nepal

ATTACHMENT

1. Objective of the Project

The objective of the Project is to increase accuracy of flood control plan by using high resolution geo-information and thereby contributing to reduce flood damage.

2. Title of the Preparatory Survey

The title of the Preparatory Survey is as "the Preparatory Survey for the Project for DEVELOPMENT OF DIGITAL ELEVATION MODEL ENABLING DISASTER RESILIENCE, FEDERAL DEMOCRATIC REPUBLIC OF NEPAL".

3. Project site

Both sides confirmed that the sites of the Project are in Nepal, which is shown in Annex 1.

4. Responsible authority for the Project

Both sides confirmed the authorities responsible for the Project are as follows:

4-1. The Survey Department under the Ministry of Land Management, Cooperatives and Poverty Alleviation will be the executing agency for the Project (hereinafter referred to as "the Executing Agency"). The Executing Agency shall coordinate with all the relevant authorities to ensure smooth implementation of the Project and ensure that the undertakings for the Project shall be managed by relevant authorities properly and on time. The organization charts are shown in Annex 2.

5. Items requested by the Survey Department, the Government of Nepal

5-1. As a result of discussions, both sides confirmed that the items requested by the Survey Department, the Government of Nepal are as follows:

1) Equipment and products

(i) Procurement

a) DEM data and Orthophoto

b) Personal Computer with Monitor

c) Software

d) Uninterruptible Power Supply (UPS)

e) Spare Parts and Consumable Parts

(ii) Installation

a) Installation of Equipment

b) Adjustment and Testing

(iii) Initial Guidance, Operating Guidance, technology transfer

2) Consulting Services

(a) Detailed Design, Support of Tender and Supervision on site

5-2. JICA will assess the feasibility of the above requested items through the survey and will report the findings to the Government of Japan. The final scope of the Project will be decided by the Government of Japan.

5-3. The Survey Department, the Government of Nepal shall submit an official request to the Government of Japan through a diplomatic channel before the appraisal of the Project, which is scheduled in November 2019.

6. Procedures and Basic Principles of Japanese Grant

6-1. The procedures and basic principles of Japanese Grant as described in Annex 3 shall be applied to the Project.

As for the monitoring of the implementation of the Project, the Team presented the form attached as Annex 4 required from the Nepali side to submit as the Project Monitoring Report.

6-2. The Team presented the obligation table as Annex 5 for smooth implementation of the Project. The contents of the Annex 5 will be elaborated and refined during the Preparatory Survey and be agreed in the mission dispatched for explanation of the Draft Preparatory Survey Report.

The contents of Annex 5 will be updated as the Preparatory Survey progresses, and eventually, will be used as an attachment to the Grant Agreement.

7. Schedule of the Survey

The Team presented schedule as follows.

7-1. The Team will proceed with further survey in Nepal until 6th October 2019.

7-2. An official request to the Government of Japan will be submitted before November 2019.

7-3. JICA will prepare a draft Preparatory Survey Report in English and dispatch a mission to Nepal in order to explain its contents around November 2019.

7-4. If the contents of the draft Preparatory Survey Report is accepted and the undertakings for the Project are fully agreed by the Nepali side, JICA will finalize the Preparatory Survey Report and send it to Nepal around March 2020.

7-5. The above schedule is tentative and subject to change.

8. Environmental and Social Considerations

8-1. The Nepali side confirmed to give due environmental and social considerations before and during implementation, and after completion of the Project, in accordance with the JICA Guidelines for Environmental and Social Considerations (April, 2010).

8-2. The Project is categorized as "C" from the following considerations:
Not located in a sensitive area, nor has it sensitive characteristics, nor falls it into sensitive sectors under the Guidelines, and its potential adverse impacts on the environment are not likely to be significant.

9. Other Relevant Issues

9-1. Warranty

Duration of warranty range and period of creation of above requested products "DEM data and Orthophoto", the Nepali side agreed upon the following manner.

1) Warranty range

Warranty covers specified items of specification of the products.

2) Warranty period

Warranty period is one year from the delivery date of the products.

9-2. Acquisition flight permission including airborne LiDAR survey

The Nepali side agreed to make necessary arrangement to acquire permission for airborne lidar survey taken covering the project area including international border.

9-3. Data Processing

The Nepali side requested to make data processing in Nepal, because C/P can check data processing by them easily. However, the Team proposed that Japanese side takes out of acquired data from Nepal and process in Japan. And the Team proposed to send C/P staff to inspect products time to time to Japan.

9-4. Data copy right

Both sides agreed that Copy right of produced data belong to the Nepali side, however data usage right remains to JICA.

9-5. Products

The Nepali side specifically requested to conduct the survey as per the approved specification by Survey Department instead of 2m grid size of the Team proposal. The Team explained that if specification is changed from 2m, possibility of change coverage of the Project area will be occurred.

The Nepali side requested to include orthophoto production in the Project. However, the Team explained that the Project will not include orthophoto production other than simple orthophoto production.

The Nepali side agreed to share the approved detail specification to the Team and requested to conduct proposed project according to the approved specification.

As a result of discussions, the Team will convey this request to Japan. After analyzing and cost estimating, the Team will answer at explanation of draft outline design (DOD).

9-6. Visibility of Japanese Grant Aid

The Nepali side acknowledged that the products shall be supplied indicating Japanese Grant Aid.

9-7. The Nepali side informed that all the mapping specifications and products should be approved by mapping committee. Since from discussion it was observed that there is variation in the requirement between Survey Department and proposal from the Team. There are issues regarding the processing data in Nepal, involvement of the technical team from Survey Department and adoption of the approved specification from Survey Department. The Nepali side will forward this record of discussions including these issues to the Ministry of Land Management, Cooperatives and Poverty Alleviation copied to JICA for the facilitation.

Annex 1 Project Site

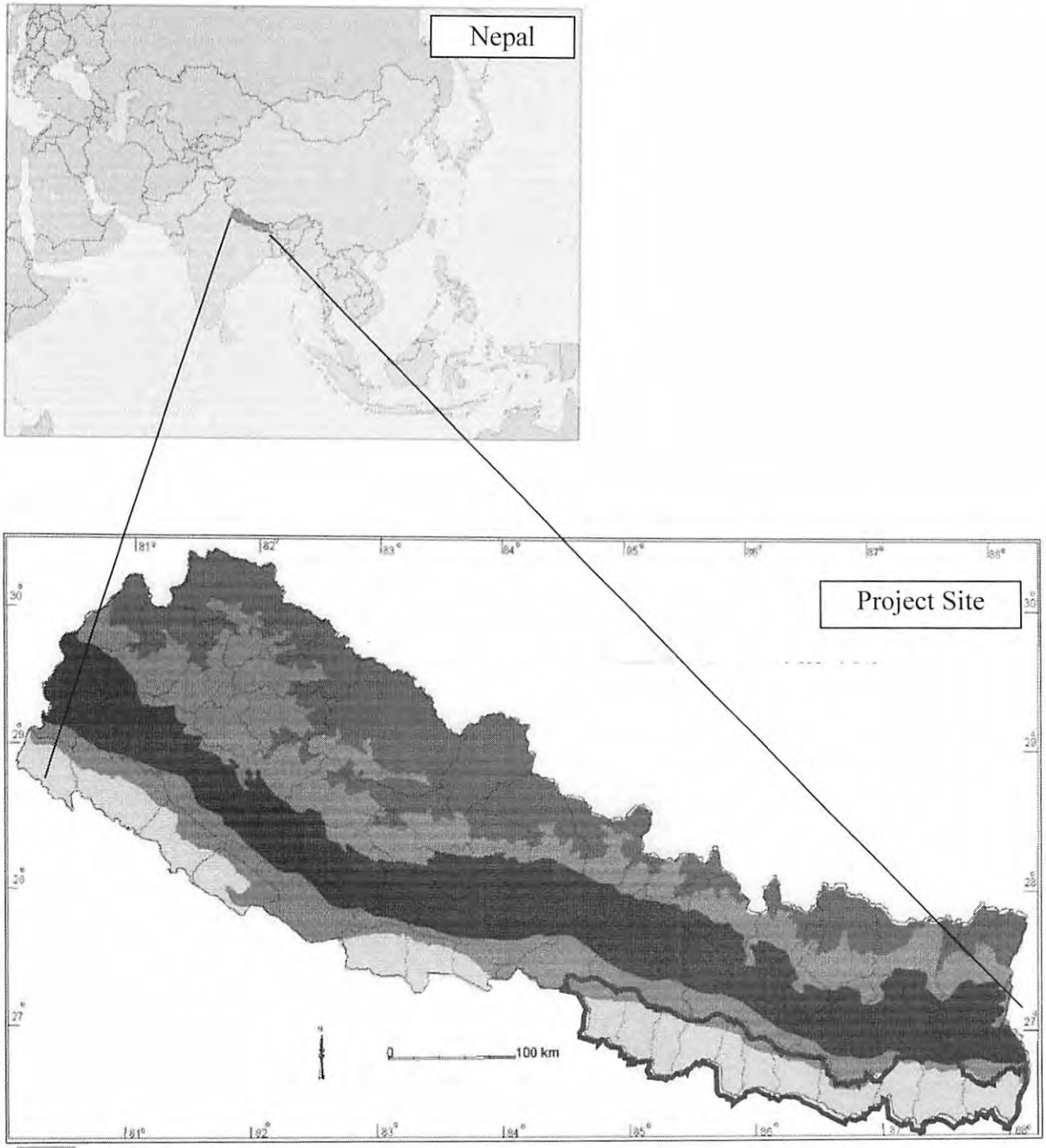
Annex 2 Organization Chart

Annex 3 Japanese Grant

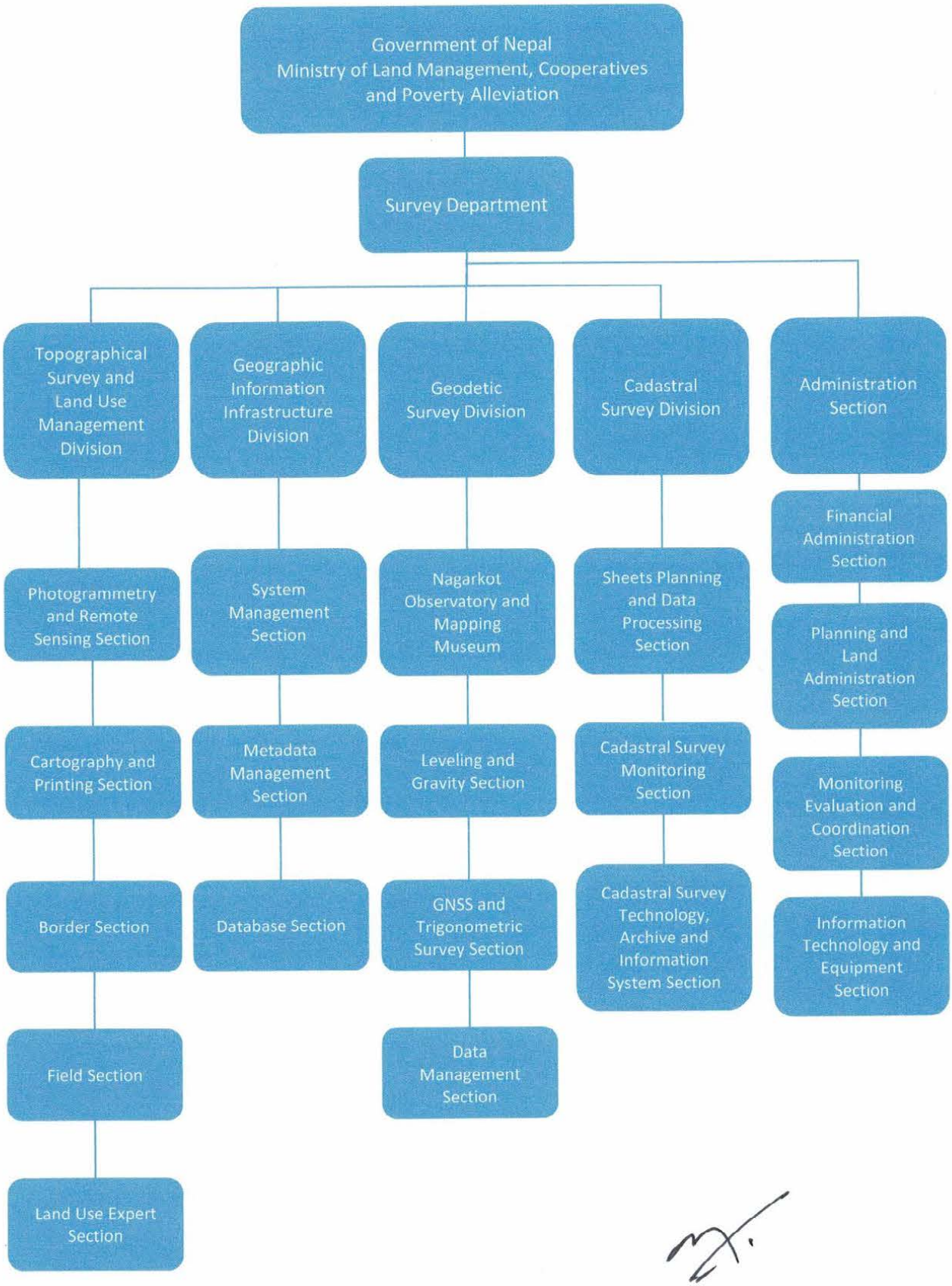
Annex 4 Project Monitoring Report (template)

Annex 5 Major Undertakings to be taken by the Government of Nepal

Project Site



Organization Chart



JAPANESE GRANT

The Japanese Grant is non-reimbursable fund provided to a recipient country (hereinafter referred to as "the Recipient") to purchase the products and/or services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. Followings are the basic features of the project grants operated by JICA (hereinafter referred to as "Project Grants").

1. Procedures of Project Grants

Project Grants are conducted through following procedures (See "PROCEDURES OF JAPANESE GRANT" for details):

(1) Preparation

- The Preparatory Survey (hereinafter referred to as "the Survey") conducted by JICA

(2) Appraisal

-Appraisal by the government of Japan (hereinafter referred to as "GOJ") and JICA, and Approval by the Japanese Cabinet

(3) Implementation

Exchange of Notes

-The Notes exchanged between the GOJ and the government of the Recipient

Grant Agreement (hereinafter referred to as "the G/A")

-Agreement concluded between JICA and the Recipient

Banking Arrangement (hereinafter referred to as "the B/A")

-Opening of bank account by the Recipient in a bank in Japan (hereinafter referred to as "the Bank") to receive the grant

Construction works/procurement

-Implementation of the project (hereinafter referred to as "the Project") on the basis of the G/A

(4) Ex-post Monitoring and Evaluation

-Monitoring and evaluation at post-implementation stage

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide basic documents necessary for the appraisal of the the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of

relevant agencies of the Recipient necessary for the implementation of the Project.

- Evaluation of the feasibility of the Project to be implemented under the Japanese Grant from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of an outline design of the Project.
- Estimation of costs of the Project.
- Confirmation of Environmental and Social Considerations

The contents of the original request by the Recipient are not necessarily approved in their initial form. The Outline Design of the Project is confirmed based on the guidelines of the Japanese Grant.

JICA requests the Recipient to take measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the executing agency of the Project. Therefore, the contents of the Project are confirmed by all relevant organizations of the Recipient based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA contracts with (a) consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the feasibility of the Project.

3. Basic Principles of Project Grants

(1) Implementation Stage

1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes (hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the Recipient to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Recipient to define the necessary articles, in accordance with the E/N, to implement the Project, such as conditions of disbursement, responsibilities of the Recipient, and procurement conditions. The terms and conditions generally applicable to the Japanese Grant are stipulated in the "General Terms and Conditions for Japanese Grant (January 2016)."

2) Banking Arrangements (B/A) (See "Financial Flow of Japanese Grant (A/P Type)" for details)

a) The Recipient shall open an account or shall cause its designated authority to open an account under the name of the Recipient in the Bank, in principle. JICA will disburse the Japanese Grant in Japanese yen for the Recipient to cover the obligations incurred by the Recipient under the verified contracts.

b) The Japanese Grant will be disbursed when payment requests are submitted by the Bank to JICA under an Authorization to Pay (A/P) issued by the Recipient.

3) Procurement Procedure

The products and/or services necessary for the implementation of the Project shall be procured in accordance with JICA's procurement guidelines as stipulated in the G/A.

4) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the Recipient to continue to work on the Project's implementation after the E/N and G/A.

5) Eligible source country

In using the Japanese Grant disbursed by JICA for the purchase of products and/or services, the eligible source countries of such products and/or services shall be Japan and/or the Recipient. The Japanese Grant may be used for the purchase of the products and/or services of a third country as eligible, if necessary, taking into account the quality, competitiveness and economic rationality of products and/or services necessary for achieving the objective of the Project. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals", in principle.

6) Contracts and Concurrence by JICA

The Recipient will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be concurred by JICA in order to be verified as eligible for using the Japanese Grant.

7) Monitoring

The Recipient is required to take their initiative to carefully monitor the progress of the Project in order to ensure its smooth implementation as part of their responsibility in the G/A, and to regularly report to JICA about its status by using the Project Monitoring Report (PMR).

8) Safety Measures

The Recipient must ensure that the safety is highly observed during the implementation of the Project.

9) Construction Quality Control Meeting

Construction Quality Control Meeting (hereinafter referred to as the "Meeting") will be held for quality assurance and smooth implementation of the Works at each stage of the Works. The member of the Meeting will be composed by the

Recipient (or executing agency), the Consultant, the Contractor and JICA. The functions of the Meeting are as followings:

a) Sharing information on the objective, concept and conditions of design from the Contractor, before start of construction.

b) Discussing the issues affecting the Works such as modification of the design, test, inspection, safety control and the Client's obligation, during of construction.

(2) Ex-post Monitoring and Evaluation Stage

1) After the project completion, JICA will continue to keep in close contact with the Recipient in order to monitor that the outputs of the Project is used and maintained properly to attain its expected outcomes.

2) In principle, JICA will conduct ex-post evaluation of the Project after three years from the completion. It is required for the Recipient to furnish any necessary information as JICA may reasonably request.

(3) Others

1) Environmental and Social Considerations

The Recipient shall carefully consider environmental and social impacts by the Project and must comply with the environmental regulations of the Recipient and JICA Guidelines for Environmental and Social Considerations (April, 2010).

2) Major undertakings to be taken by the Government of the Recipient

For the smooth and proper implementation of the Project, the Recipient is required to undertake necessary measures including land acquisition, and bear an advising commission of the A/P and payment commissions paid to the Bank as agreed with the GOJ and/or JICA. The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the Products and/or the Services be exempted or be borne by its designated authority without using the Grant and its accrued interest, since the grant fund comes from the Japanese taxpayers.

3) Proper Use

The Recipient is required to maintain and use properly and effectively the products and/or services under the Project (including the facilities constructed and the equipment purchased), to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Japanese Grant.

4) Export and Re-export

The products purchased under the Japanese Grant should not be exported or re-exported from the Recipient.

PROCEDURES OF JAPANESE GRANT

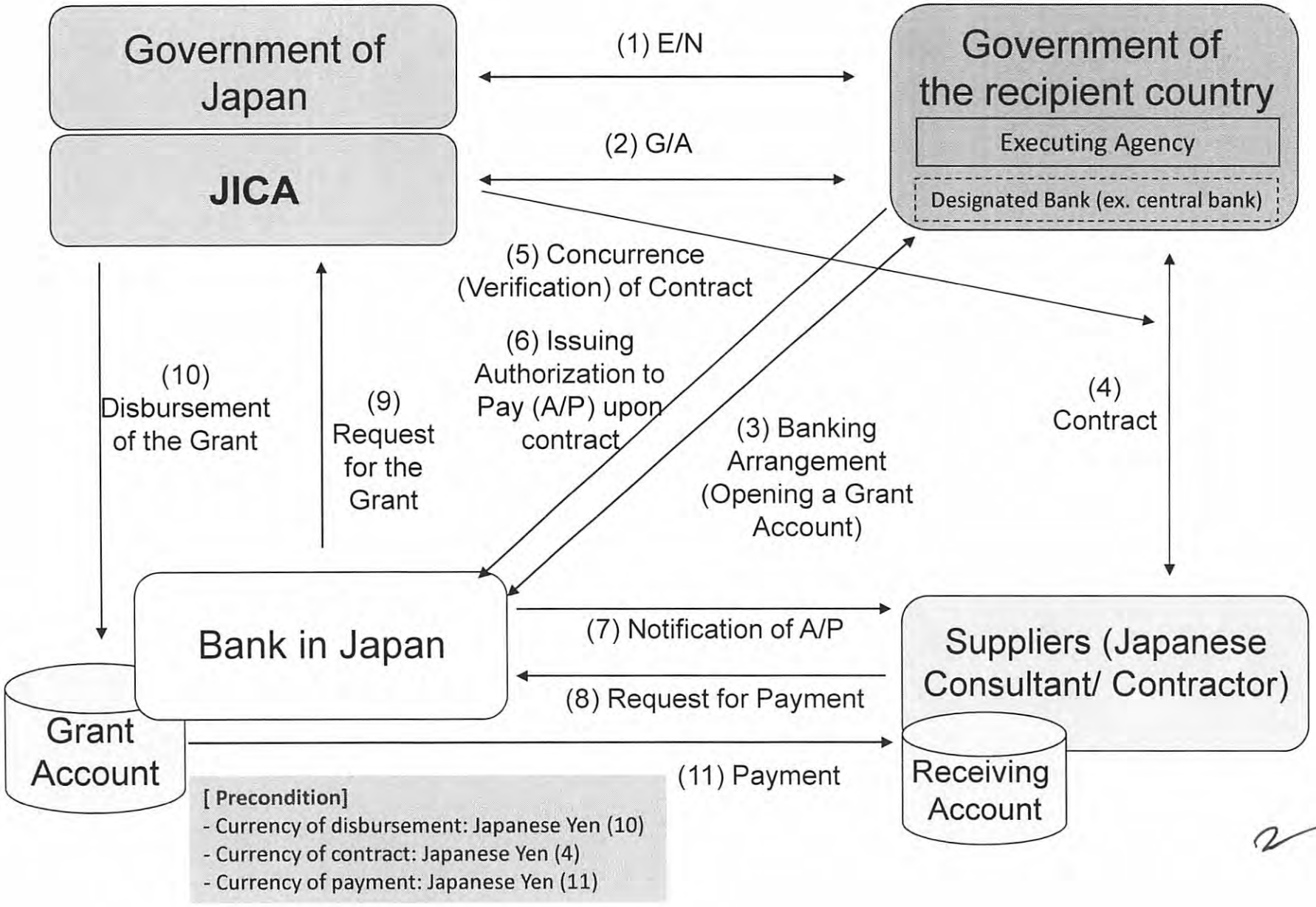
Stage	Procedures	Remarks	Recipient Government	Japanese Government	JICA	Consultants	Contractors	Agent Bank
Official Request	Request for grants through diplomatic channel	Request shall be submitted before appraisal stage.	x	x				
1. Preparation	(1) Preparatory Survey Preparation of outline design and cost estimate		x		x	x		
2. Appraisal	(2)Preparatory Survey Explanation of draft outline design, including cost estimate, undertakings, etc.		x		x	x		
	(3)Agreement on conditions for implementation	Conditions will be explained with the draft notes (E/N) and Grant Agreement (G/A) which will be signed before approval by Japanese government.	x	x (E/N)	x (G/A)			
	(4) Approval by the Japanese cabinet			x				
3. Implementation	(5) Exchange of Notes (E/N)		x	x				
	(6) Signing of Grant Agreement (G/A)		x		x			
	(7) Banking Arrangement (B/A)	Need to be informed to JICA	x					x
	(8) Contracting with consultant and issuance of Authorization to Pay (A/P)	Concurrence by JICA is required	x			x		x
	(9) Detail design (D/D)		x			x		
	(10) Preparation of bidding documents	Concurrence by JICA is required	x			x		
	(11) Bidding	Concurrence by JICA is required	x			x	x	
	(12) Contracting with contractor/supplier and issuance of A/P	Concurrence by JICA is required	x				x	x
	(13) Construction works/procurement	Concurrence by JICA is required for major modification of design and amendment of contracts.	x			x	x	
	(14) Completion certificate		x			x	x	
4. Ex-post monitoring & evaluation	(15) Ex-post monitoring	To be implemented generally after 1, 3, 10 years of completion, subject to change	x		x			
	(16) Ex-post evaluation	To be implemented basically after 3 years of completion	x		x			

notes:

1. Project Monitoring Report and Report for Project Completion shall be submitted to JICA as agreed in the G/A.

2. Concurrence by JICA is required for allocation of grant for remaining amount and/or contingencies as agreed in the G/A.

Financial Flow of Japanese Grant (A/P Type)



Project Monitoring Report
on
Project Name
Grant Agreement No. XXXXXXX

20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge (Designation) _____ Contacts Address: _____ Phone/FAX: _____ Email: _____
Executing Agency	Person in Charge (Designation) _____ Contacts Address: _____ Phone/FAX: _____ Email: _____
Line Ministry	Person in Charge (Designation) _____ Contacts Address: _____ Phone/FAX: _____ Email: _____

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

1: Project Description

1-1 Project Objective

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations

See Attachment 2.

2-4-2 Activities

See Attachment 3.

2-4-3 Report on RD

See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(Confidential until the Bidding)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 Environmental and Social Impacts

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks (*at the time of outline design*)

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:

	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-
-
-

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Date:
Ref. No.

JAPAN INTERNATIONAL COOPERATION AGENCY
JICA XXX OFFICE
[Address specified in the Article 5 of the Grant Agreement]

Attention: Chief Representative

Ladies and Gentlemen:

NOTICE CONCERNING PROGRESS OF PROJECT

Reference : Grant Agreement, dated 署名日(signed date of the G/A), for プロジェクト名(name of the Project)

In accordance to the Article 6 (3) of the Grant Agreement, we would like to report on the progress of the Project up to the following stages:

[Common]
- ☐ Preparation of bidding documents - result of detailed design
- ☐ Completion of final works under construction/procurement contract

[Construction]
- ☐ Monthly progress [Month/Year]

[Procurement of Equipment]
- ☐ Shipping/delivery, hand-over (take over) of equipment
- ☐ Installation works
- ☐ Operational training

- ☐ Other _____

Please see the details as per attached Project Monitoring Report (PMR).

Very truly yours,

[*Signature*]
[Name of the signer]
[Title of the signer]
[Name of the executing agency]

cc:
Director General
Financial Cooperation Implementation Department
Japan International Cooperation Agency
[Address specified in the Article 5 of the Grant Agreement]

Annex 5

Major Undertakings to be taken by the Government of Nepal

1. Specific obligations of the Government of Nepal which will not be funded with the Grant

(1) Before the Tender

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To open bank account (B/A)	within 1 month after the signing of the G/A	MOF		
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract(s)	DOS		
3	To submit Project Monitoring Report (with the result of Detail Design)	before preparation of bidding document(s)	DOS		

(B/A: Banking Arrangement, A/P: Authorization to pay, DOS: Department of Survey)

(2) During the Project Implementation

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the signing of the contract(s)	DOS		
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	DOS		
	2) Payment commission for A/P	every payment	MOF		
3	To ensure prompt customs clearance and to assist the Supplier(s) with internal transportation in the country of the Recipient	during the Project	DOS		
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project			
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted/ be borne by its designated authority without using the Grant	during the Project			
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project			
7	1) To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within one month after completion of each work	DOS		
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	DOS		
8	To submit a report concerning completion of the Project	within six months after completion of the Project	DOS		
10	To provide facilities for distribution of electricity and other incidental facilities necessary for the implementation of the Project outside the site(s)				
	1) Electricity The distributing line to the site	before start of the construction			
	2) Furniture and Equipment General furniture	1 month before completion of the construction			

(3) After the Project

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	Data maintenance				
2					
3					

2. Other obligations of the Government of Nepal funded with the Grant

NO	Items	Deadline	Amount (Million Japanese Yen)*
1	To provide DEM data and equipment		
2	To implement detailed design, bidding support and procurement supervision (Consulting Service)		
	Total		XXX

* The Amount is provisional. This is subject to the approval of the Government of Japan.

