CIVIL AVIATION AUTHORITY OF NEPAL
MINISTRY OF CULTURE, TOURISM AND CIVIL AVIATION
FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

DATA COLLECTION SURVEY ON AVIATION SECTOR IN FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

FINAL REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
JAPAN RADIO AIR NAVIGATION SYSTEMS ASSOCIATION

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Data Collection Survey on Aviation Sector in Federal Democratic Republic Nepal

Summary

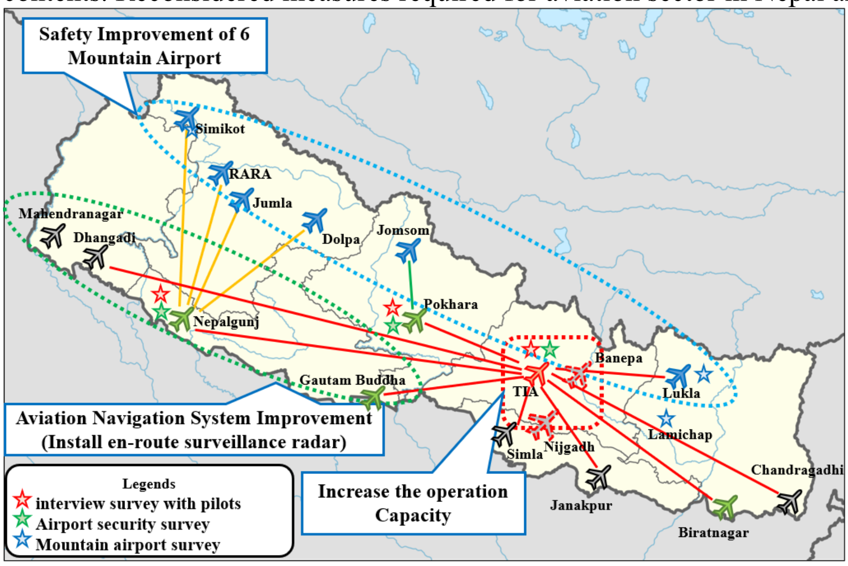
1. Basic concept of the project

(1) Background of the Survey

The Japanese government had provided various support in the aviation sector of Nepal since the 1990s through expert dispatch and grant aids in the installation and operation of air traffic control radar facilities, navigation equipment, etc. These contributed towards aviation safety and enhancing transportation capacity and had greatly improved the aviation sector; however, the following are the issues related to the current aviation sector in Nepal:

1) Insufficient handling capacity at the Tribhuvan International Airport (TIA),
2) Improvement in aviation safety (aircraft accidents still occur)
3) Airport security system does not meet the standards of the International Civil Aviation Organization (ICAO).

In response to this, the Civil Aviation Authority of Nepal (CAAN) has high prospect for cooperation in formulating master plans for the entire aviation sector in Nepal. Based on this background, this project intends to examine the current situation and issues of the aviation sector in Nepal and to find out the future potential support policy of Japan in response to diversifying issues. The areas covered by this project include airports, airways, and air security facilities in the country, which are the subject of the field survey shown in Figure 1.
The aviation sector of Nepal has been impacted by global epidemicity of COVID-19 and the travel restriction, which causes international flight cancellation in TIA, since March 2020. However, since medium- and long-term impact on the aviation sector is not clear and the research and analysis including aviation demand forecast had been completed by March 2020, the impact of COVID-19 is not considered up to Section 7 in this report.
In addition, since April 2020 it is expected that the impact of COVID-19 affects demand forecast. Therefore, considering the long-term decline of aviation demand, the demand forecast up to 2050 had been reconsidered. Furthermore, based on the results of the demand forecast, the measures required for the aviation sector in Nationwide had been reviewed and modified for the implementation time and contents. Reconsidered measures required for aviation sector in Nepal are described in Section 8.



Scope of Survey
Capacity Enhancement of Kathmandu Region
-**Tribhuvan International Airport (TIA)** -Banepa Domestic Airport (Plan) -Nijgadh Second Intl. Airport (Plan)
Enhancement of Domestic Airport
-**Gautam Buddha Airport (Expanding)** -Pokhara Intl. Airport (Under Construction) -Tarai Region (Mahendra Nagar, Dangadi, Nepalgunj, Simara, Janakpur, Biratnagar, Chandragadi)
Safety Improvement of Mountain Airport
Target Airports (Six Airports) -**Lukla, Jomsom, Jumla, Simikot, Dolpa, Rara** Pilot Interview (Base Airport) -TIA, **Pokhara, Nepalgunj**
Airport Security
- TIA, **Pokhara, Nepalgunj**

(Source: JICA Study Team)

Figure 1 Overview of the Survey

(2) Scope of Survey

The scope of this survey is as follows:

- Research comprehensively and collect information necessary for understanding the current situation, issues and state at the aviation sector in Nepal.
- Consider the future support potentials of Japan International Cooperation Agency (JICA) for the aviation sector, including specific preliminary studies for each airport.

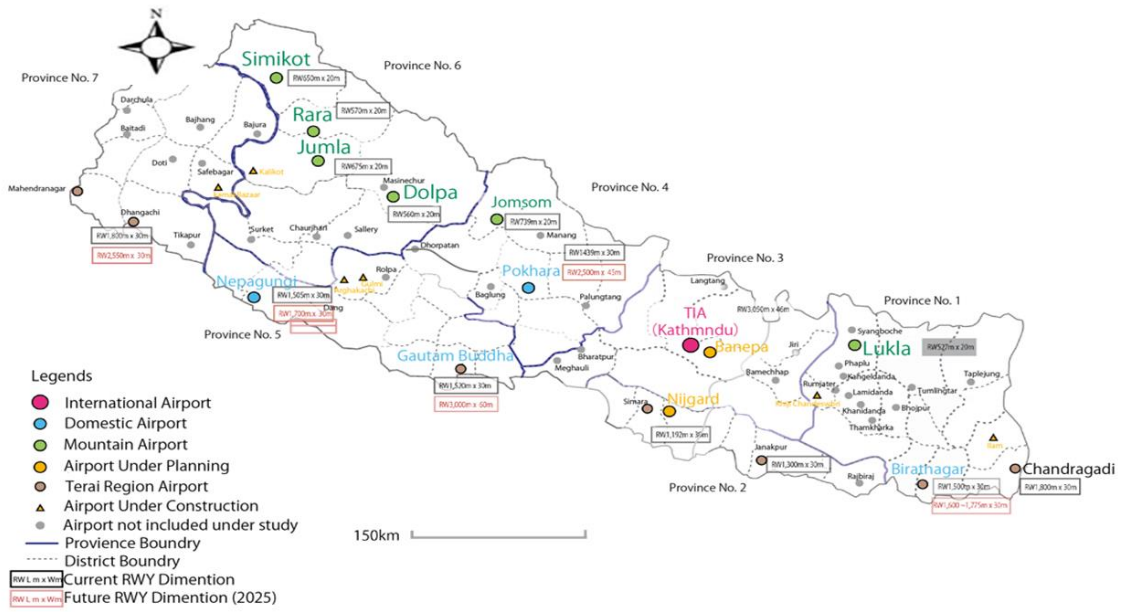
(3) Executing Agency

(1) Implementing Agency: CAAN
(2) Executing Agency: Ministry of Culture, Tourism, and Civil Aviation (MoCTCA)

2. Current Situation of Nepal

(1) Status of Air Transportation

Air transportation is one of the important means of transportation in Nepal along with land transportation. Especially in the mountainous area, airports are the main means of transportation due to the difficult topography for constructing roads.
Nepal has one international airport, four domestic hub airports, and 44 domestic airports at present, a total of 49 airports.
Six domestic airports and three international airports are under construction together with one international airport under planning. Figure 2 shows the location map of all airports.



(Source: JICA Study Team)

Figure 2 Airport Distribution Map of Nepal

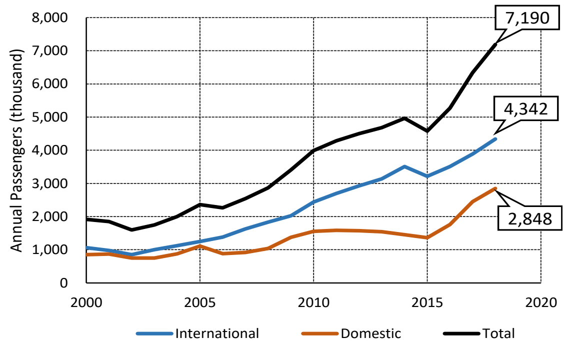
(2) Air Passenger Movement

1) Kathmandu/Tribhuvan International Airport

The Tribhuvan International Airport (hereinafter, referred to as TIA) is the hub airport for the domestic airport network in Nepal and is the only airport to operate international flights. Figure 3 shows the historical trend of air passengers at TIA. In 2018, TIA handled 4.3 million passengers per annum (mppa) in international air service, 2.9 mppa in domestic air service, and 7.2 mppa in total.

The number of international passengers has shown a steady increase since 2002, despite a temporary decrease due to the impact of the 2015 earthquake.

On the other hand, the number of domestic passengers was found to be stagnant and does not increase during the five years period from 2010 to 2015. However, after 2015 the passenger movement rose sharply.



(Source: CAAN Annual Report, TIA data, CAAN & JICA data book)

Figure 3 Historical Trend of Air Passenger at TIA

2) Domestic Hub Airports

The four airports, namely; Pokhara, Biratnagar, Nepalgunj, and Bhairahawa function as hub airports in the domestic network, serving as bases for flights to the mountain airports or as relay points between Kathmandu and mountain airports.

In addition to the four hub airports, there are five airports with the number of domestic passengers exceeding 100,000 in 2018. Lukla is included in these five airports. According to Lukla's passengers in 2018 which has fallen from the previous year, it is anticipated that transport capacity of Lukla does not meet the demand.

Table 1 shows the number of domestic passengers handled at domestic airports.

Table 1 Domestic Passenger at Domestic Hub Airport

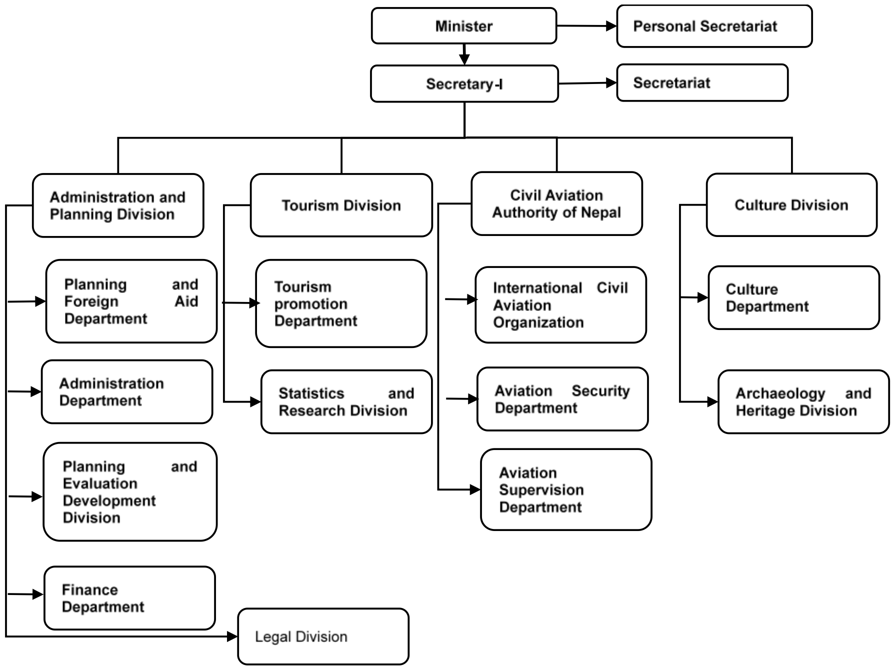
(thousand/year)

	Airport	2014	2015	2016	2017	2018
Domestic Hub Airports	Pokhara	369	275	328	446	610
	Biratnagar	311	340	377	455	538
	Nepalgunj	166	176	234	369	427
	Bhairahawa	110	108	168	300	378
Other Local Airports	Simara	51	46	79	107	231
	Bharatpur	54	54	150	258	229
	Bhadrapur	120	165	162	193	228
	Dhangadhi	50	45	62	128	178
	Lukla	87	81	120	147	125
	Janakpur	60	45	53	65	79
	Simikot	13	22	57	60	54
	Jomsom	49	36	40	42	46
	Tumlingtar	28	35	32	33	31
	Rara	3.8	4.1	13.7	18.7	19.4
	Dolpa	12.6	9.2	12.2	12.2	19.4
	Surkhet	16.9	15.2	9.8	7.6	15.5
	Bajura	5.7	9.7	8.6	10.6	11.8
	Phaplu	1.5	36.9	11.8	11.0	10.6
	Bhojpur	4.9	5.0	7.7	6.9	5.4
	Salle	1.2	2.4	1.8	2.6	2.5
	Taplejung	1.4	0.9	2.7	2.1	2.4

(Source: CAAN Annual Report, TIA data, CAAN & JICA data book)

(3) Ministry of Culture Tourism and Civil Aviation (MoCTCA)

Ministry of Culture Tourism and Civil Aviation is one of the ministries under Government of Nepal, that promotes tourism, culture and private sector involvement. It also serves as the civil aviation regulatory body of Nepal. In addition, this ministry has a vital role in contribution for Nepal's economy and at the same time preservation of the culture and heritage of the country.
The Ministry was previously established in 1978 as a Ministry of Tourism but later civil aviation and culture was also incorporated under it in 1982 and 2000 respectively. However, it was again dissolved into Ministry of Tourism and Civil Aviation and Ministry of Culture and State Restructuring in 2008. In 2012, ministry was brought to its current form as the Ministry of Culture, Tourism and Civil Aviation. The Ministry of Culture, Tourism and Civil Aviation is headed by Minister who has been elected from the member of the ruling Political Party. The highest position from the bureaucracy is the Secretary who manages all the department under the ministry. The organization chart of MoCTCA is as shown in Figure 4.

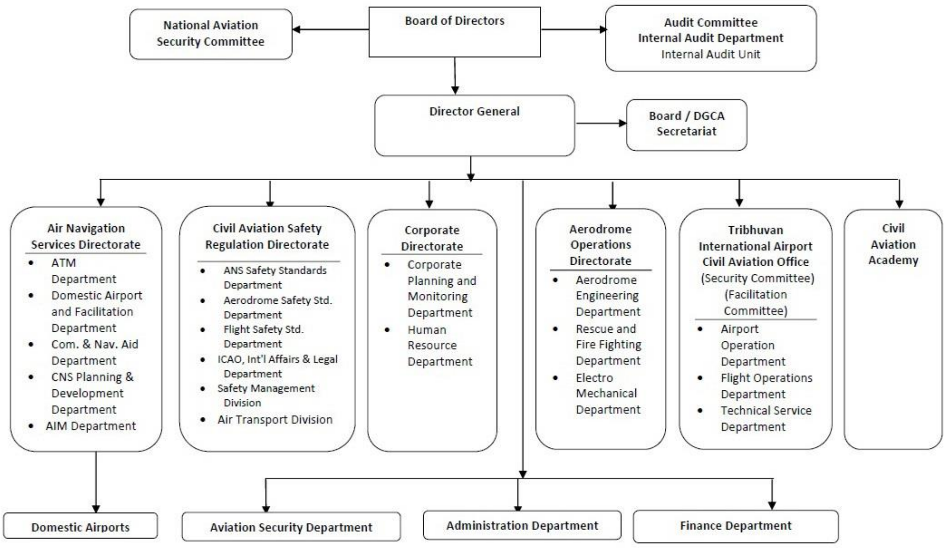


(Source: MoCTCA)

Figure 4 Organizational Chart of MoCTCA

(4) Civil Aviation Authority of Nepal (CAAN)

The Nepal Civil Aviation Authority (CAAN) is an autonomous regulatory body established on December 31, 1998 under the Civil Aviation Act 1996. The main mission of CAAN is to ensure safe, secure, efficient, standard, and quality service in civil aviation and airport operation.
Under the Board of Directors, which is chaired by the Minister of MoCTCA, CAAN is managed by the Director General who is also a member of the Board with the support by the Deputy Director Generals. The organization of CAAN is as shown in Figure 5. It consists of four Directorate, three non-afflicted departments, Tribhuvan International Airport Civil Aviation Office (TIACAO) and Civil Aviation Academy (CAA).



(Source: CAAN)

Figure 5 Organizational Chart of CAAN

(5) Future Development Policies of CAAN

The future development policies of CAAN in relation to the National Development Planning (15th Plan) are as shown in Table 2.

Table 2 Development Policy of CAAN

Items	Policies as per CAAN Civil Aviation Annual Report 2018
1. Application of international standards for aviation sector	✈ Developing Nepal Aviation Safety Plan (2018-2022) in accordance with ICAO Global Safety Plan and proceed with related measures at faster pace. ✈ Coordination among CAAN and airlines to reduce the number of accident due to climate and geographical conditions. ✈ Updating air Navigation services by introducing latest equipment ✈ Introduce e-bidding process to automate airport operations
2. Airport Infrastructure Development	✈ Three international airports are under construction to meet increasing demand - Gautam Buddha Intl. Airport: Scheduled to be in operation by 2020 - Pokhara Intl. Airport: Scheduled to be in operation by July 2021 - Nijgardh Intl. Airport: Scheduled to be in operation in 2025, currently acquiring land
3. Airline Company Improvement	✈ 27 international airline (including Nepalese company) connects TIA to 14 countries. 19 domestic airlines are in operation. ✈ By March 2019, 75 aviation recreational club (4 ultralight aviation, 1 balloon, 70 paragliders) have been registered.
4. Organization Improvement (Aviation Bureau, Airline)	✈ CAA Seminars, Workshops, Field trainings. ✈ Attend training and seminars by international organizations including ICAO and CANSO ✈ CAAN is working with airlines to promote the ICAO Next Generation Aviation Professional (NGAP) program and Global Plan. The construction of aviation museum (Kathmandu) is an example of such activities.
5. Air Route Negotiation (Bilateral)	✈ Signed bilateral Air Service Agreement with Cambodia (November29, 2019). Nepal has signed ASA with 39 countries since 1963 and Cambodia is most recent example.

(Source: CAAN Report 2018)

(6) Trends of Support Received from the International Organization or Other Donors in Aviation Sector

Table 3 shows the overview of the funding support received from the international organizations or other donors in the aviation sector.

Table 3 The Overview of the Funding Support by Other Donors

Implementation Year	Institution	Project Title	Amount （USD）	Scheme	Overview
FY1996	France	French Seventh Protocal: Rehabilitation of Airport Equipment for Hub and STOL Airports	2.5/13.0 (₣)	Loan, Grant	
FY1997～FY2002	Asian Development Bank (ADB）	Tribhuvan International Airport Improvement Project	27(USD)	Loan	
FY2007～2010	Asian Development Bank (ADB）	Civil Aviation Airport project	0.75Million	Technical Cooperation	Study on the necessity of existing airports improvement, TIA Master Plan (2010-2023)
FY2009～ongoing	Asian Development Bank (ADB）	Air Transport Capacity Enhancement Project for TIA, 3 Domestic Airports (Lukla, Rara, Simikot)	About 80Million	Loan	**TIA:** Runway and Parallel Taxiway Extension, PTB and Apron Expansion, Utility Works, ATC and Weather Observation Facilites Update **Simikot&Rara:** Airport Lighting, ATC and Weather Observation Facilities
Cancelled	Asian Development Bank (ADB）	Tribhuvan International Airport Capacity Enhancement Investment Program	240Million	Loan	Airside maintenance in accordance with TIA master plan.
FY2014～ongoing	Asian Development Bank (ADB） OPEC International Development Fund	Gautam Buddha Airport Project	About 97Million	Loan, Grant	Construction of Runway, PTB, Apron and control tower Improve existing domestic runway into parallel taxiway
FY2017～ongoing	Export-Import Bank China	New Pokhara International Airport Project	Project cost 216Million Loan 145Million	Loan	Construction of new international Airport with runway length of 2,500m, located 3km southeast of present Pokhara Airport.
FY2017～ongoing	French Civil Aviation Authority （DGAC）	Improvement of Safety management function	N/A	Grant	Technical Assistance incorporated between CAAN and DGAC with MoU signing in 2017 to provide support in airworthiness certification and audit systems for airlines.
Proposed	Asian Development Bank (ADB）	Civil Aviation Sector Improvement Program	50Million 0.5Million	Loan/Technical Assistance	Organizational Strengthening of CAAN (TIA airside maintenance, New ITB at GBIA, CAAN organizational restructuring (regulator, operator))
FY2019～ongoing	Asian Development Bank (ADB）	Preparing the South Asia Sub-regional Economic Cooperation Airport Capacity Enhancement Sector Development Program	1Million	Technical Cooperation	Support civil aviation sector reforms in restructuring and strengthening (TIA hanger relocation, investment for ITB at GBIA, construction of Domestic apron at TIA)

(Source: JICA Study Team)

From 1969 to 2015, ADB has provided Civil Aviation sector of Nepal with 7 loans and 5 technical cooperation.