(2) 2nd Field Survey

Minutes of Discussions
on the Preparatory Survey for the Project for
DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO
(Explanation on Draft Preparatory Survey Report)

With reference to the minutes of discussions signed between Survey Department, Ministry of Land Management, Cooperatives and Poverty Alleviation and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on 12th September, 2019 and in response to the request from the Government of the Federal Democratic Republic of Nepal (hereinafter referred to as "Nepal") dated 6th November, 2019, JICA dispatched the Preparatory Survey Team (hereinafter referred to as "the Team") for the explanation of Draft Preparatory Survey Report (hereinafter referred to as "the Draft Report") for the Project for DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO (hereinafter referred to as "the Project").

As a result of the discussions, both sides agreed on the main items described in the attached sheets.

Kathmandu, 6th December, 2019

Mr. Hidenori KUMAGAI
Leader
Preparatory Survey Team
Japan International Cooperation Agency

Japan

Mr. Prakash JOSHI
Director General
Survey Department
Ministry of Land Management, Cooperatives and Poverty Alleviation
Government of Nepal

ATTACHEMENT

1. Title of the Preparatory Survey

   Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO".

2. Contents of the Draft Report

   After the explanation of the contents of the Draft Report by the Team, the Nepali side agreed to its contents. JICA will finalize the Preparatory Survey Report based on the confirmed items. The report will be sent to the Nepali side around March, 2020.

3. Cost estimate

   Both sides confirmed that the cost estimate explained by the Team is provisional and will be examined further by the Government of Japan for its approval.

4. Confidentiality of the cost estimate and technical specifications

   Both sides confirmed that the cost estimate and technical specifications of the Project should never be disclosed to any third parties until all the contracts under the Project are concluded.

5. Timeline for the project implementation

   The Team explained to the Nepali side that the expected timeline for the project implementation is as attached in (Annex 1).

6. Target and indicators

   Both sides agreed that key indicators for expected outcomes are as follows. The Nepali side will be responsible for the achievement of agreed key indicators targeted in year of 2025 and shall monitor the progress for Ex-Post Evaluation based on those indicators.

[Quantitative indicators]

Indicator	Standard value (recorded value of 2018)	Target value (2025)
DEM grid spacing (m) (or, contour interval (m))	50m (From Existing topographic map) (10m)	1m (0.5m)
Elevation precision (m)	5m	0.25m
Total area covered by 1:5,000 large-scale maps (km^2)	0	300
Number of times of distribution of DEM data and/or orthophoto data	0	15
Total area covered by hazard maps* (km^2)	0	500

*.A hazard map is any types of map used for disaster risk reduction.

[Qualitative indicators]

- Updating of Existing Topographic Map Data.
- Improved Disaster Awareness of Relevant Organization.
- Improvement in Accuracy of Identification of Flood-risk Areas
- Selection of Sites for Dike Strengthening and Candidate Implementation Sites of Flood Mitigation Measures, including Construction of Reservoirs
- Use in Plans for Infrastructure Development (roads, railways, irrigation canals, etc.)

7. Ex-Post Evaluation

JICA will conduct ex-post evaluation after three (3) years from the project completion, in principle, with respect to five evaluation criteria (Relevance, Effectiveness, Efficiency, Impact, and Sustainability). The result of the evaluation will be publicized. The Nepali side is required to provide necessary support for the data collection.

8. "Soft Component" of the Project

Considering the sustainable operation and maintenance of the products and services granted through the Project, the following technical support is planned under the Project. The Nepali side confirmed to deploy necessary number of counterparts who are appropriate and competent in terms of its purpose of the technical support as described in the Draft Report.

Soft Component is planned to create digital elevation model and orthophoto for developing the flood management measures more elaborately in Terai region and consists of the following activities.

a. Maintenance for the DEM
   - Creation and update of the DEM by drone photogrammetry
   - Processing of point cloud data

b. Facilitation of the utilization of the DEM (Strengthening of the structure for updating of the DEM)
   - Improvement of usability of the DEM
   - Improvement of the DEM acknowledge of Personnel in charge of provision
   - Grasping the actual status and future challenges relating to flooding risk for Survey Department and concerned authorities.
   - Understanding how to tackle the challenges by using the DEM for Survey Department and concerned authorities.

9. Undertakings of the Project

9-1 Undertakings of the Project

Both sides confirmed the undertakings of the Project as described in (Annex 2). With regard to exemption of customs duties, internal taxes and other fiscal levies as stipulated in No. 9 in 2. During the Project Implementation of (Annex 2), both sides confirmed that such customs duties, internal taxes and other fiscal levies, which shall be clarified in the bid documents by Survey Department during the implementation stage of the Project.

The Nepali side assured to take the necessary measures and coordination including allocation of the necessary budget which is preconditions of implementation of the Project. It is further agreed that the costs are indicative, i.e. at Outline Design level. More accurate costs will be calculated at the Detailed Design stage.

Both sides also confirmed that the (Annex 2) will be used as an attachment of G/A. Both sides confirmed that Survey Department shall take necessary measures to ensure and maintain the security of the Project site and the persons related to the implementation of the Project, in cooperation with relevant authorities during the Project period. Such security measures shall reasonably reflect needs of the Consultant/the Contractor engaging in the Project, as shown in (Annex 2).

9-2 Flight permission and others

Both sides confirmed following.

Providing licensing for projects such as flight permission and data acquisition

permission, the procedure will be facilitiated by Survey Department. After the project starting, procedures of acquisition of flight permission and data acquisition permission will start as soon as possible. (Annex 4)

10. Monitoring during the implementation

The Project will be monitored by the Survey Department and reported to JICA by using the form of Project Monitoring Report (PMR) attached as (Annex 3). The timing of submission of the PMR is described in (Annex 1).

11. Project completion

Both sides confirmed that the Project completes when all DEM, orthophoto and equipment procured by the Grant are in operation. The completion of the Project will be reported to JICA promptly by the Survey Department , but in any event not later than six months after completion of the Project.The timeline is provided in Annex1.

12. Other Relevant Issues

12-1. Disclosure of Information

Both sides confirmed that the Preparatory Survey Report from which project cost is excluded will be disclosed to the public after completion of the Preparatory Survey. The comprehensive report including the project cost will be disclosed to the public after all the contracts under the Project are concluded.

12-2 Non-military use

The Nepali side understood the principle of the Japan's Development Cooperation Charter, which stresses that ODA must not be utilized for military purpose or promoting international conflicts, and agreed to ensure that the data and equipment to be procured in the Project will never be used for any military purposes.

12-3 Creation of Digital Elevation Model

12-3-1 Project Component

Regarding the components of the project, both side confirmed following matters.

a. Mesh size will be 1m. The specification will be following to the specification of the western area of Terai project.
b. Regular orthophoto will be produced in entire project area.
c. Clarify the boundary between the western area of Terai and this project, and

determine the area of the project after consultation.

d. Because of the prevailing Law (11 (d) of Land (Surveying and Mapping) Act), LiDAR Data processing will be carried out in Nepal.
e. Survey Department staff will join the data processing work to understand the processes of data processing and to assist knowledge for their inspection works.

12-3-2 Specification for the creation of Digital Elevation Model and Orthophoto

As a rule, the results and data acquisition specifications related to the digital elevation model and orthophotos shall be based on the request letter contents. (Annex4-1)

12-3-3 Work contents and Standards for Operating Specifications for Public Surveying

Both sides confirmed as follows.

The work contents, described in the request letter, do not include the rules of operating specification such as data items to be inspected and methods in each process (the describing of the vertical and horizontal accuracy and so on of the final results), so the operating specification will be based on Japanese standards for operating specification for public surveying at the inspection stages. Nepal work standards are applicable for field works such as GNSS observations, field surveying, etc. Nepalese Standard and rules of operating specifications shall prevail wherever available.

(Annex4-2)

12-3-4 Providing of information of existing control point and bench marks

The Nepali side confirmed as follows.

Since the number of existing control points to be used is expected to increase considerably, results and point description will be provided to the Japanese side.

12-3-5 Handling the re-aerial photography for topographical changes

Both sides confirmed as follows.

Even though changes occurred; due to natural disaster or other such events; after LiDAR data acquisition, the team will not acquire data again. However, this may be updated through other means like UAV/Drones for data maintenance after the training under soft component by Nepali side.

12-3-6 Responsible section for the Project implementation

The Nepali side provides the project implementation structure of Survey Department such as responsible section and person of Survey Department.
(Annex 5)

12-3-7 Inspection and approval process

Both sides confirmed following responsible work contents.

[Data Inspection]

- Japanese supplier will conduct the all inspection works by themselves.
- After overall checking, consultant will carried out sampling check with the Nepali side.

[Approval of final results]

- Survey department will inspect final result such as DEM data and Ortho photo data and so on. Survey department will provide the work completion certificate when the final results are inspected and approved.

(Annex 6-1)

12-3-8 Data disclosing

Nepali side confirmed following.

Survey Department shall disclose DEM and Orthophoto data after the work completion in accordance with "Publication and Copyright plan of DEM".
(Annex 6-2).

12-3-9 Budget adjustment of project implementation

Both sides confirmed when the project cost exceeds estimated amount, the project area shall be reduced to adjust the budget. In that case, priority area of DEM creation to start will be west edge of project area.

12-3-10 Commencement of airborne liDAR survey

Both sides confirmed that commencement of airborne liDAR survey will be February 2021 to avoid weather disturbance such as clouds, haze and so on and implement the Project without delay.

12-3-11 Project Site

Both sides confirmed that the site(s) of the Project is/are in mid and eastern part of Terai region as shown in Annex 7.

The Minutes of Discussions on the Preparatory Survey for the Project for DEVELOPMENT OF DIGITAL ELEVATION MODEL AND ORTHOPHOTO has been signed between Japan International Cooperation Agency (JICA) and Survey Department (SD) on 6 December 2019 in the presence of following participants.

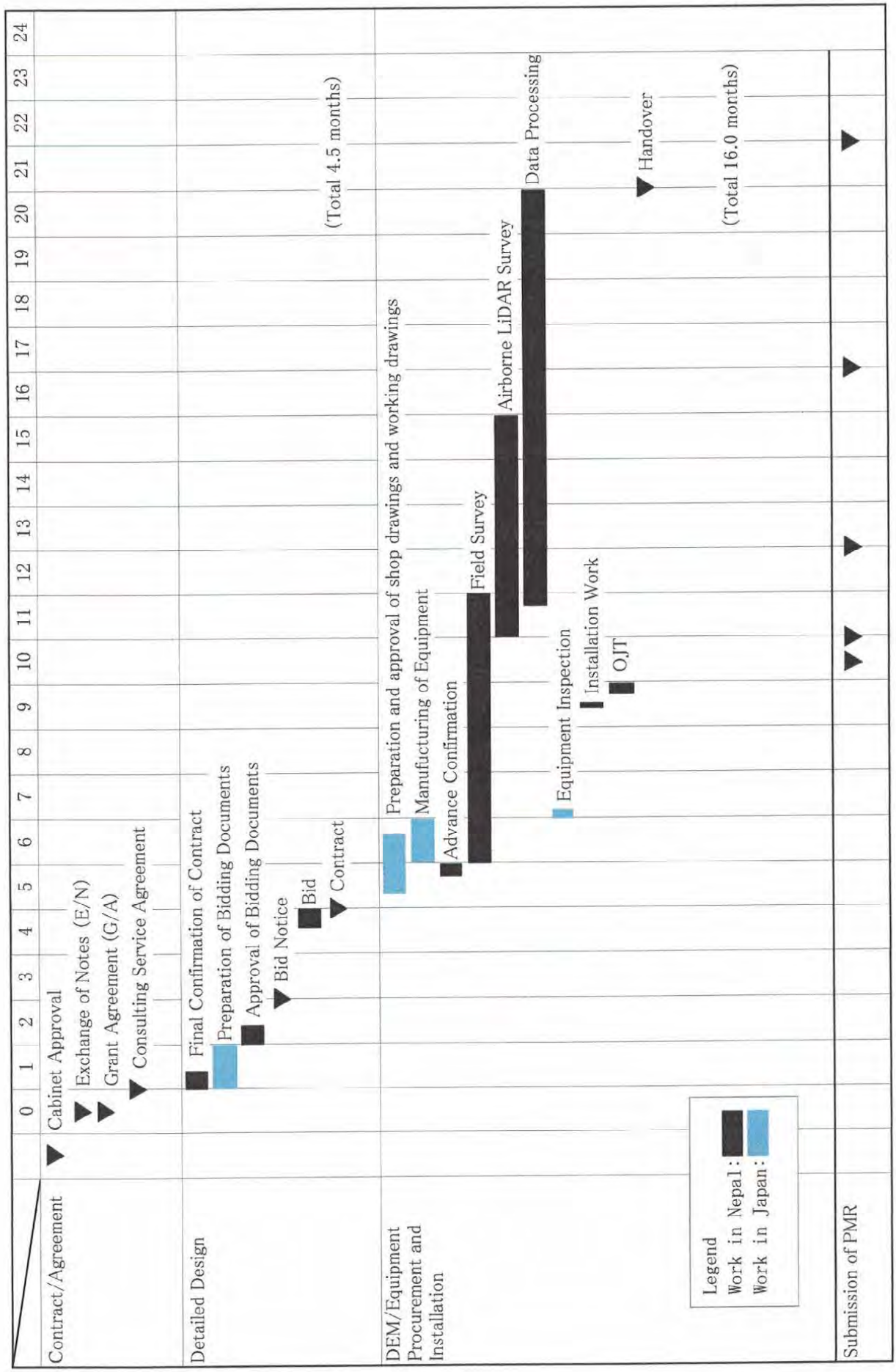
Participants from Survey Department

SN	Name	Assignment	Organization
1	Mr. Prakash Joshi	Director General	Survey Department
2	Ms. Karuna K.C.	Deputy Director General	Survey Department
3	Mr. Sushil Narsingh Rajbhandari	Chief Survey Officer	Survey Department
4	Mr. Kamal Ghimire	Director	Survey Department
5	Mr. Damodar Dhakal	Director	Survey Department
6	Mr. Abhasha Joshi	Survey Officer	Survey Department
7	Mr. Sharad Chandra Mainali	Survey Officer	Survey Department

Participants from Japanese side

SN	Name	Assignment	Organization
1	Mr. Hidenori KUMAGAI	Leader	JICA
2	Mr. Takashi HARADA	Chief Consultant/Consultation of Specifications 1	Aero Asahi Corporation (AAC)
3	Mr. Takao IKEDA	Co-Chief Consultant/ Consultation of Specifications 2	AAC
4	Mr. Bhuwneshwar Prasad SAH	Control Point and Field Survey Planning	Pasco Corporation
5	Mr. Yosuke IKEDA	Procurement Planning/Cost Estimation	Yachiyo Engineering Co., Ltd. (yec)
6	Mr. Yoji TORIUMI	Representative, Registered Architect	JICA, Nepal
7	Mr. Ram Prasad Bhandari	Program Manager	JICA, Nepal

Annex 1 Timeline
Annex 2 Major Undertakings to be taken by the Government of Nepal
Annex 3-1 Project Monitoring Report submission_form (template)
Annex 3-2 Project Monitoring Report submission_form for_grant
Annex 4-1 Specification of DEM
Annex 4-2 Rules for Operating Specifications for Public Surveying
Annex 5 Organogram
Annex 6-1 Flow of Data Disclosure
Annex 6-2 Publication and Copyright plan of DEM
Annex 7 Project Site


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Contract/Agreement
Cabinet Approval
Exchange of Notes (E/N)
Grant Agreement (G/A)
Consulting Service Agreement
Detailed Design
Final Confirmation of Contract
Preparation of Bidding Documents
Approval of Bidding Documents
Bid Notice
Bid
Contract
(Total 4.5 months)
DEM/Equipment Procurement and Installation
Preparation and approval of shop drawings and working drawings
Manufucturing of Equipment
Advance Confirmation
Field Survey
Airborne LiDAR Survey
Data Processing
Equipment Inspection
Installation Work
OJT
Handover
(Total 16.0 months)
Legend
Work in Nepal:
Work in Japan:
Submission of PMR

Major Undertakings to be taken by the Government of Nepal

1. Specific obligations of the Government of Nepal which will not be funded with the Grant

The Mission explained the necessity of confirming the actions mentioned in the table below. Survey Department raised the concern that these responsibilities of the higher responsibilities like MoF, MOLACPA, etc. can be discussed and finalized during the time of Grant Agreement.

(1) Before the Bid

NO.	Items	Deadline	In Charge	Estimated cost	Ref.
1	To sign the banking arrangement (B/A) with a bank in Japan (the Agent Bank) to open bank account for the Grant	within 1 month after the signing of the G/A			
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract(s)	SD		
3	To bear the following commissions to the Agent Bank for the banking services based upon B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)			
	2) Payment commission for A/P	every payment			
4	Facilitating in securing of lands (hereinafter referred to as "the Project site") for the installation of the Equipment	Complete before bid notice	SD		
5	To submit Project Monitoring Report (with the result of Detail Design)	before preparation of bidding document (s)	SD		

(B/A: Banking Arrangement, A/P: Authorization to pay, SD: Survey Department,

(2) During the Project Implementation

NO.	Items	Deadline	In charge	Estimated cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the			

NO.	Items	Deadline	In charge	Estimated cost	Ref.
		signing of the contract(s)			
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)			
	2) Payment commission for A/P	every payment			
3	Facilitating to the security of personnel at the Project site, when necessary		SD		
4	Facilitate the process of prompt customs clearance and to assist the Supplier(s) with internal transportation in the country of the Recipient	during the Project	SD		
5	Facilitate to accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project	SD		
6	Facilitate in obtaining the following permissions regarding the airborne liDAR survey from CAAN and related organizations: 1) Permission for parking of aircraft used for the survey 2) Domestic flight permission 3) Permission to fly on the Indian border 4) Data acquisition permission	Complete before the commencement of the airborne liDAR survey	SD		
7	Providing of information of existing control point and bench marks		SD		
8	Facilitate in securing the following storage spaces, facilities, sites, yards, etc.: 1) Storage spaces for the Equipment 2) Space for temporary offices for the Consultant and the Supplier 3) Space for parking air craft for airborne liDAR survey 4) Space for storage of material 5) Space for a seminar of Soft Component (Max. 60 persons)		SD		
9	To ensure that customs duties, internal taxes and other fiscal levies as shown below, which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted/ be borne by its designated authority without using the Grant. 1) Corporate Tax, 2) Personal Income Tax, 3) Withholding Tax, 4) Consumption Tax (VAT), 5) Excise Tax,	during the Project			

NO.	Items	Deadline	In charge	Estimated cost	Ref.
	6) Import Duties, 7) Other duties, taxes or levies, if any				
10	Transporting of the airborne liDAR survey equipment, customs procedures and tax procedures at Kathmandu airport				
11	Facilitate in obtaining a confirmation letter for: 1) Permission to undertake the Installation work at the Project site 2) Permission to enter the Project site		SD		
12	Make arrangement to bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project.	during the Project	SD		
13	1) To submit Project Monitoring Report at fixed times	within one month after fixed timing in accordance with G/A	SD		
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	SD		
14	To submit a report concerning completion of the Project.	within six months after completion of the Project	SD		
15	Make arrangements to provide facilities for distribution of electricity and other incidental facilities necessary for the implementation of the Project outside the site(s).				
	1) Electricity Facilitate for providing electricity for the Equipment at the Project site	before start of the Installation Work	SD		
	2) Furniture and Equipment General furniture	before start of the Installation Work	SD		

(3) After the Project

NO.	Items	Deadline	In charge	Estimated cost	Ref.
1	Providing security to the DEM and Equipment after handover.		SD		
2	Establishing structure for implementing operations and maintenance for the DEM and Equipment.		SD		
3	Allocating necessary staff and budget to establish proper operations and maintenance structures, including routine checks/periodic inspections and cleaning.		SD		

2. Other obligations of the Government of Nepal funded with the Grant

NO.	Items	Amount (Million Japanese Yen)*
1	To provide DEM data and equipment	
2	To implement detailed design, bidding support, procurement supervision and soft component (Consulting Service)	
	Total	-

* The Amount is provisional. This is subject to the approval of the Government of Japan.

ANNEX 3-1

Date:

Ref. No.

JAPAN INTERNATIONAL COOPERATION AGENCY

JICA XXX OFFICE

[Address specified in the Article 5 of the Grant Agreement]

Attention: Chief Representative

Ladies and Gentlemen:

NOTICE CONCERNING PROGRESS OF PROJECT

Reference : Grant Agreement, dated (signed date of the G/A), for (name of the Project)

In accordance to the Article 6 (3) of the Grant Agreement, we would like to report on the progress of the Project up to the following stages:

[Common]

- ☐ Preparation of bidding documents - result of detailed design
- ☐ Completion of final works under construction/procurement contract

[Construction]

- ☐ Monthly progress [Month/Year]

[Procurement of Equipment]

- ☐ Shipping/delivery, hand-over (take over) of equipment
- ☐ Installation works
- ☐ Operational training

- ☐ Other _____

Please see the details as per attached Project Monitoring Report (PMR).

Very truly yours,

[Signature]

[Name of the signer]

[Title of the signer]

[Name of the executing agency]

cc:

Director General
Financial Cooperation Implementation Department
Japan International Cooperation Agency
[Address specified in the Article 5 of the Grant Agreement]

Project Monitoring Report
on
Project Name
Grant Agreement No. XXXXXXX

20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:
Executing Agency	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:
Line Ministry	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

1: Project Description

1-1 Project Objective

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations

See Attachment 2.

2-4-2 Activities

See Attachment 3.

2-4-3 Report on RD

See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(Confidential until the Bidding)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 Environmental and Social Impacts

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:

	Contingency Plan (if applicable):

Actual Situation and Countermeasures
(PMR)

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/ Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-

-

-

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Specifications for DEM.

Item		Standards
Airborne Lidar Survey	Lidar points density	4 points/m^2 or more
	Distance from reference station	25 km or less
	Flight line overlap	15 % or more
	Scanning coverage	DEM creation area and area outside up to 150 m
	Elevation accuracy	±0.25 m
Aerial photography	Digital camera	Medium frame camera
	Ground pixel size	Max. 15 cm (at the nadir)
	Forward overlap	At least 15 % or more
	Overlap ratio between courses	15% or more
Digital Orthophoto	Ground pixel size	15cm
	Horizontal accuracy	±0.10 m
Deliverable	DEM	Types of elevation models: DTM (Digital Terrain Model) and DSM (Digital Surface Model) Grid spacing: 1 m
	Original data	including whole pulse data and reflection intensity data
	Digital orthophotos	Pixel size: 15 cm
	Contours	Intermediate contour interval: 50 cm
	Metadata	ISO standards
Data format	DEM	Either of the following formats: img, geotiff or tiff
	Original data	LAS (version 1.1)
	Digital Photographs (Raw data)	tiff, img
	Digital orthophotos	Either of the following formats: img, geotiff or tiff
	Contours	Shp format

Standards for Operating Specifications for Public Surveying
- Chapter 8 Airborne laser surveying

Section 1 Abstract

(Abstract)

Article 312 "Airborne laser surveying" refers to the series of work consist of collection of topographic data using an airborne LiDAR system, and creation of digital geospatial data files such as digital elevation models (hereinafter referred to as "grid data").

(Geospatial information quality level and grid interval)

Article 313 The standard of the digital elevation model is expressed by grid interval on the ground.

2 The standard relationship between the geospatial information quality level and the grid interval is defined in the following table.

geospatial information quality level	grid interval
500	≦0.5m
1000	≦1m
2500	≦2m
5000	≦5m

(Work item and process flow)

Article 314 Standard work item and process flow shall be the following.

(1) Planning
(2) Installation of fixed GNSS base stations
(3) Airborne LiDAR data collection
(4) Installation of ground control points
(5) Creation of 3D measurement data
(6) Original point cloud data creation
(7) Ground point cloud data creation
(8) Grid data creation
(9) Contour data creation
(10) Digital geospatial data file creation
(11) Quality evaluation
(12) Deliverables

Section 2 Planning

(Abstract)

Article 315 The work plan shall be prepared for each process in addition to the provisions of Article 11[*1].

2 The airborne LiDAR data collection shall be planned for the measurement specifications, flight courses, the location and observation of the fixed GNSS base stations, in consideration of the GNSS satellite distribution.

3 "Measurement specifications" include flight altitude, ground speed, swath overlap between courses (%), scanning rate, scan angle, pulse rate, nominal ground pulse distance in flight direction and orthogonal direction, and is planned to satisfy the required 3D model grid interval.

4 The ground pulse distance (β) of the 3D model data is obtained by the following formula using the grid interval (α) and the constant (θ), and is planned so that there exist one point or more in a grid.

(Formula) $\beta = \alpha / \theta$ (θ: 1.1 to 1.5)

5 Airborne LiDAR data collection is planned to satisfy the requirement of 3D model data interval. At that time, in consideration of the terrain conditions, the swath overlap between courses and round-trip flight courses shall be adjusted.

6 Swath overlap is 30% as a standard.

7 The data collection area shall be buffered by a minimum of distance 10 times of the grid interval around the project target area boundary.

8 The location of the fixed GNSS base station shall be planned in consideration of the sky view and the baseline distance.

9 The GNSS observation plan shall be conducted in consideration of the number of satellites observable referring the latest orbit information.

Section 3 Installation of fixed GNSS base stations

(Installation of fixed GNSS base stations)

Article 316 "Installation of fixed GNSS base stations" means installation of ground reference station for kinematic GNSS positioning of the LiDAR sensor in airborne laser surveying.

2 The location of fixed GNSS base station shall be planned so that the baseline distance in the project target area shall not exceed 50km.

3 In principle, GEONET station shall be used for fixed GNSS base station.

4 When a new fixed GNSS base station is installed, the horizontal and vertical geodetic coordinates shall be obtained by first-order control point survey and third-order levelling.

5 If a new fixed GNSS base station is installed, a fixed GNSS base station description report shall be created.

(Inspection of fixed GNSS base stations)

Article 317 The inspection of fixed GNSS base stations shall be conducted at the time of installation and the following items shall be inspected.

(1) Ensure appropriateness of sky view and GNSS signal receiving capability.

(2) Appropriateness of location of fixed GNSS base stations in the project target area

(3) Ensure the horizontal and vertical coordinate accuracy of the fixed GNSS base stations

(4) Check if GNSS antenna is firmly fixed.

Section 4 Airborne LiDAR data collection

(Airborne LiDAR data collection)

Article 318 "Airborne LiDAR data collection" refers to an operation to measure topographic data using an airborne LiDAR system.

(Aerial LiDAR system)

Article 319 The airborne LiDAR system shall consist of GNSS / IMU equipment, LiDAR sensor and analysis software.

2 The performance of the equipment etc. shall be as follows.

(1) Airborne GNSS antenna and receiver

(a) The GNSS antenna shall be securely fixed to the top of the aircraft.

(b) GNSS observation data shall be acquired at 1-second epochs or better.

(c) The GNSS shall be capable to observe dual frequency.

(2) Kinematic GNSS analysis software shall have the following functions as a standard.

(a) Able to analyse the baseline vector by kinematic analysis.

(b) The evaluation items of analysis results can be displayed.

(3) The GNSS surveying equipment shall have the performance listed in the following table or equivalent or better.

item	Performance
horizontal	0.3m
vertical	0.3m

(4) IMU

(a) The IMU shall be able to measure the tilts of the sensor unit along three axes as rolling, pitching, and heading, and accelerometer, with the standard deviation of the analysis results and the data acquisition interval shall be those listed in the following table, or have the same or better performance.

item	performance
rolling	0.015 degree
pitching	0.015 degree
heading	0.035 degree
sampling rate	0.005 sec

(b) The IMU shall be connected directly to the LiDAR sensor.

(5) LiDAR sensor

(a) LiDAR sensor shall be capable of capturing 2 or more returns including first and last returns.

(b) LiDAR sensor shall have scanning function.

(c) LiDAR sensor shall have function to prevent adverse effect on human body such as eye-safe function.

(d) Safety standards shall be clearly shown.

(6) The analysis software must be able to calculate the 3D position of the measured point.

(7) The airborne LiDAR system shall be boresight calibrated and the calibration shall be valid for 6 months.

(8) An inspection record that records the contents of equipment inspection shall be created prior to the commencement of work.

(Data collection)

Article 320 GNSS observation data of fixed base stations, GNSS observation data on an aircraft, IMU observation data, and LiDAR data shall be collected.

2 In principle, aviation laser measurements for the same course should be performed at a straight line and at an equal altitude. However, this does not apply when using a rotorcraft.

3 The ground speed on the same course shall be kept constant.

4 The measurement target area shall be acquired for a range obtained by extending the outer circumference of the work area by a distance that is at least 10 times the lattice interval.

5 GNSS observation shall be conducted as follows.

(1) The data acquisition interval for GNSS observations on fixed stations and aircraft shall be 1 second or less.

(2) The provisions of Article 37, Paragraph 2, Item 2[*2] shall apply mutatis mutandis to the number of GNSS satellites at the time of acquisition.

(3) The GNSS observation results, etc. shall be organized in a quality control table describing the records of the GNSS satellites, etc., data such as books, and baseline analysis results.

(Digital photography for aerial laser surveying)

Article 321 Digital photography for aerial laser surveying is image data obtained by photographing the ground surface from the air, and is taken for filtering and inspection.

2 Numerical photographs for aerial lasers shall be taken in consideration of the following items.

(1) The standard is to take images at the same time as the aviation laser measurement.

(2) The resolution shall be such that the ground shielding objects such as buildings can be confirmed, and the ground pixel size shall be 1.0 m or less as standard.

(3) Shooting shall be within the range covering the measurement area.

(Inspection of airborne laser measurement)

Article 322 Airbourne laser measurement shall be inspected as soon as the airborne laser measurement has been completed, and an accuracy management table shall be created to determine whether re-measurement is required.

2 Inspection shall be performed for each of the following items.

(1) Operation of GNSS surveying equipment installed on fixed stations and aircraft, and quality of data recording

(2) Occurrence of cycle slip

(3) Appropriateness of the airborne laser measurement area

(4) the shooting area and image quality of digital photographs for airborne laser survey

(5) Appropriateness of the flight altitude and courses

3 Inspection of the kinematic analysis results shall be checked for the following items on each flight course.

(1) Minimum number of satellites

(2) DOP (PDOP, HDOP, VDOP) value

(3) Difference between double running solutions

(4) The quality of the solution

(5) Average and maximum standard deviation of positions

4 The inspection of the optimal orbit analysis results shall be performed for the following items on each flight course.

(1) Consistency of GNSS and IMU solutions

(2) Average and maximum standard deviation of positions

(3) Average and maximum standard deviation of tilting

5 Inspection of measurement data shall be performed for the following items.

(1) Data voids for each course

(2) Flight line deviations from the predetermined flight course

6 The following items shall be prepared as inspection materials.

(1) Number of satellites and PDOP diagram during the measurement time period obtained from kinematic analysis

(2) Check map of data voids overlaid with the measurement area for each course

(3) Flight line map together with the predetermined flight course

(4) Airborne laser measurement record

(5) Airborne laser measurement work report

(6) Notes and records describing the layout of GNSS satellites, etc.

(7) GNSS / IMU calculation accuracy management table

7 When a fixed station other than the GEONET is used, the following items shall be prepared as inspection materials.

(1) Fixed station observation record book

(2) GNSS observation data file manual

8 If re-measurement is required based on the inspection results, it shall be promptly performed.

Section 5 Installation of ground control point

(Installation of ground control point)

Article 323 "Installation of ground control point" refers to an operation of installing a reference point (hereinafter referred to as "GCPs") for performing inspection and adjustment of 3D measurement data.

2 GCPs shall be installed according to the following items.

(1) The location of a GCP shall be flat area with minimum length of 2 to 3 times of grid interval such as ground, vacant land, road, park, rooftop, etc., without any obstructions such as trees or sidewalk steps in order to ensure appropriate GPS signal observation.

(2) The number of GCPs shall be a value obtained by dividing the target area (km^2) by 25 and plus 1 as standard, and the minimum number is 4 points.

(3) In principle, the points shall be installed at the four corners of the work area, and in consideration of the location of the flat land and bench marks, it shall be uniformly distributed throughout the work area.

(Surveying of ground control point)

Article 324 GCPs shall be surveyed according to the following items.

(1) The horizontal coordinates shall be obtained by the fourth-order control point survey specified in Chapter 2 of Part 2[*3]. However, if there is no known triangular point nearby available, GNSS single positioning method stipulated in Article 59, Paragraph 6, Item 2[*4] can be applied.

(2) The vertical coordinate shall be obtained by the fourth-order levelling specified in Chapter 3 of Part 2[*5]. However, if there is no known benchmark point nearby available, GNSS static positioning method specified in Chapter 2 of Part 2[*2] can be applied.

2 GCP index map and a GCP description report shall be prepared. An on-site photo shall be attached to the GCP description report.

Section 6 Creation of 3D measurement data

(Creation of 3D measurement data)

Article 325 "Creation of 3D measurement data" refers to an operation of integrating and analysing airborne LiDAR data to create three-dimensional coordinate data of a measurement position.

2 When creating the 3D measurement data, error data such as multi-reflection noise to building walls or others shall be removed by referring cross-sectional or bird's-eye view display.

3 The ground coordinate of 3D measurement data shall be centimetre unit.

(Inspection of 3D measurement data)

Article 326 The inspection of 3D measurement data shall be performed by comparison with the ground control points.

2 The comparison between ground control point and 3D measurement data shall be carried out as follows.

(1) The 3D measurement data to be compared with the ground control point is obtained by averaging all the measurement data in a circle with a radius of grid interval or a square with a width of a double of grid interval.

(2) The differences between the ground control point and the 3D measurement data and their average and RMS error shall be obtained at each ground control point.

(3) The difference between a ground control point and an averaged 3D measurement data shall be obtained at all ground control points, and their RMS error shall be obtained.

(4) The inspection results shall be reported in the 3D measurement data inspection table and the ground control point description table.

3 Measures to the inspection results of the preceding paragraph shall be performed as follows.

(1) If the absolute value of the average value of the difference is exceeding 25cm or the RMS error is exceeding 30cm, as a result of inspection at each ground control point, the reason shall be clarified and appropriate action such as recalculation or re-measurement shall be carried out.

(2) As a result of inspection at all ground control points, if the absolute value of the average difference is exceeding 25cm or the RMS is exceeding 25cm, clarify the reason and recalculation or re-measurement shall be taken place. However, if the tendency of difference is consistent in the entire work area, correction measure based on the provisions of Article 333 shall be performed.

(Inspection of vertical value between courses)

Article 327 For the inspection of vertical value between courses, the check points shall be selected in the overlaps between courses, and the vertical values for each course shall be compared and inspected.

2 The selection and inspection of check points are as follows.

(1) The number of check points will be more than course length (km) / 10 + 1.

(2) The check points are distributed at the end points of the course of the overlaps and evenly above and below the overlapping area.

(3) In the case of terrain conditions such as mountainous areas and linear areas, the arrangement and points can be changed.

(4) The check point shall be selected at a flat and clear point, and the vertical value is obtained by averaging all the measurement data in a circle with a radius of grid interval or a square with a width of a double of grid interval.

(5) The difference of the vertical value of the check point of each course for each overlaps, and their average shall be obtained.

(6) When the absolute value of the average of the vertical difference for each overlapping course is exceeding 30cm, check points shall be re-selected or the calibration value is re-measured and the measurement data is re-corrected from the inspection result.

3 The inspection results of vertical values between courses shall be reported in the table of inspection residuals between courses. In addition, as for the index map, the inter-course check point index map is created.

(Re-inspection)

Article 328 After the work is completed, prepare the ground control point location map, ground control point information table, 3D measurement data inspection table, ground control point survey table, inter-course check point location map, and inter-course

inspection residual table. The following items shall be inspected using digital photographs for airborne laser surveying.

(1) Adequacy of distribution and location of the ground control points

(2) Appropriateness of the mean and standard deviation of the difference between the ground control point and the 3D measurement data

(3) Appropriateness of distribution and location of check points

(4) Appropriateness of the average value and standard deviation of the difference in vertical values at the check points

(Creation of photo map data for airborne laser survey)

Article 329 The creation of photo map for airborne laser survey shall be performed by orthogonal transformation using the digital photographs for airborne laser survey and the 3D measurement data.

2 The photo map data file shall be created according to the following items.

(1) In principle, the area of one file is the area of the national land map.

(2) The data format is TIFF.

(3) The coordinate information file is in the Esri World File format.

(Creating water body polygon data)

Article 330 The water body polygon data is created for the area of the water body using the photo map data.

2 "Water body" means a place where the surface of the river, pond, etc. is covered with water including sea.

3 Water body polygon data is created if the water area is large enough in comparison with grid interval. However, when there is no water area, this work is skipped.

(Calculation of data voids)

Article 331 The data void rate is based on the grid interval, and the rate of missing 3D measurement data is calculated.

2 "Data void" refers to a case where 3D measurement data position is divided by a grid interval and there is no 3D measurement data in one grid. However, water part is not included.

3 The data void rate indicates the ratio of void data to the target area, and is calculated by the following formula.

The data void rate = (number of void data / number of grids) ×100

4 The calculation is performed by each map frame of the national land map, and the data void rate is reported in the data void rate table.

5 The data void rate shall not exceed 10% when the grid interval exceeds 1 meter, and 15% when the grid interval is less than 1 meter.

(Inspection of data)

Article 332 Data inspection shall be performed using graphic compilation system.

2 Inspection shall be performed for each of the following items.

(1) Paying attention to major features (roads, etc.), check whether there is an apparent image gap on airborne laser photomap data

(2) No missing of water body polygon data

(3) Adequacy of water body polygon data gap

(4) Adequacy of data void rate

Section 7 Original point cloud data creation

(Original point cloud data creation)

Article 333 "Original point cloud data creation" refers to an operation of creating 3D coordinate data inspected and adjusted from the 3D measurement data using the ground control point data.

2 When the absolute value of the average value of the difference between the ground control point and the 3D measurement data is exceeding 25cm, the entire region shall be adjusted.

3 As for adjustment, the elevation value of the 3D measurement data of the entire region is corrected by parallel movement with a uniform vertical shift.

(Inspection of original data)

Article 334 The original data is inspected before and after the adjustment, and inspected again at the end of the work.

2 When original data is created after adjustment, it is checked whether the average value and standard deviation of the differences are within the allowable range, using the ground control point residual table.

Section 8 Ground point cloud data creation

(Ground point cloud data creation)

Article 335 "Ground point cloud data creation" refers to an operation of creating ground surface 3D coordinate data from original point cloud data by filtering method.

2 The ground point cloud data is created for area buffered by a minimum of distance 10 times of the grid interval around the project target area boundary.

3 "Filtering" refers to the work of removing data other than the ground surface. The following are standard items to be omitted.

transportation facilities	road facilities	road bridge (more than 5m in length), viaduct, pedestrian bridge, lighting pole, signal light, road information board, etc.
	railroad facilities	railroad bridge (more than 5m in length), viaduct (including monorail viaduct), overpass, platform, platform shed, aerial wire support pole, signal light pole
	moving objects	parking vehicle, railway vehicle, ship
buildings	buildings and related facilities	houses, factories, warehouses, public facilities, station buildings, wall-less huts, greenhouses, plastic houses, stadium stands, gates, swimming pools (including foundations), fences
small objects		monument, shrine gate, water tank, fertilizer tank, water tower, hoist, chimney, tower, radio tower, lighthouse, pipe line (ground, air), power line
water part	water related facilities	floating pier, water level gauge facility, river information board
plant		tree*1, bamboo*1, hedge*1
others	others	areas under large-scale construction work *2, excavation parts for subway construction, material storage, etc.
remarks		* 1 The part regarded as the ground surface shall be adopted as much as possible. * 2 The ground surface that looks as permanent shall be adopted.

4 If a problem occurs in the terrain expression in the filtering of the large-scale ground shielding part, the interpolation is performed using the surrounding unfiltered ground data.

(Creating low-density polygon data)

Article 336 The low-density polygon data is created at an area where the ground data density is very low after filtering.

2 "Low density" refers to a case in which original data is collectively removed by filtering.

3 Decision of "low density" or not shall be made by referring contour lines, etc., where the accuracy of the Article 80*6 digital topographic map data cannot be satisfied.

(Matching with existing data)

Article 337 Consistency with existing data shall be compared and inspected by setting an overlapping section between existing data and ground data.

2 The number of check points is one or more for each basic land map frame area, and the check points are selected in flat areas such as ground, vacant land, roads, parks, etc., where little influence of the ground control point and ground shielding is expected. In principle, check point shall have at least 100 measurement points.

3 The inspection shall be conducted as follows.

(1) Compare averaged ground data within the overlapping area.

(2) Calculate the mean and standard deviation of the difference.

(3) If the standard deviation is exceeding 30cm, clarify the reason in consideration of the original data and take appropriate measures such as recalculation or remeasurement.

(4) When there is no ground data as existing data, grid data of existing data can be used as substitute.

(5) The inspection results are reported in the existing data verification table.

(Creating filtering quality check map)

Article 338 The filtering quality check map is created to check whether filtering is properly performed and whether there is no abnormality in the created ground data.

2 Two types of filtering quality check maps as "Airborne Laser Photo Map Data and Contour Data Overlay Map" and "Airborne Laser Photo Map Data, Original Data, Water Polygon and Low Density Polygon Overlay Map" shall be created. However, when the airborne laser photo map data is not created, shaded colour gradient map created from the original data can be used as substitute.

3 The filtering quality check map shall be prepared by each national land basic map frame.

4 The filtering quality check map is printed out at a scale corresponding to the geospatial information quality level of the grid interval.

5 The following table is the standard for the contour interval and colour in the "Airborne Laser Photo Map Data and Contour Data Overlay Map". In addition, elevation values are added to the index contour line, and a symbol is added to the depression part.

contour line	interval	colour
index	5m	Yellow
intermediate	1m	red

6 The color classification in the "Airborne Laser Photo Map Data, Original Data, Water Polygon and Low Density Polygon Overlay Map" is based on the following table.

item	colour
Points adopted as ground data in the original data	red
Points deleted by filtering in the original data	yellow
Water body polygon boundary	deep blue
Low density polygon boundary	green

7 The filtering quality check map shall be prepared for area buffered by a minimum of distance 10 times of the grid interval around the map frame.

(Checking filtering quality)

Article 339 Filtering quality check shall be performed for each of the following items using a filtering quality check map.

(1) Appropriateness of acceptance / rejection of original data of filtering objects prescribed in Article 335, Paragraph 3

(2) Suitability of water body polygon area

(3) Suitability of low density polygon area

2 As for filtering, quality check shall be conducted for 5% of the total.

3 If it is difficult to judge whether the filtering is good or bad, it shall be checked by a cross-sectional expression using a graphic compilation system.

Section 9 Grid data creation

(Grid data creation)

Article 340 "Grid data creation" refers to an operation of creating a sequence of elevation data at each grid point from ground data by interpolation.

2 The accuracy of the elevation value of the grid data is in the following table as standard.

item	RMS error
When there is ground data within the grid	≦0.3m
When there is no ground data within the grid	≦2.0m

3 Grid data shall be filed by each national basic map frame.

4 The elevation interpolation method for the grid data is based on the use of TIN or nearest neighbor methods in consideration of the topography, the usage of the grid data and the density of the ground data. However, Kriging interpolation method can be applied for area of many data voids.

5 About each point of grid data, the attribute showing a filtering condition or a water part condition shall be added as needed.

6 The unit of elevation value in the grid data is 0.1m.

(Creation of grid data check map)

Article 341 The grid data check map is created to check whether the created grid data is normal and whether the data consistency between neighbouring maps is properly kept.

2 When the grid data is checked by the graphic compilation system, the creation of grid data check map can be omitted.

3 The grid data check map is based on the shaded colour gradient map created by each national land basic map frame, and the boundary lines of the low-density polygons are superimposed.

4 The shaded colour gradient map is created with geospatial information quality levels of 5,000 to 10,000 as a standard.

5 When there is existing data for adjacent to the target area, the grid data check map shall be created for area buffered by a minimum of distance 10 times of the grid interval around project target area boundary.

(Inspection of grid data)

Article 342 Grid data inspection shall be performed for each of the following items using a grid data check map or graphic compilation system.

(1) Appropriateness of predetermined grid interval, etc.

(2) Incorrect or missing elevation values

(3) Area of water

(4) Low density area

(5) Consistency between neighbouring frame data

Section 10 Contour data creation

(Contour data creation)

Article 343 "Creation of contour line data" refers to an operation of creating contour line data by automatic generation from ground data or grid data.

2 Contour line data is created as follows.

(1) The contour line data shall be created by each national land basic map frame.

(2) The interval of ground data or grid data is shown in the following table as standard. Ground data and grid data of area buffered by a minimum of distance 10 times of the grid interval around project target area boundary shall be used for the creation of contour data.

geospatial information quality level	intermediate contour	index contour	ground data, grid data		
			1m	2m	5m
500	1m	5m	○	—	—
1,000	1m	5m	○	—	—
2,500	2m	10m	○	○	—
5,000	5m	25m	○	○	○

(Inspection of contour data)

Article 344 The inspection of contour line data shall be performed using a graphic compilation system, print out maps, etc.

2 The contents of inspection are as follows.

(1) Mistakes and omissions in contour data

(2) Adequacy of contour shape

Section 11 Digital geospatial data file creation

(Abstract)

Article 345 In this section, "Digital geospatial data file creation" means creating a digital geospatial data file according to the product specifications and recording it on an electromagnetic recording medium.

2 The digital geospatial data files in this section are as follows.

(1) Original data

(2) Ground data

(3) Grid data

(4) Water body polygon boundary line

(5) Low density polygon boundary line

(6) Digital photomap data for airborne laser survey

(7) Location information file

(8) Contour line data

(9) Stored data list

Section 12 Quality evaluation

(Quality evaluation)

Article 346 For the quality evaluation of digital topographic map data files, the provisions of Article 44[*7] shall be applied.

Section 13 Deliverables

(Create metadata)

Article 347 The provisions of Article 45[*8] shall be applied to the creation of metadata for digital geospatial data files.

(Deliverables)

Article 348 The deliverables to be provided are as follows.

(1) Digital geospatial data file

(2) Work records

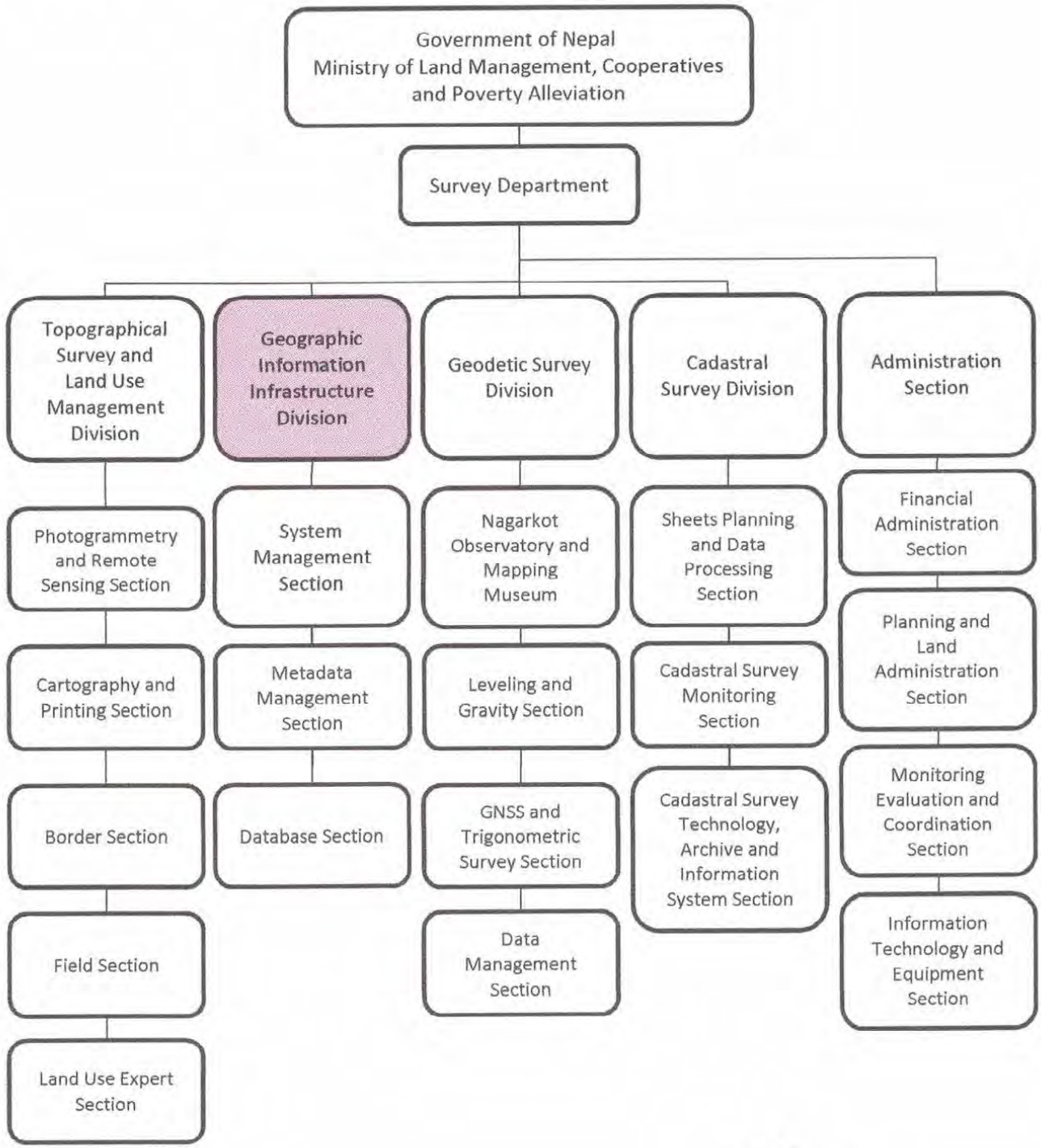
(3) Quality control table

(4) Quality evaluation table

(5) Metadata

(6) Others

Organogram of Survey Department



Flow of Data Disclosure

1. Creation of DEM data (by the Supplier)

↓

2. Inspection of DEM data (by Survey Department and the Consultant)

↓

3. Approval of DEM data (Survey Department)

↓

4. Handover to Government of Nepal

↓

5. Issuing of Certificate of Completion works for DEM to the Supplier (by Survey Department)

↓

6. Disclosure of DEM metadata

Publication and Copyright plan of DEM

The publication and the copyright of DEM developed by the grant aid project are proposed as follows.

(1) Target of publication of DEM

All the DEM of the target area of the project shall be open. DEM shall be open not only Nepal people but also foreigners. When someone requests the original data of the laser survey, it shall be open if the purpose of use is appropriate.

(2) Copyright of DEM

The copyright of DEM developed by the grant aid project belongs to DOS, and Japan is vested to have right of using the DEM.

(3) Distribution of DEM

The DEM shall be distributed at the office in charge of data sales in GIID. The flow of sales for existing digital products shall be applied to the distribution of the DEM. The turnaround time from order to receipt in the office should be reduced using the tools such as the one developed in the soft component in the project.

In near future, it is desirable to establish an environment enabling data order through Internet even though the receipt of the data is made in Survey Department as it is.

(4) Variety of DEM Products and their prices

Variety of DEM products shall be as follows.

1) Coordinate system

a. Based on geodetic reference system and projection defined in Nepal

b. Based on WGS84 and UTM projection

2) File unit

The extent of 10 km x 10 km shall be one file. Several file formats which are appropriate considering user needs should be prepared.

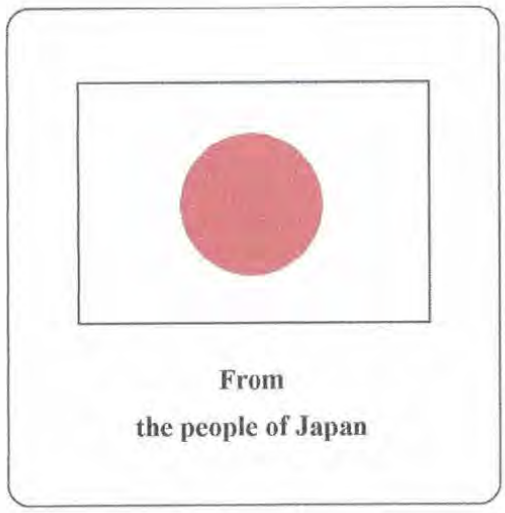
The price should be free of charge ideally, but if it is difficult, it should be affordable, for instance about following price so that anyone who wants DEM can get it.

Set 300 Rs. for the extent of one sheet of 1:25,000 scale topographic map, and calculate unit price per area. Data price shall be area of data to be provided multiplied by unit price. Three hundred Rs. corresponds to the highest price of layer data among 8 layers of 1:25,000 digital topographic map.

In the case of distributing original laser survey data, it shall be free of charge.

(5) Description about the assistance by Japan

In some kind of explanatory document of DEM, the description showing DEM has been developed by the assistance of Japan with the logo of Japan's ODA as shown below shall be put on.



Development of Digital Elevation Model and Orthophoto

Total Project Site area 15,000 sq.km.

Province no 1: Jhapa, Morang, Sunsari
Province no 2: Saptari, Siraha, Dhanusha, Mahottari, Sarlahi, Rautahat, Bara, Parsa
Provnice no 3: Part of Chitawan

Data Source:
Survey Department, Nepal

0 50,000 100,000 200,000 300,000 400,000 Meters

Legend

- Project Area
- District

ANNEX 7

Appendix 5　Soft Component Plan

1. Background of the Soft Component

If a detailed digital elevation model (detailed DEM) is developed through this project, it will be possible to develop flood management measures more elaborately. Furthermore, this model can also be utilized for water resource development including irrigation, urban planning, road and railway construction and land use planning in the flat Terai region.

In this way, once a detailed DEM of East Terai Region is developed, using the model, multiple deliverables will be created and utilized. To ensure that the model will be effectively utilized, it is deemed necessary to inform the possibility of deliverables and services utilizing the model to many relevant agencies and provide the model in a format that can be easily accessed and processed.

Also, since there was no full-fledged DEM in the past, it is necessary to enable the Survey Department to explain how this model can be used in flood management to agencies relating to disaster prevention, aiming to establish collaboration with such agencies. In river areas, terrain changes caused by flooding have occurred frequently. As such, it is important for the Survey Department to establish a structure to update and maintain the detailed elevation model to facilitate sharing of information with the agencies relating to disaster prevention and appropriate use of the information by such agencies.

Currently, there is an issue in the area of survey in Nepal that the DEMs that have been created are not utilized effectively. It is considered necessary to establish a structure for operation and maintenance of the detailed DEM to be developed in this project, while resolving this issue.

With the above-described background, a soft component (technical assistance) plan is developed to ensure that the outputs of this project will at least be sustained.