Since 1996, ADB assisted with the TIA development projects (loans), which includes expansion of international terminal building, construction of cargo handling facilities, improvement of safety-related roads and advisory consulting service. In the Civil Aviation Airport Project from 2007, a master plan of TIA airport was prepared. The Air Transport Capacity Enhancement Project (grant/loan) has being carried out since 2009 to support the extension of runway and maintenance of airside in accordance with the master plan. From 2014, the support for the construction of Gautam Buddha Airport was also initiated.

(7) Overview of Japan's Cooperation in Nepal 's Aviation Sector

Table 4 shows the summary of Japan's previous cooperation in Nepal's Aviation Sector.

Table 4 Summary of Japan's Previous Cooperation

Implementation Year	Project Title	Grant Amount （Yen）	Project Overview
1994-2002	Dispatch of JICA Expert Aviation safety and Radar control		Conduct training for the operation and maintenance of equipment delivered during "Kathmandu International Airport Development Project".
1995-1997	Grant Aid Kathmandu International Airport Development Project	3.6 billion	Preparation of airport surveillance radar and conduct necessary training
1999-2001	Grant Aid ATC facility improvement project in TIA modernization project	1.2 billion	To enhance the effectiveness of radar installed during "Kathmandu International Airport Development Project" and perform safe ATC operation, carry out maintenance of ATC equipment and update radio equipment together with installation of new weather observation facilities.
2006-2008	Follow-up project on ATC system improvement		System improvement project for delivered equipment.in "Air Traffic Control Improvement Project in the TIA Modernization Program"
2009-2014	ATC Technology Senior volunteer		—
2013-2015	Grant Aid Tribhuvan International Airport Modernization Project (ATC Radar）	989 million	Installation of secondary radar system and replacement of existing surveillance radar in TIA.
2014-2018	Technical cooperation Project for development of spare parts management center and en-route radar control service	-	Develop capacity related to spare parts management of aviation safety equipment throughout Nepal and operation and maintenance of en-route air radar control services.
2016-Present	Grand Aid Improvement of aviation safety facility project	1.4 billion yen	Improvement of aviation safety equipment at eight major airports in Nepal (TIA, Danghadi, Chandragadi, Lukla, Jomsom, Jumla, Rara, Simicot).
2018-Present	Technical Cooperation Project Capacity development in operation and Maintenance of aviation safety equipment		Technical support for operation and management of localizer and IFR design system provided by "Improvement of aviation safety facility project". Technical support for expansion of equipment provided by "Development of spare parts management center and en-route radar control service"

(Source: JICA Study Team)

Through grant aids and technical cooperation projects, CAAN's ability to ensure aviation safety has been improving steadily mainly through installation and maintenance of equipment and capacity development of CAAN staff. Seeing the achievement, Japan forms strong presence among development partners and government of Nepal and CAAN expect further continuing cooperation in aviation sector. Although, CAAN has proper organizational structures as one of the governmental agencies, it has issues related to insufficiency of controllers and technicians at local airports.

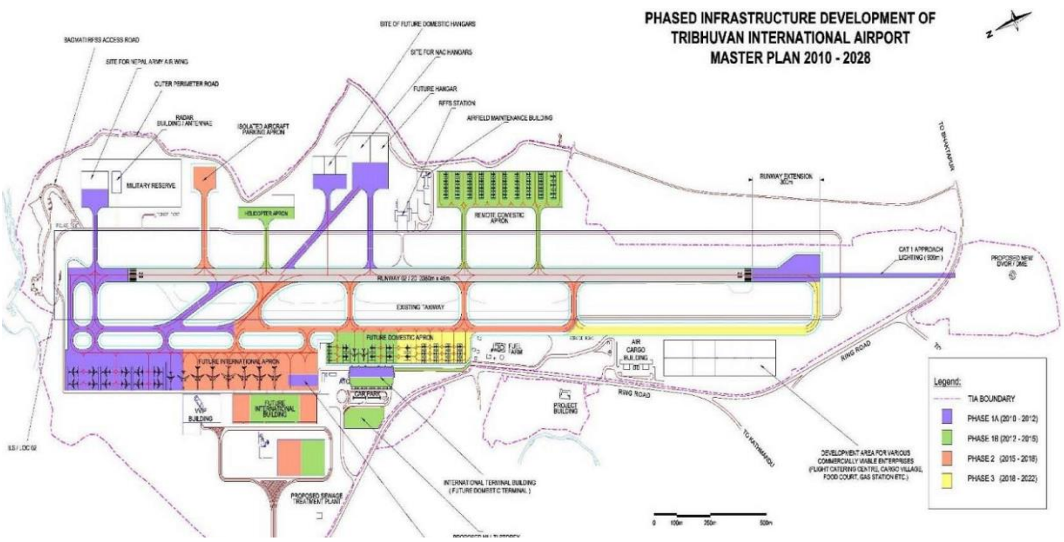
Therefore, in future along with development of air traffic control services and expansion of aviation safety equipment to meet increasing demand for air traffic, Japan look forward to assisting in enhancement of necessary personals through trainings and improving the training contents to meet required positions.

3. Status And Issues in Nepal Aviation Sector

(1) Capacity enhancement of airport in Kathmandu

1) TIA

Currently, the Air Transport Capacity Enhancement Project (ATCEP) and Transport Project Preparatory Facility (TPPF) project are in progress. The figure below shows the master plan of TIA from 2010 to 2028 which has been formulated in 2008. It includes runway extension, runway safety area extension, parallel taxiway and apron expansion.



(Source: CAAN)

Figure 6 Master Plan from 2010 to 2028

Initially, ATCEP was initially planned to be entirely funded by ADB, but the construction of No. 2 to 5 in Table 5 was awarded by a Spanish company through an international bidding for a single package, but the contract was canceled in 2016. After that, it will be carried out with the funds of CAAN, and it will be divided into 4 packages. The construction of 2 to 4 will proceed with domestic competitive bidding and 5 will proceed with international bidding. No. 6 is not included in ATCEP, but the procedure for development with ADB funds is in progress.

Table 5 Work Items of ATCEP

No.	Contract No. Progress	Contract Value	Contractor
1. Rehabilitation of Runway and Taxiways of TIA (Runway and taxiway repair work)	TIA/CED/ICB/01/2016-2017 Construction start date: 2018/11/12 Completion date: 2020/5/5	4.27 Billion NPR	China National Aero-Technology International Engineering Corporation
2. ITB Expansion, Reconfiguration and Associated Works at TIA （ITB expansion/renovation, new apron construction due to relocation of departure gate)	NCB-02 On progress Progress Rate 50% （2019/12）	0.77 Billion NPR	M/s Sharma-Prera-Ashish JV

No.	Contract No. Progress	Contract Value	Contractor
3. Utility Works at TIA	NCB-03 On Progress	0.19 Billion NPR	M/s Ashish-Prera JV
4. Runway Extension Works at TIA (Runway extension work)	NCB-02 Surface Course remain	0.84 Billion NPR	Kalika-Tundi JV
5. Apron and Taxiway Expansion Works at TIA (Apron and taxiway expansion work)	ATCEP/ICB-01R 2020/2Contract Preparation work		China National Aero-Technology International Engineering Corporation
6. Parallel Taxiway Extension Works (parallel taxiway extension work)	On progress of selection of ADB review Consultant		Under PQ evaluation

(Source: JICA Study Team)

2) Background of the Site Selection of Banepa Airport

The Banepa Airport was planned in order to ease the traffic congestion at the Tribhuvan International Airport by diverting the domestic short takeoff and landing (STOL) aircraft to this airport.

A suitable site was further selected by CAAN in 2018 from the four selected sites based on the comparison carried out with the list of 34 points on technical, social, environmental and biological

CAAN has prepared a detailed feasibility study (FS) for the Banepa Airport construction. The report consists of comparison of the two options for the runway length of 1200 m and 800 m. The summary of comparison of the two options (Option-1 and Option-2) is shown in Table 6.

Table 6 Summary of the Two Options

Characteristics	Option-1	Option-2
Runway dimensions	1,200 m x 30 m	800 m x 20 m
Airport area	34.84 ha（Approximate）	24.15 ha (Approx.)
Target aircraft	ATR-42/ Jetstream-41	DHC-6 Twin Otter
Airport code	2’C’	1’B’
Runway orientation	16/34	16/34
Future extension	Not possible	Not possible
Approach	Two ways	Two ways
Obstacles	No prominent obstacles	No prominent obstacles
Nearest airport	TIA（approx. 9 nmi）	TIA（approx. 9 nmi）
Runway longitudinal slope	1%	1%
Transvers slope	1% from RWY centerline	1% from RWY centerline
Apron area	31,540 m^2	21,170 m^2
Number of bays	16 for DHC 5 for ATR-42	20 for DHC-6
Boundary fence length	3,970 m	2,810 m
Maximum excavation depth	50 m	21 m
Excavation complexity	Hard rock may be encountered	Hard rock may be encountered
Earthwork excavation (total)	5,394,000 m^3	699,000 m^3
(Hard rock volume)	2,138,000 m^3	13,000 m^3
Earthwork in filling	108,000 m^3	457,000 m^3

(Source: Banepa Detailed FS)

3) Nijgadh International Airport Project

The Nijgadh Second International Airport is a project to build a second international airport in Nijgadh municipality, Bara District, about 60 km south-southwest of Kathmandu. In 2010, a FS was conducted by a Korean company (Landmark Worldwide Company). The airport construction plan is shown in Table 7 and the planned view after construction is shown in Figure

7. Completion date is not fixed.

Table 7 Overview of Airport

Aerodrome Reference Code		4'E'
Airport Area		40km^2 (4,000ha)
Runway		4,000m x 60m x 2sets, Bituminous Paved (Asphalt Concrete)
Stage Development	**Phase-Ⅰ**	Passenger 15mppa、Project Cost 650 million USD, Construction Period 4years
	Phase-Ⅱ	Passenger 30mppa、Project Cost 3,200 million USD, Construction Period 5years
	Phase-Ⅲ	Passenger 67mppa, Project Cost 6,700million USD, Construction Period 5years

(Source: CAAN)

(Source: CAAN)

Figure 7 Plan View of the Nijgadh Airport

The progress status of the current project is as follows, but the completion date is undecided.

Table 8 Work Progress of Nijgadh International Airport Project

Item	Work Progress	Note
Environmental Impact Assessment	Approved in May 2018	
Land Aquisition	On Progress （60%）	✈ Project Cost：NRs. 1.555 billion ✈ MoCTCA request Ministry of Land Management, Cooperatives and Poverty Alleviation for Resettlement Program, responding to 1495 squatters in the vicinity（5 January, 2020）
Civil Work	On Progress	✈ Project Cost：NRs. 150 billion ✈ MoCTCA request MOFE to take necessary measures for felling trees around the airport due to the construction of the airport. (28 November, 2019) ✈ Department of Forest and Soil Conservation request Division Forest Office to estimate felling tree numbers due to the construction of the airport. (12 January, 2020)
River Training Work	On Progress （60%）	✈ Project Cost：NRs. 250 million
Fonce Work	Complete	✈ Project Cost：NRs. 39.9 million

(Source: CAAN)

Fast Track project is part of National Pride Project of Nepal, which consist of construction of highway linking Kathmandudistrict and India. The Project will also serve as an access road connecting Nijgadh Airport with Kathmandu. The overview of the Project is shown inTable 9. The total length of fast track is 72.5 km (the original proposed was 76.2km). It includes construction of 87 bridges and 3 tunnels.

Table 9 Overview of the Fast Track Project

Features		Contents
a)	Carriageway and length	The expressway consists of a dual carriageway with double lane high design speed highway. Overall length is 72.5 from Khokana (Lalitpur) to Nijgadh (Bara) which interconnect the Kathmandu and Makwanpur districts in between.
b)	Tunnel	The expressway also includes a 1.35 km long twin tube tunnel. The proposed width of the tunnel is 11 m and 22 m in 2-lane and 4-lane, respectively.
c)	High bridges	The expressway consists of many high-rise concrete bridges connecting steep mountains in order to achieve a smooth gradient and gentle curve sustaining high design speed. This work makes use of the latest technology in bridging, tunneling, and highway construction engineering.
d)	EIA	A strict environmental consideration was implemented from the start of the project during planning, preliminary design, and alignment. Significant and frequent environmental impacts were examined in order to achieve dynamic output in environmental protection and impact mitigation measures.
e)	Status	Although the overall length had been calculated previously it is expected that a minor deviation could arise with the exact length, numbers and length of tunnels because of geographical, financial and technical factors during the final stages of detailed planning/DPR and during the implementation phase of the project. It is predicted that the travel time could be reduced to over an hour after completion.

(Source: Nepal Army（https://www.nepalarmy.mil.np/fasttrack/home）

(2) Development of Domestic Airports

The site survey of Gautam Buddha International Airport and Pokhara International Airport, which are implemented as National Pride Project, currently in progress are carried out and the present status and issues of the project are discussed. The domestic airport development plans in the Tarai area are summarized in Table 10.

Table 10 Plans for the Development of Domestic Airports

No	Airport	Plan
1	Gautam Buddha International Airport	Under Construction (scheduled to complete in 2020)
2	Pokhara International Airport	Under Construction (Scheduled complete in 2021)
3	Mahendranagar Airport	Master plan in progress
4	Dangadi Airport	Master plan done
5	Nepalgunj Airport	Master plan done
6	Simara Airport	No plan
7	Janakpur Airport	Apron expansion in progress
8	Biratnagar Airport	Master plan done
9	Chandragadhi Airport	Master plan done

(Source: JICA Study Team)

(3) Safety Improvement of the Mountain Airports

In Nepal, about one to two aircraft accidents (fixed-wing aircraft/ rotary-wing aircraft) occur every year. Most of these aircraft accidents occur at the mountain airports. Taking this in consideration, the study also includes safety improvement of the mountain airports, whereby the current status of airport facilities and aviation safety system at the six major airports were examined and based on that, issues are identified. In the process of the study, interviews were conducted with airline pilots, dispatchers, and traffic controllers of CAAN, and current situation and issues were grasped based on the results of the survey. Accordingly, four airports were prioritized among other six airports and field surveies were conducted at those four airports.

Ultimately, after analyzing the results of the field survey and interviews relating to the airport facilities and aviation safety systems, considerations for the improvement of mountain airport safety systems will be done.

In this survey, targeted mountain airports for grasping current situation and issues are shown in Figure 8.

(Source: JICA Study Team)

Figure 8 Airport Location of the Six Mountain Airports

Table 11 shows the number of passengers handled by each of the six mountain airports in FY2018.

Table 11 General Features of the Six Airports

Airport Name	Simikot	Rara	Jumla	Dolpa	Jomsom	Lukla
Annual passenger numbers (person)	54,261	19,360	14,163	19,352	46,401	124,929
Number of takeoff and landing (times)	13,960	2,360	1,588	1,556	3,209	31,636
Altitude (m)	2,971	2,720	2,375	2,804	2,736	2,846

(Source: CAAN)

As to the approach towards the selection of mountain airport field survey, interviews were conducted with CAAN's ATC and engineers, airline dispatchers and pilots, thereafter, the results were summarized as described in the above paragraphs.

Moreover, interviews were also conducted with the Director General of CAAN and Joint Secretary of MoCTCA from which the prioritization was made from the viewpoint of aviation policy in Nepal.

Results of interview with stakeholders are summarized in Table 12.

As per the result of the interviews, there were many common points with respect to recommendation made for airport facilities and aviation safety system made by ATC, engineers, and pilots. Those points are on the improvement of communication, installation of monitoring system, and provision for weather forecasting system.

On the other hand, from the perspective of aviation policy, airports in hinterlands with high tourism

demand should be prioritized for improvement of airport facilities and implementation of safety improvement measures.Additionally, looking at the history of aircraft accidents and number of casualties, Lukla, Jomsom and Simikot excluding Jumla, have high number of tourist arrival.
Based on this evaluation, the following are the four airports, where site survey will be conducted for examining the safety improvement measures: Simikot Airport, Rara Airport, Jomsom Airport, Lukla Airport.
For Jumla Airport and Dolpa Airport, where the field survey was not conducted, the materials obtained from CAAN had been summarized.

Table 12 Summary of Pilot Interview

		Simikot	Rara	Jumla	Dolpa	Jomsom	Lukla
ATC & Engineers	Communication	・No coverage of RCAG ・Flight between two airports could experience communication interruption of around 5-15 min. ・Congestion of network in the western part due to use of same frequency ・Poor quality HF makes it unusable					
	Navigation	・No navigation support facilities ・No survey regarding the validation of GPS and absence of backup					
	Surveillance	・Mountain airports are out of coverage of the airline surveillance radar (monitoring by ADS-B/ WAM/MLAT required)					
	Metrological	・Require high accuracy weather forecast equipment					
Pilot	Airport facility	・Runway extension	・Runway extension ・Overrun measures	・Runway extension	・Runway slope improvement ・Overrun measures	・Runway extension	・Runway extension ・Overrun measures ・Apron expansion
	Communication	・Need of reliable and un interrupting communication					
	Navigation	・Provide navigation data including topography information ・VFR flight route to be developed by CAAN ・Landing assistance facilities are required					
	Surveillance	・Mountain airports are out of coverage of the airline surveillance radar (monitoring by ADS-B/ WAM/MLAT required)					
	Metrological	・Airport weather forecast required					
		—	—	—	・Metrological forecast equipment ・Weather forecast information	・Metrological forecast equipment (esp. wind)	・Weather forecast information ・Metrological forecast equipment (esp. wind)
	Others		Difficulty in direct approach	Guidance light required			Guidance light required
CAAN DG, Dy. DG	Aviation policy	High tourist demand	High tourist demand	—	—	High tourist demand	High tourist demand
Number of Accident (cases)		7	1	3	3	2	8
Casualties (person)		7	—	18	3	18	32

(Source: JICA Study Team)

(4) Improvement of Aviation Safety System

Based on the results of interviews with pilots and visit to mountain airports, the following points are concluded, to improve the aviation safety system at mountain airports.

1) Communication

The VHF communication between the controller and pilot is not possible due to presence of dead zone for communication. In addition, the existing communication network to the mountain airport is done with HF communication that has poor sound quality or with telephone networks. Mostly, data necessary for control operation is exchanged by voice using the telephone.

2) Navigation

At mountain airports, there are no ground navigation support facilities such as VOR/DME, the VFR flights are flying with reference to GPS position information. However, the accuracy of GPS position information is not assured.

3) Surveillance

The existing surveillance radar has nocoverage in the northern mountainous are, so the flight position information of those flight in mountainous area cannot be tracked by the controllers.

4) Weather

There is no enough metrological equipment installed at mountain airports and since the installation of aviation weather radar is not completed, it is not possible to obtain efficient weather information for the mountain airport or en-route conditions for the safety of flight.