2. Soft Component Objectives

Object 1: Maintenance of the DEM is sustained. (Establishment of the DEM maintenance capabilities)

Staff of the Survey Department understands the basic and applied technology regarding the function and methods of operation and maintenance of the procured equipment so that the equipment will be effectively utilized continually in the years ahead. Also, they can maintain the DEM continually by using the procured equipment. In this context, the capacity of the Survey Department to update and maintain the digital elevation model in the flood control field properly will be strengthened.

Object 2: Utilization of the DEM is facilitated. (Strengthening of the structure for use of the DEM)

Usability of the DEM is widely recognized by the people and an environment enabling the people to easily access the detailed DEM is established. Also, staff of the Survey Department understands the method of using the DEM and is able to create various thematic maps by making use of the procured equipment. In addition, the organizations related to flood control field recognize that feedback on topographical changes information from these organizations to the Survey Department is important.

3. Soft Component Outputs

Output 1: Maintenance of the DEM (Establishment of the DEM maintenance capabilities)

Output1-1 Creation and update of the DEM by drone photogrammetry

(After establishing an environment enabling the creation of orthophotos and the DEM, by integrating the model with the existing DEM, a wide-area DEM can be maintained appropriately. The DEM can be maintained appropriately in accordance with the chronological terrain changes.)

(1) Staff of the Survey Department is able to perform appropriate operation and maintenance of the procured equipment.

(2) Staff of the Survey Department maintains procedures, develops operation plans according to the objectives and continually updates the DEM using the procured equipment. (Also for flood countermeasures, the Survey Department develops work plans for topographical changes required for disaster prevention, and digital elevation models can be updated and maintained appropriately.)

Output1-2 Processing of point cloud data

(After establishing an environment for point cloud processing, outputs such as ground data, DTM (Digital Terrain Model), DSM (Digital Surface Model), etc. can be created from original point cloud data obtained from photogrammetry using drones, Airborne LiDAR Survey, terrestrial laser scanner survey, etc.)

(1) Ground data can be extracted from original Airborne LiDAR data.

(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment.

Output 2: Facilitation of the Utilization of DEM (Strengthening of the structure for utilization of the DEM)

(The DTM/DSM obtained from photogrammetry using drone, Airborne LiDAR Survey, terrestrial laser scanner survey, etc. can be effectively utilized for applied implementation.)

(1) Specifications and usability of the DEM are acknowledged by many agencies and people.

(2) Personnel in charge of provision are able to explain the specifications and usage examples of the DEM.

(3) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM.

(4) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM.

(5) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood.

(6) The importance of feedback on topographical changes information from these organizations to the Survey Department is recognized by the organizations related to flood control field recognize.

4. Methods for Confirming Output Achievement maintenance of the DEM data

The table below shows the methods for confirming output achievement.

Output 1: Maintenance of the DEM (Establishment of the DEM maintenance capabilities)

Output	Items for Confirming Level of Achievement
Output1-1 Creation and update of the DEM by drone photogrammetry	
(1) Staff of the Survey Department is able to perform appropriate operation and maintenance of the procured equipment.	- Give an assignment as a case study to confirm operational proficiency.
(2) Staff of the Survey Department maintains procedures, develops operation plans according to the objectives and continually updates the DEM using the procured equipment. (Also for flood countermeasures, the Survey Department develops work plans for topographical changes required for disaster prevention, and digital elevation models can be updated and maintained appropriately.)	- Confirm if the prepared procedures are appropriate.
Output1-2 Processing of point cloud data	
(1) Ground data can be extracted from original Airborne LiDAR data.	- Give an assignment as a case study to confirm operational proficiency.
(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment.	- Confirm if the prepared procedures are appropriate.

Output 2: Facilitation of the Utilization of DEMs (strengthening of the DEM utilization structure)

Output	Items for Confirming Level of Achievement
(1) Specifications and usability of the detailed DEM are acknowledged by many agencies and people.	- Conduct a questionnaire survey on seminar participants. (*See Activity column for seminar.) - Conduct an email-based questionnaire survey on agencies assumed likely to use the models.
(2) Personnel in charge of provision are able to explain the specifications and usage examples of the DEM.	- Check if the personnel are able to explain the resolution and height accuracy of the detailed DEM and the DEM previously created from the digital contour data and satellite data provided by the Survey Department. - Check if the personnel are able to correctly explain several usage examples of the detailed DEM.
(3) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM.	- Give an assignment as a case study to confirm operational proficiency.
(4) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM.	- Give an assignment as a case study to confirm operational proficiency.
(5) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood.	- Based on the lecture of "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using digital elevation models", the trainers can prepare pamphlet and explain it by themselves at the seminar.

Output	Items for Confirming Level of Achievement
(6) The importance of feedback on topographical changes information from these organizations to the Survey Department is recognized by the organizations related to flood control field recognize.	- The feedback information on flood control field from the related organizations will be sorted out and, the trainees can prepare pamphlet and explain it by themselves at the seminar.

5. Activities (Input Plan) and deliverables

The following activities are carried out to achieve the outputs.

Output 1: Maintenance of the DEM (Establishment of the DEM maintenance capabilities)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
First term First on-site training (classroom lectures, guidance for preparation of plans and procedures, hands-on training using the equipment)			
Output 1-1 Creation and update of the DEM by drone photogrammetry **Target personnel and its number**			
(1) Staff of the Survey Department are able to perform appropriate operation and maintenance of the procured equipment. Survey Department (6 persons): Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Overall lecture on drone photogrammetry (principle, workflow, etc.) ▪ Lecture and hands-on training on drone photogrammetry planning (photography planning, control point positioning), on-site operations (driving, safety measures) and analysis method of acquired data ▪ Lecture and hands-on training on the management method of the old and new DEMs	Survey results of the hands-on training area 1) Adjustment calculation result 2) Point cloud data 3) Orthophotos	0.53 M/M (16 days) Including trip [Haneda→ Kathmandu]
(2) Staff of the Survey Department maintains procedures, develops operation plans according to the objectives and continually updates the DEM using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Attendees complete the following procedures under the guidance of the instructor based on the learnings from the lectures and hands-on training. - Procedure for operation of drones (driving, maintenance, safety measures, etc.) - Procedure for creating DEMs by drone photogrammetry - Procedure for maintaining and updating DEMs by drone photogrammetry (Updating a part of the existing digital elevation models by drone photogrammetry) - DEM maintenance procedure	1) Procedure for operation of drones (driving, maintenance, safety measures, etc.) 2) Procedure for creating DEMs by drone photogrammetry 3) Procedure for maintaining and updating DEMs by drone photogrammetry 4) DEM maintenance procedure	0.13 M/M (4 days)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Output 1-2 Processing of point cloud data **Target personnel and its number**			
(1) Ground data can be extracted by processing the original Airborne LiDAR data. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Classroom lecture on point cloud data acquisition principle and workflow for each surveying method (drone photogrammetry、Airborne LiDAR Survey, terrestrial laser survey, etc.) ▪ Hands-on training in ground data extraction (filtering) by automated and manual processing ▪ Lecture and hands-on training on creation of grid data ▪ Lecture and hands-on training on creation of contour data	Data from the hands-on training area 1) Ground data 2) Grid data 3) Contour data	0.30M/M (9 days)
(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment. Survey Department (6 persons): Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Attendees complete the following procedures under the guidance of the instructor based on the learnings from the lectures and hands-on training. - Procedure for extraction of ground data - Procedure for creation of grid data - Procedure for creation of contour data	1) Procedure for extraction of ground data 2) Procedure for creation of grid data 3) Procedure for creation of contour data	0.17M/M (5 days) Including trip [Kathmandu→ Haneda]
Second term Second on-site training (Verification, evaluation and review of the outputs of the first term)			
Output 1-1 Creation and update of DEMs by drone photogrammetry **Target personnel and its number**	After implementing the first on-site training (in about one months after the training), perform measurement of the outputs produced in the first term and take necessary improvement measures.		
(1) Staff of the Survey Department are able to perform appropriate operation and maintenance of the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	Staff of the Survey Department are assigned to perform planning, photographing, analysis and product creation by themselves for a pre-determined area. ▪ Confirmation of implementation status and issues to be tackled ▪ Confirmation of failure occurrence and repair status as well as issues to be tackled	Survey results of the assigned area 1) Adjustment calculation result 2) Point cloud data 3) Orthophotos	0.50 M/M (15 days) Including trip [Haneda→ Kathmandu]
(2) Staff of the Survey Department maintains procedures, develop operation plans	▪ Guidance for reflection of issues on the procedures ▪ Guidance for reflection of failure	Revised procedures	0.06 M/M (2 days)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
according to the objectives and continually updates the DEM using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	occurrence and repairs on the procedures		
Output 1-2 Processing of point cloud data **Target personnel and its number**	After implementing the first on-site training (in about 1 month after the training), perform measurement of the outputs produced in the first term and take necessary improvement measures.		
(1) Ground data can be extracted by processing the original Airborne LiDAR data. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	Staff of the Survey Department are assigned to perform data processing and product creation by themselves for a pre-determined area. ▪ Confirmation of implementation status and issues to be tackled	Survey results of the assigned area 1) Ground data 2) Grid data 3) Contour data	0.17 M/M (5 days)
(2) Staff of the Survey Department maintains procedures and continually performs point cloud data processing using the procured equipment. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Guidance for reflection of issues on the procedures	Revised procedures	0.13 M/M (4 days) Including trip [Kathmandu→ Haneda]

Output 2: Facilitation of the Utilization of DEMs (Strengthening of the DEM utilization structure)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
First term First on-site training (preparations for holding a seminar, classroom lectures, guidance for creation of procedures) Target personnel and its number			
(1) Specifications and usability of the detailed DEM are acknowledged by many agencies and people. Survey Department	▪ Prepare for holding a seminar to introduce the specifications and usage examples of the detailed DEM. ▪ Create a pamphlet (draft) about the detailed DEM.	Pamphlet (draft)	0.20M/M (6 days) Including trip [Haneda→ Kathmandu]

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
(3 persons): Sales Staff of "Geographic Information Infrastructure Division (GIID)"			
(2) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lectures and hands-on training on creation of thematic maps ▪ Attendees complete procedures for creating the following thematic maps under the guidance of the instructor based on the learnings from lectures and hands-on training. - Profile and cross section - Shading map - Contour map - Elevation tints map - Bird's eye view - Slope classification map - Difference map	Procedures for creating the following thematic maps 1) Profile and cross section 2) Shading map 3) Contour map 4) Elevation tints map 5) Bird's eye view 6) Slope classification map 7) Difference map	0.10M/M (3 days)
(3) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lectures and hands-on training on analysis of sediment changes ▪ Attendees complete the procedure for analyzing sediment changes under the guidance of the instructor based on the learnings from lectures and hands-on training.	Procedure for analyzing sediment changes	0.07 M/M (4 days) Including trip [Kathmandu→ Haneda]
(4) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Lectures on the current situation of riverbed rise, riverbank erosion and flooding caused by road embankment in the eastern Tarai region. ▪ Lectures on that the DEM enables precise flood analysis and to create an accurate hazard map, then appropriate flood countermeasures can be implemented based on the analysis and the map. ▪ Under the guidance of the trainer, prepare a draft pamphlet explaining the use of DEM for flood control.	1) Instruction on "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using DEM " 2) Pamphlet (draft) of the above.	0.17 M/M (5 days) Including trip [Haneda→ Kathmandu]
(5) The importance of feedback on topographical changes information from the organizations related to flood control field to the Survey Department will be recognized. Survey Department (6 persons) : Staff of "Topographical Survey and	▪ Lecture on the below. In order to conduct appropriate flood control projects and river management, it is necessary to update the DEM information of the location when there is a change in topography or land use in the river area. Therefore, it is important to obtain feedback on the topographical and geographical changes from the related agency responsible for river	1) Sorting out of the importance feedback information on topographical changes from the organizations related to flood control field 2) Pamphlet (draft) of the above.	0.23M/M (7 days) Including trip [Kathmandu→ Haneda]

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	management and infrastructure construction to the Survey Department, and it is necessary for this to be recognized by flood control organizations. ▪ Preparing a pamphlet (draft) under the guidance of the trainer to explain at the seminar. (The seminar is targeted at flood control organizations.)		
Second term Second on-site training (verification, evaluation and review of technology transfer outputs) Target personnel and its number			
(1) Specifications and usability of the detailed DEM are acknowledged by many agencies and people. Survey Department, Department of Road, Forest Research and Training Centre, Department of Hydrology and Meteorology, Department of Water Resources and Irrigation, Department of Mines and Geology, International Center for Integrated Mountain Development (ICIMOD), donors, etc. (60 persons)	▪ Hold a seminar to introduce the specifications and usage examples of the detailed DEM by inviting about 60 persons from potential user agencies. ▪ Capture the effectiveness of the seminar based on questionnaires and media reports. ▪ Prepare a pamphlet.	1) Results of questionnaire survey on recognition by relevant agencies 2) Results of survey on the content and frequency of reports by newspaper and TV. 3) Pamphlet about the detailed DEM	0.27 M/M (9 days) Including trip [Haneda→ Kathmandu]
(2) Personnel in charge of provision are able to explain the specifications and usage examples of the detailed elevation model. Survey Department (5 persons) : Sales Staff of "Geographic Information Infrastructure Division (GIID)"	▪ Provide guidance to personnel in charge of provision of detailed DEMs at the Survey Department on the specifications and usage examples of the models. ▪ The personnel summarize the outcome as user manual.	User manual explaining the detailed DEM.	0.10 M/M (3 days)
(3) Thematic maps (profile and cross section, shading map, contour map, elevation tints map, bird's eye view, slope classification map, difference map, etc.) can be created from the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management	▪ Guidance to reflect issues on procedures, etc.	Revised procedures	0.10 M/M (3 days)

Target personnel for output	Activities	Deliverables	Implementation resources (Required M/M)
Division" and "Geographic Information Infrastructure Division (GIID)"			
(4) Analysis of arbitrary terrain changes (sediment changes, etc.) can be performed based on the DTM/DSM. Survey Department (6 persons) : Staff of "Topographical Survey and Land Use Management Division" and "Geographic Information Infrastructure Division (GIID)"	▪ Guidance to reflect issues on procedures, etc.	Revised procedures	0.17 M/M (5 days) Including trip [Kathmandu→ Haneda]
(5) The current situation and topographical issues related to flood risk, and flood control measures using DEM will be understood. Same number to (1) (60 persons)	▪ Under the guidance of the trainer, a pamphlet explaining the use of DEM for flood control will be created and its contents will be explained at the seminar.	Pamphlet of "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using digital elevation models"	0.13M/M (4 days) Including trip [Haneda→ Kathmandu]
(6) The importance of feedback on topographical changes information for flood control field from the related organizations to the Survey Department will be recognized. Same number to (1) (60 persons)	▪ Pamphlet on the feedback information on topographical changes for flood control field from the related organizations will be prepared and its contents will be explained at the seminar.	Pamphlet of the feedback information on topographical changes for flood control field from the related organizations	0.17 M/M (5 days) Including trip [Kathmandu→ Haneda]

6. Procurement of Implementation Resources

6-1 Output 1: Maintenance of the DEM (Establishment of the DEM maintenance capabilities)

Procurement of implementation resources for each activity is as described in the table below.

Table List of Implementation Resources to be Procured for Output 1

Activity	Procurement of Implementation resources
Creation and update of the DEM by drone photogrammetry	・ Japanese consultant serves as instructor to teach equipment operation and creation of procedures to enable the staff of the Survey Department to create DEMs. ・ 0.67 M/M from one month prior to the handing over of the DEM, and 0.57 M/M after one month from the completion of the First term
Processing of point cloud data	・ Japanese consultant serves as instructor to teach equipment operation and creation of procedures to enable the staff of the Survey Department to process point cloud data. ・ 0.47 M/M from one month prior to the handing over of the DEM, and 0.30 M/M after one month from the completion of the First term

Drone, which is one of the equipment to be procured for this project, is not specifically designed for surveying. However, since it is used for surveying in this project, knowledge of photogrammetry is required to operate it. Also, to maintain the DEM using the drone, it is necessary to fully understand the difference from the DEMs to be created by Airborne LiDAR Survey in this project in terms of creation method as well as the characteristics of each model.

As such, it is determined appropriate that the contracting consultant who has ample knowledge and working experience in aerial survey including the latest surveying and measurement technologies such as drone photogrammetry, and well understands the purposes and use of the digital terrain models (DTM) in Nepal provide direct support as the implementation resources for the soft component relating to the DTM maintenance.

6-2 Output 2 Facilitation of the Utilization of DEMs (Strengthening of the DEM utilization structure)

Procurement of implementation resources for each activity is as described in the table below.

Table List of Implementation Resources to be Procured for Output 2

Activity	Procurement of Implementation resources
Holding of a seminar Creation of pamphlet	・Held by Japanese consultant in cooperation with the staff of the Survey Department ・0.20 M/M from 3 months prior to the handing over of DEM, 0.30 M/M after 3 months from the handing over of DEM
Guidance to the personnel in charge of provision at the Survey Department	・Provided by Japanese consultant ・0.10 M/M at the project completion
Creation of thematic maps from the DTM/DSM	・Provided by Japanese consultant ・0.10 M/M from 3 months prior to the handing over of DEM, 0.10 M/M after 3 months from the handing over of DEM
Analysis of the DTM/DSM	・Provided by Japanese consultant ・0.13 M/M from 3 months prior to the handing over of DEM, 0.17 M/M after 3 months from the handing over of DEM
Understanding of the topographical issues related to flood risk and flood control measures using DEM	・A Japanese consultant will implement this in cooperation with the Survey Department staff ・0.17 M/M from 3 months prior to the handing over of DEM, 0.13 M/M after 3 months from the handing over of DEM
Recognition of the importance of feedback on topographical changes information for flood control field from the related organizations	・A Japanese consultant will implement this in cooperation with the Survey Department staff ・0.23 M/M from 3 months prior to the handing over of DEM, 0.17 M/M after 3 months from the handing over of DEM

As information is not actively exchanged among the government agencies of Nepal, it is necessary to hold a seminar where the Survey Department can meet potential users of the detailed digital terrain models, such as the Department of Hydrology and the Department of Water Resources and Irrigation, to facilitate the use of such models. The Survey Department provided so far digital geospatial information, but there is a need to promote the use of detailed digital topographic maps by providing data, placing a greater

emphasis on the viewpoint of users. Since the Survey Department tends to be devoid of such viewpoint, support by the Japanese consultant is essential.

Also, it is necessary to teach the basic and general method of DTM/DSM-based analysis to the staff of the Survey Department by the experienced Japanese consultant.

7. Implementation Schedule

7-1 Output 1: Maintenance of the DEM (Establishment of the DEM maintenance capabilities)

Activities for maintenance of the DEM are carried out in the first and second terms. In the first term, lectures and hands-on training will be conducted on applied operation of drones (photographing plan, on-site operations, data analysis) for the purpose of surveying, processing of Airborne LiDAR data and creation of various types of data will be carried out one month prior to the handover of the DEM. For the lectures and hands-on training on the processing of Airborne LiDAR data, data from this project will be used. Above this includes the acquisition of knowledge necessary for update and maintenance from the perspective of flood control.

The second term activities will be implemented about one month after the first term. Implementation status of the assignments given in the first term will be checked and verified, issues in operation will be extracted and associated procedures will be updated accordingly. Operation technology, which is highly sustainable and yet suitable to the current situation of the Survey Department, will be transferred.

7-2 Output 2: Facilitation of the Utilization of the DEM (Strengthening of the DEM utilization structure)

Activities to facilitate the utilization of the DEM will be carried out in the first and second terms. In the first term, preparations will be made for holding a seminar, pamphlets on the detailed DEM will be created about three months prior to the handover of the DEM. Creation and analysis of thematic maps, which are scheduled before the handover of the DEM, will be carried out using temporary data or data of other regions since the method is the same. In addition, the current situation of flood risk in the eastern Terai region, the use of DEM for flood countermeasures, and the topographic changes required for update and maintenance are understood.

About three months after the first term, the seminar will be held, the pamphlet will be completed. Also, guidance will be given to the personnel in charge of provision of the DEM at the Survey Department to ensure that explanations about the detailed elevation model will be smoothly provided to users. Moreover, procedures for creation and analysis of thematic maps using the detailed DEM will be updated through hands-on training using the DEM created in this project. At the seminar, presentations will be given on the use of DEM for flood control and the importance of feedback of topographic change information in river areas from the agency in charge of flood control when updating DEM.

Table Soft Component Implementation Schedule

Year		2021												2022								
Month		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
Installation	**Initial operational guidance (implemented by procurement contractor)**											Handover										
Soft component	**Maintenance of the DEMs Output 1**											1.13MM		0.87MM								
	Facilitation of the utilization of DEMs Output 2									0.43MM 0.40MM				0.67MM 0.30MM								

8. Deliverables of Soft Component

All deliverables of Soft Component are shown in the table below.

Table All deliverables of Soft Component

Output	Deliverables
1: Maintenance of the DEM 1-1 Creation and update of the DEM by drone photogrammetry	1) Survey results of the hands-on training area ①Adjustment calculation result, ②Point cloud data, and ③Orthophotos 2) Procedure for operation of drones (driving, maintenance, safety measures, etc.) 3) Procedure for creating DEMs by drone photogrammetry 4) Procedure for maintaining and updating DEMs by drone photogrammetry 5) DEM maintenance procedure 6) Procedure for maintaining and updating DEM for flood control measurement
1: Maintenance of the DEM 1-2 Processing of point cloud data	1) Data from the hands-on training area ①Ground data, ②Grid data, and ③Contour data 2) Procedure for extraction of ground data 3) Procedure for creation of grid data 4) Procedure for creation of contour data
2: Facilitation of the Utilization of DEMs	1) Pamphlet (draft) about the detailed DEM 2) Procedures for creating the following thematic maps 3) Procedure for analyzing sediment changes 4) Instructions of "Description of Rivers and Floods in the Eastern Terai Plain" and "Explanation on flood control measures using digital elevation models" 5) Procedure for the feedback information on topographical changes for flood control field from the related organizations 6) Survey result on the effectiveness of the seminar ①Survey results on awareness of related organizations by questionnaire ②Survey results on Press content and frequency ③Pamphlet about the detailed DEM 7) User Manual for the detailed DEM 8) Pamphlet of "Description of Rivers and Floods in the Eastern Terai Plain"

Output	Deliverables
	and “Explanation on flood control measures using digital elevation models” 9) Pamphlet of the feedback information on topographical changes for flood control field from the related organizations

9. Soft Component Cost Estimation

This section is closed due to confidentiality.

10. Responsibilities and Obligations of Nepali Side

(1) Cooperation in implementing the soft component

- Appointment of responsible person and selection of attendees concerning the implementation of the soft component
- Provision of place for implementation of the soft component
- Provision of projector, screen, etc. for classroom lectures
- Effective use of the DEM information and peripheral equipment granted to the Survey Department
- Cooperation with the Japanese consultant

(2) Establishment of administrative structure

- Continual facilitation of the utilization of the detailed DEM under the initiative of the staff who attended the soft component so that the content learned by the attendees will be sustained on a long-term basis.

(3) Implementation of periodic inspection, etc.

Daily inspection, periodic inspection and response to failures should be continually carried out by making use of the plans and procedures created in this project. These works should aim at improvement of the operation and maintenance skills of the staff. Procedures should be reviewed as appropriate and revised where necessary. Appropriate plans, procedures, etc. can be continually maintained by implementing operation management and maintenance based on the PDCA cycle.

(4) Securing of budget

Continual securing of budget for the activities described above.

Activity Itinerary

Output		Output		1. Maintenance of digital elevation model		2. Facilitation of use of digital elevation model		Rental car
Course		Course		1-1 Creation and update of digital elevation models by Drone photogrammetry	1-2 Processing of point cloud data		Related Flood Management	(unit)
Schedule		Days				13	12	
2021/9/15	Wed	First term	Day 1			Travel [Haneda→Bangkok→Kathmandu]		1
2021/9/16	Thu		Day 2			Preparation for holding seminar		1
2021/9/17	Fri		Day 3			Creation of pamphlet (draft)		1
2021/9/18	Sat		Day 4			Preparation for lectures and hands-on training on creation of thematic maps		
2021/9/19	Sun		Day 5			Preparation for holding seminar		1
2021/9/20	Mon		Day 6			Creation of pamphlet (draft)		1
2021/9/21	Tue		Day 7			Lectures and hands-on training on creation of thematic maps		1
2021/9/22	Wed		Day 8			Lectures and hands-on training on creation of thematic maps		1
2021/9/23	Thu		Day 9			Preparation for lectures and hands-on training on sediment change analysis		1
2021/9/24	Fri		Day 10			Lectures and hands-on training on sediment change analysis	Travel[Haneda→Bangkok→Kathmandu]	1
2021/9/25	Sat		Day 11			Preparation for holding seminar	Confirmation of schedule	1
2021/9/26	Sun		Day 12			Travel [Kathmandu→Bangkok→]	Preparation for the lecture	1
2021/9/27	Mon		Day 13			Travel [→Haneda]	Confirmation on the contents of the seminar	1
2021/9/28	Tue		Day 14				Lecture on rivers and flood situation in Eastern Tarai Region	1
2021/9/29	Wed		Day 15				Lecture on flood management activities by relevant organization using DEM	1
2021/9/30	Thu		Day 16				Lecture on the topographic/geographyic information needed for flood management and the needs of feed back from the relevant organizations.	1
2021/10/1	Thu		Day 17				Preparation of draft of pamphlet	1
2021/10/2	Fri		Day 18				Creation of draft of pamphlet	1
2021/10/3	Sat		Day 19				Preparation for holding seminar	1
2021/10/4	Sun		Day 20				Travel[Kathmandu→Bangkok→]	1
2021/10/5	Mon		Day 21				Travel [→Haneda]	1
							Total number of rental cars (first dispatch)	20

Output		Output	1. Maintenance of digital elevation model		2. Facilitation of use of digital elevation model		Rental car
Course		Course	1-1 Creation and update of digital elevation models by Drone photogrammetry	1-2 Processing of point cloud data		Related Flood Management	(unit)
Schedule		Days	20	14			
2021/11/1	Mon	Day 1	Travel [Haneda→Bangkok→Kathmandu]				1
2021/11/2	Tue	Day 2	Orientation, discussion on schedule, etc.				1
2021/11/3	Wed	Day 3	General lecture on Drone photogrammetry				1
2021/11/4	Thu	Day 4	Lecture on Drone photogrammetry planning and on-site operations				1
2021/11/5	Fri	Day 5	Same as above				1
2021/11/6	Sat	Day 6	Preparation for hands-on training in Drone photogrammetry				
2021/11/7	Sun	Day 7	Lecture on safety and maintenance of Drones, hands-on driving training				1
2021/11/8	Mon	Day 8	Hands-on training in driving Drones				1
2021/11/9	Tue	Day 9	Same as above				1
2021/11/10	Wed	Day 10	Same as above				1
2021/11/11	Thu	Day 11	Lecture and hands-on training on analysis of acquired data (adjustment calculation)				1
2021/11/12	Fri	Day 12	Lecture and hands-on training on analysis of acquired data (adjustment calculation)				1
2021/11/13	Sat	Day 13	Preparation for lectures on creation of written procedures				1
2021/11/14	Sun	Day 14	Lecture and hands-on training on analysis of acquired data (adjustment calculation)				1
2021/11/15	Mon	Day 15	Lecture and hands-on training on analysis of acquired data (point cloud data, orthophotos)				1
2021/11/16	Tue	Day 16	Lecture on management method of old and new DEMs				1
2021/11/17	Wed	Day 17	Hands-on training on management method of old and new DEMs				1
2021/11/18	Thu	Day 18	Creation of written procedures				1
2021/11/19	Fri	Day 19	Same as above				1
2021/11/20	Sat	Day 20		Preparation for lectures on acquisition of point cloud data for each survey method			1
2021/11/21	Sun	Day 21	Creation of written procedures				1
2021/11/22	Mon	Day 22 (Day 1)		Lecture on principle and workflow of point-cloud data acquisition			1
2021/11/23	Tue	Day 23 (Day 2)		Lecture on processing of laser point cloud data			1
2021/11/24	Wed	Day 24 (Day 3)		Lecture and hands-on training on creation of ground data			1
2021/11/25	Thu	Day 25 (Day 4)		Hands-on training on creation of ground data			1
2021/11/26	Fri	Day 26 (Day 5)		Same as above			1
2021/11/27	Sat	Day 27 (Day 6)		Preparation for lectures on creation of written procedures			
2021/11/28	Sun	Day 28 (Day 7)		Lecture and hands-on training on creation of grid data			1
2021/11/29	Mon	Day 29 (Day 8)		Hands-on training on creation of grid data			1
2021/11/30	Tue	Day 30 (Day 9)		Lecture and hands-on training on creation of contour data			1
2021/12/1	Wed	Day 31 (Day 10)		Creation of written procedures			1
2021/12/2	Thu	Day 32 (Day 10)		Same as above			1
2021/12/3	Fri	Day 33 (Day 12)		Travel [Kathmandu→Bangkok→]			1
2021/12/4	Sat	Day 34 (Day 13)		Travel [→Haneda]			
						Total number of rental cars (second dispatch)	31