(5) Efforts in the Improvement of Airport Security

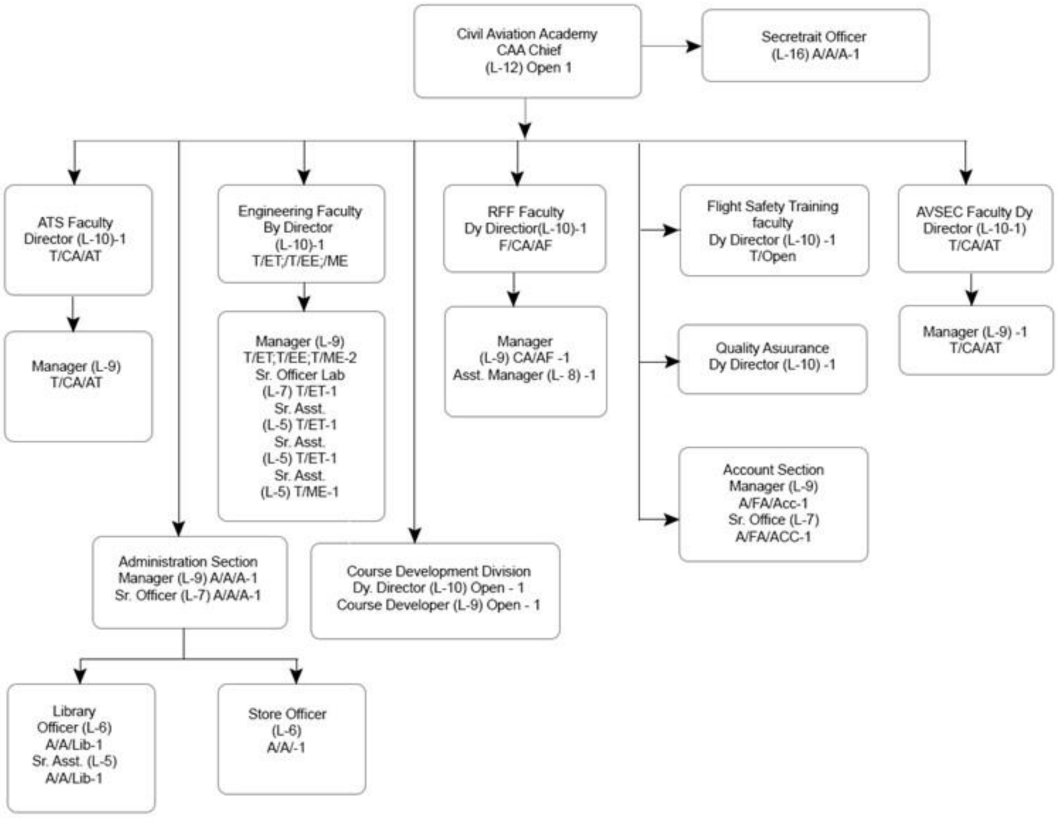
CAAN is updating its X-ray inspection equipment in line with the expansion of TIA's international passenger terminal. The upgrading of equipment includes introduction of dual-view X-ray inspection equipment (HS 100100T-2is, HS-6040-2is) that automatically detects explosives and liquids, which also promoted and improved the security of airport.

(6) Human Resource Development System of the Civil Aviation Agency of Nepal (CAAN)

CAAN constitutes the Human Resource Development Policy-2013/14 for the following purposes:

a) To examine in-house and abroad trainings regarding regulatory and service provider disciplines required for CAAN employees according to different service, group, subgroup and level categories in line with the objective of CAAN operation system establishment.
b) Nomination of suitable employees and ensure their participation in various appropriate studies, trainings, observation visits, conferences, or seminars in order to enhance their work efficiency and capacity.
c) To provide advice, as required, to concerned directorate and department for the formulation of training plan in a way that it can be of help to the employees in their career progression.
d) To enhance the effectiveness of service of CAAN by bringing about substantial reforms in the development of HR.
e) To record and manage different kinds of trainings, seminars or workshops in which CAAN employees take part in a unified way.
f) To develop the Civil Aviation Academy (CAA) to international standards by equipping necessary resources capable of conducting trainings relating to all disciplines required by CAAN as envisioned by the National Civil Aviation Policy 2063B.S.
g) To attract and retain the adequately trained manpower in CAAN, as one of the objectives of this policy.

Necessary trainings were categorized in the training program created in Dcember 2013, and timing of implementation, person in charge, and period of the training were considered. Although most of those trainings are carried out by CAA, it is considerd to be carried out by ICAO.
The predecessor of CAA is the Civil Aviation Training Center that has been operated since 1976, providing training mainly for Air Traffic Controller of Nepal in compliance to ICAO standard. CAA’s purpose is to provide high-quality trainings for the aviation sector professionals from in and out of Nepal.
Figure 9 shows the organization of the Civil Aviation Academy consisting of the Air Traffic Services Faculty (ATS), Engineering Faculty, Aerodrome Rescue and Fire Fighting Faculty, Aviation Security Faculty, Flight Safety Training Faculty (a total of five faculties), and Curriculum Development Division, Quality Assurance Division, Administration Section and Accounting Section.



(Source: CAAN)

Figure 9 Organization of the Civil Aviation Academy

(7) Improvements to Safety Audit

With the aim of satisfying ICAO safety standards, CAAN has tied up a technical cooperation program with the Republic of France on 14 September 2017 as MOU. This MOU is aimed for promoting bilateral cooperation for the newly developed Nepal's civil aviation sector effective for four years.
CAAN has been receiving support from the European Union (EU) and ICAO for safety audits and confirmation of flight operation and airworthiness. Besides EU and ICAO, CAAN has started cooperation relationship with Boeing and FAA.

(8) Organization of Accident Investigation Commission

The Aviation Accident Investigation Commission is formed in the Ministry of Culture, Tourism, and Civil Aviation and the commission members are assigned by the order of the minister once an accident occurred. Accident investigation is conducted by the commission members. Among the ICAO member states, accident investigation is conducted normally by the team of a nation, where the accident occurred, a nation where the accident aircraft is registered, a nation where the airline involved in the accident belonged to, and an Accident Investigation Commission in the state where the accident aircraft is designed and manufactured. However, in many cases, the accident investigation is conducted by the nation itself where the accident occurred.
In the case of Nepal's accident investigation, the members of the Accident Investigation Commission are required to cooperate with the investigation commission members of the accident aircraft manufacturer in order to exchange information. This requires the commission members to acquire a certain level of knowledge and experience in the accident investigation field.

The accident investigation report is submitted to the Minister of Culture, Tourism, and Civil Aviation by the Accident Investigation Commission. From the recurrence prevention point of view, the Accident

Investigation Commission would be required to submit a recommendation, which will be instructed to the airlines and related entities by the Minister. Thus, the Accident Investigation Commission members are formed by both aviation field members and other related members.
According to the Aircraft Accident Investigation Procedure Manual of CAAN established in July 2011, the serious accident with fatalities is investigated by accident investigation commission members selected from the following ten entities under the consideration of the Ministry of Culture, Tourism, and Civil Aviation. The accident with no fatalities is investigated by a team formed by the Chief Investigator's discretion so that the members are varied.

Table 13 Organization of Accident Investigation Commission

1.	Flight operations	**6.**	Structures
2.	Maintenance and aircraft records	**7.**	Systems
3.	Site survey	**8.**	Power plants
4.	Cabin safety	**9.**	Flight recorders
5.	Medical and Human factors	**10.**	Meteorology and Air Navigation Services

(9) Issues

The issues extracted in this chapter and the study policy in this survey are summarized in Table 14. The results of the preliminary study are described in Chapters 4-6.

Table 14 The issue and study policy of aviation sector in Nepal

Item	Issue	Study Policy
Airport Capacity Enhancement in Kathmandu Metropolitan Area	✈ The maximum runway capacity at TIA is nearing its limit. ✈ Even after the completion of master plan, handling capacity of airport in Kathmandu area will be insufficient due to limited runway capacity. ✈ Ramechhap airport located 150km from Kathmandu about 4 hours by road cannot serve as an alternative airport for TIA. ✈ Although the Nijgadh second international airport is planned to have two runways and annual passengers of 67 million to serve as a complement airport of TIA, it takes time to show the effect since some specialized work such as 1.35 km tunnel and bridges are included in the construction work of fast track connecting to Kathmandu.	As a measure to enhance the airport capacity of Kathmandu metropolitan area, it looks difficult to handle the aviation demand only by developing Lamechhap Airport and Nijgadh second International airport as alternative. The construction of Banepa domestic airport seems to be effective solution. On the other hand, issues related to construction of Banepa domestic airports as described in 3.1.3, measures to improve the airport capacity in the Kathmandu metropolitan area including measures for Banepa domestic airport development is described in Chapter 4.
Enhancement of Domestic Air Transportation	✈ After the start of operation of Pokhara International Airport and Gautam Buddha International Airport, some passenger using TIA are expected to use those airports. This will increase the air traffic demand in Nepal rather than complementing TIA. ✈ Airports in Terai region are being developed according to the airport master plan created by each airport, and it is expected that domestic operator will be using bigger aircrafts with the increase in domestic demand. ✈ Airports under construction by CAAN are in the mountain region with runway length of 700m or less. Due to this, if regular flights come to those airports, aircraft which can be operated will be	When working on the capacity enhancement of Kathmandu area, the situation listed on the left will be reflected.

Item	Issue	Study Policy
	STOL aircraft.	
Improvement of Mountain Airport Safety (Issues for airport facilities)	✈ Many of the present mountain airport have runway length of 700m or less, which is not enough for the STOL aircraft's takeoff and landing. ✈ Additionally, the distance from end of the runway to end of the runway strip can hardly be secured at some airports.	At mountain airports, it is difficult to extend the runway due to topographical condition, but consideration for extending runway as much as possible are described in Chapter 5.
Air Navigation Facility Issues (Communication)	a) VHF communication Dead Zone ✈ Between Nepalganj-Simikot, Pokhara-Jomsom, Kathmanu-Lukla, there are dead zones for VHF communication, where air-to-ground communication cannot be performed. This led to pilot without information on surrounding aircraft and weather data to ensure safety during flight and while landing. ✈ Two sites for installation of RCAG have been selected in the preparatory survey of grant aid project "Main Airport Aviation Safety Equipment development plan". Although it was not adopted in the end, the confirmation for the range of VHF communication for the elimination of current dead zone on the selected site was verified.	In order to improve VHF communication at mountain airports and their surrounding airspace, consideration for installing RCAGs at locations that can cover major airports is discussed in Chapter 5.
Air Navigation Facility Issues (Communication)	b) Lack of communication line to mountain airports ✈ The information exchange between the mountain airport and base airport are performed by poor quality HF communication and telephone line. Since HF communication has lots of voice breakages, the necessary information is notified and acquired through telephone line. ✈ At mountain airports, AMHS lines are not available except for some airports. Therefor, flight information and weather information are reported only by voice, the amount of information is limited, accuracy and timeliness are lacking.	Currently, there is no communication line other than telephone lines for communication between airports. In Chapter 5, consideration for the introduction of digital HF including securing a backup communication line, and depending on situation, diversion of ground-to-air communication depending on the situation are discribed.
Air Navigation Facility Issues (Navigation)	✈ Since radio waves do not reach the mountainous areas, navigation assistance facilities such as VOR / DME cannot be used, and it is difficult to install similar ground navigation assistance facilities. ✈ Due to this, VFR aircraft uses GPS information as a reference. However, the GPS accuracy in Nepal is not guaranteed to be used at a level for aircraft navigation. Therefor, it is necessary to verify the GPS accuracy and introduce a position accuracy supplementing system. ✈ In mountainous areas, it is necessary to be able to fly while ensuring a safe distance between aircrafts and between aircraft and topography.	GPS information has an error, and further accuracy is required for flight operations. Therefore, the introduction of SBAS, which is a system to reinforce GPS accuracy, will be discussed in Chapter 5.
Air Navigation Facility Issues (Surveillance)	✈ The enroute surveillance radar currently in operation does not cover the northern mountainous areas. ✈ Regarding the installation of ADS-B under the guidance of ICAO, most of the aircraft operating in the mountainous airport are not equipped with ADS-B related systems, Therefor, it is difficult to use ADS-B for aircraft surveillance in the northern mountainous areas at present. ✈ There are steep mountains around the mountain airport, and the visibility range is often limited. ✈ The introduction of the conventional monitoring system is not considered realistic because there are	Consideration for the introduction of surveillance system that also has a WAM function, such as MLAT in Japan, to mountain airport is necessary. It is discussed in Chapter 5.

Item	Issue	Study Policy
	problems in acquiring a place to install airport radars, transporting equipment and materials for installation work, and labors.	
Air Navigation Facility Issues (Weather)	✈ <u>Shortage of Human Resources:</u> DHM has assigned staff at TIA to observe weather and provide weather information. But due to limited personnel, air traffic controller is acting for the weather observation at the mountain airport. The number of airports which are sent professional staff for weather observation from DHM is limited, and it is under the situation that wether obsercation can not be conducted based on the specialized viewpoint. ✈ <u>Lack of Metrological Equipment:</u> Wind direction / velocity, temperature, and hygrometer are installed at mountain airports, but other observation devices and devices to grasp changes in weather conditions are not installed. Since changes of weather situation, accidents and flight cancellation have occurred due to deterioration of weather conditions along the flight route and changes in weather conditions around the destination airport. ✈ <u>Lack of Weather Forecasting Technology:</u> Due to the lack of observational data from the meteorological instruments around mountain airports, it is difficult for DHM to construct a forecasting model. Above all, at mountain airports, it is very difficult to predict the weather condition due to the unique topographical characteristics around each airport. Building a unique weather prediction model requires a large amount of data collection and a research period for model building.	At present, DHM is introducing meteorological observation systems at 88 locations nationwide. The system is planned to be installed at some airports, but it will be necessary to install these systems at mountain airports in the future and automatically acquire weather data around the airport For the airport where the weather condition changes drastically, a small doppler radar or wind shear sensor installation needs to be considered to detect changes in weather condition and inform pilot about the condition to improve safety. It is further discussed in Chapter 5.
Improvement of Air Navigation System	✈ Regarding the maintenance of aviation security systems, it is necessary to consider facilities and functions that not only improve safety but also improve efficiency of air traffic control and increase the capacity of TIA.	Consideration will be made for introducing an aviation security system that will contribute to the expansion of TIA capacity. Especially for TIA where ILS cannot be installed, consider GBAS with flexible landing system. Additionally, it is important to examine compatibility and effectiveness of new flight procedures using those ground facilities.
Improvement of Air Navigation System (Expansion of Radar Coverage to Western Nepal)	✈ Most of central Nepal is within the radar coverage area, but the mountainous area and western Nepal (Tarai Plain) falls under blind areas. ✈ There are distinct routes for international flights and domestic flights in this area, the problem is that some areas along those routes are not within the radar coverage area. ✈ Regarding the monitoring of high-altitude air routes in the same area, there are currently four ADS-B stations installed, and it is considered that there is no problem because all aircraft flying the air routes are equipped with ADS-B. However, due to mixed operation of aircrafts with ADS-B and smaller aircrafts without it, it causes the surveillance ineffective in the range of low-	To solve this problem, it is necessary to obligate all aircraft operating over this region to install ADS-B, so that even low-altitude around the airport in western part can be monitored. However, there is an issue of cost allocation, other means also need to be considered.

Item	Issue	Study Policy
	altitude air routes and around airports.	
Improvement of Air Navigation System (Development of Information Network)	✈ Currently, the Civil Aviation Authority of Nepal does not have a network that centrally manages information necessary for air traffic control such as flight plan information, weather information, and aircraft position information. For this reason, the ACC (Area Control Centre) and the controllers at each airport cannot share the necessary information, and the controllers cannot provide the necessary information to pilots and airlines ✈ Obtaining meteorological information during the flight is an important issue, but it is also a big issue in obtaining appropriate meteorological information before flight, and it is necessary to take some measures to reduce error in assumed judgements of pilots.	It is necessary to consider how to connect each airport in Nepal and obtain weather information at the destination airports easily.
Improvement of Air Navigation System (Visibility from ATC Tower at TIA)	✈ The ATC tower at TIA lacks visual coverages of domestic apron. If the controller lacks visibility, it will be difficult to guide when traffic is crowded, which will affect smooth arrivals and departures. In addition, it is important for the controller to confirm the position of the aircraft, which leads to not only improvement in efficiency but also improvement in safety.	Since the improvement of efficiency could help in enhancement of TIA capacity, it is important to consider measures for these issues.
Improving Airport Security	✈ The improvement of security equipment is in progress at TIA and major domestic airports but not yet at mountain airports. ✈ Although TIA security devices are being updated, it is desirable to install more advanced devices in the future.	In the medium to long term, it is desirable to improve security equipment at mountain airports and upgrade security equipment at international airports.
Capacity Development of Human Resources of CAAN	✈ Although initial trainings were conducted at 4-storey training facility at TIA, which collapsed because of the 2015 earthquake, the CAA (Civil Aviation Academy) set through JICA project is in use, but it is too small. A new training facility is under construction, which will be started operation by 2022. ✈ The curriculum for the first-time employees is based on that of Singapore Academy and other institutions as references. CAAN requests Japan to support the curriculum development for the administrative employees training, excluding Air Traffic Controllers and Fire Extinguishing Rescue Worker	It is necessary to identify the background education of those being hired as CAAN staff and consider implementing consistent education starting from hiring to management and to retirement.
Features of Civil Aviation Academy	✈ There is a shortage of resident instructors. ✈ Training materials which follow the purpose and curriculum fully lead less preparation work of resident instructors, and also it will be possible that any eligible instructor can provide the standardized level of trainings. Since CAAN and CAA received the membership of ICAO TRAINAIR PLUS program, it is believed that they can prepare appropriate training materials. Forming a project team for training materials temporarily would be recommended because skills for setting up new training materials and modifying them can be improved by concentrated hands-on jobs. ✈ Due to less opportunity to learn aviation technology, CAAN staff has a request to get more opportunities to attend training and seminars. The	Consideration for the investigation of the CAA training items and see whether proper training is provided for each occupation. Also, confirm the implementation status of the training in which Japan is providing technical cooperation. Regarding the lack of training, it is necessary to consider the possibility of implementing under the JICA scheme and make a proposal.

Item	Issue	Study Policy
	need for SMMS training is particularly high.	
Improvement of Safety Supervision Function	✈ Within CAAN's organization, there is a safety regulation department that sets standards, but no department or agency to control or oversees auditing those works. In order to implement properly safety management, the ICAO has proposed the establishment of a regulator, which is an organization that audits the business situation from the aspect of safety management, in addition to the agency that is said to be a provider of air traffic control. ✈ Currently, MoCTCA and CAAN are newly installed as the Air Service Authority of Nepal (ASAN) and are considering the separation of responsibility between rule-making department and safety auditing department in the future. ✈ CAAN has challenges to clear safety standards provided by ICAO as soon as possible and to establish the function of regulator as a new entity.	Although CAAN is considering the organizational restructuring of regulators and providers, it will be needed to investigate the status of the establishment of the new organization and whether it can carry out its work smoothly. Depending on the situation, consideration for the need of technical cooperation will be seen.
Aviation Accident Investigation/Recurrence Prevention Measures	✈ Since there is no analysis device for FDR (Flight Data Recorder) or CVR (Cockpit Voice Recorder), the analysis is either outsourced to the aircraft manufacturing country or consider technical cooperation of France. ✈ There is need for the human capacity who receive training for the development of tools related to accident investigation, regarding accident investigation methods, there are some needs of training in Japan. ✈ There is no systematical follow-up from MoCTCA, CAAN or airlines, on the recommendation for accident recurrence prevention system as a part of the results in an accident investigation. ✈ While an accident investigation has been conducted, no incident investigation has been done. In the future, both accident and incident investigation are to be surveyed in order to manage setting recurrence prevention measures.	Analysis of the past accident investigation reports and confirmation regarding the implementation status of accident investigation techniques, management, and recurrence prevention follow-up is carried out. It is also necessary to consider technical cooperation regarding accident investigation.

(Source: JICA Study Team)

(10) Consistency in National Development Plans and Measures

The national development plan of Nepal shows issues and implementation policies for each sector. Regarding the aviation sector, they intend to improve the safety, reliability, and convenience of aviation services in Nepal, thereby stimulating the demand using aviation services domestically and internationally and leading to economic growth in Nepal. In addition, it is also serving as important social connections securing traffic routes to remote areas where land traffic is unavailable.

1) Improvement of Aviation Services

In the recent year, increasing airport capacity to meet the rapidly increasing air demand and improving customer service at airports and with airlines are recognized as challenges.

<u>Enhancement of Airport Capacity</u>

The on-time completion of ongoing Gautam Buddha International Airport project and Pokhara New international Airport project is urgent task and one of the important goals.
In addition, the expansion of TIA and the construction of the Nijgardh Second International Airport are in progress to meet the air traffic demand in Kathmandu, but the expansion of the current TIA airport is not sufficient, and the huge capital investment and securing access road are

required for the Nijigardh Second International Airport. Therefor, consideration for the construction of domestic airport within Kathmandu area was also made.