First term

Output		Output			1. Maintenance of digital elevation model		2. Facilitation of use of digital elevation model		Rental car
Course		Course			1-1 Creation and update of digital elevation models by Drone photogrammetry	1-2 Processing of point cloud data		Related Flood Management	(unit)
Schedule		Days			17	9	20	9	
2022/1/5	Wed	Day 1			Travel [Haneda→Bangkok→Kathmandu]				1
2022/1/6	Thu	Day 2			Orientation, discussion on schedule, etc.				1
2022/1/7	Fri	Day 3			Confirmation of resolving status of issues from the first term, confirmation of remaining issues and new challenges				1
2022/1/8	Sat	Day 4			Organization of documents				
2022/1/9	Sun	Day 5			Planning and guidance for Drone photogrammetry in assigned area				1
2022/1/10	Mon	Day 6			Drone photogrammetry and on-site operations in assigned area				1
2022/1/11	Tue	Day 7			Same as above				1
2022/1/12	Wed	Day 8			Same as above				1
2022/1/13	Thu	Day 9			Verification and guidance of adjustment calculation result of assigned area				1
2022/1/14	Fri	Day 10			Same as above				1
2022/1/15	Sat	Day 11			Organization of documents				
2022/1/16	Sun	Day 12			Guidance for creation of point cloud data of assigned area				1
2022/1/17	Mon	Day 13			Same as above				1
2022/1/18	Tue	Day 14		Day 1	Guidance for creation of orthophotos of assigned area		Travel[Haneda→Bangkok→Kathmandu]		1
2022/1/19	Wed	Day 15	Second term	Day 2	Verification of failure and repair responses and tackling of issues		Sending of seminar invitation letters		1
2022/1/20	Thu	Day 16		Day 3	Guidance for revision of written procedures		Media briefing concerning the seminar		1
2022/1/21	Fri	Day 17		Day 4	Same as above		Creation of pamphlet		1
2022/1/22	Sat	Day 18 (Day 1)		Day 5		Organization of documents	Preparation for guidance for revision of thematic maps creation procedures		
2022/1/23	Sun	Day 19 (Day 2)		Day 6		Verification and guidance for ground data extraction of assigned area	Guidance for revision of thematic maps creation procedures		1
2022/1/24	Mon	Day 20 (Day 3)		Day 7		Same as above	Revision of thematic maps creation procedures		1
2022/1/25	Tue	Day 21 (Day 4)		Day 8		Verification and guidance on grid data of assigned area	Preparation for guidance on specifications and usage examples of detailed DEMs		1
2022/1/26	Wed	Day 22 (Day 5)		Day 9		Verification and guidance on contour data of assigned area	Guidance on specifications and usage examples of detailed DEMs		1
2022/1/27	Thu	Day 23 (Day 6)		Day 10		Revision of written procedures	Guidance for creation of manual for explaining detailed DEMs to users		1
2022/1/28	Fri	Day 24 (Day 7)	Second term	Day 11		Same as above	Preparation for holding seminar	Travel [Haneda→Bangkok→Kathmandu]	1
2022/1/29	Sat	Day 25 (Day 8)		Day 12		Travel [Kathmandu→Bangkok→]	Preparation for guidance on revision of procedure for analysis of sediment changes	Confirmation on the contents of presentation for the seminar	1
2022/1/30	Sun	Day 26 (Day 9)		Day 13		Travel [→Haneda]	Guidance on revision of procedure for analysis of sediment changes	Sorting our of the following items. - The contents of each pamphlet - Feedback information on the topographic changes	1
2022/1/31	Mon			Day 14			Preparation for holding seminar	Preparation for holding seminar	1
2022/2/1	Tue			Day 15			Holding of seminar	Holding of seminar	1
2022/2/2	Wed			Day 16			Creation of pamphlet	Analysis of seminar results	1
2022/2/3	Thu			Day 17			Analysis of seminar results	Finalization of the following items. - The contents of each pamphlet - Feedback information on the topographic changes	1
2022/2/4	Fri			Day 18			Revision of procedure for analysis of sediment changes	Travel [Kathmandu→Bangkok→]	1
2022/2/5	Sat			Day 19			Travel[Kathmandu→Bangkok→]	Travel [→Haneda]	1
2022/2/6	Sun			Day 20			Travel[→Haneda]		
								Total number of rental cars (third dispatch)	29
								Total number of rental cars	80

Appendix 6　References

Annex 6-1　Land Act (Survey and Measurement) , 2019 (1963)
*See clause 11E “Power to give permission to make survey and mapping”

Annex 6-2　Ministry of Land, Infrastructure, Transport and Tourism
Standards for Operating Specifications for Public Surveying
Notification date: March 31st, 2008
Notification Number: 413
(1) Control Point Survey
(2) Leveling
(3) Airborne Laser Surveying

11D.[73] Aerial survey, map publication etc. may be made by obtaining approval: Notwithstanding anything contained in the other Sections of this Act, if any person, other than the prescribed authority**,** wishes to make an aerial survey, use the control stations set up by the Government of Nepal, publish maps prepared by the Government of Nepal or sell maps published abroad within ……Nepal[74] such a person may do so, subject to the observance of the prescribed terms and conditions.

Provided that, no map published in aboard shall be sold in Nepal if it contradicts with the map prepared by Government of Nepal.

11E. [75] Power to give permission to make survey and mapping: (1) The Government of Nepal may give permission to any person or body to carry out acts of survey and mapping as prescribed, subject to the survey and measurement made pursuant to this Act.

(2) The matters relating to the fees leviable for the issuance of permission pursuant to Sub-section (1), the terms and conditions to be observed by the permission holder person or body and other relevant matters shall be as prescribed.

12. Penalties: (1) If, in making survey and measurement or setting up control point stations, any person obstructs, or causes someone to obstruct, the survey and measurement of land or setting up of such stations by disfiguring fences or signals, instigating people or manhandling or otherwise, the prescribed authority may punish such a person making such obstruction with a fine of up to Fifty Rupees for the first time, of Fifty to One Hundred Rupees for the second time and of One Hundred to Five

73 Inserted by the Eighth Amendment.
74 Amended by the Republic Strengthening and Some Nepal Laws Amendment Act, 2066.
75 Inserted by the Eighth Amendment.

Annex 6-2 Ministry of Land, Infrastructure, Transport and Tourism
Standards for Operating Specifications for Public Surveying
Notification date: March 31st, 2008 Notification Number: 413

(1) Control Point Survey

Part 2 Control Point Survey
Chapter 1 General Rules

Section 1 Outline

(Outline)

Article 18 This part specifies work procedures and other matters of control point survey.

2 "Control point survey" refers to determining the position coordinates or elevations of control points based on known points.

3 "Control points" refer to survey markers installed as reference points for survey and having numerical position coordinates.

4 "Known points" refer to existing control points (hereinafter referred to as "existing points") whose coordinates are used as given in conducting control point survey.

5 "Resurveyed points" refer to the existing points, other than known points, to be resurveyed in control point survey.

6 "New points" refer to both new control points to be installed in control point survey (hereinafter referred to as "newly installed points") and resurveyed points.

(Classification of control point survey)

Article 19 Control point survey is classified into two: Narrowly defined control point survey excluding leveling (hereinafter referred to as "control point survey") and leveling.

2 Control points are classified into two: Narrowly defined control points to be installed in control point survey (hereinafter referred to "control points") and bench marks to be installed in leveling.

Section 2 Entries in Product Specification

(Product specification)

Article 20 A product specification shall systematically define the said control point survey or leveling in terms of the overview and scope of it, data product identification, contents and structures of data, reference system, data quality, distribution of data products, meta data, etc.

Chapter 2 Control Point Survey

Section 1 Outline

(Outline)

Article 21 "Control point survey" refers to determining the positions of control points that are new points based on known points.

2 Control point survey shall be classified into 1st, 2nd, 3rd, and 4th order control point surveys, depending on the type of known points, distances between known points, and distances between new points.

3 Control points to be installed in 1st, 2nd, 3rd, and 4th order control point surveys shall be called 1st, 2nd, 3rd, and 4th order control points, respectively.

4 GNSS is a generic term for satellite positioning systems that determine positions using signals from artificial satellites and includes such satellite positioning systems as GPS, quasi-zenith satellite system, GLONASS, and Galileo. GPS, quasi-zenith satellite system, and GLONASS shall be applied to GNSS survey. Note that quasi-zenith satellites can be handled as equivalent to GPS satellites and that these satellites shall be referred to as GPS/quasi-zenith satellites.

(Types of known points, etc.)

Article 22 The types of known points, distances between known points, and distances between new points in each of the classifications of control point survey specified in Paragraph 2 of the previous article shall normally be as shown in the following table:

Item \ Classification	1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Types of known points	GEONET stations, 1st to 4th class triangulation station, and1st order control points	GEONET stations, 1st to 4th class triangulation station, and 1st and 2nd order control points	GEONET stations, 1st to 4th class triangulation station, and 1st and 2nd order control points	GEONET stations, 1st to 4th class triangulation station, and 1st to 3rd order control points
Distance between known points (m)	4,000	2,000	1,500	500
Distance between new points (m)	1,000	500	200	50

2 Existing points installed in basic survey or public survey not included in the classifications shown in the previous paragraph can be used as known points according to the specifications in the previous paragraph by identifying to which of the classifications in the previous paragraph the survey for installing the said existing points corresponds.

3 In 1st and 2nd order control point surveys, known points can be set exclusively to GEONET stations (excluding attachment markers; The same shall apply hereafter). In this case, the limitation on a distance between known points shall not apply. However, the GEONET stations to be used as known points shall be the ones near the survey area.

4 Known points to be used in 3rd or 4th order control point survey may include known points of the same order installed through rigorous horizontal and vertical net adjustment computations or three-dimensional net adjustment computation. In this case, however, such known points shall consist of half or less of the known points to be used.

(Methods of control point survey)

Article 23 The methods for control point survey shall normally be as follows:

i. 1st and 2nd order control point surveys shall be performed, in principle, using the connected traverse method.

ii. 3rd and 4th order control point surveys shall be performed using either the connected traverse method or the single line traverse method.

2 The work method in the connected traverse method shall normally be as shown in the following table:

<table>
<tr><th colspan="2">Classification / Item</th><th>1st order control point survey</th><th>2nd order control point survey</th><th>3rd order control point survey</th><th>4th order control point survey</th></tr>
<tr><td rowspan="9">Connected traverse method</td><td>Number of known points in one traverse net</td><td colspan="2">$2 + \frac{Number\ of\ new\ points}{5}$ or more (round up)</td><td colspan="2">3 points or more</td></tr>
<tr><td>2 points or more if only GEONET stations are used as known points</td><td colspan="2">------</td><td>------</td></tr>
<tr><td>Number of sides of unit polygon</td><td>10 or less</td><td>12 or less</td><td>------</td><td>------</td></tr>
<tr><td rowspan="2">Number of sides of route</td><td>5 or less</td><td>6 or less</td><td rowspan="2">7 or less</td><td rowspan="2">10 or less
(15 or less)</td></tr>
<tr><td colspan="2">Depending on the trees to fell and topographical conditions, the number of sides can be increased with the consent from the planning agency.</td></tr>
<tr><td>Distance between nodes</td><td>250 m or more</td><td>150 m or more</td><td>70 m or more</td><td>20 m or more</td></tr>
<tr><td rowspan="2">Route length</td><td>3 km or less</td><td>2 km or less</td><td rowspan="2">1 km or less</td><td rowspan="2">500 m or less
(700 m or less)</td></tr>
<tr><td colspan="2">5 km or less if a GNSS survey device is to be used. This shall not apply, however, if only GEONET stations are used as known points.</td></tr>
<tr><td>Limitation on eccentric distances</td><td colspan="4">S/e≧6 where S: Distance between surveyed points
e: Eccentric distance
If only GEONET stations are used as known points, S shall be regarded as distance between new points, and an eccentric distance for installing one new point shall normally be 100 m or less regardless of this equation.</td></tr>
<tr><td>Route shape</td><td colspan="2">New points that belong to the peripheral route of a traverse net shall be selected in an area with exterior angles of 40 deg. or less from a straight line that connects nearest known points that belong to the peripheral route. The included angles in a route shall be 60 deg. or more. However, this shall not apply if not possibledue to the topographical conditions.</td><td colspan="2">New points that belong to the peripheral route of a traverse net shall be selected in an area with exterior angles of 50 deg. or less from a straight line that connects nearest known points that belong to the peripheral route. The included angles in a route shall be 60 deg. or more. However, this shall not apply if not possible due to the topographical conditions.</td></tr>
<tr><td>Average net order</td><td>------</td><td>------</td><td colspan="2">The average net order shall be two or less when performing simple horizontal net adjustment computation.</td></tr>
</table>

Remarks	1. A "route" refers to one that extends from a known point to another known point, from a known point to a node, or from a node to another node. 2. A "unit polygon" refers to a polygon formed with routes and without any route in it. 3. In 3rd or 4th order control point survey, horizontal direction angles shall be observed when conducting simple horizontal net adjustment computation using a conditional equation. 4. In 4th order control point survey, the number of sides in a route and the length of a route can normally be the specifications enclosed in brackets when using GEONET stations and 1st to 4th class triangulation stations that have been installed using only GEONET stations as known points, and using equipment specified in Article 35, Paragraph 2.

3 The work method in the single line traverse method shall normally be as shown in the following table:

<table>
<tr><th colspan="2">Classification / Item</th><th>1st order control point survey</th><th>2nd order control point survey</th><th>3rd order control point survey</th><th>4th order control point survey</th></tr>
<tr><td rowspan="6">Single line traverse method</td><td>Tie-in surveyof horizontal direction angle</td><td colspan="4">Horizontal direction angles shall be observed at one or more known points. However, the tie-in survey of horizontal direction angles shall be skipped if a GNSS survey device is to be used.</td></tr>
<tr><td>Number of sides of route</td><td>7 or less</td><td>8 or less</td><td>10 or less</td><td>15 or less
(20 or less)</td></tr>
<tr><td>Number of new points</td><td>2 or less</td><td>3 or less</td><td>------</td><td>------</td></tr>
<tr><td rowspan="2">Route length</td><td>5 km or less</td><td>3 km or less</td><td rowspan="2">1.5 km or less</td><td rowspan="2">700 m or less
(1km or less)</td></tr>
<tr><td colspan="2">This shall not apply if only GEONET stations are used as known points.</td></tr>
<tr><td>Route shape</td><td colspan="2">New points shall be selected in an area on both sides at 40 deg. or less from a straight line that connects two known points. The included angles in a route shall be 60 deg. or more. However, this shall not apply if not possible due to the topographical conditions.</td><td colspan="2">New points shall be selected in an area on both sides at 50 deg. or less from a straight line that connects two known points. The contained included angles in a route shall be 60 deg. or more. However, this shall not apply if not possible due to the topographical conditions.</td></tr>
<tr><td>Specifications for mutatis mutandis application</td><td colspan="4">The specifications for corresponding items in the connected traverse method shall be applied mutatis mutandis to the distance between nodes, limitation on eccentric distances, average net order, relaxation of limitation on numbers of sides of routes, and relaxation of limitation on route lengths when using a GNSS survey device.</td></tr>
<tr><td colspan="2">Remarks</td><td colspan="4">1. 1st and 2nd order control point surveys shall be performed using the single line traverse method only if it is unavoidable.
2. In 4th order control point survey, the number of sides in a route and the length of a route can normally be the specifications enclosed in brackets when using GEONET stations and 1st to 4th order triangulation stations that have been installed using only GEONET stations as known points and using equipment specified in Article 35, Paragraph 2.</td></tr>
</table>

(Work item and process flow)

Article 24 The work item and process flow shall be as follows:

i. Operation plan
ii. Point selection
iii. Installation of survey markers
iv. Observation
v. Computation
vi. Quality evaluation
vii. Deliverables, etc.

Section 2 Operation Plan

(Outline)

Article 25 The operation plan shall be made pursuant to the specifications in Article 11. In addition, a net adjustment plan map shall be made by determining the approximate locations of new points on a topographic map.

Section 3 Point Selection

(Outline)

Article 26 Throughout this chapter, "point selection" refers to surveying the current statuses of known points (except GEONET stations) on site based on a net adjustment plan map and selecting the locations of new points to make a point selection map and a net-adjustment diagram.

(Current status survey of known points)

Article 27 The current status survey of known points shall check for presence of abnormalities, etc. and create a report of current status survey of control points.

(Selection of new points)

Article 28 New points shall be selected at adequate locations in view of their use in subsequent operations, etc.

(Agreement about installation of monuments)

Article 29 The planning agency, before installing permanent monuments in other land than the one of which it has ownership or custody, shall obtain approval such as an agreement about installation of monuments from the owner or custodian of such land.

(Creation of point selection map and net-adjustment diagram)

Article 30 After the locations of new points are selected, the locations and visibility lines, etc. shall be entered in a topographic map to create a point selection map.

2 A net-adjustment diagram shall be created based on a point selection map and approved by the planning agency.

Section 4 Installation of Survey Markers

(Outline)

Article 31 Throughout this chapter, "installation of survey markers" refer to installing permanent monuments, etc. at the locations of newly installed points.

(Installation of permanent monuments)

Article 32 At the location of a newly installed point, a permanent monument shall be installed in principle and a notice of installation location of a survey marker (which refers to a document

for notification based on Article 21, Paragraph 1 of the Act to be read for Article 39 of the Act. The same shall apply hereafter.) shall be created.

2 The specifications and installation method of permanent monuments shall conform to Appendix 5.

3 Permanent monuments that have been installed shall be recorded in photographs, etc.

4 Permanent monuments can be equipped, if required, with an IC tag on which a unique number, etc. are recorded.

5 Marking stakes can be used as 3rd and 4th order control points.

(Creation of description of control points)

Article 33 Description of control points shall be created for permanent monuments that have been installed.

2 Permanent monuments that have been installed using only GEONET stations as known points shall be indicated as "Control points using only GEONET stations as known points" in the remarks column of the description of control points.

Section 5 Observation

(Outline)

Article 34 Throughout this chapter, "observation" refers to observing the horizontal angles, vertical angles, distances, etc. between relevant points (hereinafter referred to as "TS-type observation") using Total Stations (including data collectors; hereinafter referred to as "TS"), theodolites, distance measurement instruments, etc. (hereinafter referred to as "TS, etc.") and recording phase data, etc. in radio waves received from GNSS satellites (hereinafter referred to as "GNSS observation").

2 Observation can be performed using both a TS, etc. and GNSS survey devices.

3 During observation, survey marker leveling shall be performed if required.

(Devices)

Article 35 The devices to be used for observation shall normally be equivalent to or better than the devices listed in the following table:

Device	Performance	Applicable surveys
1st order Total Station	See Attached Table 1	1st to 4th order control point surveys
2nd order Total Station		2nd to 4th order control point surveys
3rd order Total Station		4th order control point survey
1st order GNSS survey device		1st to 4th order control point surveys
2nd order GNSS survey device		1st to 4th order control point surveys
1st order theodolite		1st to 4th order control point surveys
2nd order theodolite		2nd to 4th order control point surveys
3rd order theodolite		4th order control point survey
Distance measurement instrument		1st to 4th order control point surveys
3rd order level		Survey marker leveling
2nd order staff		Survey marker leveling
Steel tape	JIS 1st order	------

Regardless of the specifications in the previous paragraph, 4th order control point survey shall be performed using one of the following devices when applying a route having 15 sides or less and a route length of 700 meters or less described in Article 23, Paragraph 2 or a route having 20 sides or less and a route length of 1 kilometers or less described Paragraph 3 of the same article.

i. Total Station having a 2nd order performance or better

ii. GNSS survey device having a 2nd order performance or better

iii. Theodolite and distance measurement instrument having a 2nd order performance or better

(Inspection and adjustment of devices)

Article 36 Devices to be used for observation shall be inspected as appropriate before start of observation and during an observation period and adjusted if required.

(Implementation of observation)

Article 37 Before observation, an observation diagram shall be created based on a net-adjustment diagram approved by the planning agency.

2 Observation shall be performed based on a net-adjustment diagram and others according to the following specifications:

i. The method of TS-type observation shall be as shown in the following table. However, one pair of repetitious observation shall be performed in horizontal angle observation if the device does not support change displacement of graduated circle.

ClassificationClassification / Item		1st order control point survey1st order control point survey	2nd order control point survey		3rd order control point survey3rd order control point survey	4th order control point survey4th order control point survey
			1st order Total Station, 1st order theodolite	2nd order Total Station, 2nd order theodolite		
Horizontal angle observation	Reading unit	1"	1"	10"	10"	20"
	Number of pairs	2	2	3	2	2
	Horizontal graduated circle changeability	0°, 90°0°, 90°	0°, 90°0°, 90°	0°, 60°, 120°0°, 60°, 120°	0°, 90°0°, 90°	0°, 90°0°, 90°
Vertical angle observation	Reading unitReading unit	1"1"	1"1"	10"10"	10"10"	20"20"
	Number of pairsNumber of pairs	11	11	11	11	11
Distance measurement	Reading unit	1 mm	1 mm	1 mm	1 mm	1 mm
	Number of sets	2	2	2	2	2

a. The instrument height, reflecting mirror height, and target height shall be measured in units of millimeters.

b. When using a TS, horizontal angle observation, vertical angle observation, and distance measurement shall be performed simultaneously in collimation.

c. In horizontal angle observation, one pair of observation shall be to read once per collimation with the telescope in forward and backward directions.

d. In vertical angle observation, one pair of observation shall be to read once per collimation with the telescope in forward and backward directions.

e. In distance measurement, one set of observation shall be to read twice per collimation.

f. During distance measurement, the temperature and atmospheric pressure (referred to as "meteorological conditions" throughout this chapter) shall be measured as follows:

(1) Measure the meteorological conditions at a survey point where the TS or distance measurement instrument has been set up properly (hereinafter referred to as "observation point"). In 3rd and 4th order control point survey, however, the meteorological conditions can be corrected using the standard atmospheric pressure without measuring the atmospheric pressure.

(2) Measure the meteorological conditions just before the start or just after the end of distance measurement.

(3) If there is an elevation difference of 400 meters or more between an observation point and a survey point where a reflecting mirror has been set up properly (hereinafter referred to as "reflection point"), measure the meteorological conditions at the observation and reflection points. However, the meteorological conditions at a reflection point can be obtained by calculation.

g. In horizontal angle observation, number of observation directions shall be five or less in a pair of observation.

h. Observation values shall be recorded using a data collector. If a data collector is not used, however, observation values shall be noted in an observation sheet.

i. If a TS is used, all the vertical angle observation values and distance measurement values obtained according to the required number of pairs of horizontal angle observation can be adopted and the average values of them can be used.

ii. GNSS observation shall be performed as follows:

a. Observation at an observation distance of 10 kilometers or more shall be performed at two frequencies using a 1st order GNSS survey device. However, observation using a 2nd order GNSS survey device can be performed by installing nodes to make the observation distance less than 10 kilometers.

b. Observation at an observation distance of less than 10 kilometers shall be performed at one frequency using a GNSS survey device with a 2nd order performance or better. However, observation using a 1st order GNSS survey device can be performed at two frequencies.

c. The method of GNSS observation shall normally be as shown in the following table:

Observation method	Observation time	Data acquisition interval	Applicable surveys
Static method	120 min. or more	30 sec. or less	1st and 2nd order control point surveys (10 km or more)
	60 min. or more	30 sec. or less	1st and 2nd order control point surveys (less than 10 km) 3rd and 4th order control point surveys
Short-time static method	20 min. or more	15 sec. or less	3rd and 4th order control point surveys
Kinematic method	10 sec. or more *1	5 sec. or less	3rd and 4th order control point surveys

RTK method *3	10 sec. or more *2	1 sec.	3rd and 4th order control point surveys
Network-type RTK method*3	10 sec. or more *2	1 sec.	3rd and 4th order control point surveys
Remarks	*1 The time shall be sufficient to acquire data of 10 epochs or more. *2 The time shall be sufficient to acquire data of 10 epochs or more after obtaining a FIX solution. *3 A case in which analysis is performed in post-processing shall also be included.		

d. The numbers of satellites to be used by observation method shall normally be as shown in the following table:

Observation method / Combination of GNSS satellites	Static method	Short-time static method Kinematic method RTK method Network-type RTK method
GPS/quasi-zenith satellites	4 or more satellites	5 or more satellites
GPS/quasi-zenith and GLONASS satellites	5 or more satellites	6 or more satellites
Remarks	1. Observation using GLONASS satellites shall be performed using two or more GPS/quasi-zenith satellites and two or more GLONASS satellites, respectively. 2. Observation at 10 km or more using the static method shall be performed using five or more GPS/quasi-zenith satellites or six or more GPS/quasi-zenith and GLONASS satellites.	

e. The antenna height shall be measured in units of millimeters.

f. In elevation tie-in survey observation, a difference of ellipsoidal heights can be used as an elevation difference if the distance is 500 meters or less.

g. Observation shall not be performed when GNSS satellites are in an unbalanced arrangement in view of their health status, orbital schedule, etc.

h. The minimum altitude angle of a GNSS satellite shall normally be 15 degrees.

i. The static method and short-time static method shall be performed as follows:

(1) The static method of observation refers to receiving signals from GNSS satellites simultaneously at GNSS survey devices set up properly at multiple observation points and to obtaining base line vectors between the observation points by base line analysis.

(2) The short-time static method of observation refers to receiving signals from GNSS satellites simultaneously at GNSS survey devices set up properly at multiple observation points and shortening the observation time through such processing as making many combinations of satellites in base line analysis to obtain base line vectors between the observation points.

(3) When creating an observation diagram, a plan for observation using multiple GNSS

survey devices simultaneously (hereinafter referred to as "session") shall be entered.

(4) Except when only GEONET stations are used as known points, observation shall be performed by forming polygons with closed traverse routes that connect known and new points and performing one of the following:

(i) Perform observation by forming polygons to be used for inspection using a combination of different sessions.

(ii) Perform overlapping observation on one or more side for inspection using different sessions.

(5) When only GEONET stations are used as known points, observation shall be performed by forming routes that connect each of all the GEONET stations to be used with one or more other GEONET stations. Sessions not included in check routes on connections between GEONET stations shall be handled according to (4)-(i) or (ii).