Improve customer service at airport and with airlines

Just like the airport construction projects, it is considered to utilize PPP scheme for the operation of local airport. It is also mentioned to operate rocal airports which are important for both society and tourism for 365 days and improving accessibility through providing the aviation service between regional airports.

2) Safety of Aviation Services

In Nepal, there are constant number of aircraft accidents, and one of the goals is to eliminate them. Regarding the improvement of aviation safety, efforts are being implemented by introducing the latest CNS (communication, navigation, surveillance) related equipment and facilities. At the same time, efforts to improve aviation safety monitoring system satisfied with international standard are considerd.

In addition, they aim to reduce future accidents through applying lessons learned from accidents obtained by investigations in systematic, effective, scientific, continuous and neutral methods.

Regarding security, the main goal is to improve the security check system at an international standard.

3) Improve Reliability of Air Services

Implementing a scheduled flight operation is mentioned in the national development plan. There is no clear reference in the national development plan regarding the cause analysis and effects the scheduled operation. However, the congestion at TIA of the domestic hub causes delayed flight operation.

Further aviation demand is expected by implementing measures to expand airport capacity to meet aviation demand, mitigating congestion at major airports and improve customer service, and improving aviation service safety for on-time operation.

Furthermore, under the Civil Aviation Act of Nepal, it is expected that the CAAN will be divided into operators and regulators to improve the operational efficiency and the professionalism of staff, and this will lead to improvement of operational efficiency and high professionalism. In addition, the Government of Nepal will develop a strategy for national air transport agreements, thereby signing aviation agreements with new countries, or through diplomatic routes to facilitate entry into international markets not served by Nepalese airlines. Thanks to this, it aims to improve Nepal’s economy by increasing number of tourist and profitability of Nepalese airline.

In addition to these sector-wide growth strategies, in national development plan, the Remote Area Air Transport Fund will be effectively used to secure important air routes to improve access to remote area which can not be expected profit.

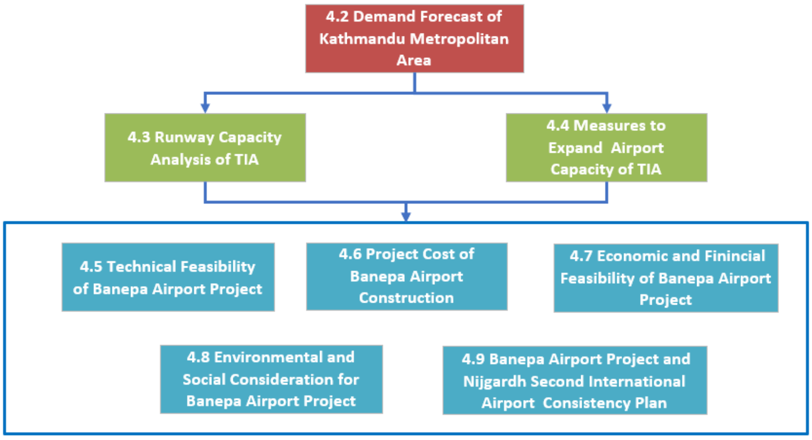
Based on these policies of government of Nepal, following chapters contains improvement of air services, follow-on project such as Gautam Buddha International Airport, Pokhara New International Airport and Nijgardh Second International Airport which is under planning phase. Also, verification will be done for the construction possibility of Banepa domestic airport which has been examined by CAAN.

As per the history of Japan’s support until now, analysis will be made on the aviation safety and room for improvement of security check systems, then Japan’s future support plans will be considered.

4. Preliminary Study for the Capacity Enhancement of Airport in Kathmandu Metropolitan Area

(1) Overview

In this chapter the measures to towards enhancement of airport capacity of Kathmandu Metropolitan Area will be examined as per the flow shown in Figure 10, to the issues that are described in chapter 3. The project proposals in this report, including project scope and project cost, should be reviewed at the further study for project formulation.



(Source: JICA Study Team)

Figure 10 Flow on the Measures to Enhance Airport Capacity in Kathmandu Metropolitan Area

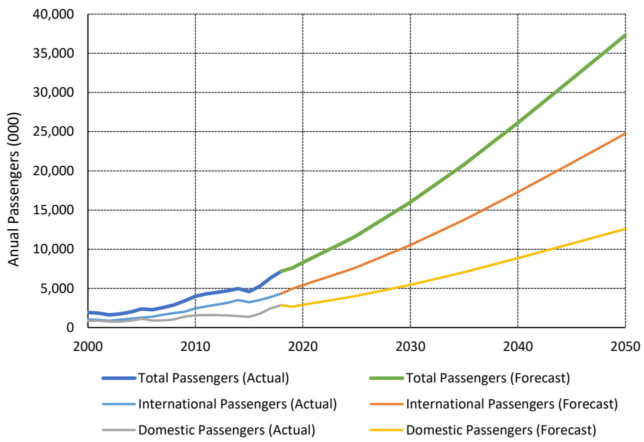
(2) Air Demand Forecast in Kathmandu Metropolitan Area

The annual air passenger demand is estimated based on the forecast model and future GDP as shown in Table 15 and Figure 11.

Table 15 Annual Passenger Forecast

	International Passenger		Domestic Passenger	
	Passenger (1000 person)	Annual Growth Rate	Passenger (1000 person)	Annual Growth Rate
2018 (actual)	4,342		2,848	
2030	10,531	7.7%	5,459	5.6%
2040	17,281	5.1%	8,844	4.9%
2050	24,747	3.7%	12,587	3.6%

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 11 Passenger Demand Forecast

Table 16, Table 17, and Table 18 show the design day movement and the peak hour movement based on the peak characteristic analysis.

Table 16 Peak Movement (International Flight)

	2030	2040	2050
Design Day Movement (times/day)	181	269	386
Peak Hour Coefficient	0.080	0.080	0.080
Peak Hour movement (times/hr)	14	22	31

(Source: JICA Study Team)

Table 17 Peak Movement (Domestic Flight)

	2030	2040	2050
Design Day Movement (times/day)	328	509	660
Peak Hour Coefficient	0.093	0.093	0.093
Peak Hour movement (times/hr)	31	47	61

(Source: JICA Study Team)

Table 18 Peak Movement (Domestic + International)

	2030	2040	2050
Design Day Movement (times/day)	509	778	1,046
Peak Hour Coefficient	0.086	0.086	0.086
Peak Hour movement (times/hr)	44	67	90

(Source: JICA Study Team)

(3) Analysis of Runway Capacity of TIA

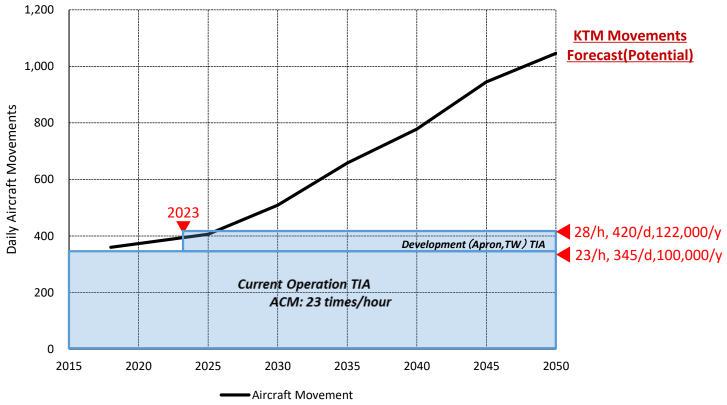
The design day aircraft movements at TIA is estimated as in Table 19.

Table 19 Design Day Aircraft Movements

	2018 (Actual)	2025	2030	2035	2040	2045	2050
International	109	133	181	236	269	329	386
Domestic	251	273	328	422	509	616	660
Total	360	406	509	658	778	945	1,046

Note: Unit, Movement/day
(Source: JICA Study Team)

The runway capacity of TIA is expected to increase from current 23～24 times/hour to 28 times/hour when parallel taxiway is completed. If the peak duration is 15 hours/day, current processing capacity is 345～360 movement and 420 movement when parallel taxiway is completed. However as shown in Figure 12, the aircraft movement demand will reach the runway capacity by around 2025.



(Source: JICA Study Team)

Figure 12 Relationship between Aircraft Movement and Runway Capacity

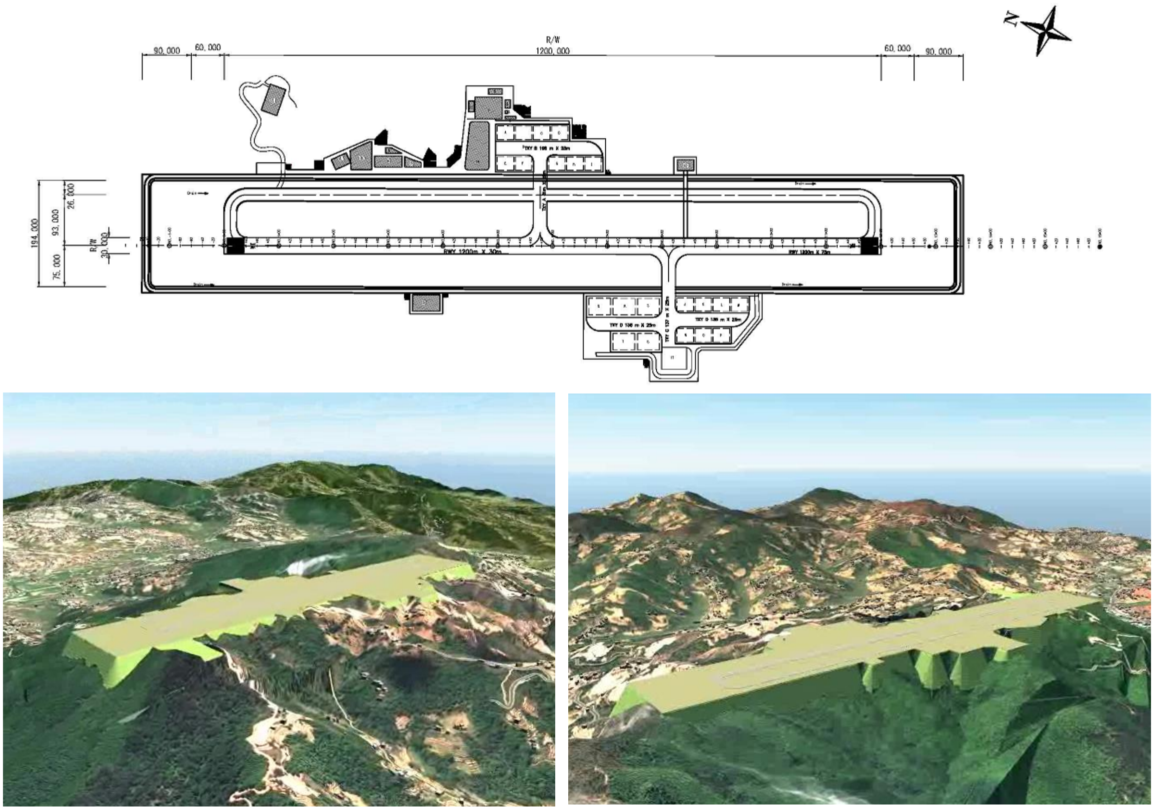
(4) Technical Feasibility of Construction of Banepa Airport Project

Under conditions of construction of Banepa International Airport, earthwork volume was calculated to satisfy the necessary runway strip and RESA in case of ICAO Airport Code 3C. It was also examined under to balance the cut volume and fill volume so that the soil will not be carried out outside the airport site. Calculation result is shown in Table 20. The runway longitudinal slope and cross slope were set as levels. The slope of embankment is 1:0.3.

Table 20 Earthwork Volume Calculation Result (Airport Code 3C, Parallel Taxiway)

	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m） Airport Code 3C Parallel Taxiway	4,198,851	3,877,949	EL=1808m, RW slope Level

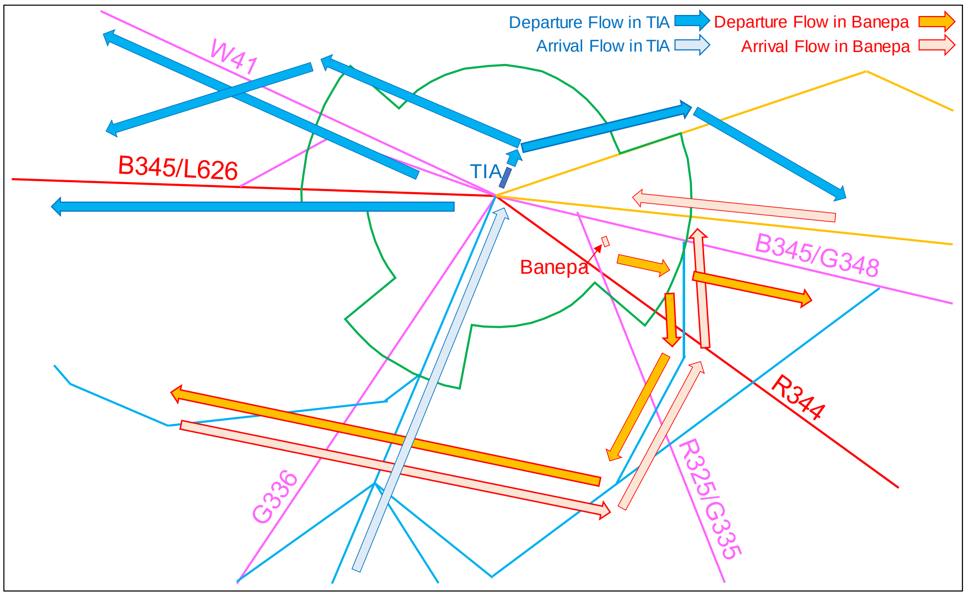
(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 13 Banepa Airport Bird's-eye View（RW1,200m, Parallel Taxiway）

Considering the construction of Banepa Airport, since it is located in the terminal area of TIA, it is necessary to take into account airspace setting and departure/arrival routes for both airports.
First, assuming that the current terminal area does not change, it is necessary to divide the eastern low altitude zone of TIA around Banepa Airport into the airspace for Banepa Airport.
If the airspace for both TIA and Banepa Airport are operated separately due to the reorganizing of airspace, the assumed departure/ arrival routes at each airport are as shown in Figure 14. Since Banepa airport is basically allocated for smaller aircraft and small turboprop aircrafts, it is assumed that the altitude zone for the operation will be low. In addition, as the location of Banepa airport is towards the east side of TIA, the departure/arrival aircraft from/to Banepa Airport can be operated without disturbing the traffic flow of aircraft operating from TIA, by using east side airspace for incoming and outgoing flights.



(Source：JICA Study Team)

Figure 14 Possible Departure/Arrival Routes at TIA and Banepa Airport

(5) Project Cost of Banepa Airport Construction Project

Table 21 shows the approximate construction cost at Banepa Airport site. The construction cost shown below was estimated as a preliminary study based on the CAAN Detailed FS.

Table 21 Estimated construction cost of Banepa Airport (option-1)

S. NO	Work Item	Option-1 ('000 NRs)	Remarks
A	General	75,561	
B	Earth Work	5,621,076	Cut Volume 4,000,000m^3 10% soil, 80% soft rock and 10% hard rock Fill Volume 3,600,000m^3
C	Pavement Work	619,489	Asphalt Pavement 105,000m^2
D	Drainage Work	843,000	
E	Boundary Fence Work	91,177	
F	Miscellaneous Work	23,855	
G	Road and Parking Work	1,200,000	
H	Building and Utility Work	3,046,185	
I	CNS/ATM	1,695,000	
	Total of Construction Cost	13,215,343	
	Contingency (10%)	1,321,534	
	VAT (13%)	1,717,995	
	Total of Construction Cost	16,254,872	
	Consultant Cost	528,614	
	Contingency (10%)	52,861	
	VAT (13%)	68,720	
	Total of Consultant Cost	650,195	
	PIU (Management Cost)	550,000	
	Total of Construction and Consultant Cost	17,455,067	

	Total of Construction and Consultant Cost (Japanese Yen)	16,756,864	1NRs=0.96JPY

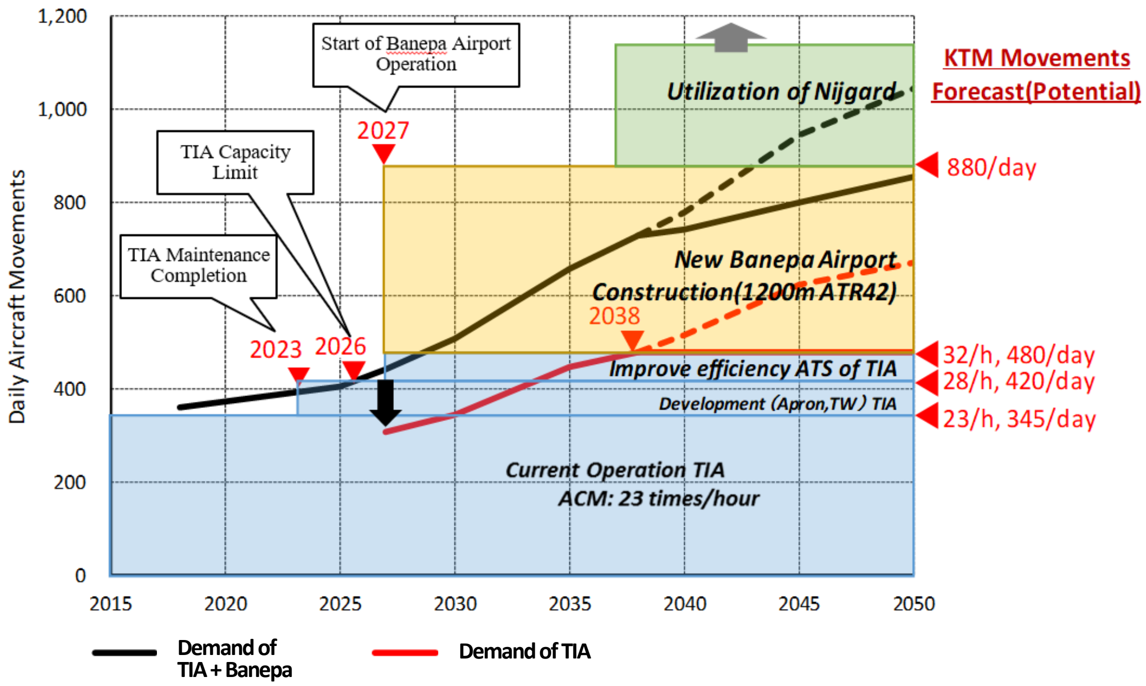
(Source: JICA Study Team)

(6) Financial and Economic Viability of Banepa Airport Project

1) Project Scenario

The project development scenario of Banepa Airport is set as follows. Figure 15 shows the relationship between air traffic demand and capacity of airport facilities in Kathmandu area. As for the capacity of airport facility, since the bottleneck are brought by peak hour aircraft movements and runway capacity, design day aircraft movements is used for this study.

i. Aviation demand in Kathmandu metropolitan area is growing steadily
ii. In 2023, expansion work of apron, parallel taxiway, and international passenger terminal building will be completed.
iii. As shown in Figure 15, as for the future aviation demand in Kathmandu metropolitan area, the capacity of facilities of TIA will reach the limit due to runway capacity in 2026 (construction of second runway is impossible due to difficulty in land acquisition).
iv. By starting the operation of Banepa Airport in 2027 and aloocating domestic flights withSTOL aircraft and ATR42 to Banepa airport, mixture of STOL aircrafts and jet/propeller aircrafts, which prevent from runway capacity of TIA improving, will be mitigated. In addition, by improving the ATS of TIA, air control system will be optimized and runway capacity will also increase. In other words, carring out those two projects, one is development project of Banepa airport and the other is improvement of the ATS of TIA, will bring large effect. Figure 15 shows expectedproject effect forthe airport facility capacity.
v. Banepa Domestic Airport has capacity to handle the aviation demand until 2050. On the other hand, TIA will reach its runway capacity limit in 2038.
vi. After 2038, it will be necessary to share the operation with Nijgardh International Airport and handle the total aviation demand in Nepal.