(6) In the static and short-time static methods, the antenna height shall be measured up to the GNSS antenna base. Note that the antenna height shall normally be a vertical distance measured from the marker top to the GNSS antenna base.

j. The kinematic method of observation refers to receiving signals from GNSS satellites simultaneously at an observation point where a reference GNSS survey device has been set up properly (hereinafter referred to as "base station") and a mobile observation point (hereinafter referred to as "mobile station") and performing necessary observation required for initialization (determining the integer ambiguity). Then, observation shall be performed after moving the mobile station to multiple observation point in turn and, based on the result, base line vectors between base and mobile stations shall be obtained. Note that initialization and base line analysis shall be performed after the end of observation.

k. The RTK method refers to receiving signals from GNSS satellites simultaneously at base and mobile stations, transferring signals acquired at the base station to the mobile station via radio communication devices, etc., and immediately performing base line analysis at the mobile station to obtain base line vectors between the base and mobile stations. Then, observation shall be performed after moving the mobile station to multiple observation point in turn and immediately obtaining base line vectors between the base and mobile stations. Note that base line vectors shall be obtained using the direct or indirect observation method.

(1) The direct observation method refers to receiving signals from GNSS satellites simultaneously at base and mobile stations and making base line analysis to obtain base line vectors between the base and mobile stations. The observation distance in the direct observation method shall normally be 500 meters or less.

(2) The indirect observation method refers to receiving signals from GNSS satellites simultaneously at the base and two or more mobile stations, making base line analysis to obtain two base line vectors, and using the difference between the obtained base line vectors to obtain a base line vector between the mobile stations. The distance between the base and mobile stations in the indirect observation method shall be 10 kilometers or less whereas the distance between the mobile stations to be indirectly obtained shall normally be 500 meters or less.

l. The network-type RTK method refers to receiving correction data, etc. or area correction parameters calculated by a distributor (a person who is entitled to receive the observation data of the GEONET station network of the Geospatial Information Authority or a person who

distributes data in a format that allows it to be used in survey based on three or more GEONET stations; The same shall apply hereafter.) at mobile stations via communication lines of mobile phones, etc. and, simultaneously, receiving signals from GNSS satellites at the mobile stations and immediately performing analysis processing at the mobile stations to obtain position coordinates. Then, observation shall be performed after moving the mobile stations to multiple observation point in turn and immediately obtaining the position coordinates of the mobile stations.

Analysis processing can be performed as post-processing if correction data, etc. or area correction parameters are acquired from a distributor after the end of observation. Note that base line vectors shall be obtained using the direct or indirect observation method.

(1) The direct observation method refers to obtaining base line vectors through base line analysis using correction data, etc. at arbitrary locations near a mobile station calculated by a distributor and observation data of mobile stations.

(2) The indirect observation method refers to obtaining base line vectors using one of the following methods:

(i) The indirect observation method based on the two-station simultaneous observation method refers to obtaining a base line vector between two mobile stations based on a difference between three-dimensional orthogonal coordinates obtained in simultaneous observation performed at the two mobile stations.

(ii) The indirect observation method based on the one-station quasi-simultaneous observation method refers to obtaining a base line vector between two mobile station position coordinates based on a difference between two sets of three-dimensional orthogonal coordinates, the one obtained at a mobile station and the other obtained at the same mobile station that has been moved promptly to another observation point. The observation shall be promptly performed as go and back observation (Observation in the same direction is also allowed) in order to check the base line vector using overlap.

iii. Differential leveling shall be performed using one of the following methods:

a. Direct leveling shall be performed pursuant to the specifications for 4th order leveling.

b. Indirect leveling shall be performed as follows:

(1) The instrument height, reflecting mirror height, and target height shall be measured in units of millimeters.

(2) Vertical angle observation and distance measurement shall be performed on two fixed points that are set up on one end of an indirect leveling section.

(3) The tolerance of closure errors in indirect leveling shall be three centimeters multiplied by the observation distance (in units of kilometers). However, the tolerance shall be three centimeters if the observation distance is less than one kilometer.

(4) Vertical angle observation and distance measurement shall be performed as 1st order control point survey if the distance is 500 meters or more and as 2nd order control point survey if the distance is less than 500 meters. In vertical angle observation, three pairs of observation shall be performed and, wherever possible, simultaneous observation in forward and backward directions shall be performed.

(5) The distance of an indirect leveling section shall be two kilometers or less.

(Check and remeasurement of observation values)

Article 38 Observation values shall be checked and, if they exceed the tolerances, remeasured.

i. The tolerances in TS-type observation shall normally be as shown in the following table:

Classification / Item		1st order control point survey	2nd order control point survey		3rd order control point survey	4th order control point survey
			1st order Total Station, 1st order theodolite	2nd order Total Station, 2nd order theodolite		
Horizontal angle observation	Double angle difference	15"	20"	30"	30"	60"
	Observation difference	8"	10"	20"	20"	40"
Vertical angle	Variance of altitude constants	10"	15"	30"	30"	60"
Distance measurement	Variance of measurement values in one set	20 mm	20 mm	20 mm	20 mm	20 mm
	Variance of average values in each set	20 mm	20 mm	20 mm	20 mm	20 mm
Survey marke leveling	Variance of go and back observation values	20 mm √S	20 mm √S	20 mm √S	20 mm √S	20 mm √S
Remarks		S is the observation distance (one way, in kilometers).				

ii. The result of base line analysis by GNSS observation shall be a FIX solution.

(Measurement of eccentricity element)

Article 39 If a control point cannot be observed directly, an eccentric point shall be set and an eccentricity element shall be measured and, when exceeding the tolerance, remeasured.

i. In GNSS observation, azimuth points can be set up if line of sight in the zero direction for eccentricity element cannot be satisfied.

ii. In GNSS observation, the installation distance of azimuth points shall normally be 200 meters or more, four times as long as the eccentric distance or more. Note that observation shall be performed pursuant to the specifications in Article 37, Paragraph 2, Item ii.

iii. An eccentric angle shall normally be measured as shown in the following table:

Eccentric distance	Device and measurement method	Measurement unit	Check items and tolerances
Less than 30 cm	Draw a line of direction on an eccentricity measurement sheet and measure the angle using a protractor.	1°	------
30 cm or more Less than 2 m	Draw a line of direction on an eccentricity measurement sheet and obtain the angle through calculation.	10'	------
2 m or more Less than 10 m	Use a Total Station or theodolite and apply Article 37 mutatis mutandis.	1'	Double angle difference 120" Observation difference 90"
10 m or more Less than 50 m		10"	Double angle difference 60" Observation difference 40"
50 m or more Less than 100 m			Double angle difference 30" Observation difference 20"
100 m or more Less than 250 m		1"	Double angle difference 20" Observation difference 10"

iv. An eccentric distance shall normally be measured as shown in the following table:

Eccentric distance	Device and measurement method	Measurement unit	Check items and tolerances
Less than 30 cm	Perform measurement using a ruler.	mm	------
30 cm or more Less than 2 m	Perform go and back measurement by reading twice using a steel tape.	mm	Variance between go and back measurements: 5 mm
2 m or more Less than 50 m	Use a Total Station or distance measurement instrument and apply Article 37 mutatis mutandis.	mm	Apply Article 38 mutatis mutandis.
50 m or more			
Remarks	1. Eccentricity correction calculation can be skipped when the eccentric distance is less than 5 mm and the side length is more than 1 km. 2. Correction other than inclination correction can be skipped when the eccentric distance is less than 10 m.		

v. An elevation difference between an original point and an eccentric point shall normally be measured as shown in the following table:

Eccentric distance	Device and measurement method	Measurement unit	Check items and tolerances
Less than 30 cm	Set up an eccentric point at the same elevation as its original point using an independent level.	----	------
30 cm or more Less than 100 m	Perform observation pursuant to the specifications for 4th order leveling. However, the number of survey points in one-way observation can be one using the same staff for back sight and foresight.	mm	Variance between go and back measurements 20 mm √S
	Perform observation pursuant to the specifications for vertical angle observation in 4th order control point survey. However, vertical angle observation in the forward and backward directions can be substituted with two pairs of vertical angle observation in one direction with two different instrument heights.	20"	Variance of altitude constants: 60" Variance of elevation differences between go and back measurements: 100 mm
100 m or more Less than 250 m	Perform measurement pursuant to the specifications for 4th order leveling.	mm	Variance between go and back measurements: 20 mm √S
	Perform measurement pursuant to the specifications for vertical angle observation in 2nd and 3rd order control point survey.	10"	Variance of altitude constants: 30" Variance of elevation differences between go and back measurements: 150 mm
Remarks	S is the measurement distance (in kilometers).		

Section 6 Calculation

(Outline)

Article 40 Throughout this chapter, "calculation" refers to obtaining the horizontal position coordinates and elevation of a new point as specified in the following items:

i. A distance on a datum plane using a TS, etc. shall be calculated using an ellipsoidal height. Note that an ellipsoidal height shall be obtained from an elevation and a geoidal height.

ii. A geoidal height shall be a value obtained using one of the following methods:

a. From a geoid model provided by the Geospatial Information Authority.

b. From a local geoid model obtained in GNSS observation, leveling, etc.in a region where no geoid model described in Paragraph a. has been created yet.

iii. In 3rd and 4th order control point surveys, a distance on a datum plane can be calculated using an elevation in place of an ellipsoidal height. In this case, latitude and longitude calculation can be skipped.

(Calculation method, etc.)

Article 41 Calculation can be performed using either the calculation formula provided in Appendix 6 or other calculation formula that is confirmed to have an accuracy equivalent to or better than that of the former.

2 Calculation results shall be displayed in the units shown in the following table:

Classification / Item	Rectangular coordinates *	Latitude and longitude	Elevation	Geoidal height	Angle	Side length
Unit	m	seconds	m	m	seconds	m
Decimal place	0.001	0.0001	0.001	0.001	1	0.001
Remarks	*Rectangular coordinates that comply with the world geodetic system specified in the plane rectangular coordinate system					

3 An elevation observed with a TS, etc. can be calculated to 0.01-meter decimal place.

4 Base line analysis in GNSS observation shall be normally performed as specified in the following items:

i. Calculation results shall be displayed in the units shown in the following table:

Classification / Item	Base line vector component
Unit	m
Decimal place	0.001

ii. The orbit information of GNSS satellites shall normally be in the broadcast ephemeris.

iii. In base line analysis in the static method and short-time static method, PCV correction shall be performed in principle.

iv. Meteorological elements shall be corrected using the standard atmosphere adopted by the base line analysis software.

v. Base line analysis shall be performed at two frequencies if the base line length is 10 kilometers or more and at one or two frequencies if the base line length is less than 10 kilometers.

vi. The latitude and longitude of a fixed point in base line analysis shall be a value in the table of results (hereinafter referred to as "original epoch coordinates") or a value that has undergone semi-dynamic correction using crustal movement correction parameters provided by the Geospatial Information Authority (hereinafter referred to as "observation epoch coordinates"). Note that crustal movement correction parameters to be used in semi-dynamic correction shall be the ones that corresponds to the survey implementation timing. In base line analysis hereafter,

latitudes and longitudes obtained using the latitude and longitude of a fixed point shall be entered one by one.

vii. The ellipsoidal height of a fixed point in base line analysis shall be a value obtained from the elevation and geoidal height in the table of results and shall be either original or observation epoch coordinates. If the fixed point is a GEONET station, however, it shall be either an ellipsoidal height (original epoch coordinates) in the table of results or the observation epoch coordinates. In base line analysis hereafter, ellipsoidal heights obtained using the ellipsoidal height of a fixed point shall be entered one by one.

viii. The elevation angle of a GNSS survey device to be used for base line analysis shall be a reception elevation angle specified at the time of observation.

(Check calculation and remeasurement)

Article 42 Check calculation shall be performed after the end of observation as specified in the following items. If the result of check calculation exceeds the tolerance, either necessary remeasurement shall be performed or an appropriate measure shall be taken.

i. TS-type observation

a. Regarding all the unit polygons and all the check routes selected according to the following conditions, closure errors for horizontal position coordinates and elevations shall be calculated to check the conformity of observation values.

(1) A check route shall connect a known point with another known point.

(2) A check route shall be the shortest possible route.

(3) All the known points shall be connected with each other by one or more check routes.

(4) For all the unit polygons, one or more routes shall overlap with check routes.

b. The tolerances in check calculation using TS, etc. shall normally be as shown in the following table:

Item \ Classification		1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Connected traverse/single line traverse	Closure error of horizontal coordinates	100 mm + 20 mm √NΣS	100 mm + 30 mm √NΣS	150 mm + 50 mm √NΣS	150 mm + 100 mm √NΣS
	Closure error of elevation	200 mm + 50 mm ΣS/√N	200 mm + 100 mm ΣS/√N	200 mm + 150 mm ΣS/√N	200 mm + 300 mm ΣS/√N
Unit polygon	Closure error of horizontal coordinates	10 mm √NΣS	15 mm √NΣS	25 mm √NΣS	50 mm √NΣS
	Closure error of elevation	50 mm ΣS/√N	100 mm ΣS/√N	150 mm ΣS/√N	300 mm ΣS/√N
Variance of elevation differences between go and back measurements		300 mm	200 mm	150 mm	100 mm

Remarks	N is a number of sides and ΣS is a route length (in kilometers)

ii. GNSS observation

a. Observation except when only GEONET stations are used as known points

(1) Observation values shall be checked for all the sessions using one of the following methods:

(i) Select a polygon with a minimum number of sides in a combination of different sessions and calculate the circuit closure errors of a base line vector.

(ii) Compare the variance of overlapping base line vectors in different sessions.

(2) The tolerances of check calculation shall normally be as shown in the following table:

Tolerances of circuit closure errors and variances of overlapping base line vectors

Classification		Tolerance	Remarks
Circuit closure errors of base line vectors	Horizontal (ΔN, ΔE)	20 mm √N	N: Number of sides ΔN: Closure error or variance of north-south component on horizontal plane ΔE: Closure error or variance of east-west component on horizontal plane ΔU: Closure error or variance of height component
	Height (ΔU)	30 mm √N	
Variance of overlapping base line vectors	Horizontal (ΔN, ΔE)	20 mm	
	Height (ΔU)	30 mm	

b. Observation when only GEONET stations are used as known points

(1) The latitude and longitude and ellipsoidal height of a known point to be used for check calculation shall be observation epoch coordinates.

(2) Observation values shall be checked using one of the following methods:

(i) Connections between GEONET stations shall be calculated for a route with a minimum number of sides. If two or more routes have the same minimum number of sides, calculation shall be performed for the route with the shortest route length.

(ii) All the GEONET stations shall be connected with each other by one or more check routes.

(iii) Sessions not included in calculation of connections shall be handled according to Item a. - (1) - (i) or (ii).

(3) The tolerances of check calculation shall normally be as shown in the following table:

(i) Tolerances of closure errors between GEONET stations

Classification		Tolerance	Remarks
Connected traverse or single line traverse	Horizontal (ΔN, ΔE)	60 mm + 20 mm √N	N: Number of sides ΔN: Closure error of north-south component on horizontal plane ΔE: Closure error of east-west component on horizontal plane ΔU: Closure error of height component
	Height (ΔU)	150 mm + +30 mm √N	

(ii) The to(ii) Tolerances of circuit closure errors and variances of overlapping base line vectors shall conform, mutatis mutandis, to the specifications in Item a. - (2).

2 The results of calculation check shall be summarized in quality control sheet for control points.

(Adjustment computation)

Article 43 Adjustment computation shall be performed as follows:

2 The three-dimensional net adjustment computation that fixes one known point using a GNSS survey device shall be performed by forming closed polygons as specified in the following items. However, this shall not include a case in which only GEONET stations are used as known points.

i. In three-dimensional net adjustment computation, the latitude and longitude of a known point to be used shall be original epoch coordinates and the ellipsoidal height shall be a value obtained from the elevation and geoidal height in the table of results. However, the ellipsoidal height of a GEONET station shall be an ellipsoidal height in the table of results.

ii. In three-dimensional net adjustment computation, the weight (P) shall be the inverse matrix of one of the following variance-covariance matrixes.

a. Values of variance-covariance matrixes obtained in base line analysis
However, this shall be limited to a case in which the analysis method and analysis time are the same for all the base lines.

b. Fixed values for horizontal and height variance
However, the fixed values of variance shall be $d_N = (0.004\ m)^2$ $d_E = (0.004\ m)^2$ $d_U = (0.007\ m)^2$.

iii. In three-dimensional net adjustment computation, the tolerances shall be either of the following:

a. The tolerances of each component of a base line vector shall normally be as shown in the following table:

Classification / Item	1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Residual error of component of base line vector	20 mm	20 mm	20 mm	20 mm
Closure error of horizontal coordinates	$\Delta s = 100\ mm + 40\ mm\ \sqrt{N}$ Δs: Distance obtained from the result value of a known point and the result of three-dimensional net adjustment computation N : The minimum number of sides to a known point (one with the shortest route length if the number of sides are the same)			
Closure error of elevation	Shall normally be 250 mm to +45 mm $\sqrt{N}$ where N: Number of sides			

b. The tolerances based on the azimuth, slope distance, and ellipsoid relative height shall normally be as specified in the following table:

Classification / Item	1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Residual error of azimuth	5 sec.	10 sec.	20 sec.	80 sec.

Residual error of slope distance	20 mm + 4 x 10^{-6}D where D: Measurement distance
Residual error of ellipsoidal height	30 mm + 4 x 10^{-6}D where D: Measurement distance
Closure error of horizontal coordinates	$\Delta s = 100 \text{ mm} + 40 \text{ mm} \sqrt{N}$ Δs: Distance obtained from the result value of a known point and the result of three-dimensional net adjustment computation N: The minimum number of sides to a known point (one with the shortest route length if the number of sides are the same)
Closure error of elevation	Shall normally be 250 mm to + 45 mm $\sqrt{N}$ where N: Number of sides

3 The rigorous horizontal and vertical net adjustment computations, simple horizontal and vertical net adjustment computations, and three-dimensional net adjustment computation that fix two or more known points shall be performed based on a net-adjustment diagram. The adjustment computation shall be performed as specified in the following items:

i. TS-type observation

a. In rigorous horizontal net adjustment computation, the weight (P) shall be one of the values shown in the following table:

Weight / Classification	m_S	γ	m_t
1st order control point survey	10 mm	5×10^{-6}	1.8"
2nd order control point survey			3.5"
3rd order control point survey			4.5"
4th order control point survey			13.5"

b. In simple horizontal and vertical net adjustment computations, a direction angle shall be calculated using the inverse of a number of observation points in each route as the weight (P); A horizontal location and an elevation shall be calculated using the inverse of a sum of distances of routes (which shall be to 0.01 kilometer decimal place) as the weight (P).

c. In rigorous horizontal and vertical net adjustment computations, the tolerances of items shall normally be as shown in the following table:

Classification / Item	1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Residual error of one direction	12"	15"	------	------
Residual error of distance	80 mm	100 mm	------	------

Standard deviation of horizontal angle per unit weight	10"	12"	15"	20"
Standard deviation of new point coordinates	100 mm	100 mm	100 mm	100 mm
Residual error of vertical angle	15"	20"	------	------
Standard deviation of vertical angle per unit weight	12"	15"	20"	30"
Standard deviation of elevation of new point	200 mm	200 mm	200 mm	200 mm

d. In simple horizontal and vertical net adjustment computations, the tolerances of items shall normally be as shown in the following table:

Classification / Item	3rd order control point survey	4th order control point survey
Residual error of direction angle of route	50"	120"
Residual error of coordinate difference of route	300 mm	300 mm
Residual error of elevation difference of route	300 mm	300 mm

ii. GNSS observation

a. Observation except when only GEONET stations are used as known points

(1) In three-dimensional net adjustment computation, the latitude and longitude of a known point to be used shall be original epoch coordinates and the ellipsoidal height shall be a value obtained from the elevation and geoidal height in the table of results. However, the ellipsoidal height of a GEONET station shall be an ellipsoidal height in the table of results.

(2) The elevation of a new point shall be a value obtained using one of the following methods:

(i) Correct the ellipsoidal height using a geoidal height obtained from a geoid model provided by the Geospatial Information Authority**.**

(ii) In a region where no geoid model described in Item (i) has been created yet, correct the ellipsoidal height using a geoidal height obtained from a local geoid model obtained in GNSS observation and leveling, etc.

(3) In three-dimensional net adjustment computation, the weight (P) shall conform, mutatis mutandis, to the specifications in Item ii of the previous paragraph.

(4) In three-dimensional net adjustment computation, the tolerances of items shall normally be as shown in the following table:

Classification / Item	1st order control point survey	2nd order control point survey	3rd order control point survey	4th order control point survey
Residual error of slope distance	80 mm	100 mm	------	------
Standard deviation of horizontal location of new point	100 mm	100 mm	100 mm	100 mm
Standard deviation of elevation of new point	200 mm	200 mm	200 mm	200 mm

b. Observation when only GEONET stations are used as known points

(1) In three-dimensional net adjustment computation, the latitude and longitude and ellipsoidal height of a known point to be used shall be current-term coordinates.

(2) The latitude and longitude and ellipsoidal height of a new point shall be the latitude and longitude and ellipsoidal height obtained in three-dimensional net adjustment computation that has undergone semi-dynamic correction and shall be original epoch coordinates.

(3) The elevation of a new point shall be determined pursuant to the specifications in Item a. - (2).

(4) In three-dimensional net adjustment computation, the weight (P) shall conform, mutatis mutandis, to the specifications in Item ii of the previous paragraph.

(5) In three-dimensional net adjustment computation, the tolerances of items shall conform, mutatis mutandis, to the specifications in Item a. - (4).

4 For an observation point with a coordinate difference between an estimated value used in adjustment computation and an adjustment computation result value exceeds one meter, repetitious computation shall be performed by repeating adjustment computation using the adjustment computation result value as an estimated value.

5 A program to be used for adjustment computation shall be the one for which the calculation results have been confirmed to be correct.

6 The results of adjustment computation shall be summarized in quality control sheet for control Points.

Section 7 Quality Evaluation

(Quality evaluation)

Article 44 "Quality evaluation" refers to evaluating control point survey results to ensure that they meet the data quality requirements specified in the product specification.

2 The executing organization shall perform quality evaluation based on the quality evaluation procedure.

3 Necessary adjustments shall be made when items that do not meet the quality requirements are found as a result of the evaluation.

Section 8 Deliverables, etc.

(Creation of metadata)

Article 45 The metadata of control point results shall be created to include necessary items for management and utilization of files according to the product specification.

(Deliverables, etc.)

Article 46 The deliverables, etc. shall include the following items. However, this shall not apply depending on the operation method.

i. Observation sheet
ii. Observation record
iii. Computation Sheet
iv. Net-adjustment diagram
v. Control point survey result table
vi. Description of control points
vii. Agreement about installation of monuments
viii. Notice of installation location of survey marker
ix. Distribution map of control points
x. Quality control sheet for control point
xi. Quality evaluation sheet
xii. Ground photographs of survey markers
xiii. Report on current status survey of control points
xiv. Result digital data
xv. Verification survey sheet
xvi. Metadata
xvii. Other materials

(2) Leveling

Chapter 3 Leveling

Section 1 Outline

(Outline)

Article 47 "Leveling" refers to determining the elevations of bench marks that are new points based on known points.

2 Leveling shall be classified into 1st, 2nd, 3rd, and 4th order and minor leveling, depending on the type of known points, route lengths between known points, accuracies of observation, etc.

3 Bench marks to be installed in 1st, 2nd, 3rd, and 4th order and minor leveling shall be called 1st, 2nd, 3rd, and 4th order and minor bench marks, respectively.

(Types of known points, etc.)

Article 48 The types and route lengths of known points shall normally be as shown in the following table:

Item \ Classification	1st order leveling	2nd order leveling	3rd order leveling	4th order leveling	Minor leveling
Types of known points	1st class bench mark 1st order bench mark	1st and 2nd class bench marks 1st and 2nd order bench marks	1st to 3rd class bench marks 1st to 3rd order bench marks	1st to 3rd class bench marks 1st to 4th bench marks	1st to 3rd class bench marks 1st to 4th order class bench marks
Route length between known points	150 km or less	150 km or less	50 km or less	50 km or less	50 km or less

(Leveling route)

Article 49 A "leveling route" refers to a route that connects two or more known points. A leveling route that cannot be connected directly in leveling shall be connected in cross sea (river) leveling.

(Methods of leveling)

Article 50 The methods of leveling shall normally be as follows:

i. Direct leveling method

ii. Cross sea (river) leveling method

Leveling shall be performed depending on the observation distance as shown in the following table:

Survey method	Observation distance
Alternate method	Approx. 300 m or less for 1st order leveling. Approx. 450 m or less for 2nd to 4th order leveling.
Theodolite method	Approx. 1 km or less for 1st to 4th order leveling.
Tilting screw method	Approx. 2 km or less for 1st to 4th order leveling.

(Work item and process flow)

Article 51 The work item and process flow shall be as follows:

i. Operation plan
ii. Point selection
iii. Installation of survey markers iv. Observation
v. Computation
vi. Quality evaluation
vii. Deliverables, etc.

Section 2 Operation Plan

(Outline)

Article 52 The operation plan shall be made pursuant to the specifications in **Article 11**. In addition, a height adjustment plan map shall be made by determining the approximate locations of new points on a topographic map.

Section 3 Point Selection

(Outline)

Article 53 Throughout this chapter, "point selection" refers to surveying the current statuses of known points and leveling routes in the field based on an adjustment plan map and selecting the locations of new points to make a point selection map and a leveling net-adjustment diagram.

(Current status survey of known points)

Article 54 The current status survey of known points shall check for presence of abnormalities, etc. and create a report of current status survey of control points.

(Selection of new points)

Article 55 New points shall be selected at adequate locations in view of their use in subsequent operations, etc.

(Agreement about installation of monuments)

Article 56 The planning agency, before installing permanent monuments in other land than the one of which it has ownership or custody, shall obtain approval such as an agreement about installation of monuments from the owner or custodian of such land.

(Creation of point selection map, leveling net-adjustment diagram, etc.)

Article 57 After the locations of new points are selected, the locations and routes, etc. shall be entered in a topographic map to create a point selection map.

2 A leveling net-adjustment diagram and a leveling routes shall be created based on a point selection map. However, a leveling net-adjustment diagram shall be approved by the planning agency.

Section 4 Installation of Survey Markers

(Outline)

Article 58 Throughout this chapter, "installation of survey markers" refer to installing permanent monuments, etc. at the locations of newly installed points.

(Installation of permanent monuments)

Article 59 At the location of a newly installed point, a permanent monument shall be installed in principle and a notice of installation location of a survey marker shall be created.

2 The specifications and installation method of permanent monuments shall conform to Appendix 5.

3 Permanent monuments that have been installed shall be recorded in photographs, etc.

4 Permanent monuments can be equipped, if required, with an IC tag on which a unique number, etc. are recorded.

5 Marking stakes can be used as 4th order and minor bench marks.

6 For bench marks with permanent monuments installed, coordinates shall be obtained using the observation method specified in Article 37 or the single point observation method and

noted in a result digital data file. If the coordinates of known point are obtained, the handling of them can be checked with the custodian of the said point.

i. The "single point observation method" refers to obtaining the coordinates of a survey point independently using the network-type RTK method specified in Article 37.

ii. The observation using the single point observation method to obtain the coordinates of a bench mark and tolerances of variance shall be as follows:

a. Two sets of observation shall be performed. The observation values in the first set shall be the adopted values. After the end of observation, the re-initialization for check and then the second set of observation shall be performed. However, the results of the second set of observation shall be check values.

b. The number of sets of observation and tolerances of variances shall normally be as shown in the following table:

Number of satellites to be used	Number of sets of observation	Data acquisition interval	Tolerance		Remarks
5 or more satellites	Two sets including 10 or more epochs after obtaining FIX solution	1 sec.	ΔN ΔE	100 mm	ΔN: Variance between sets for north-south component on horizontal plane ΔE: Variance between sets for east-west component on horizontal plane However, comparison using plane rectangular coordinates is possible.

iii. The results to 0.1-meter decimal place can be entered in the result digital data file.

iv. If a bench mark cannot be observed directly, an eccentric point shall be set and an eccentricity element shall be measured using TS, etc.