(Source: JICA Study Team)

Figure 15 Relationship between capacity increment and demand for arrival and departure

Table 22 Outcome Forecast

Project	Specification	Expected outcome
Construction of Banepa Domestic Airport	Serve STOL and ATR42 class Aircraft R/W1200m, For ATR42	ACM 400/day
Improve ATS at TIA	Flight Procedure Design (Missed approach, Flight interval, etc.,), Improve runway handling capacity	ACM 4/h,60/day, 18,000/year

(Source: JICA Study Team)

2) Outcome of Economic Analysis

The summary of the result of economic analysis of the project are as shown in Table 23. The result shown below was calculated based on the estimated construction cost stipulated in Table 21.

Table 1.1-23 Summary Result of Economic Analysis

Items	Calculation Result	
	Case A（TIA+Banepa）	Case B（Only Banepa）
Economic Internal Rate of Return（EIRR）	20.7%	22.5%
Economic Net Present Value（ENPV）	113,484 million NPR	23,396 million NPR
Benefit Cost Ratio（BCR）	4.97	4.54

(Source: JICA Study Team)

3) Outcome of Financial Analysis

The summary of results of financial analysis are shown in Table 24. The result shown below was calculated based on the estimated construction cost stipulated in Table 21.

Table 24 Summary Result of Financial Analysis

Items	Calculation Result	
	Case A（TIA+Banepa）	Case B（Only Banepa）
Financial Internal Rate of Return（FIRR）	10.2%	‐5.5%
Financial Net Present Value（FNPV）	2,057 million NPR	‐11,968 million NPR
Benefit Cost Ratio（BCR）	1.01	0.20

(Source: JICA Study Team)

(7) Environmental Impact Assessment of Nepal

In Nepal, before the implementation of projects, it is required to either carry out Initial Environmental Examination (IEE) or EIA based on the project type. When the Environmental Protection Act (EPA(1997)) was formulated in 1996, and Environment Protection Rule (EPR(1997)) was formulated in 1997, the legal framework for Environmental Impact Assessment was created.
EPA (1997) and EPR (1997) stipulate the EIA approval process, projects which are required IEE or EIA preparation.
Initial Environmental Survey (IEE) applies to small project with relatively small environmental impacts as described in EPR (1997) attachment 1. In the IEE, TOR of survey is formulated, the impact on the environment is investigated and analyzed according to the TOR, and then takes mitigation measures. The IEE report is submitted to the relevant authorities for approval.

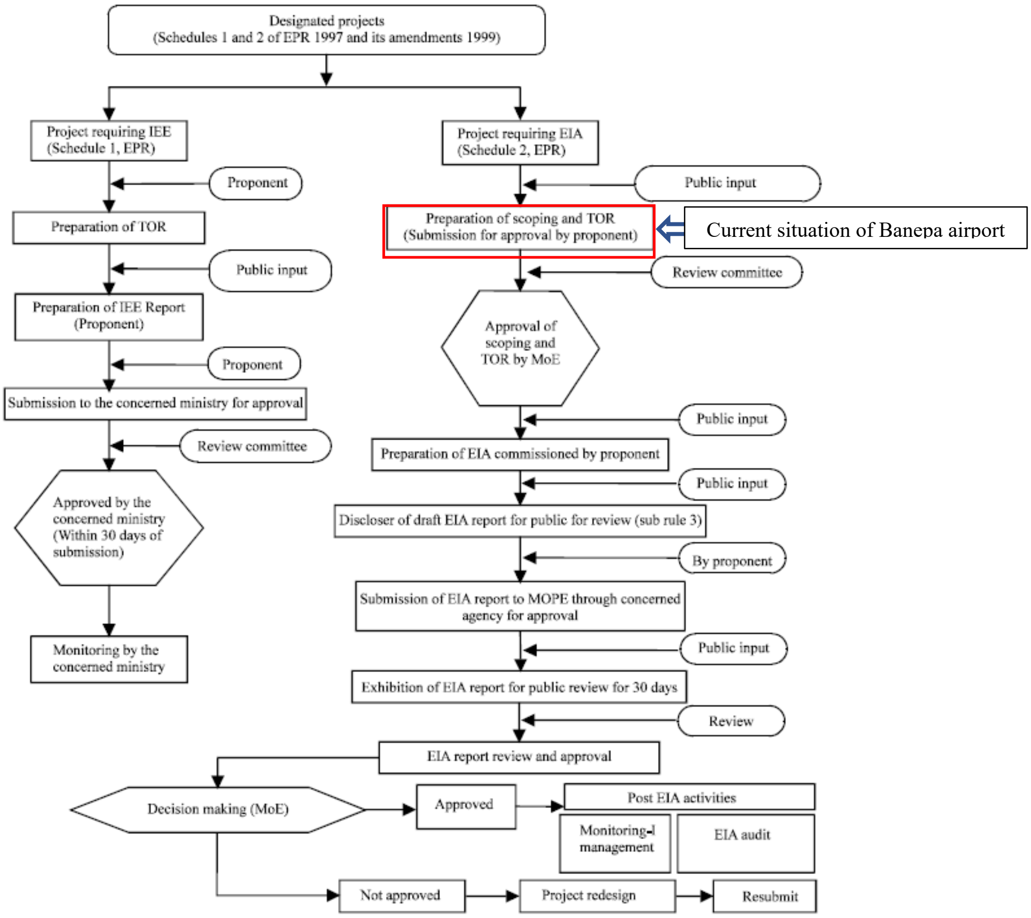


Figure 16 Flow of EIA in Nepal

CAAN is proceeding with the EIA procedure for Banepa domestic airport, and in 2018, the TOR and scoping document were prepared and submitted to the Ministry of Forests and Environment, which is the responsible agency, for approval.
The categories of the “Japan International Cooperation Agency Environmental and Social Considerations Guidelines” (hereinafter “JICA Guidelines”) are as follows.

Applicable Guideline：JICA Guidelines (April 2010)
JICA Category classification: A
Classification basis: As it corresponds to the “airport sector”, which is a sector that has a high impact in the JICA Guidelines, it is necessary to consider the following items when implementing the project.

(8) Consistency with coming up of Nijgadh second International Airport

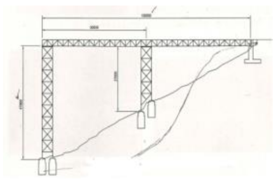
The viability of Nijgadh Airport to serve as an alternative international airport of TIAdepends on the completion of Fast Track. While it seems that earthwork is being started, construction work on structures such as bridges and tunnels has not started yet, and it is expected that it will take at least 10 years to complete.
Hence, it is assumed that it is not function as an alternative airport for TIA whose handling capacity will exceed its limit by 2023.

5. Preliminary Study of Measures Related to Improving Safety of Mountainous Airport

(1) Study on Facility Improvement Plan

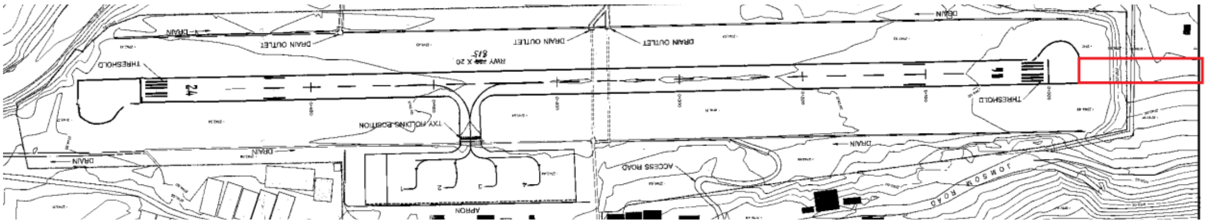
During the study three airport are prioritized for the requirement of improvement of facilities, those airports are Lukla, Jomsom, and Simikot. The possibility of runway extension was examined, and the results are summarized in Table 25.

Table 25 Summary of Runway Extension of Mountain Airport

	Lukla Airport	Jomsom Airport	Simikot Airport
Current Runway Dimension & Orientation	530m x 20m 06/24	815m x 20m 06/24	650m x 20m 10/28
RWY Extension Direction & Extension Length	RWY06 side 100m and 30m wide	RWY06 side 100m and 80m Wide	Both RWY10 and RWY28 side 100m each and 80m Wide
Method of Extension	Steel Structure 	Embankment	Embankment (RWY28 side) Cutting (RWY10)
Estimated cost	4 BillionNPR or More	230 MillionNPR	600 MillionNPR
Transportation of construction materials	There are no roads, needs to be transported by helicopter with capacity to lift 3 tons(total weight of steel is 2,500 tons).The transportation can be made in 850 trips, if five trips per day, it takes 166 days to complete (but considering provision of efficiency 230 to 250 days is needed). The timely maintenance after every 50 hrs and 100 hrs are required, thus, another spare helicopter is may be needed for spare part transportation.	The road is connected from Pokhara to Jomsom, and materials and equipment can be transported by vehicle. Embankment materials can be procured locally.	Roads are connected from the Chinese side, and materials and equipment can be transported from China. Embankment materials can be procured locally.
Challenges	In addition to runway length other issues existing are shortage of apron spots and insufficient width of runway strip, but its difficult to expand current facilities	Land acquisition required for runway extension	Land acquisition required for runway extension
Evaluation of runway extension	Aprons and Landing area are difficult to expand, and it is desirable to build a new airport in another location	It is desirable to extend the runway	It is desirable to extend the runway

(Source: JICA Study Team)

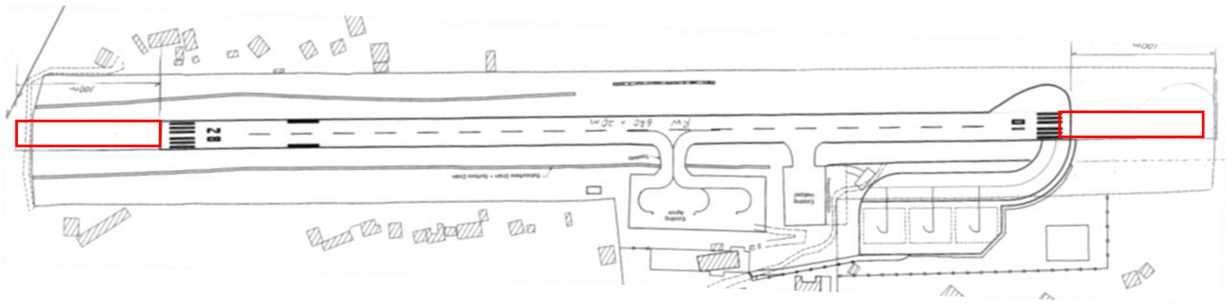
Lukla Airport has a steep topography at the side of runway extension allowing construction provision of landing strip width of about 30m. In addition, there are many issues during transportation of materials, moreover, it will cost 4 BillionNPR to extend the runway 100m. Since it is not a fundamental solution for improving facilities as there is difficulty in expanding current airport facilities such as apron due to limited land, it is desiable to construct new airport around the neaby ridge.
As for the Jomsom Airport, there is a river very close to RWY24 side, making it difficult to extend. For extension in RWY06 side, there is space for the extension, which is currently assumed for around 100m possibility. However, since the extension area is outside the boundry of airport, it is necessary to acquire the land.



(Source: JICA Study Team

Figure 17 Runway Extension Plan of Jomsom

For Simikot Airport currently the runway length is 650m and the runway strip width is around 30m on either side of runway centerline. The runway can be extended for about 100m on both RWY10&28 side of runway.
Since there is stream in the direction of RWY28 side it is necessary to introduce culvert such as box culvert. Also, since some area of runway extension falls outside the current airport boundy, it is also necessary to acquire the necessary area of land.



(Source: JICA Study Team)

Figure 18 Runway Extension Plan of Simikot

(2) Improvement of aviation safety system at mountain airport

In this section the improvement of safety system of mountain airports and how to improve the aviation safety system for flights to those mountain airports will be addressed.

Table 26 Countermeasures and consideration for communication

Measures	Details	Considerations
Introduction of RCAG	✈ VHF transceiver station to be set up near Nepal Telecom base station in Chitresthan (Lukla), Maithapla and Bharta Lagna (Simikot/Rara/Jomsom)	✈ Confirmation on timely maintenance possibility ✈ Examine communication coverage before installing ✈ Need of solar panel as back-up power supply
Introduction of Digital HF	✈ Introduction of digital HF at major mountain airports (those airports with large number of passengers and lack AMHS)	✈ Preliminary investigation and assignment of multiple frequencies are required because it depends on ionospheric condition. ✧ Switch to communicable channel according to the state of ionosphere ✈ For use in ground-to-air communication, on-board device is necessary to be mount. ✧ Installation of onboard equipment is expensive and require new certification procedure for airlines.

(Source: JICA Study Team)

Table 27 Countermeasures and Considerations for Data Communication

Measures	Details	Consideration
Introduction of VSAT	✈ Except for Lukla Airport, which have VSAT installed already and Jomsom Airport, which has an optical fiber network in city, high-speed data communication will be possible at mountain airports. ✈ Ensure redundancy of ground-to-ground communication ✈ By introducing VSAT, it will become possible to introduce AMHS	✈ Require installation of ground antennas ✈ Require paying usage fee for the networks ✈ Increased in cost will be a burden for airline or passenger while using the network
Introduction of AMHS	✈ Reliable communication will be possible through use of data communication avoiding use of telephone or mobile phones. ✈ In cooperation with weather system, weather information can be automatically notified.	✈ Prerequisite is the introduction of network infrastructures such as installation of VSAT

(Source: JICA Study Team)

Table 28 Countermeasures and considerations for Navigation

Measures	Details	Consideration
Technical Assistance of Flight design procedure for mountain airports (Cloud Break)	✈ Instrumental Flight for mountain airport is realized by setting Flight procedure. ✈ It is possible to achieve both improvement of safety and improvement of service rate.	✈ There are no international standards so CAAN must design it own ✈ Ground installation of equipment such as LOC is required ✈ Requires training of pilots and controllers.
Recommendation GPS onboard with RAIM function	✈ Providing technical support to establish operation rules using GPS ✈ In order to operate using GPS, GPS onboard is recommended before making it mandatory.	✈ Airlines need to equip aircraft with compatible equipment. ✈ CAAN needs to change domestic regulations for flights. ✈ CAAN needs to disclose flight route information to fly with GPS (currently routes are set by airlines by themselves)

(Source: JICA Study Team)

Table 29 Countermeasures and Considerations for Air Surveillance

Measures	Details	Consideration
Recommendation using Satellite Network for tracking device	✈ V2 Tracker mounted on aircrafts for mountain flights (fixed wing/rotor wing) can obtain reliable position information ✧ Currently connection with mobile phone networks only ✈ Help in quicker search and rescue operations by obtaining its position ✈ If ground network is established thereby CAAN and airline share information, CAAN can provide control services referring to the position information	✈ Charges for satellite data usage will incur for airline ✈ Need changes in the regulations so that CAAN can recommend satellite communication for the onboard tracking device
Installation of MLAT to mountain airports	✈ Position information of aircraft can be obtained through signal of Mode A/C mounted on aircraft. ✈ In case of A-MLAT (made in Japan), it is possible to obtain aircraft position around airport ✈ With the use of position information by the controllers, obstacles and traffic information can be shared with pilots, thereby ensuring flight safety.	✈ Topographic condition may limit the range for the surveillance ✈ Depending on location of antenna, regular maintenance may be difficult to carry out.

(Source: JICA Study Team)

Table 30 Countermeasures and Consideration for Weather observation

Measures	Details	Considerations
Installation of wind shear detector	✈ Needs to be installed at the end of runway in Lukla, Jomsom, Simikot and Rara Airports where the wind is strong and common.	✈ Current equipment has mechanism to uplink to aircraft by data link ✈ Since small mountain aircraft do not support those data links it is necessary to consider monitoring by controllers and notifying by voice communication.
Introduction of ITV	✈ Real time weather condition can be grasped for places where aircraft is difficult to fly without visibility.	✈ It may be difficult for the installation and maintenance of ITV around mountain airports.

(Source: JICA Study Team)

6. Preliminary Study of Projects Related to Aviation Safety System and Airport Security System

(1) Improvement of Aviation Safety System throughout Nepal

In this section measures that are required to be implemented for the improvement of safety and operational efficiency of aircraft in Nepal as whole will be discussed. In addition, consideration on the matters while implementing improvement measures will be also addressed.

Table 31 Countermeasures and Consideration for Flight Scene Monitoring at TIA

Measures	Details	Consideration
Introduction of MLAT at TIA	✈ In line with TIA's gradual development scenario, MLAT needs to introduce to improve monitoring ability. ✧ Phase 1 : Infront of domestic terminal ✧ Phase 2 : Whole airport	✈ Although TIA has a M/P showing its final form, it is necessary to develop a plan to optimize the operation according to its phase development and status. ✈ If the facilities' arrangement in the airport change depending on the development plan, it is necessary to change the location of antenna or increase the number of antennas accordingly. ✈ MLAT will be introduced to provide efficient airfield operation in view of introducing airport guidance system such as A-SAGCS in future

(Source: JICA Study Team)

Table 32 Countermeasures and Consideration of Aircraft Surveillance

Measures	Details	Consideration
Introduction of air route surveillance radar	✈ Introducing enroute surveillance radar in Nepalgunj airport. ✈ By installing radar, it will be possible to acquire the position data of aircraft flying on domestic routes in the low altitude zone in western Nepal.	✈ In consideration with the CAAN's plan to install ADS-B, expectation of the time preriod for installing ADS-B by airlines and the necessity of radar installation should be agreed with CAAN.

(Source: JICA Study Team)

Table 33 Countermeasures and Consideration on Operation of ATC in TIA

Measures	Details	Consideration
Introduction of Airport CDM (A-CDM) to TIA	✈ The necessary information will be shared in real time between all stakeholders in the airport (air traffic controllers, flight managers, airport operators, ground handling, weather etc.). ✈ Due to quick information sharing among all stakeholders, each stakeholder can obtain necessary information for operational decision making easily and it will improve operational efficiency. ✈ It will eliminate delays.	✈ For the introduction of A-CDM, it is necessary to provide education to air traffic control agencies (including the TIA operation department) and airlines through technical assistance. ✈ For technical assistance, it is necessary to establish operational procedures in Nepal, while installing demonstration equipment at TIA, by conducting simulated operations and drafting operation manuals.
Shortening of separation minima within TIA terminal control area	✈ Revising the departure and missed approach procedures at TIA, so that they do not interfere with the arrival aircrafts. ✈ If there is no interference with the arriving aircraft, the separation minima of the arrival aircrafts in the terminal area can be reduced to less than 10 NM.	✈ It is necessary to design flight procedures with a view to review the air traffic control operation procedures in the terminal area ✈ When shortening separation minima and radar separation minuma, it is necessary to train air traffic controllers. Therefore, it is required to set training and study period by technical assistance.

(Source: JICA Study Team)

(2) Improvement of Airport Security at TIA

As mentioned in previous sections, a new X-ray inspection equipment is installed behind the check-in counters in 2019 in line with the present on-going renovation and layout change of international passenger terminal building at TIA. As a result, the baggage checked thereafter is not handled by the passenger increasing security.
However, this equipment does not have function for inspecting explosives, so it is desirable to introduce next-generation equipment that can perform explosive inspection too for in-line checked baggage in future.

(Source: Rapiscan Home Page)

Figure 19 In-line checked baggage inspection equipment (Next-generation explosive inspection equipment)

For passenger inspection and carry-on baggage inspection, X-ray inspection equipment are updated in 2019, together with explosive inspection equipment, thereby strengthening security.

		
Photo 1 X-ray equipment for checked-in baggage behind check -in counter	**Photo 2 Explosive inspection device installed in security area after immigration**	**Photo 3 X-ray inspection device in security area after immigration (installed in 2019)**

(Source: JICA Study Team)

(3) Improvement of Airport Security at Other Airports

For Pokhara international airport and Gautam Buddha international airport, the terminal building is under construction. Since those airports are international airport it is desirable to provide security facility in accordance with international standards.
For the mountain airports, most of the airport has no x-ray inspection device for luggage, staff perform manual inspection. In future when propeller aircraft such as ATR42-600s Aircraft comes into operation, it is desirable to install X-ray inspection equipment in line with maintenance of passenger terminal buildings.

		
Photo 4 Inspection of baggages at Jomsom	**Photo 5 Rara airport passenger terminal**	**Photo 6 Simikot airport check-in counter**

(Source: JICA Study Team)

7. Examining Future JICA Assistance in Aviation Sector in Nepal

(1) Overview

The chapter 3 of this report stated various issues in relation to Nepal aviation sector and measures for those issues were examined in Chapters 4-6. In this chapter, roadmaps towards addressing those issues were created based on the short-term, medium-term and long-term resolving methods. Subsequently, short-term measures were examined and the projects that could be assisted by JICA were sorted out. The flow of the study is a shown inFigure 20.

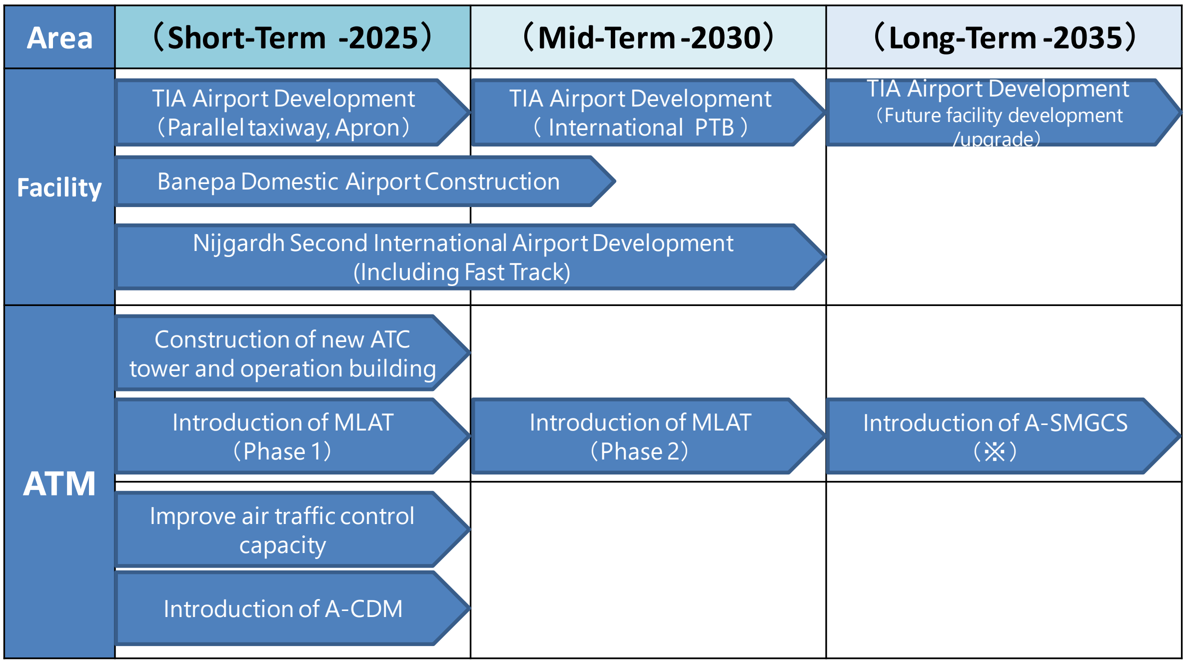
(Source: JICA Study Team)

Figure Figure 20 Study Flow for Future JICA Field of Support

(2) Measures to address issues in the aviation sector in Nepal (short, medium and long term)

1) Measure of Capacity Enhancement of Airport in Kathmandu Metropolitan Area

Improving the airport facility capacity for future demand in the Kathmandu Metropolitan Area is an urgent issue. TIA is planning to develop facilities over the medium to long term, but this alone cannot secure sufficient capacity to handle future demand. From the results of the study in Chapter 4, it may be possible to share the demand with the new Nijgadh second international airport in the future, but short-term measures are necessary, and the construction of the Banepa domestic airport will be necessary to increase the airport capacity in Kathmandu metropolitan area. And it can be judged that this is a highly effective measure by constructing Banepa Domestic Airport for ATR42 and STOL aircraft and additionally improving the control operation capacity of TIA.



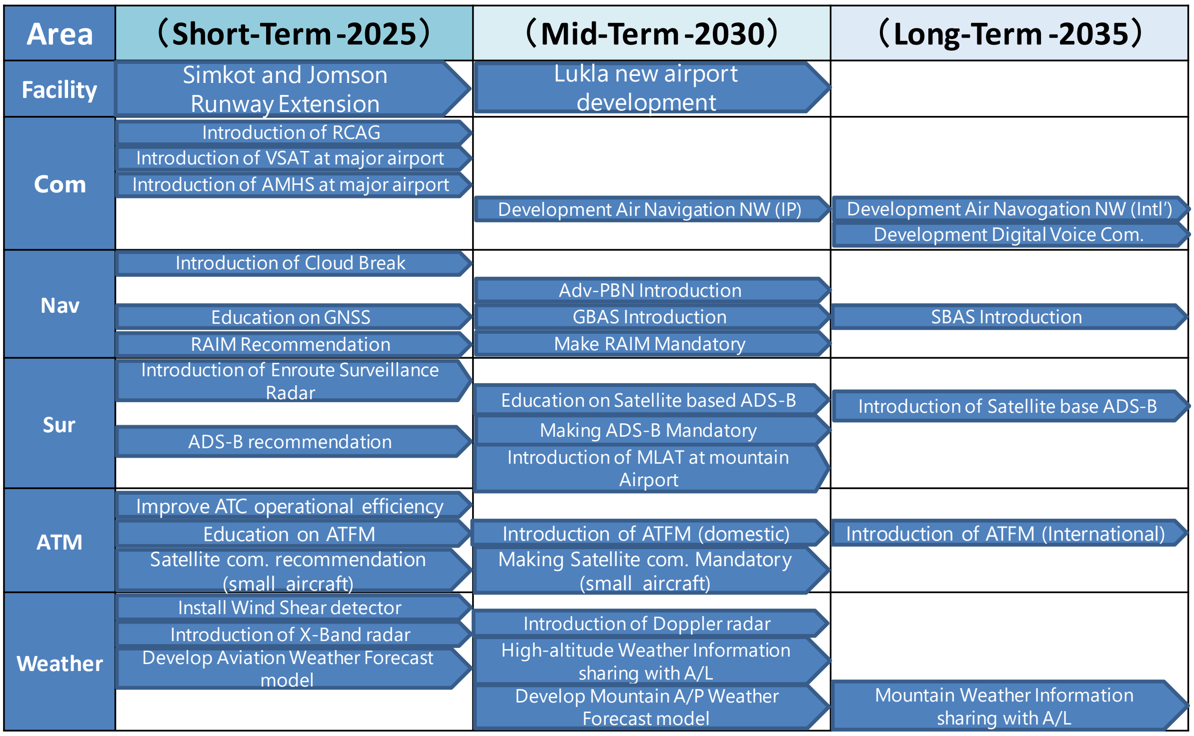
※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source: JICA Study Team)

Figure 21 Roadmap for Capacity Enhancement of Airport in Kathmandu Metropolitan Area

2) Roadmap for Improvement of Mountain Airport Safety/Aviation Safety System

As for the measures to improve the mountain airport safety/air navigation system, various improvement measures are as shown in Figure 22.



(Source: JICA Study Team)

Figure 22 Mountain airport safety/air security system improvement roadmap

(3) Examining Future Cooperation of Japan in Aviation Sector

In this section, the priority criteria are set for the short-term measures from the improvement plans for the Nepal aviation sector, as in Section 7.3. The measures will be examined from the seven viewpoints and the three-levels of evaluation criteria as shown in Table 34.

Based on the results of this survey, the issues in the aviation sector in Nepal is divided into three categories: A) Capacity enhancement of Kathmandu Metropolitan area; B) Measures to improve the safety of mountain airports; and C) improvement in aviation safety and airport security.

The evaluation described below does not indicate the priority of future cooperation projects. In addition, the proposal of construction of Banepa Airport is preliminarily considered based on the request from CAAN. Therefore, it is not implying any commitment of the Government of Japan or JICA as future assistance.

Table 34 Evaluation Cretria For Short-Term Measures

	Items	Evaluation Criteria	Categories		
			A	B	C
1	Urgency/Signifi-cance of the task	Based on how important the issues are addressed by CAAN in its urgency and in maintaining safe and efficient operation of aircraft.	Very High	High	Average
2	Coherence with aviation policy	Coherence of issues with contents of the 15th National Development Plan of Nepal.	Coherent	Almost Coherent	Less Coherent
3	CAAN's requirement	Check whether the measures considered matchs with CAAN's need and policies.	Very High	High	Average
4	Technical difficulty and sustainability	Check the capability of CAAN in implementation and maintenance of the technology. Whether CAAN can realize state-of-the-art technology and/or operations which are set to future goal by ICAO and achieve minimum level of techonology or operation	Very High	High	Average

	Items	Evaluation Criteria	Categories		
			A	B	C
		in maintaining safe operation of aircraft.			
5	Cost	Appropriateness of the total project cost obtained. Cost born by the party and maintenance cost by CAAN appropriate	Cost-effective	Medium cost-effective	Less cost-efective

(Source JICA Study Team)

Regarding the requirement of CAAN, on March 22, 2020, The Director General of CAAN Mr. Rajan Pokhrel, submitted a document regarding the request for the JICA's cooperation. The contents are as shown in the Table 35 with the remark to the requests from the study teams.

Table 35 Remarks on the CAAN's Request

Item	Assistance Request	Remark from Survey Team
ATFM/ ACDM	【Assistance Request Content】 ✈ Implementation of ATFM and A-CDM in Nepal 【Reason】 1 : ATFM and A-CDM are included in ICAO-APAC seamless ATM plan 2 : ATFM is necessary component for the implementation of following: ① Integrated collaborative airspace management ② Air traffic flow management ③ Strategic Air traffic capacity management 3 : A-CDM is necessary to achieve efficient airprot operation through collaborative decision making 4 : Japan is pioneer in implementing ATFM/A-CDM in APAC region and has presented how to realize future operation in many working papers at ICAO meeting 【Condition】 ✈ For the implementation of ATFM and A-CDM, it is necessary to receive aircraft position data and flight plan information in real time.	✈ As for the support scheme, it is necessary to consider how to provide it, and at same time, it needs to proceed technical cooperation for the education of ATFM and A-CDM operational concept in the early stages. ✈ Japan is the third country in the world to introduce ATFM operation and systems, and Japan has accepted study tour from many Asian countries ✈ In Japan, A-CDM has been introduced at Haneda and Narita airports. ✈ Although ATFM and A-CDM expect to expand the airport and airspace capacity, and improve the operational efficiency of ATC, it is difficult to provide quantitative indicators to measure the achievement.
GBAS for Tribhuvan International Airport	【Assistance Request Content】 ✈ Introduction of GBAS to TIA 【Reason】 1: Necessity to make a precision approach from both sides of the runway to improve flight rate. 2: Necessity to provide professional assistance from Japanese research institute (ENRI) for conduting ionosphere for GBAS introduction 3: Through the collaborative research between ENRI and Nepalese university, obtain Know-How of GBAS from Japan, which can be utilized in the introduction to airports other than TIA	✈ Long-term technical cooperation is required for obtaining data and acquisition as ionosphere ✈ During the introduction of GBAS, it is necessary to develop formula for the delay caused due to ionosphere, based on obtained data. ✈ Introduction of GBAS and prior counter measures of ionosphere are issues for ICAO to implement GNSS in Asia-Passific region. ✈ Introduction of GBAS in Nepal, it is required Japan's technical cooperation which is suitable technology for introduction into Asia-Pacific region.
New ATC Control Tower and Operations Building at Kathmandu	【Assistance Request Content】 ✈ Construction of new ATC tower at TIA ✈ Construction new operation building 【Reason】 1 : Visibility problem from exsiting ATC tower as airport expands 2 : Due to lack of space at VFR room at ATC tower, the workspace for air traffic controllers is limited by new systems intrioduction 3 : Present tower is almost 30 years old since its construction 4 : Operation building lacks planning about building facilities, making it difficult for efficient operation	✈ Need to collaborate with ADB-supported airport expansion projects ✈ The construction of new ATC tower will not provide directly capacity enhancement of TIA, but it is highly important to implement form ensuring visibility and the future plans for the introduction of air navigation systems.
Cooperation & Training Programs in Aviation Skills Development	【Assistance Request Content】 ✈ Provide training program on new technologies for CAAN ✈ Contens of program include ATFM/A-CDM, GBAS, AMAN, DMAN etc. 【Reason】 ✈ Previous training program, which is proceed by past grant aid scheme, enhanced human resource development of CAAN. ✈ Due to evolving techonologies and techniques, it is	✈ There are various trainings in which Japan can initiate technical cooperation on technologies for the abilities that CAAN lacks.

	important to seek training and education from Japan which can increase CAAN's capacity.	

(Source JICA Study Team)

The Table 36 summarizes the evaluation results of proposal of Japan's future cooperation in aviation sector of Nepal. As for the comprehensive evaluation rating with A, it is rated and decided based on 5 of the criteria, the CAAN's requirement, Technical difficulty, viewpoint of Japanese technology, cost and prospect of the cooperation, which will decide Japan's future cooperation with Nepal's aviation sector. Section 7.5 describes specific measures.

Table 36 Evaluation Results of Proposals of Japan's Future Cooperation in Aviation Sector

Area	No	Short term (~5yrs)	Evaluation Points					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
Facility	①	Banepa domestic airport development	A	A	B	B	B(*)	A
ATM	②	Construction of new control tower and MLAT at TIA (Aircraft Position monitoring)	A	A	A	A	B	A
	③	Improvement of airport capacity of TIA (ATS Improvement)	A	A	A	B	A	A
	④	Introduce airport CDM (A-CDM) at TIA (Considering some system introduction support)	A	A	A	B	A	A
Facility	⑤	Runway Extension	A	B	B	C	B	B
Communication	⑥	Introduction of RCAG (3 location)	A	A	B	B	B	A
	⑦	Introduction of Digital HF (6 Major Airports)	B	B	B	B	A	B
	⑧	Introduction of VSAT (5 airports, Lukla installed)	A	A	B	A	A	A
	⑨	Introduction of AMHS (5 airports, Lukla Installed)	A	A	A	A	B	A
Navigation	⑩	Recommendation of GPS equipped with RAIM function	B	B	C	A	B	C
	⑪	Design support for flight procedure (Cloud Break) for mountain airports	A	A	A	C	B	B
Surveillance	⑫	Satellite communication recommended for tracking device	A	B	B	B	B	B
	⑬	Introduction of MLAT (6 mountain airports)	A	A	C	C	C	C
Weather	⑭	Introduction of wind shear detector	A	A	A	B	A	A
	⑮	Introduction of ITV (around 6 major airports)	A	A	A	B	C	B
ATM	⑯	Assistance for introducing GBAS	A	A	A	A	B	A
Surveillance	⑰	Introduction of air route monitoring radar (MSSR)	A	A	C	B	B	B
Weather	⑱	Introduction of weather radar (X-band radar)	A	A	A	B	A	A
ATM	⑲	Introduction of ATFM (Considering some system introduction support)	B	A	A	A	A	B

(The project proposals in this report, including project scope and project cost, should be reviewed at the further study for project formulation.)
(Source JICA Study Team)

(4) Proposals for Japan's Future Cooperation in Nepal Aviation Sector

1) Overview

Table 37 shows the outline of the proposed measures. For the details about the airport capacity enhancement in the Kathmandu metropolitan area, the improvement of the safety of the mountain airport, and the improvement of the aviation security system will be discussed in the following sections.

Table 37 Proposals for Japan's Future Cooperation in Nepal Aviation Sector

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
Facility	①	Banepa domestic airport development	Increase operation capacity of TIA	✈ Develop new Banepa domestic airport with runway of 1,200m. ✈ Regarding ODA loan, it is necessary to verify CAAN's stance for browing as external debt is high. ✈ Implementing together with ②, ③, and ④ is effective in improving the capacity of TIA. ✈ The project proposals in this report, including project scope and project cost, should be reviewed at the further study for project formulation.	Loan
ATM	②	Construction of new ATC tower and introduction of MLAT at TIA (Aircraft position monitoring on airport surface)	Track the movement of aircraft and GSE around domestic terminal	✈ In consideration to airport master plan, the new ATC tower needs to be constructed at the height entire airport can be seen. ✈ Along with the the above, a management building and facility management building needs to be built. ✈ Necessary to carry out phase development in line with expansion of TIA →Phase1：Around domestic terminal →Phase2：entire airport	Grant Aid
	③	Improvement of airport capacity of TIA (ATS Improvement)	Increase aircraft movement in TIA	✈ 3 years of technical cooperation ✈ Reduce radar separation minima by improvement of radar control technique ✈ Design flight procedure to shorten separation minima ✈ Increase airport capacity by shortening the separation minima	Technical Cooperation
	④	Introduce airport CDM (A-CDM) at TIA (Considering some systems introduction support)	By sharing of necessary information between stakeholders will lead to smooth airport operation and reduce delay of flight	✈ Regarding A-CDM, technical assistance is provided to air traffic service provider (including TIA operation departments) and airlines. ✈ Support in development of operation manuals, considering that the operation will start in actual ✈ Introduce an evaluation system and conduct trial operation so that effect of operation can be sensed.	Technical Cooperation
Communication	⑥	Introduction of RCAG (3 locations)	Ground-to-air communication will be possible (eliminating blind spot)	✈ Install near Nepal Telecom's communication base stations (3 locations, on the mountain) near Lukla, Simikot/ Rara and Jomson Airport ※ Necessity to confirm the capability of continuous maintenance ※ It is necessary to check whether it can satisfy the coverage requirement for operation ※ Installation of solar panels as a back-up source is required	Grant Aid
	⑧	Introduction of VSAT (5 airports other than Lukla)	Redundancy in communication between mountain airports, ACC and hub airports	✈ AMHS is available by introducing VSAT to major mountain airports. ✈ Possible to Exchange information more reliably than digital HF. ※Construction of ground equipment such as antennas is required ※In order to use a satellite communication line, it is necessary to pay a usage fee constantly.	Grant Aid

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
	⑨	Introduction of AMHS (5 airports other than Lukla)	Accelerate information sharing and exchange by data communication between airports	✈ Reliable information sharing platform by shifting from telephone and mobile phone communication to data base communication ✈ Huge amount of data exchange possible ✈ Redundancy of ground-to-ground communication can be ensured ✈ Automatic notice of weather information by linking with weather systems ※Moutainous airports except for Lukra and Jomsom are connected by microwave network, VSAT and optic fiber must be introduced	Grant Aid
Navigation	⑯	Assistance for introducing GBAS	Increase Service rates without introducing expensive equipment like ILS	✈ GNSS education with two years of technical Assistance ✈ Education on GBAS theory, operation method and system configuration ✈ Training for airlines through stakeholder meetings.	Technical Cooperation
Weather	⑭	Introduction of wind shear detector	The system will be able to detect dangerous sudden changes in airflow and notice it to landing aircraft.	✈ Introduced to four airports, Lukla, Jomsom, Simikot and Rara where have strong winds blow often and install near the end of the runway. ✈ Initially, it is installed at Lukla Airport only. ✈ For technical cooperation, CAAN will be the main counterpart, but it is considered that DHM staff will also participate in the training.	Grant Aid Technical Cooperation
	⑱	Introduction of weather radar (X-band radar)	Perform high-precision weather observations around airports and enroute to improve the accuracy of weather forecast	✈ Technical cooperation for enroute weather forecasts model development. ✈ Assuming gradual installation, in the first stage, it will be installed around TIA, hub airports, and some points where weather condition changes drastically on the routes of small aircraft. ※Need to consider on the coordination between DHM and CAAN. ※Necessary to discuss with DHM jointly with CAAN regarding type of weather data which is required to airlines. ✈ For technical cooperation, DHM will be the main counterpart, but it is considered that the training will also be attended by air traffic controllers.	Grant Aid Technical Cooperation

(Source JICA Study Team)

2) Measures in Technical Cooperation

Grand Aid Projects

In order to improve the safety and efficiency of air traffic control operations in TIA, a new ATC tower will be proposed in line with the ongoing TIA expansion project. In addition, a new administration building and facility management building has also been proposed in line with the the new ATC tower, to accommodate the installation and upgrading of new technology systems because exsiting administration building and facility management building is decrepit and lack of space due to still exsisting past equipment and it causes to be low efficiency of operation and maintenance work.