(Creation of description of benchmarks)

Article 60 Description of benchmarks shall be created for permanent monuments that have been installed.

Section 5 Observation

(Outline)

Article 61 Throughout this chapter, "observation" refers to observing the elevation differences between relevant points using levels, staffs, etc.

(Devices)

Article 62 The devices to be used for observation shall normally be equivalent to or better than the devices listed in the following table:

Device	Performance	Remarks
1st order level	See Attached Table 1	1st to 4th order leveling
2nd order level		2nd to 4th order leveling

3rd order level		3rd to 4th order leveling Minor leveling
1st order staff		1st to 4th order leveling
2nd order staff		3rd and 4th order leveling
1st order theodolite		1st to 4th order leveling (cross sea)
1st order Total Station		1st to 4th order leveling (cross sea)
Distance measurement instrument		1st to 4th order leveling (cross sea)
Calculator for leveling operation	------	------
Telescopic staff		Minor leveling

i. 1st order leveling shall be performed using 1st order staffs with a staff correction value of 50μm/m or less at an air temperature of 20 degrees and a variance of 30μm/m or less between staff correction values of No. I and No. II staffs.

ii. The level to be used in cross sea (river) leveling shall be either a tubular level or an automatic level. However, an automatic level shall be used only in the Alternate method.

2 A calculator to be used for leveling operation shall be the one for which the calculation results have been confirmed to be correct.

(Inspection and adjustment of devices)

Article 63 Devices to be used for observation shall be inspected and adjusted as appropriate. The reading units and tolerances in inspection and adjustment of errors in lines of sight through observation shall normally be as shown in the following table:

Item \ Classification	1st order level	2nd order level	3rd order level
Reading unit	0.01 mm	0.1 mm	1 mm
Tolerance	0.3 mm	0.3 mm	3 mm

2 Inspection and adjustment shall be performed on the following items before starting observation. The result of inspection and adjustment shall be recorded on the calculator for leveling operation or leveling observation sheet. In 1st and 2nd order leveling, inspection and adjustment shall be performed approximately every 10 days during an observation period.

i. Tubular levels shall be inspected and adjusted for circular level and parallelism with the master axis and lines of sight.

ii. Automatic and electronic levels shall be inspected and adjusted for circular levels and lines of sight and inspected with compensators.

iii. Levels attached to staffs shall be inspected.

(Implementation of observation)

Article 64 Observation shall be performed based on a leveling routes according to the following specifications:

2 Direct leveling

i. Observation shall be performed by reading the staff scale and the distance between the level and back sight or foresight staff (hereinafter referred to as "length of sight").

a. The reading units of a length of sight and a staff scale shall be as shown in the following table. A length of sight shall be read in units of meters.

Classification / Item	1st order leveling	2nd order leveling	3rd order leveling	4th order leveling	Minor leveling
Length of sight	Max. 50 m	Max. 60 m	Max. 70 m	Max. 70 m	Max. 80 m
Reading unit	0.1 mm	1 mm	1 mm	1 mm	1 mm

b. Observation shall be performed by reading once per collimation and the method of reading the staff shall normally be as shown in the following table:

Classification / Order of observation	1st order leveling		2nd order leveling		3rd and 4th order leveling Minor leveling
	Tubular level Automatic level	Electronic level	Tubular level Automatic level	Electronic level	Tubular level Automatic level Electronic level
1	Back sight small scale	Back sight	Back sight small scale	Back sight	Back sight
2	Foresight small scale	Foresight	Back sight large scale	Back sight	Foresight
3	Foresight large scale	Foresight	Foresight small scale	Foresight	----
4	Back sight large scale	Back sight	Foresight large scale	Foresight	----

ii. Observation shall be performed as go and back observation except for minor leveling.

iii. Two staffs shall be paired and the first and second staffs shall be exchanged between the go and back observation. An even number of survey points shall be measured.

iv. In 1st order leveling, the air temperature shall be measured in units of degrees at the start and end of observation and every time a fixed point is reached.

v. The lengths of sight shall be equal and the level shall be set up on a straight line that connects the two staffs wherever possible.

vi. If leveling performed as go and back observation is to measure many survey points between bench marks, fixed points shall be set up as appropriate to be used commonly in go and back observation.

vii. In 1st order leveling, the lower part of a staff, below a height of 20 centimeters from the bottom, shall not be read.

viii. Observation of one day shall end at a bench mark in principle. If it is unavoidable to end observation at a fixed point, it shall be ended in a way to allow for check for presence of abnormalities of the fixed point at the restart of observation.

3 Cross sea (river) leveling

i. Observation shall be performed using either the Alternate method, theodolite method, or tilting screw method.

ii. The number of sets of observation, reading unit, etc. shall normally be as shown in the

following table:

Item \ Survey method		Alternate method	Theodolite method	Tilting screw method
Observation distance (S)		Max. 300 m (450 m)	Max. 1 km	Max. 2 km
Performance of devices to be used		1st order level 1st order staff	1st order Total Station 1st order theodolite 1st order level, 1st order staff (2nd order level)	1st order level with tilting screw 1st order staff
Quantity of devices to be used		1 set	2 sets	
Observation condition		------	Simultaneous observation on both banks	
Thickness of white lines on target board		40 mm x S	------	40 mm x S
Observation time period		Sometime from three hours before to four after meridian passage at the observation point		
Number of sets (n)		60 x S	80 x S	
Number of days for observation		n/25	n/40	
Reading unit of target (staff)	Near bank	0.1 mm (1 mm)	1 sec.	0.1 mm (1 mm)
	Far bank	1 mm	1 sec. Distance of 1 mm	1/10 of tilting screw scale
Calculation unit	Instrument height on near bank	------	0.1 mm (1 mm)	------
	Target height on far bank	------	0.1 mm (1 mm)	0.1 mm (1 mm)
Tolerance of variance of altitude constants		------	5 sec. (7 sec.)	------
Measurement of distance		------	Apply Articles 37 and 38 mutatis mutandis.	------
Observation method		One set of observation shall be to read once per collimation each, once for staff on near bank, 5 times for staff on far bank, and once for staff on near bank in this order. When half of all the observation sets per day have been completed, take the	Perform observation of the far bank as vertical angle observation. Perform two pairs of observation, each pair consisting of reading once per collimation at the right and left positions of a telescope. This shall be 1 set of observation. Before and after observation on the far bank, (1 set), perform observation on the near bank as vertical angle observation by casting a collimation to	After reading the staff scale on the near bank once per collimation, read the tilting screw scale at three locations (lower line of the target board on the far bank, horizontal position of the level, and upper line of the target board on the far bank) and then observe again the upper line of the target board on the far bank, horizontal position

	level and staffs to the other bank and perform observation in the same way.	any two scale positions of a staff erected at a cross sea bench mark. One set of observation shall be to perform the above procedure simultaneously on both banks. The number of sets per day shall normally be 20 to 60 sets. Approximately halfway through all the number of sets, interchange the devices and staffs on both the banks and perform observation in the same way.	of the level, and lower line of the target board on the far bank. One set of observation shall be to perform the above procedure simultaneously on both banks. The number of sets per day shall normally be 20 to 60 sets. Approximately halfway through all the sets, interchange the devices and staffs on both the banks and perform observation in the same way.
Remarks	1. S is the observation distance (in kilometers). The number in the column "number of days of observation" is the standard number of sets per day. 2. When calculating the number of sets and the number of days of observation, the observation distance (in kilometers) shall be obtained to one decimal place and the multiplication result shall be rounded up to an integer. 3. Perform an even number of sets of observation. The number of days of observation that is less than one day shall be rounded up to one day. 4. Apply the numbers enclosed in brackets in this table to the 2nd to 4th order leveling.		

4 Newly installed points shall be observed when 24 or more hours elapse after installation of permanent monuments.

(Remeasurement)

Article 65 In observation in 1st, 2nd, 3rd, and 4th leveling, remeasurement shall be performed if the variances of go and back observation values in the sections divided by bench marks and fixed points exceed the tolerances.

i. The tolerances of variance of go and back observation values shall normally be as shown in the following table:

Classification / Item	1st order leveling	2nd order leveling	3rd order leveling	4th order leveling
Variance of go and back observation values	2.5 mm √S	5 mm √S	10 mm √S	20 mm √S
Remarks	S is the observation distance (one way, in kilometers).			

ii. In remeasurement in 1st and 2nd order leveling, no observation values in the same direction shall be adopted.

(Inspection measurement)

Article 66 In 1st and 2nd order leveling, inspection measurement shall be performed between nearest known points. Note that the tolerances of variances between the result in inspection measurement and the previously observed elevation differences or elevation differences in the survey result shall normally be as shown in the following table. In addition, inspection

measurement shall be performed as one-way observation in principle.

Classification / Item	1st order leveling	2nd order leveling
Variance with previously observed elevation difference	2.5 mm √S	5 mm √S
Variance with elevation difference in measurement result	15 mm √S	
Remarks	S is the observation distance (one way, in kilometers).	

Section 6 Calculation

(Outline)

Article 67 Throughout this chapter, "calculation" refers to obtaining the elevation of a new point according to the following specifications:

i. Staff correction calculation and normal orthometric height correction calculation (orthometric correction) shall be performed in 1st and 2nd leveling. In 1st order leveling, however, normal orthometric height correction calculation can be substituted with orthometric height correction calculation (correction using an actually measured gravity). Note that staff correction calculation in 2nd order leveling shall be performed if the elevation difference between bench marks is 70 meters or more and the staff correction amount shall be calculated using a staff correction value at an air temperature of 20 degrees centigrade.

ii. Movement correction calculation shall be performed in leveling aimed at land subsidence survey at a basis date to be set.

iii. Calculation shall be performed to a reading unit shown in the table in Article 64, Paragraph 2, Item i, a.

(Calculation method)

Article 68 Calculation can be performed using either the calculation formula provided in Appendix 6 or other calculation formula that is confirmed to have an accuracy equivalent to or better than that of the former.

(Check calculation and remeasurement)

Article 69 Check calculation shall be performed after the end of observation. If the result of check calculation exceeds the tolerance, either necessary remeasurement shall be performed or an appropriate measure shall be taken.

i. Regarding all the unit leveling circuits (which refer to leveling circuits formed with new leveling routes and without any leveling route in it; The same shall apply hereafter) and all the check routes selected according to the following conditions, circuit closure errors and closure errors from one known point to another known point shall be calculated to check the conformity of observation values.

a. A check route shall connect a known point with another known point.

b. All the known points shall be connected with each other by one or more check routes.

c. For all the unit leveling circuits, part of the routes shall overlap with check routes.

ii. The tolerances of check calculation shall normally be as shown in the following table:

Item \ Classification	1st order leveling	2nd order leveling	3rd order leveling	4th order leveling	Minor leveling
Circuit closure error	2 mm √S	5 mm √S	10 mm √S	20 mm √S	40 mm √S
Closure error from a known point to another known point	15 mm √S	15 mm √S	15 mm √S	25 mm √S	50 mm √S
Remarks	S is the observation distance (one way, in kilometers).				

2 The results of calculation check shall be summarized in quality control sheet for leveling.

(Adjustment computation)

Article 70 Adjustment computation shall be performed as follows:

i. The adjustment computation in direct leveling shall be performed with the inverse of a distance as the weight using an observation equation or condition equation.

ii. The adjustment computation for a route where direct leveling and cross sea (river) leveling are mixed shall be performed with the inverse of square of the standard deviation as the weight using an observation equation or condition equation.

iii. The tolerances in adjustment computation shall normally be as shown in the following table:

Item \ Classification	1st order leveling	2nd order leveling	3rd order leveling	4th order leveling	Minor leveling
Standard deviation of observation per unit weight	2 mm	5 mm	10 mm	20 mm	40 mm

2 A program to be used for adjustment computation shall be the one for which the calculation result have been confirmed to be correct.

3 The results of adjustment computation shall be summarized in quality control sheet for leveling.

Section 7 Quality Evaluation

(Quality evaluation)

Article 71 The quality evaluation of leveling results shall conform, mutatis mutandis, to the specifications of Article 44.

Section 8 Deliverables, etc.

(Creation of metadata)

Article 72 The creation of metadata of leveling results shall conform, mutatis mutandis, to the specifications of Article 45.

(Deliverables, etc.)

Article 73 The deliverables, etc. shall include the following items. However, this shall not apply depending on the operation method.

i. Leveling observation sheet
ii. Leveling observation result table and leveling network adjustment table
iii. Leveling routes
iv. Leveling computation sheet
v. Leveling net-adjustment diagram
vi. Description of benchmarks
vii. Result digital data
viii. Agreement about installation of monuments
ix. Notice of installation location of survey marker
x. Ground photographs of benchmarks
xi. Report on current status survey of control points
xii. Quality control sheet for leveling
xiii. Quality evaluation sheet
xiv. Leveling verification survey sheet
xv. Metadata
xvi. Other materials

(3) Airborne LiDAR Survey

Chapter 8 Airborne LiDAR Survey

Section 1 Abstract

(Abstract)

Article 312 "Airborne LiDAR Survey" refers to the series of work consist of collection of topographic data using an airborne LiDAR system, and creation of geospatial data files such as digital elevation models (hereinafter referred to as "grid data").

(Geospatial information quality level and grid interval)

Article 313 The standard of the digital elevation model is expressed by grid interval on the ground.

2 The standard relationship between the geospatial information quality level and the grid interval is defined in the following table.

geospatial information quality level	grid interval
500	≦0.5m
1000	≦1m
2500	≦2m
5000	≦5m

(Work item and process flow)

Article 314 Standard work item and process flow shall be the following.

(1) Planning
(2) Installation of GNSS reference stations
(3) Airborne LiDAR data acquisition
(4) Installation of reference control points
(5) Creation of 3D measurement data
(6) Original data creation
(7) Ground data creation
(8) Grid data creation
(9) Contour data creation
(10) Geospatial data file creation
(11) Quality evaluation
(12) Deliverables

Section 2 Planning

(Abstract)

Article 315 Before commencing work, the applicable work plan including the methods of work, main equipment, workforces and schedule shall be prepared and submitted to the planning authority for its approval. The same shall apply when a work plan is to be changed.

2 The airborne LiDAR data acquisition shall be planned for data acquisition specifications, flight lines, the location and observation of the GNSS reference stations, in consideration of the GNSS satellite distribution.

3 "Data acquisition specifications" include flight altitude, ground speed, swath overlap between flight lines (%), scanning rate, scan angle, pulse rate, nominal ground pulse distance in flight direction and orthogonal direction, and is used to plan to satisfy the required 3D measurement data interval.

4 The ground pulse distance (β) of the 3D measurement data is obtained by the following formula using the grid interval (α) and the constant (θ), and is planned so that there exist one point or more in a grid.

(Formula) $\beta = \alpha / \theta$ (θ: 1.1 to 1.5)

5 Airborne LiDAR data acquisition is planned to satisfy the requirement of 3D measurement data interval. At that time, in consideration of the terrain conditions, the swath overlap between flight lines shall be adjusted or round-trip flight lines shall be set.

6 Swath overlap is 30% as a standard.

7 The LiDAR survey coverage shall be buffered by a minimum of distance 10 times of the grid interval around the survey area boundary.

8 The location of the GNSS reference station shall be planned in consideration of the sky view and the baseline distance.

9 The GNSS observation plan shall be conducted in consideration of the number of satellites observable referring the latest orbit information.

Section 3 Installation of GNSS reference stations

(Installation of GNSS reference stations)

Article 316 "Installation of GNSS reference stations" means installation of ground reference station for kinematic GNSS positioning of the LiDAR sensor in airborne LiDAR survey.

2 The location of GNSS reference station shall be planned so that the baseline distance in the survey area shall not exceed 50km.

3 In principle, CORS shall be used for GNSS reference station.

4 When a new GNSS reference station is installed, the horizontal and vertical geodetic coordinates shall be obtained by first-order control point survey and third-order levelling.

5 If a new GNSS reference station is installed, a GNSS reference station description report shall be created.

(Inspection of GNSS reference stations)

Article 317 The inspection of GNSS reference stations shall be conducted at the time of installation and the following items shall be inspected.

(1) Ensure appropriateness of sky view and GNSS signal receiving capability.

(2) Appropriateness of location of GNSS reference stations in the survey area

(3) Ensure the horizontal and vertical coordinate accuracy of the GNSS reference stations.

(4) Check if GNSS antenna is firmly fixed.

Section 4 Airborne LiDAR data acquisition

(Airborne LiDAR data acquisition)

Article 318 "Airborne LiDAR data acquisition" refers to an operation to measure topographic data using an airborne LiDAR system.

(Aerial LiDAR system)

Article 319 The airborne LiDAR system shall consist of GNSS / IMU equipment, LiDAR sensor and analysis software.

2 The performance of the equipment etc. shall be as follows.

(1) Airborne GNSS antenna and receiver

(a) The GNSS antenna shall be securely fixed to the top of the aircraft.

(b) GNSS observation data shall be acquired at 1-second epochs or better.

(c) The GNSS shall be capable to observe dual frequency.

(2) Kinematic GNSS analysis software shall have the following functions as a standard.

(a) Able to analyse the baseline vector by kinematic analysis.

(b) The evaluation items of analysis results can be displayed.

(3) The GNSS surveying equipment shall have the performance listed in the following table or equivalent or better.

item	Performance
horizontal	0.3m
vertical	0.3m

(4) IMU

(a) The IMU shall be able to measure the tilts of the sensor unit along three axes as rolling, pitching, and heading, and accelerometer, with the standard deviation of the analysis results and the data acquisition interval shall be those listed in the following table, or have the same or better performance.

item	performance
rolling	0.015 degree
pitching	0.015 degree
heading	0.035 degree
sampling rate	0.005 sec

(b) The IMU shall be connected directly to the LiDAR sensor.

(5) LiDAR sensor

(a) LiDAR sensor shall be capable of capturing 2 or more returns including first and last returns.

(b) LiDAR sensor shall have scanning function.

(c) LiDAR sensor shall have function to prevent adverse effect on human body such as eye-safe function.

(d) Safety standards shall be clearly shown.

(6) The analysis software must be able to calculate the 3D position of the measured point.

(7) The airborne LiDAR system shall be boresight calibrated and the calibration shall be valid for 6 months.

(8) An inspection record that records the contents of equipment inspection shall be created prior to the commencement of work.

(Data acquisition)

Article 320 GNSS observation data of GNSS reference stations, GNSS observation data on an aircraft, IMU observation data, and LiDAR data shall be collected.

2 In principle, airborne LiDAR data acquisitions for the same flight line should be performed at a straight line and at an equal altitude. However, this does not apply when using a rotorcraft.

3 The ground speed on the same flight line shall be kept constant.

4 The data acquisition shall be conducted for the area buffered at a distance of at least 10 times of the grid interval from the survey area boundary.

5 GNSS observation shall be conducted as follows.

(1) The data acquisition interval for GNSS observations on GNSS reference stations and aircraft shall be 1 second or less.

(2) The provisions of Article 37, Paragraph 2, Item 2[*2] shall apply mutatis mutandis to the number of GNSS satellites at the time of acquisition.

(3) The GNSS observation results, etc. shall be organized in a quality control sheet describing the records of the GNSS satellites, etc., data such as observation records, and baseline analysis results.

(Aerial photographs for airborne LiDAR survey)

Article 321 Aerial photographs for airborne LiDAR survey is image data obtained by photographing the ground surface from the air, and is taken for filtering and inspection.

2 Aerial photographs for airborne LiDAR survey shall be taken in consideration of the following items.

(1) The standard is to take images at the same time as the airborne LiDAR data acquisition.

(2) The resolution of image shall be identifiable size of ground features such as buildings, and the standard size of ground sample distance (GSD) shall be 1.0 m or less.

(3) The range of aerial photography shall cover the survey area.

(Inspection of airborne LiDAR data acquisition)

Article 322 Airborne LiDAR data acquisition shall be inspected as soon as the data acquisition has been completed, and a quality control sheet shall be created to determine whether re-acquisition of data is required.

2 Inspection shall be performed for each of the following items.

(1) Operation of GNSS surveying equipment installed on GNSS reference stations and aircraft, and quality of data recording

(2) Occurrence of cycle slip

(3) Appropriateness of the area of data acquisition

(4) The area and image quality of aerial photographs for airborne LiDAR survey

(5) Appropriateness of the flight altitude and flight lines

3 Inspection of the kinematic analysis results shall be checked for the following items on each flight line.

(1) Minimum number of satellites

(2) DOP (PDOP, HDOP, VDOP) value

(3) Difference between double running solutions

(4) The quality of the solution

(5) Average and maximum standard deviation of positions

4 The inspection of the smoothed best estimate of trajectory analysis results shall be performed for the following items on each flight line.

(1) Consistency of GNSS and IMU solutions

(2) Average and maximum standard deviation of positions

(3) Average and maximum standard deviation of tilting

5 Inspection of measurement data shall be performed for the following items.

(1) Data voids for each flight line

(2) Flight line deviations from the predetermined flight line

6 The following items shall be prepared as inspection materials.

(1) Number of satellites and PDOP diagram during the data acquisition time period obtained from kinematic analysis

(2) Inspection map of LiDAR survey coverage overlaid with the data acquired area for each flight line

(3) Flight trajectory chart together with the predetermined flight line

(4) Flight operation sheet of airborne LiDAR survey

(5) Flight daily report of airborne LiDAR survey

(6) Observation sheets and records describing the layout of GNSS satellites, etc.

(7) Quality control sheet for GNSS/IMU analysis

7 When a GNSS reference station other than the CORS is used, the following items shall be prepared as inspection materials.

(1) Observation record at GNSS reference station

(2) Description of GNSS observation data file

8 If re-acquisition of data is required based on the inspection results, it shall be promptly performed.

Section 5 Installation of reference control point

(Installation of reference control point)

Article 323 "Installation of reference control point" refers to an operation of installing a reference point for performing inspection and adjustment of 3D measurement data.

2 Reference control point s shall be installed according to the following items.

(1) The location of a Reference control point shall be flat area with minimum length of 2 to 3 times of grid interval such as ground, vacant land, road, park, rooftop, etc., without any obstructions such as trees or sidewalk steps in order to ensure appropriate GNSS signal observation.

(2) The number of Reference control point s shall be a value obtained by dividing the survey area (km^2) by 25 and plus 1 as a standard, and the minimum number is 4 points.

(3) In principle, the points shall be installed at the four corners of the survey area, and in consideration of the location of the flat land and bench marks, it shall be uniformly distributed throughout the survey area.

(Surveying of reference control point)

Article 324 Reference control point s shall be surveyed according to the following items.

(1) The horizontal coordinates shall be obtained by the fourth-order control point survey specified in Chapter 2 "Control Point Survey". However, if there is no known triangular point nearby available, GNSS single positioning method stipulated in Article 59, Paragraph 6, Item 2 can be applied.

(2) The vertical coordinate shall be obtained by the fourth-order levelling specified in Chapter 3 "Leveling". However, if there is no known benchmark point nearby available, GNSS static positioning method specified in Chapter 2 "Control Point Survey" can be applied.

2 Distribution map of reference control points and a description of reference control point shall be prepared. An on-site photo shall be attached to the description of reference control point.

Section 6 Creation of 3D measurement data

(Creation of 3D measurement data)

Article 325 "Creation of 3D measurement data" refers to an operation of integrating and analysing airborne LiDAR data to create three-dimensional coordinate data of a measurement position.

2 When creating the 3D measurement data, error data such as multi-reflection noise to building walls or others shall be removed by referring cross-sectional or bird's-eye view display.

3 The ground coordinate of 3D measurement data shall be centimetre unit.

(Inspection of 3D measurement data)

Article 326 The inspection of 3D measurement data shall be performed by comparison with the reference control points.

2 The comparison between reference control point and 3D measurement data shall be carried out as follows.

(1) The 3D measurement data to be compared with the reference control point is obtained by averaging all the 3D measurement data in a circle with a radius of grid interval or a square with a width of a double of grid interval.

(2) The differences between the reference control point and the 3D measurement data and their average and RMS error shall be obtained at each reference control point.

(3) The difference between a reference control point and an averaged 3D measurement data shall be obtained at all reference control points, and their RMS error shall be obtained.

(4) The inspection results shall be reported in the Inspection sheet of 3D measurement data and the Inspection result of 3D measurement data.

3 Measures to the inspection results of the preceding paragraph shall be performed as follows.

(1) If the absolute value of the average value of the difference is exceeding 25cm or the RMS error is exceeding 30cm, as a result of inspection at each reference control point, the reason shall be clarified and appropriate action such as recalculation or re-acquisition of data shall be carried out.

(2) As a result of inspection at all reference control points, if the absolute value of the average difference is exceeding 25cm or the RMS is exceeding 25cm, clarify the reason and recalculation or re-acquisition of data shall be taken place. However, if the tendency of difference is consistent in the entire survey area, correction measure based on the provisions of Article 333 shall be performed.

(Inspection of elevation between flight lines)

Article 327 For the inspection of elevation between flight lines, the check points shall be selected in the overlaps between flight lines, and the elevations for each flight line shall be compared and inspected.

2 The selection and inspection of check points are as follows.

(1) The number of check points will be more than flight line length (km) / 10 + 1.

(2) The check points are distributed at the end points of the flight line of the overlaps and evenly above and below the overlapping area.

(3) In the case of terrain conditions such as mountainous areas and linear areas, the arrangement and points can be changed.

(4) The check point shall be selected at a flat and clear point, and the elevation is obtained by averaging all the 3D measurement data in a circle with a radius of grid interval or a square with a width of a double of grid interval.

(5) The difference of the elevation of the check point of each flight line for each overlaps, and their average shall be obtained.

(6) When the absolute value of the average of the vertical difference for each overlapping flight line is exceeding 30cm, check points shall be re-selected or the calibration value is re-measured and the measurement data is re-corrected from the inspection result.

3 The inspection results of elevations between courses shall be reported in the residuals between flight lines. In addition, as for the index map, the distribution map of inspection points between flight lines is created.

(Re-inspection)

Article 328 After the work is completed, prepare the distribution map of reference control points and inspection points between flight lines, description of reference control point, inspection sheet of 3D Measurement Data , inspection result of 3D measurement data and residuals between flight lines. The following items shall be inspected using aerial photographs for airborne LiDAR survey.

(1) Adequacy of distribution and location of the reference control points

(2) Appropriateness of the mean and standard deviation of the difference between the reference control point and the 3D measurement data

(3) Appropriateness of distribution and location of check points

(4) Appropriateness of the average value and standard deviation of the difference in elevations at the check points

(Creation of orthophoto data for airborne LiDAR survey)

Article 329 The creation of orthophoto data for airborne LiDAR survey shall be performed by ortho-rectification using the aerial photographs for airborne LiDAR survey and the 3D measurement data.

2 The orthophoto data file shall be created according to the following items.

(1) In principle, the file unit of orthophoto data is based on the sheet of the national base map.

(2) The data format is TIFF.

(3) The coordinate information file is in the Esri World File format.

(Creating water body polygon data)

Article 330 The water body polygon data is created for the area of the water body using the orthophoto.

2 “Water body” means a place where the surface of the river, pond, etc. is covered with water including sea.

3 Water body polygon data is created if the water area is large enough in comparison with grid interval. However, when there is no water area, this work is skipped.

(Calculation of data voids)

Article 331 The data void rate is based on the grid interval, and the rate of missing 3D measurement data is calculated.