Table 38 Project Outline for Improvement of ATC in TIA

Subject	Improvement of Air Traffic Control Capacity in TIA
Implementation Period	4 years
Background of Project	TIA has expanded its airport facilities to meet increasing passenger demand until now. On the other hand, due to the expansion, the apron in front of the domestic terminal is no longer visible from the ATC tower, the safety and efficiency of air traffic control operation in airport are impaired. Furthermore, the ATC tower in TIA has been more than 30 years old since its construction. The building has become obsolete and the VFR room, the office rooms required for operation and the rooms where systems are installed are becoming small, which is also one of the causes of the decrease in operational efficiency.
Purpose	In this project, the safety and operational efficiency of control operation in TIA will be improved by construction of a new ATC tower and introducing airport surface surveillance system. Furthermore, by constructing a new administration building and facility management building will ensure the expandability of facilities which is necessary for future operation and system improvement.
Project Content	1：New ATC tower (②) In consideration to the TIA expansion plan currently being implemented, a new ATC tower will be constructed at a height that ensure the visibility for monitoring entire airport. 2：New construction of administration and facility building (②) At the same time, by constructing new administration currently being and facility management building, regarding some systems are currently operated will reach renewal time, it will be replaced, and it is necessary for preparing to start new operation by upgraded system. 3：Introduction of MLAT (②) Upon establishing new ATC tower, the entire airport will be visible, at the same time MLAT will be installed to monitor the position of aircraft and GSEs on airport surface in order to improve the operational efficiency of airport surface movement.
Project Partner	CAAN
Project Outcome	Quantitative effect ✈ It will be able to monitor the movement status of aircraft and vehicles on domestic aprons. (0% → 100%) ✈ It will be able to confirm the movement status of aircraft and vehicles on entire airport surface by surveillance system. (0% → 100%) Qualitative effect ✈ The operational safety and efficiency of flight scenes in TIA are improved. ✈ The introduction of next-generation air navigation systems in Nepal becomes easily.
Prerequisite/External condition	■Prerequisite ✈ For smooth transition of operation and system, the system to be installed in the new facility will be newly installed and the system to be transferred from the old facility will be minimized. ✈ Not only will visibility be increased by raising the control tower, but the system will also be introduced to ensure that the moving aircraft and GSEs can be grasped. ✈ The system introduced in the project will be soft-part and the basic know-how necessary for operation and maintenance will be provided in it, while at the same time working with technical professionals to increase the capacity of the Kathmandu metropolitan area is considered.

(Source JICA Study Team)

Technical Cooperation

In order to enhance airport capacity in Kathmandu metropolitan area, a new flight procedure system will be designed for TIA and technical cooperation for the introduction of A-CDM will be implemented to improve the operational efficiency of the airport.

Table 39 Technical Cooperation to Enhance Airport Capacity in Kathmandu Metropolitan Area

Subject	Technical Cooperation Project to Enhance Airport Capacity in Kathmandu Metropolitan Area
Implementation Period	3 years
Background of Project	In Nepal, the limit of runway capacity of TIA located in the kathmandu metropolitan area is approaching as the air traffic demand increases. Although there is only one runway at present, it is difficult to develop a second runway within the current airport site, so consideration for the development of a new airport to meet air traffic demand in the metropolitan area has been carried out. On the other hand, in order to enhance the overall airport capacity in the future, it is essiential to improve not only in the tangible elements of airport facilities development but also in the intabgible elements of improving efficiency of air traffic control operation and introducing new technologies in TIA. Additionlly, improving services for aircraft using TIA and improving operational efficiency are important measures that lead to capacity enhancement. Under these circumstances, CAAN worry about improvement technologies for (1) the introduction of A-CDM at TIA, (2) improvement the air traffic control efficiency of TIA and (3) air navigation systems (CNS/ATM as such GBAS, MLAT, High Speed Data Network, etc.), and considers to request Japan's technical cooperation to realize those technologies.
Purpose	With this project, the air traffic control capability in the Kathmandu metropolitan area will be improved by introducing A-CDM, improving the air traffic control capability in TIA, and improving the technology related to next-generation air navigation systems.
Project Content	1: Introduction of A-CDM at TIA (④) In order to expand the capacity of TIA, it is necessary to improve efficiency of ATC and airport operations. introduction of A-CDM is considered as a precondition. 2: Promotion of airspace operational efficiency to improve air traffic control capacity at TIA (③) In order to expand the throughput and capacity in the Kathmandu metropolitan area, a new flight procedure will be designed with the aim of improving the air traffic control capacity of the TIA. 3: Improvement of air traffic control technology by introducing air navigation systems (⑯) The basic knowledge about the systems and required training and education for operation and maintenance when introducing GBAS, MLAT and high-speed data network,
Project Partner	CAAN (ATCO, ATSEP), DHM, Airline (operation manager)
Project Outcome	Quantitative effect ✈ The existing flight delay of 30 mins or more at TIA will be decreased. (0% → 30%) ✈ Shorten the average separation minima for approach control. (10NM → 7NM) Qualitative effect ✈ By proper information exchange, air traffic control and airport operations will be smooth, the delay time at the time of departure will be shortened, and at the same time the congestion of TIA will be solved. ✈ By redesigning flight procedures at TIA, we will reduce separation minima for landing aircrafts and increase the number of aircraft movement in TIA. ✈ Acquire the knowledge about the basic air traffic control system and the technique for operation and maintenance, which are necessary for the introduction of new air navigation systems.
Prerequisite/External condition	■Prerequisite ✈ Regarding the introduction of A-CDM, it is introduced a system that allows trial operation, and it is developed required operational rules and set up necessary system parameters for utilizing the system. ✈ The system to consider for starting operation in A-CDM is premised on a system that streamlines departure and arrival at airports such as DMAN and AMAN. ✈ It proceeds to design new departure/arrival or miss-approach procedures and create an environment that can shorten separation minima in terminal approach area. ✈ For GBAS, the system necessary to study the effect of ionosphere will be established and research on the correction coefficient due to effect of the ionosphere needs to be conducted.

(Source JICA Study Team)

Loan Projects

As a measure to enhance the airport capacity in the Kathmandu metropolitan area, it is proposed to implement the ODA loan project for the development of Banepa Domestic Airport as shown in Table 40.

Table 40 Project Outline for Banepa Domestic Airport Development

Subject	Banepa Domestic Airport Development Project
Implementation Period	7years and 3months (After Nepal government approval and start of investigation)
Background of Project	Nepal is a landlocked country in between India and China, airways is the important means of transportation and distribution as well as land transportation. The number of international passengers at TIA, the only international airport in Nepal, has increased from 2.02 million in 2009 to 4.34 million in 2018 and the number of domestic passengers has increased from 1.37 million in 2009 to 2.84 million in 2018. In order to meet the increasing demand, TIA is developing facilities such as runway extension and constructing a new apron. However, the shortage of runway capacity has become a major issue, especially with the increase in the number of aircraft movement of small domestic aircrafts. In order to improve the airport capacity of the Kathmandu metropolitan area, CAAN is implementing measures such as developing of the Nijgardh second International Airport, the development of Pokhara International Airport, Gautam Buddha International Airport and the utilization of Ramechhap Airport. Considering from point of the functionality and construction schedule, these measures seems to be not effective. Banepa domestic airport project is planned to be situated at Banepa in Kavrepalanchok district. Because domestic small aircraft flights in TIA will be shifted to Banepa airport for contributing enhancement of the airport capacity in Kathmandu metropolitan area. The planned site is on a ridge in a hilly area. Since it is necessary to carry out earthwork cutting and filling of 4 million cubic meter within the limited area, the difficulty in the construction will be high.
Purpose	As the runway capacity of TIA is at its peak due to the large number of domestic small aircraft in service, construction of Banepa Domestic Airport at Banepa near Kathmandu and shifting the domestic small aircraft operation to Banepa will lead to increase airport capacity of Kathmandu metropolitan area. In addition, this will improve the convenience of air transportation and will help to promote economic growth in Nepal.
Project Content	1：Airport facility development (following facilities are new) ① Civil works: Runway, taxiways, aprons, access roads, parking lots, perimeter roads ② Architectural work: passenger terminal building, ATC tower, administrative building, fire and rescue station, electricrification facility, water supply facility, sewage treatment facility ③ Aeronautical lighting systems: Runway lights, taxiway lights, apron lights ④ Vehicle: Airport chemical fire vehicles 2：Consulting services (detailed design, bid assistance, construction supervision, Environmental management and supervision)
Project Partner	CAAN
Project Outcome	Quantative Effect: ✈ The number of domestic passengers, domestic cargo volume, the number of aircraft movement of domestic flight and delay time at Tribhuvan International Airport Qualitative Effect: ✈ Improving convenience and safety of air transportation, improving tourist satisfaction and promoting regional economic growth

(Source JICA Study Team)

3) Measures to Improve Safety at Mountain Airports

Grand Aid Projects

The implementation of projects shown in Table 41 is considered to be effective in promoting CAAN's ability to improve operation of mountain flights.

Table 41 Project Outline for Safety Improvement at Mountain Airport

Subject	Improvement of flight safety at mountain airports
Implementation Period	2 years
Background of Project	In Nepal, flights to the mountain airport face the problem with communication in mountainous area, therefore, pilots cannot obtain essential information for operational safety of flight. At the same time, air traffic controller could not provide essential information to pilots for operational safety of flight. Additionally, the air traffic controllers at mountain airport uses only voice communication, usually through telephone or mobile for information exchange to another airport or ACC, so that this leads to lack for rapid information sharing of flight plan and weather information.
Purpose	This project focuses on introducing air-to-ground communication system and ground-to-ground communication system, which will ensure communication between pilots and air traffic controllers in mountainous area. Moreover, information sharing between controllers will be facilitated smoothly to improve safety of mountain flights.
Project Content	1：Introduction of RCAG (⑥) The ground station for RCAG will be installed near Nepal Telecom's base stations which are established in Chitresthan, Maithapla and Bharta Lagna, it will be able to communicate between air traffic controllers and pilots as per the mountain flights of Lukla, Simikot, Rara, Dolpa, Jumla and Jomsom. 2：Introduction of VSAT (⑧) Satellite communication antennas will be installed at Simikot, Rara, Jomson, Jumla, and Dolpa airport and digital communication line will be secured between mountain airports, hub airports and ACC to share flight plan information and weather information at high speed. 3：Introduction of AMHS（⑨） AMHS network and terminals will be installed at Simikot, Rara, Jomson, Jumla and Dolpa airport to enable reliable transmission of arrival/departure information, flight plan information, and weather information at mountain airports.
Project Partner	CAAN
Project Outcome	Quantitative effect: The pilots will be able to communicate with the air traffic controllers on all flights to the six mountain airports. (0% → 100%) The arrival/departure information of all flights at the six-mountain airport can be sent/received through AMHS. (0% → 100%) Qualitative effect: ✈ The safety of mountain flight will be improved by being available constant communication between the mountainous flight pilots and the air traffic controllers. ✈ Similar accidents and incidents which occured at past time could be reduced.
Prerequisite/External condition	■Prerequisite ✈ The RCAG installation site is preferable location, where maintenance can be performed, by installing it near the communication station of Nepal Telecom. ✈ When installing RCAG, it is necessary to install solar panels and storage batteries to ensure a backup power source. ✈ AMHS introduction is required high-speed digital network and it must be introduced together with VSAT. ✈ Soft component for installed systems shall be conducted for CAAN's staff in order to enhance their skill to operate or manage the systems. This will lead to ensure their reliable maintence performance. ✈ Replacement parts are delivered together with the main unit that can cope with failures that may occur within about three years after the system installation. The future procurement method for the replacement parts is decided considering the customs of the Nepalese government.

(Source JICA Study Team)

4) Measures Improve Aviation Safety and Airport Security

Grand Aid Projects

By implementing the project shown in Table 42 through Japan’s assistance, DHM's meteorological observation and forecasting accuracy will be improved, resulting in the improvement of the safety of aircraft operation in Nepal, such as, the occurrence of sudden weather changes. This will reduce the number of accidents that have been happening.

Table 42 Project Outline for Improvement of Aviation Weather Information

Subject	Improve of Weather Forecast Capability
Implementation Period	2 years
Background of Project	In Nepal, meteorological radars have been introduced to observe and predict high-altitude weather related to aircraft operations. A project has been implemented to install meteorological radars for observing high-altitude meteorological conditions at three locations in Nepal. One has already been installed in western Nepal. On the other hand, the plan is still in progress and has not yet achieved the safety and efficiency improvements in aircraft operation. Further, there is a collision has occurred on a mountain during flight to the destination airport due to sudden change in the weather conditions in mountain areas, which is called by CFIT (Controlled Flight into Terrain), it is one of characteristics in aircraft accident in Nepal.
Purpose	In this project, introducing X-band radar and wind shear detector will be possible to grasp the current situation in the mountainous areas, where weather conditions change drastically in Nepal, and it will be possible to acquire necessary data for weather forecast. Furthermore, the safety of mountain flights is improved by detecting wind shear that occurs near the end of the runway before aircraft landing at mountain airports.
Project Content	<u>1：Introduction of X-band Radar</u> X-band radars will be installed at a total of three locations on the east, west and south sides of the Kathmandu basin. With the introduction of the X-band radar, technical cooperation will be provided to DHM based on the local meteorological observation data for the development of a highly accurate aviation weather forecast model. <u>2：Introduction of Wind Shear Detector</u> Wind shear detectors will be installed at four airports, Lukla, Jomsom, Simikot and Rara. However, since it may be necessary to verify the effectiveness of the wind shear detector and establish a method for providing information to the pilot, it will be introduced firstly at Lukla Airport, which has the highest demand in this project, and prceed to establish operational procedures.
Project Partner	DHM, CAAN
Project Outcome	<u>Quantative effect:</u> ✈ Regarding aircrafts entering and leaving the airspace within the Kathmandu basin, air traffic controller will be able to notify the pilot in advance of changes in local weather conditions. (0% → 100%) ✈ Wind shear which occurs near the end of the runway will be detected early at Lukla airport and can be notified to pilots and controllers. (0% → 100%) <u>Qualitative effect:</u> ✈ The accuracy of aviation weather information will be improved and the safety of flight operations on air routes will be improved. ✈ By building a model for aviation weather forecast, the forecasting accuracy will be improved, pilots will be able to obtain weather forecast information before departure and will be able to fly safely depending on the weather conditions on the flight route, thereby, reducing the occurance of accidents.
Prerequisite/External condition	■Prerequisite ✈ In order to achieve much safer operation using aviation weather information, CAAN has to establish operational procedures how to use pre-flight and in-flight weather information together with airlines and be implement information sharing and notification thoroughly. ✈ Soft component for installed systems is conducted to train how to operate or manage the system. In addition, weather forecast model using X-band ladar is constructed taking into account the cooperation with technical cooperation programs. ✈ Replacement parts are deliverd together with the main unit that can cope with failures that may occur within about three years after the system instllation. The future procurement method for the replacement parts is decided considering the customs of the Nepalese government. ■External Condition ✈ It is necessary to organize weather information that will finally be available, along with the progress status of the ongoing World Bank project (introduction of C-band radar and automatic weather observation device). ✈ Based on the above, it is necessary to proceed with discussion on what kind of weather forecast model can be developed in consultation with DHM.

(Source JICA Study Team)

Technical Cooperation

For implementing weather observation and accuracy of weather forecast, it is necessary to develop new forecast model which is based on acquired data by introduction of weather observation radar and wind shear detector. At result, it will be expected to improve operational safety of flight by supporting to develop weather forecast model by technical cooperation of Japanese experts.

Table 43 Project Outline for Improvement of Aviation Weather Information

Subject	Technical Cooperation Project to Improve Precise Weather Information
Implementation Period	3 years
Background of Project	In Nepal, the installation of aviation weather observation equipment is not enough, and the accuracy of aviation weather forecast is low, which is regarded as a major problem. In addition, due to the lack of accuracy of aviation weather forecast, it is not sufficient for airlines to consider operational plans using the weather forecasts prior to flight, the sudden change of weather conditions during flight on en-route impairs the flight safety and service. This situation is a common factor leading to frequent accidents. So, it is necessary to improve aviation weather observation and forcast accuracy in order to reduce aircraft accidents in Nepal. With the support of the World Bank, DHM is installing a high-altitude weather observation radar and a ground-based weather observation system, but it is necessary to install an X-band radar, which is necessary to catch local weather changes. Furthermore, it is necessary to develope a more accurate weather forcast model based on all these meteorological observation data.
Purpose	In this project, the introduction of wind shear detection equipment will improve the safety of landing at mountain airports. In addition, the flight safety on enroute can be improved by introducing a radar that can observe local weather conditions. At the same time, improved forecast accuracy can lead to confirm the risk due to changes in weather conditions prior to flight operation, and it is able to reduce the possibility of accidents by changing and/or coordinating of flight plan.
Project Content	<u>1：Establishment operational method with wind shear detector(⑭)</u> It is developed an operational method including notification method to the pilot when wind shear is detected using the wind shear detector. In addition, it is provided necessary education and training on the maintenance method of the newly introduced wind shear detector. <u>2：Developing weather forcast model (⑱)</u> By combining multiple data such as C-band radar and high-altitude meteorological wind data including the observation results by X-band radar, it will be developed a model that can predict the state of aviation weather that changes rapidly locally. Furthermore, education and training will be provided to air traffic controllers and flight managers regarding aircraft operation methods using the weather forcast data.
Project Partner	DHM, CAAN (ATCO and ATSEP) and Airline (operation manager)
Project Outcome	<u>Quantaive effect:</u> ✈ It will be possible to check the occurrence of wind shear at airports equipped with wind shear detector. (0% → 100%) ✈ It becomes possible to know in advance weather condition changes such as rainfall at the location, where the X-band radar is installed. (0% → 100%) <u>Qualitative effect:</u> ✈ Accidents due to sudden weather changes such as wind shear at mountain airports will be reduced. ✈ In Nepal, the accuracy of aviation weather forecast will be improved and the number of accidents due to changes in weather conditions on enroute will be reduced. ✈ By acquiring aviation weather forecast information prior to flight and establishing a habit of operating based on its information, the number of accidents in Nepal will decrease and the safety of aircraft operation will be improved.
Prerequisite/External condition	■Prerequisite ✈ The wind shear detector will be installed at Lukla Airport, its performance will be evaluated, at the same time, the operation method such as the notification method to the pilot will be examined. ✈ The introduction of X-band radar will be limited to the Kathmandu basin and it will be verified what kind of data can be acquired and what kind of forcast model can be developed. ✈ As the location where local weather forecast information is required, it will be considered to other candidate sites where are preferable location for introduction of X-band radar and considered future development plans.

(Source JICA Study Team)

8. Demand Forecast Considering the Impact of Covid-19 and Review of Airport Capacity Expansion Measures in Kathmandu Region

(1) Air Passenger Demand Forecast Considering the impact of COVID-19

1) Procedure for Air Passenger Demand Forecast Considering the impact of COVID-19

The demand analysis considering the impact of COVID-19 is conducted in the following three periods.

2020 — A short-term future trend is assumed based on the monthly passenger number trend in 2020.

2021-2025 — Regarding the short-term demand recovery scenario, IATA announced it in July 2020, stating that "global demand is expected to recover to 2019 level around 2024."
Regarding TIA's short-term demand forecast up to 2025, a recovery period is assumed based on the IATA outlook and characteristics of route distance in Nepal.

After 2030 — Demand is expected to recover to level before the COVID-19 epidemic by 2030, and demand will be reviewed based on regression analysis.