2 “Data void” refers to a case where 3D measurement data position is divided by a grid interval and there is no 3D measurement data in one grid. However, water body is not included.

3 The data void rate indicates the ratio of void data to the survey area, and is calculated by the following formula.

The data void rate = (number of void data / number of grids) ×100

4 The calculation is performed by each map sheet of the national base map, and the data void rate is reported in the inspection result of data void rate.

5 The data void rate shall not exceed 10% when the grid interval exceeds 1 meter, and 15% when the grid interval is less than 1 meter.

(Inspection of data)

Article 332 Data inspection shall be performed using graphic compilation system.

2 Inspection shall be performed for each of the following items.

(1) Paying attention to major features (roads, etc.), check whether there is an apparent image gap on orthophoto

(2) No missing of water body polygon data

(3) Adequacy of water body polygon data gap

(4) Adequacy of data void rate

Section 7 Original data creation

(Original data creation)

Article 333 “Original data creation” refers to an operation of creating 3D coordinate data inspected and adjusted from the 3D measurement data using the reference control point data.

2 When the absolute value of the average value of the difference between the reference control point and the 3D measurement data is exceeding 25cm, the entire region shall be adjusted.

3 As for adjustment, the elevation value of the 3D measurement data of the entire region is corrected by parallel movement with a uniform vertical shift.

(Inspection of original data)

Article 334 The original data is inspected before and after the adjustment, and inspected again at the end of the work.

2 When original data is created after adjustment, it is checked whether the average value and standard deviation of the differences are within the allowable range, using the Inspection result of original data.

Section 8 Ground data creation

(Ground data creation)

Article 335 "Ground data creation" refers to an operation of creating ground surface 3D coordinate data from original data by filtering method.

2 The ground data is created for area buffered by a minimum of distance 10 times of the grid interval around the survey area boundary.

3 "Filtering" refers to the work of removing data other than the ground surface. The following are standard items to be omitted.

transportation facilities	road facilities	road bridge (more than 5m in length), viaduct, pedestrian bridge, lighting pole, signal light, road information board, etc.
	railroad facilities	railroad bridge (more than 5m in length), viaduct (including monorail viaduct), overpass, platform, platform shed, aerial wire support pole, signal light pole
	moving objects	parking vehicle, railway vehicle, ship
buildings	buildings and related facilities	houses, factories, warehouses, public facilities, station buildings, wall-less huts, greenhouses, plastic houses, stadium stands, gates, swimming pools (including foundations), fences
small objects		monument, shrine gate, water tank, fertilizer tank, water tower, hoist, chimney, tower, radio tower, lighthouse, pipe line (ground, air), power line
water part	water related facilities	floating pier, water level gauge facility, river information board
plant		tree[*1], bamboo[*1], hedge[*1]
others	others	areas under large-scale construction work [*2], excavation parts for subway construction, material storage, etc.
remarks		* 1 The part regarded as the ground surface shall be adopted as much as possible. * 2 The ground surface that looks as permanent shall be adopted.

4 If a problem occurs in the terrain expression in the filtering of the large-scale ground shielding part, the interpolation is performed using the surrounding unfiltered ground data.

(Creating low-density polygon data)

Article 336 The low-density polygon data is created at an area where the ground data density is very low after filtering.

2 "Low density" refers to a case in which original data is collectively removed by filtering.

3 The low density area shall be determined by the shape of contour lines, etc., which cannot meet the accuracy of the digital topographic map data in the table below.

geospatial information quality level	RMS error of horizontal position	RMS error of vertical position	RMS error of contour line
250	≦0.12 m	≦0.25 m	≦0.5 m
500	≦0.25 m	≦0.25 m	≦0.5 m
1,000	≦0.70 m	≦0.33 m	≦0.5 m

geospatial information quality level	RMS error of horizontal position	RMS error of vertical position	RMS error of contour line
2,500	≦1.75 m	≦0.66 m	≦1.0 m
5,000	≦3.50 m	≦1.66 m	≦2.5 m
10,000	≦7.00 m	≦3.33 m	≦5.0 m

(Consistency with existing data)

Article 337 Consistency with existing data shall be compared and inspected by setting an overlapping section between existing data and ground data.

2 The number of check points is one or more for each national base map sheet, and the check points are selected in flat areas such as ground, vacant land, roads, parks, etc., where little influence of the reference control point and ground shielding is expected. In principle, check point shall have at least 100 measurement points.

3 The inspection shall be conducted as follows.

(1) Compare averaged ground data within the overlapping area.

(2) Calculate the mean and standard deviation of the difference.

(3) If the standard deviation is exceeding 30cm, clarify the reason in consideration of the original data and take appropriate measures such as recalculation or re-acquisition of data.

(4) When there is no ground data as existing data, grid data of existing data can be used as substitute.

(5) The inspection results are reported in the inspection result of existing data.

(Creating filtering inspection map)

Article 338 The filtering inspection map is created to check whether filtering is properly performed and whether there is no abnormality in the created ground data.

2 Two types of filtering inspection maps as "Overlay map of LiDAR orthophoto and contour data" and " Overlay map of LiDAR orthophoto, original data, water polygon and low-density polygon" shall be created. However, when the orthophoto data for airborne LiDAR survey is not created, color shaded relief map created from the original data can be used as substitute.

3 The filtering inspection map shall be prepared by each national base map sheet.

4 The filtering inspection map is printed out at a scale corresponding to the geospatial information quality level of the grid interval.

5 The following table is the standard for the contour interval and colour in the “Overlay map of LiDAR orthophoto and contour data”. In addition, elevation values are added to the index contour line, and a symbol is added to the depression part.

contour line	interval	colour
index	5m	Yellow
intermediate	1m	red

6 The color classification in the “Overlay map of LiDAR orthophoto, original data, water polygon and low-density polygon” is based on the following table.

item	colour
Points adopted as ground data in the original data	red
Points deleted by filtering in the original data	yellow
Water body polygon boundary	deep blue
Low-density polygon boundary	green

7 The filtering inspection map shall be prepared for area buffered by a minimum of distance 10 times of the grid interval around the map frame.

(Checking filtering quality)

Article 339 Filtering quality check shall be performed for each of the following items using a filtering inspection map.

(1) Appropriateness of acceptance / rejection of original data of filtering objects prescribed in Article 335, Paragraph 3

(2) Suitability of water body polygon area

(3) Suitability of low-density polygon area

2 As for filtering, quality check shall be conducted for 5% of the total.

3 If it is difficult to judge whether the filtering is good or bad, it shall be checked by a cross-sectional expression using a graphic compilation system.

Section 9 Grid data creation

(Grid data creation)

Article 340 “Grid data creation” refers to an operation of creating a sequence of elevation data at each grid point from ground data by interpolation.

2 The accuracy of the elevation value of the grid data is in the following table as a standard.

item	RMS error
When there is ground data within the grid	≦0.3m
When there is no ground data within the grid	≦2.0m

3 Grid data shall be filed by each national basic map frame.

4 The elevation interpolation method for the grid data is based on the use of TIN or nearest neighbor methods in consideration of the topography, the usage of the grid data and the density of the ground data. However, Kriging interpolation method can be applied for area of many data voids.

5 About each point of grid data, the attribute showing a filtering condition or a water body condition shall be added as needed.

6 The unit of elevation value in the grid data is 0.1m.

(Creation of grid data check map)

Article 341 The grid data check map is created to check whether the created grid data is normal and whether the data consistency between neighbouring maps is properly kept.

2 When the grid data is checked by the graphic compilation system, the creation of grid data check map can be omitted.

3 The grid data check map is based on the color shaded relief map created by each national base map sheet, and the boundary lines of the low-density polygons are superimposed.

4 The color shaded relief map is created with geospatial information quality levels of 5,000 to 10,000 as a standard.

5 When there is existing data for adjacent to the survey area, the grid data check map shall be created for area buffered by a minimum of distance 10 times of the grid interval around survey area boundary.

(Inspection of grid data)

Article 342 Grid data inspection shall be performed for each of the following items using a grid data check map or graphic compilation system.

(1) Appropriateness of predetermined grid interval, etc.

(2) Incorrect or missing elevation values

(3) Area of water body

(4) Low density area

(5) Consistency between neighbouring frame data

Section 10 Contour data creation

(Contour data creation)

Article 343 "Creation of contour data" refers to an operation of creating contour data by automatic generation from ground data or grid data.

2 Contour data is created as follows.

(1) The contour data shall be created by each national base map sheet.

(2) The interval of ground data or grid data is shown in the following table as a standard. Ground data and grid data of area buffered by a minimum of distance 10 times of the grid interval around survey area boundary shall be used for the creation of contour data.

geospatial information quality level	intermediate contour	index contour	ground data, grid data		
			1m	2m	5m
500	1m	5m	○	—	—
1,000	1m	5m	○	—	—
2,500	2m	10m	○	○	—
5,000	5m	25m	○	○	○

(Inspection of contour data)

Article 344 The inspection of contour data shall be performed using a graphic compilation system, print out maps, etc.

2 The contents of inspection are as follows.

(1) Mistakes and omissions in contour data

(2) Adequacy of contour shape

Section 11 Geospatial data file creation

(Abstract)

Article 345 In this section, “Geospatial data file creation” means creating a geospatial data file according to the product specifications and recording it on an electromagnetic recording medium.

2 The geospatial data files in this section are as follows.

(1) Original data

(2) Ground data

(3) Grid data

(4) Water body polygon boundary

(5) Low-density polygon boundary

(6) Orthophoto data for airborne LiDAR survey

(7) Location information file

(8) Contour data

(9) Stored data list

Section 12 Quality evaluation

(Quality evaluation)

Article 346 The geospatial data files shall be evaluated to ensure they meet the data quality standards stipulated in the product specifications.

2 The implementation organization shall carry out the quality evaluation based on the procedures of quality evaluation.

3 The necessary processing shall be applied when items are found, as a result of the evaluation, that does not meet the quality requirements.

Section 13 Deliverables

(Create metadata)

Article 347 The metadata of geospatial data files shall be prepared to include the necessary items for the management and utilization of the file according to the product specifications.

(Deliverables)

Article 348 The deliverables to be provided are as follows.

(1) Geospatial data file

(2) Work records

(3) Quality control sheet

(4) Quality evaluation sheet

(5) Metadata

(6) Others

Appendix 7　Other Relevant Data

Annex 7-1　Present Condition and Structural Measures for Rivers of East Tarai Region

Annex 7-2　Road damage in the eastern Terai area due to the 2019 flood

Annex7-1 Present Condition and Structural Measures for Rivers of East Tarai Region

1. Lal-Bakeya River

Over view

The Lal Bakeya River has its origin in the Churia Range. The left tributary Lal River and the right tributary Bakeya River join in East Tarai Region and enter India. Its channel length till the Indian border is about 80 km. In the Tarai region, levees are built on both sides. Riverbank erosion countermeasures such as revetment and spur dikes have been implemented (**Fig.1**). These structures were built with funding from India and Nepal.

For the revetment, cobble stones and gabions are used (**Fig.2**). For spur dikes, sandbags covered with coarse fiber nets or gabions are used (**Fig.3**). Guide dikes are built pararrel to levees at the local road bridge between Birganji and Kadarhana. Revetment and gabions are installed over the guide dikes upstream of the bridge to prevent erosion. Bamboo stick are inserted into the riverbed as bamboo piling, and scabs are placed over the river bed to promote sedimentation between the spur dikes (**Fig.4**). Gabions are apploied to the revetment of embankment (**Fig. 5**). In this way, the enginees of the river management office are implementing riverbank erosion countermeasures using materials obtained locally.

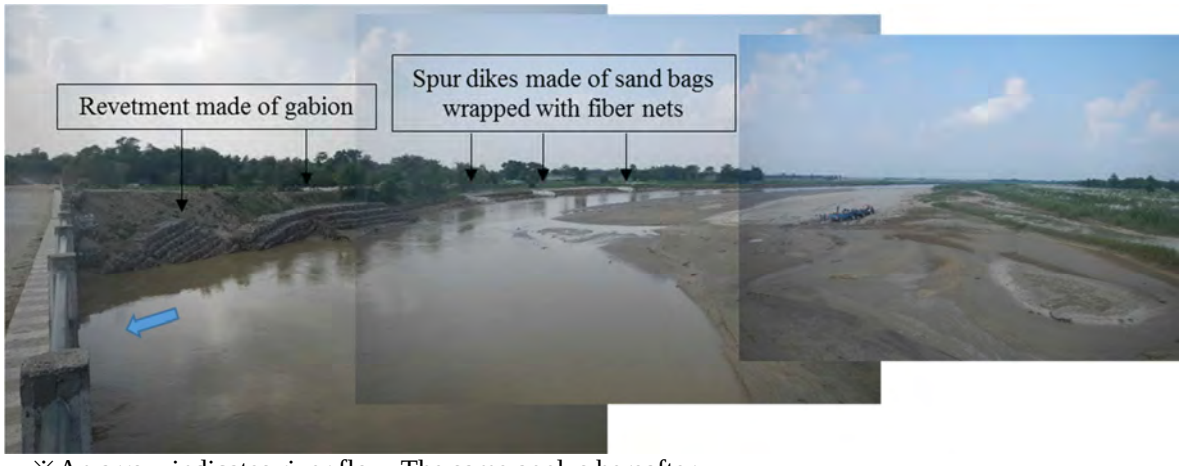
(Structure of a large spur dikes)

In the case of a 275m long spur dike, as a standard structure of a large scale spur dike, 85m at the top is convered with gabions, 90m in the middle is covered with cobble stones, and 100m at the base is earth embankment.

Challenges

Sediment is transported from the geologically fragile Upper Churia Range. It accumulates on the riverbed. The rising riverbed makes floods more likely to occur along with the effects of climate change. In the July 2019 flood, embankments were eroded on the left bank at 2 sites. One of the two has already been repaired (**Fig.6**). At the site already repaired, ganions and sand bags were used. A total of five spur dikes made of gabions have been built on both the upstream and downstream sides of the repaired site (**Fig. 7, 8**). With the limited budget, structural measures are being implemented using local materials (**Fig.9**). The remaining site is under repair (**Fig.10, 11**). The difference in ground level between the river side and the settlemet side is about 2 to 3m visually (**Fig12**). If this situation continues, the risk of flood overflow will increase.

Current Conditions (Fig.1～12 was taken by JICA Project Team on September 15, 2019.)



※An arrow indicates river flow. The same applys hereafter.

Fig.1 Revetment and spur dikes

The above photo was taken on the local road bridge between Birganji and Kadarhana. The revetment prevents riverbank erosion and sediment is deposited on the riverbed between the spur dikes.

Fig.2 Revetment made of gabions①

The upstream riverbank of the bridge is protected from erosion by the revetment.

Fig.3 Spurs dikes made of sand bags and covered with nets

The sand bags are used as an alternative of gabions as cobble stones are becoming more scares.

Fig.4 Bamboos and fascine set between spurs dikes

Sedimentation is promoted with scabs and bamboo piles placed between spur dikes.

Fig.5 Revetment made of gabions②

The above photo was taken on the road with bridge.

Fig.6 Lower left bank embankment under repair

This part of levee, downstream of the bridge of the above fig.6 was socured during July 2019 flood. This has been repaired with sand bags and gabions as urgent countermeasures.

Fig.7 Spur dikes made of gabions①

Spur dike made of gabions has installed upper stream of the scoured part.

Fig.8 Spur dikes made of gabions②

Two spur dikes made of gabions has installed downstream of the scoured part.

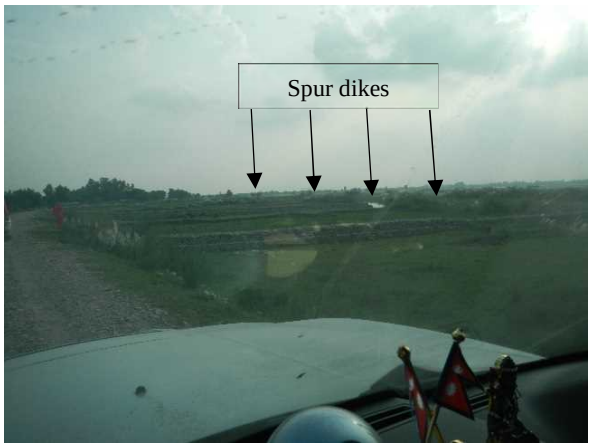


Fig.9 Spur dikes made of gabions③

A series of spur dikes made of gabions (L=100m) has been constructed. Between the spur dikes, sedimentation is promoted and paddies are developed.

Fig.10 Sand bags in preparation

Sandbags have been prepared for repair of scoured part of levee (Fig.12).

Fig.11 Left bank embankment under repair

This part of the levee was scoured with flood overflow on July 2019. This is under repair with sand bags and fabric nets.

Fig.12 River channel raised by sedimentation from surrounding farmland

Riverbed is higher than surrounding farms due to sedimentation. The risk of flood overflow is increasing.

2. Bagmati River

Onver view

Bagmati River originates the Nepal side of Himalayas. It crosses the Maharabat Range and the Churia Range and descends through Tarai into India. The total length of the channel till the Ganges is 593 km. The length of the channel in Nepal is about 175 km. In the Tarai Region, levees have been constructed together with revetment and spur dikes. These structures were constructed as a rehabilitation project on the Bagmati River with fund from India and Nepal, based on the agreement of the Ganga Flood Control Committee of India in 1994. The project started in 2000 and was completed in 2018. The levee is 44 km long on the left bank and 33 km on the right bank (**Fig.13**). It also includes a large-scale of 320m-long spurs that is not seen in Japan (**Fig.14**).

Challenges

1) Rise of Riverbed

The riverbed also rises remarkably in the Bagmati River due to the sediment from the upper mountain areas. During the flood of July 2019, a long spur was washed away (**Fig.15**). Current most prominent problem is the insufficient length of the railway bridge that is located immediately downstream of the Indian border The length of the road bridge constructed immediately downstream of the railway bridge in parallel with the railway is also insufficient. The embankment structures of the approach road to the bridges hinder the flow of sediment. Here, the rise of the riverbed is remarkable, and there is a concern that floods will cause the levee to be overflowed and be eroded.

2)Drainage problem

Drained water from the right side of the river in Nepal flows down along the right levee and flows into India. The railway embankment in India, which extends from east to west along the border between India and Nepal, impedes the flow of drainage from Nepal and it is flooded over upstream. Such drainage problem is occurring in Indian territory. The solution was proposed by Indian in August 2019. It is to construct a drainage culvert through the right levee into river channel on the Nepalese side. On the other hand, the Nepal proposed a plan to drain water using the old river channel existing in India. It is currently under discussion.

3) Backwater problem

On the Nepal side near the Indian border, floods have occurred along the Manusmara River and the Jahaj River. These are tributaries of the Bagmati River, due to the backwater effect from the Bagmati river.

4) Insufficient river width

At 30 km upstream from the Indian border, the river is narrow. The cross-section area of the river is insufficient.

Current Conditions (Fig.13～15 was taken by JICA Project Team on September 15, 2019.)

Fig.13 Bagmati River Improvement Plan Implemented by India

Bagmati River improvement was implemented with Indian and Nepalese funds based on the 1994 agreement. The construction was commenced on 2000 and completed on 2018.

Fig.14 Spur dike built on the right bank of the river

It has been 32 years since its construction. Sedimentation has been promoted between the spur dike upstream and the space is used for agricultural activity.

Fig.15 Spur dike scoured by July 2019 flood

The spur dike was scoured by July 2019 flood. The point is 3km upstream from the Indian border. The deapth of the water in front is 6~7.5m. The flood of July 2019 reached the top of the levee.

3. Lakhandai River

This river flows east of Bagmati River. A series of spurs have been developed as a countermeasure for riverbank erosion.

4. Pasaha River

The embankment was eroded in 2016. The damage also affected the Postal High Way under construction.

5. Khando River

Flood risk is increasing due to sedimentation over the riverbed. There is a plans to rehabilitate its embankment with Indian funds.

6. Kamala River

The turbidity of the river is high. This implies the sediment concentration is high. Levees are built on both banks. Revetments of concrete blocks are being constructed upstream and downstream of the bridge of East ~ West Highway. The riverbed is higher than the surrounding farmlands. (**Fig.16, 17**)

Current Conditions (Fig.16～17 was taken by JICA Project Team on September 16, 2019)

Fig.16 Revetment installed on right bank

Revetment is constructed on the dike slope. River water turbidity is high.

Fig.17 Raised riverbed

The riverbed (left in Fig.17) is higher than the farm land (right in Fig.17).

7. Kharak Khola River

On the East-West Highway bridge, spur dikes and revetment are installed at the embankment of the approach road on the upper left. These structures seems effectively placed against erosion (**Fig.18, 19**). Its riverbed is rising due to sedimentation (**Fig.20**).

Current Conditions (Fig.18～20 was taken by JICA Project Team on September 16, 2019.)

Fig.18 Double-walled revetment with gabions and spur dikes with gabions

Revetment of gabions are constructed at the flow - hit part of the embankment of approach road. In addition, spur dikes are installed upper stream.

Fig.19 Three double-tiered spur dikes

The first piles of the spur dikes constructed upper stream have been buried with sediment.

Fig.20 Sedimentation of the riverbed

Sediment have been deposited on the riverbed.

8. Mauhari River

At the East-West highway bridge, the footing of the bridge piers are exposed, and sedimentation of riverbed was not observed.

9. The River east of Mauhari River, and further east of Barhamha

At the bridge on the East-West Highway, the bridge pier footing is not visible and the space between the beams and the riverbed is nerrow, so it is assumed that the riverbed is rising (**Fig.21**).

Current Conditions (Fig.21 was taken by JICA Project Team on September 16, 2019.)

Fig.21 A river east of Mauhari River and further east of Barhamha

The bridge footing has been buried under sediment and the height of the space between the riverbed and the bridge beam has been low.

10. Koshi River

Overview

Kosi River originates in Tibet and joins the Ganges River in India via Nepal. The basin area is 87,481 square meters (24% of Japan's land area), of which 23% is located in Nepal.

Levees, revetments, and spur dikes are developed on both sides from the Koshi River Intake Weir to the upstream 40 km point (**Fig.22, 23**). Many large spur dikes over 200m in length have been constructed. The annual average discharge in this section is 2166m^3 / sec, while the design high water discharge is 27,014m^3 / sec. The largest flood in recent years occurred on August 24, 1954, with a discharge of 24,200 m3 / sec. At that time, there was no levee on either side of the river, therefore, the flood caused severe damage to its surrounding areas. The Kosi River Intake Weir built on the Indian border and the improvement of the river channel up to 40 km upstream are all funded by the Government of India. The construction of the weir and river channel improvement have been implemented through to the following schedule.

<History of Kosi River improvement and intake weir construction>
1959: Embankment construction completed
1962: Intake weir construction completed

The Nepalese government manages the upstream from 40km point. The Government of Nepal's Kosi and Baklaha River Management Office will formulate a master plan (MP) later 2019 for the upstream section from 40 km point. This MP focuses on the planning of small-scale riverbank erosion prevention measures.

Challenges

The rise of the riverbed is the most urgent and serious problem (**Fig.24, 25**). The Kosi River is the second most sedimentary river in the world. The average soil erosion rate in the basin is 2477 t / km^2 / yr. Sediment flows from the Kosi River through the Ganges River into Bangladesh and pours into the Bay of Bengal. A new island, New Mule Island, is formed at the estuary. The riverbed 500m upstream of the Kosi Weir Bridge is higher than the road pavement surface of the bridge. The riverbed is visually more than 5m higher than the ground level of the surrounding areas. Risk of flood overflow and erosion is icreasing.

The Kosi River used to be an unstable river that has undergone continuous changes of its channel direction. Since it was fixed with levees, the sediment that had been dispersed over the alluvial fan has been concentrated on its channel.

Current Conditions (Fig.22～25 was taken by JICA Project Team on September 17, 2019.)

Fig.22 Spur dikes installed on the riverbank①

Fig.23 Spur dikes installed on the riverbank②

Spur dikes have been continuously installed along the levees.

Fig.24 Settlement area lower than river chaneel

From the left bank of the Kosi River, the difference in elevation between inside and outside the levee is apparently seen.

Fig.25 Road lower than river chaneel

The riverbed is higher than the road across the levee.

11. Upstream of Kosi River 40km point, Bakraha River, Domsh Bakraha River, Hoandra River, and Chisan River River

Overview

These five rivers are under the management of the Kosi and Baklaha River Management Offices. The levees have been completed on the Baklaha River. The river channel improvement has not been implemented for Domush-Baklaha River, Hoandra River or Chisan River. Levees have not been developed in these rivers. Construction of levees and revetment is required for these rivers. In the case of river erosion in these five rivers, emergency measures are taken to protect the riverbank with revetment made of gabions and bamboo piles.

For these five rivers, small-scale master plans have been prepared for erosion control. Construction of revetment made of gabions have been proposed.

Challenges

In the segment in the mountains, the five rivers do not require levees. Here, the riverbank occurs and its countermeasures are needed.The most serious problem is riverbed sedimentation in the segment downstream on the fan. However, the scale of structural measures against these problems is small in terms of budget.

The riverbed of these rivers has been higher than the surrounding areas. The risk of erosion is increasing. In the Bakraha River, gabion spur dikes with height of 3m was constructed, but 12 years later it was buried under the riverbed. The river management office manager is worried that the riverbed will rise further in the future.

Annex7-2 Road damage in the eastern Terai area due to the 2019 flood

1. Road damage due to flood in July 2019 in the eastern Terai area (Fig.1～8 was taken by Department of Road on August 4 – 5, 2019)

※An arrow indicates river flow. The same applys hereafter.

Fig.1 Damaged section of Rajabiraj – Kunali Road near by Tilathi village of Saptari, Province 2

The cross-sectional area of the pipe constructed under the road was insufficient. The flood from the left side of the photo was hindered by the road embankment, the water level rose, and the embankment was eroded by being overtopped.

Fig.2 Damaged section of Janakpur – Yadukuha Road, Province 2

The embankment of approach road overhanging the river hindered the flood and was eroded. An arrow indicates the flood flow that hit and eroded the embankment.

Fig.3 Damaged section of Bagmati – Aruwa Road, Rautahat

The embankment of the road impeded the flood flow causing overflow. The arrow shows that the flood has overflowed the road and damaged the pavement and embankment.

Fig.4 Damaged section of Janakpur – Kaptol Kamal Road, Province 2 ①

The cross-sectional area of the culvert was insufficient. The flood from the left side overtopped and eroded the embankment. The red dashed line indicates the lost road embankment.

Fig.5 Damaged section of Janakpur – Kaptol Kamal Road, Province 2 ②

When the embankment of the road is rehabiltated, it is necessary to construct a culvert under the embankment so that the flood flows through freely without hinderance.The red dashed line indicates the lost road embankment.

Fig.6 Damaged section of Bagamati – Aruwa Road, Rautahat ①

The flood was hampered by road embankment and overflowed, and the pavement was damaged. An above arrow indicates the flood flow overflowing the road.

Fig.7 Damaged section of Bagamati – Aruwa Road, Rautahat ②

The Minister and Department of Road inspected the situation.

※The red line indicates the alignment of Postal Highway
Souce: Department of Road

Fig.8 The planned alignment of Postal Highway

The flood in July 2019 also damaged Postal Highway under construction.

2. Road damage due to flood in July 2019 in the eastern Terai area (Fig.9～10 was taken by JICA Project Team on September 15, 2019)

Fig.9 Drainage inhibition by road embankment①

Fig.10 Drainage inhibition by road embankment②

The drain water on the right (upstream) in **Fig. 9** and **Fig.10** is impeded by the road embankment and cannot flow down to the left (downstream) and is stagnant upstream. During flood, the water level on the upstream rises and there occurrs a risk of overflowing the road embankment. Depending on the magnitude and location of the flood, pavement and embankment may be damaged.