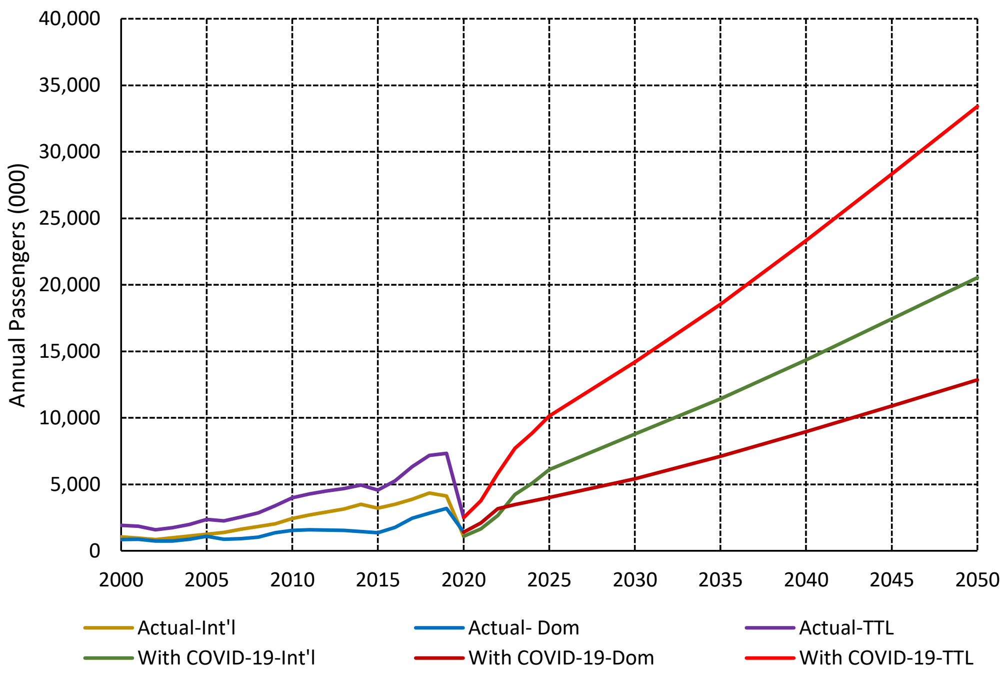
2) Annual Air Passenger Demand

The annual passenger demand is estimated from the prediction formula and future GDP as shown in follows.

Table 44 Annual Air Passenger Forecast

	International Passenger		Domestic Passenger	
	Passenger (1000 person)	Annual Growth Rate	Passenger (1000 person)	Annual Growth Rate
2019 (Actual)	4,139		3,188	
2020 (Actual)	1,105	-73%	1,406	-56%
2021	1,658	50%	2,109	50%
2022	2,652	60%	3,164	50%
2023	4,243	60%	3,480	10%
2024	5,092	20%	3,758	8%
2025	6,110	20%	4,028	7%
2030	8,774	7.5%	5,424	6.2%
2040	14,360	5.0%	8,958	5.1%
2050	20,541	3.6%	12,867	3.7%

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 23 Air Passenger Demand Forecast

3) Comparison of Demand Forecast in Chapter 4 and Demand Review in Chapter 8

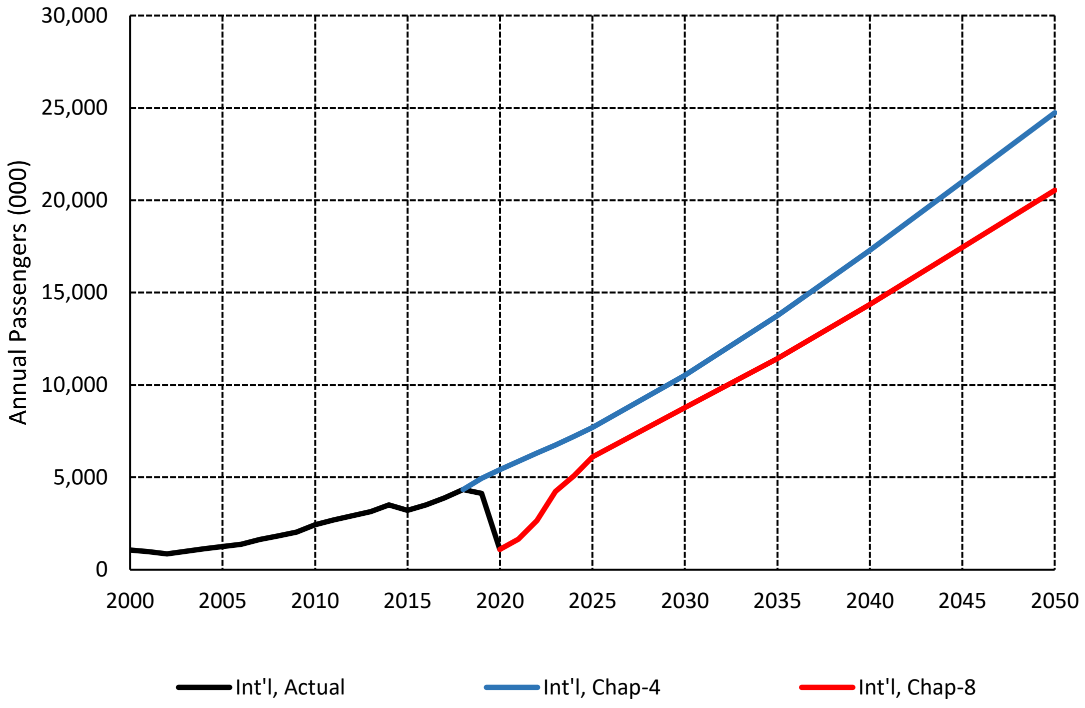
The impact of COVID-19 on aviation demand is confirmed by comparing the years reaching the same demand scale based on the results of Without COVID-19 and With COVID-19. The results are shown in Table 45 and Figure 24, and confirmed as follows for international and domestic, respectively.

Table 45 Comparison of the Year of Reach a Certain Demand

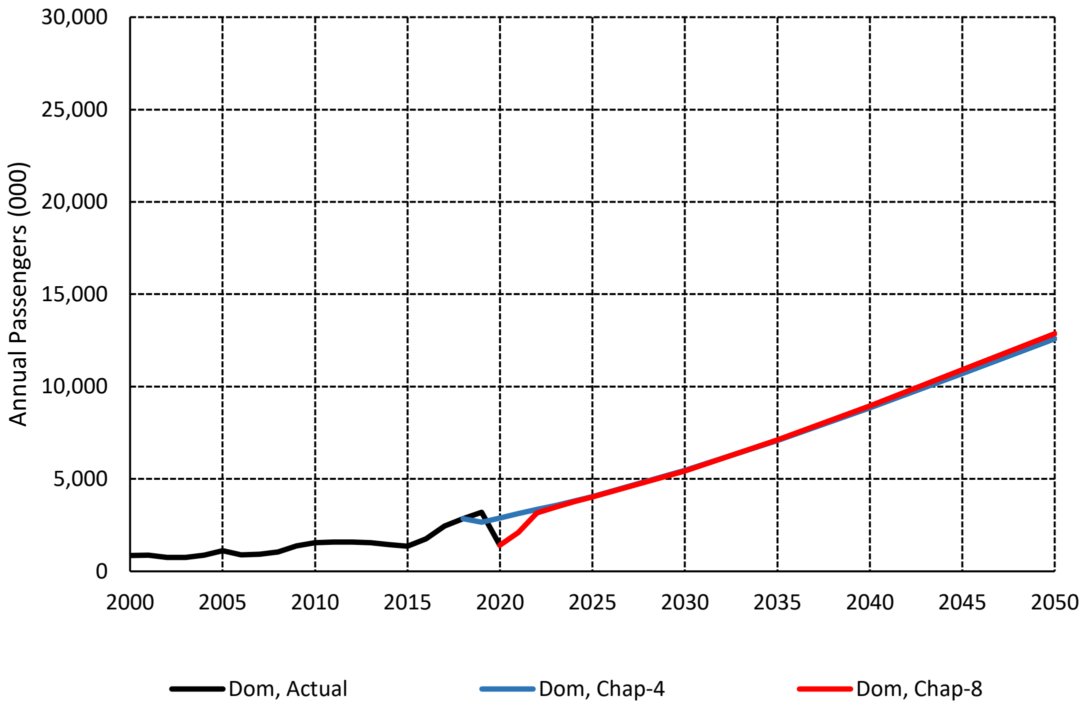
	Annual Demand (thousands)	Year of Reach		Difference in Year
		Demand in Chap-4	Demand in Chap-8	
International	10,000	2029	2032	3 years
	15,000	2037	2041	4 years
	20,000	2044	2049	5 years
Domestic	5,000	2029	2029	0 year
	10,000	2043	2043	0 year

(Source: JICA Study Team)

(International)



(Domestic)



(Source: JICA Study Team)

Figure 24 Comparison of Without and With COVID-19 Demand Review

(2) Annual Aircraft Movement

The annual aircraft movement is estimated as shown in following tables.

Table 46 Annual Aircraft Movements (international)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	152	224	321
Design day ratio	1/320	1/320	1/320
Annual Aircraft Movement (times/year)	48,600	71,700	102,700

(Source: JICA Study Team)

Table 47 Annual Aircraft Movements (Domestic)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	326	513	678
Design day ratio	1/260	1/260	1/260
Annual Aircraft Movement (times/year)	84,800	133,400	176,300

(Source: JICA Study Team)

Table 48 Annual Aircraft Movements (International plus Domestic)

	2030	2040	2050
Annual Aircraft Movement (times/year)	133,400	205,100	279,000

(Source: JICA Study Team)

(3) Policy for Expansion of Airport Capacity of Kathmandu Metropolitan Area

1) Relationship between TIA Capacity and Future Demand

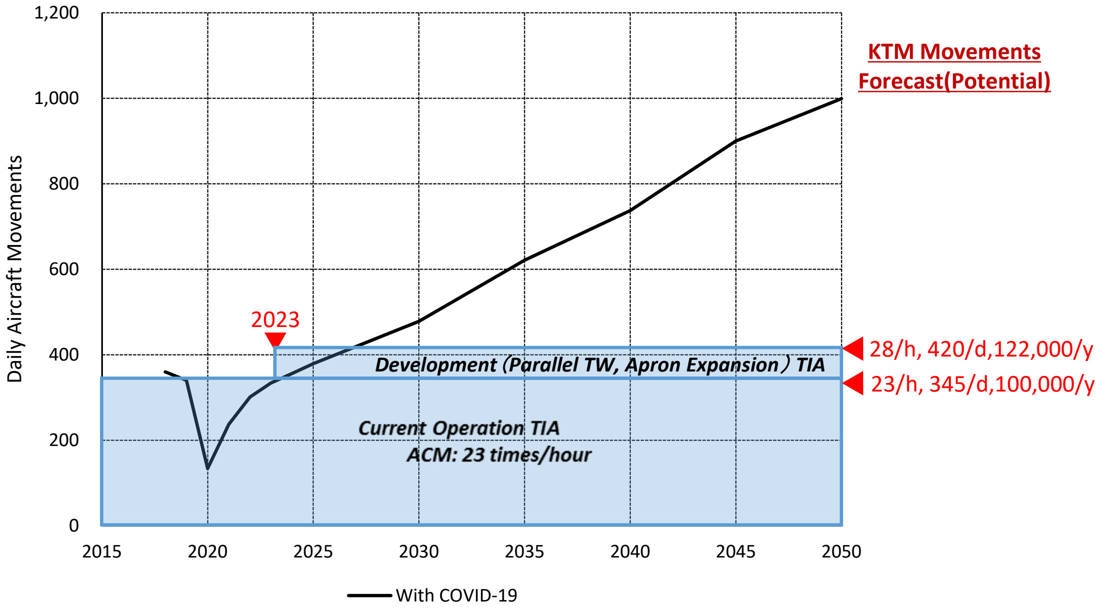
Design day aircraft movements in TIA is estimated as shown below.

Table 49 Design Day Aircraft Movements in TIA

	2018 (Actual)	2025	2030	2035	2040	2045	2050
International	109	105	152	196	224	272	321
Domestic	251	273	326	425	513	628	678
Total	360	378	478	621	737	900	999

Note: Unit, Movement/day
(Source: JICA Study Team)

The capacity of TIA is currently expected to be 23-24 times/hour and estimated to be 28 times/hour after completion of parallel taxiway. Regarding the daily capacity of TIA, in the case of assumption of consecutive peak duration of 15 hours, current capacity will be 345-360 times/day, and 420 times/day after completion of parallel taxiway. As shown in Figure 25, it is expected that the daily aircraft movements will reach the airport capacity in around 2027.

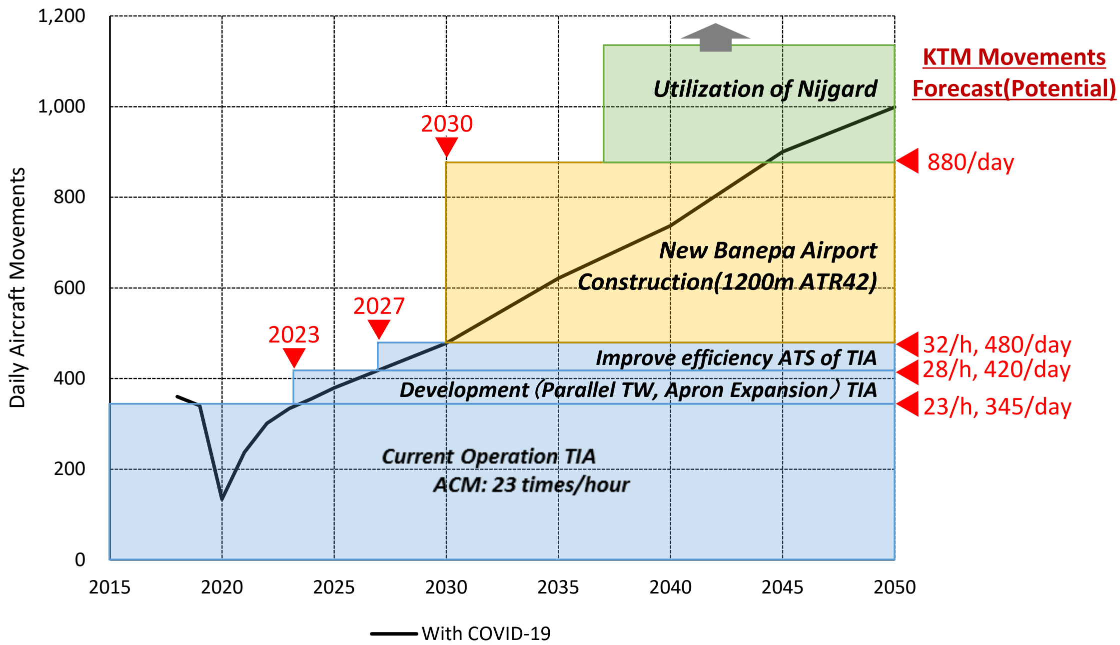


(Source: JICA Study Team)

Figure 25 Relationship between Aircraft Movements and Airport Capacity of TIA

2) Outline of Policy for Expansion of Airport Capacity

As mentioned above, since it is expected that the aircraft movements of TIA will reach the airport capacity in the future, it is necessary to urgently take measures to expand the airport capacity in Kathmandu Metropolitan Area. Figure 26 shows the relationship between aircraft movement in TIA and the expansion of airport capacity, and the policies for expansion of capacity are detailed below.



(Source: JICA Study Team)

Figure 26 Relationship between Capacity expansion Policy and Demand

(A) Development of Parallel Taxiway at TIA

At the time of completion of parallel taxiway currently under construction, the runway capacity of TIA is estimated to be 28 times/hour (420 times/day) besed on the results of the runway occupancy time survey conducted in this study.
However, since it is expected that the aircraft movements will exceed the runway capacity after 2027, it is necessary to take measure for expansion of airport capacity.

(B) Development of Banepa New Airport

In case of introducing new flight procedure design and improvement of air traffic control operation, the runway capacity of TIA will increase to 32 times/hour. Therefore, even if increasing of air traffic demand fall down temporally due to the impact of COVID-19, the demand of ACM in TIA will exceed to maximum runway capacity at 2030.
According to mentioned before, it is favorable to develop Banepa airport up to 2030 for maximizing slot of large aircraft and decreacing ACM of small aircraft in TIA which are proceeded as measure of airport volume expansion in Kathmandu Metropolitan Area.

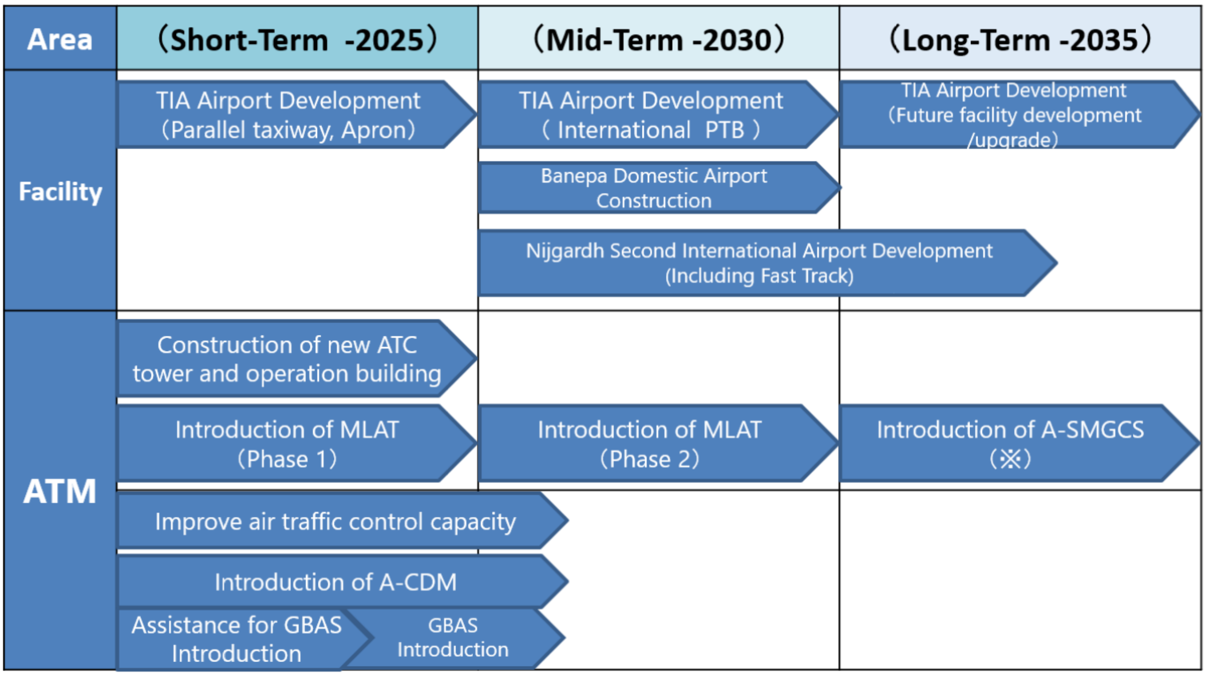
3) Evaluation of Policy for Expansion of Airport Capacity in Kathmandu Metropolitan Area

As shown in Figure 26, the effect of capacity expansion by the development of Banepa Airport is great. The measurement of airport capacity expansion in the Kathmandu Metropolitan area is reconsidered based on the result of demand forecast by considering the impact of COVID-19. At result, if current TIA upgrade project, which is parallel taxiway development, and improvement of air traffic operational efficiency are proceeded, our result of demand forecast shows that runway capacity in TIA will be exceeded in 2030. Therefore, start year of Banepa airport project will be delay abour three years which is compared with former plan, however, positive impact which is provided by new Banepa airport construction will be quite big for expanding airport capacity in Kathmandu Metropolitan Area.

(4) Review of Japan's Future Support in the Aviation Sector

1) Roadmap for Aviation Capacity Enhancement in Kathmandu Metropolitan Area

The airport capacity for the future demand in the Kathmandu metropolitan area is expected to exceed the runway processing capacity by 2027 after the completion of the current development projects such as the parallel taxiways, even after taking into account the impact of COVID-19. Furthermore, even if the efficiency of control operations is improved, the runway handling capacity of TIA is expected to be exceeded by 2030. From this, it is proposed that the timing of implementation of some of the short-term measures described in Chapter 7 needs to be revised and implemented as medium-term measures, considering the temporary drop in aviation demand due to the impact of COVID-19 and international movement restrictions in 2021.



※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source: JICA Study Team)

Figure 27 Roadmap for Aviation Capacity Enhancement of Kathmandu Metropolitan Area

2) Roadmap for Improvement of Mountain Airport Safety/Aviation Safety System

The measures to improve the mountain airport safety/air navigation system are proceeded by considering improvement of air transport safety. Those measures do not relate with change of air traffic demand which is affected by COVID-19, therefore, it is necessary for aviation safety improvement in Nepal

3) Measures to Expand Facility Capacity in Kathmandu Metropolitan Area

As for the measures to enhance the aviation capacity of Kathmandu Metropolitan area, Table 50 shows the result of review for the improvement measures considering short term requirements.
Regarding GBAS, which was requested by CAAN, after considering the impact of COVID-19, the inclusion of GBAS as a short-term measure was considered since TIA runway processing capacity was delayed by about three years.

Table 50 Proposal for Future Area of Cooperation in Nepal Aviation Sector

Area	No	Short-term (~5yrs)	Expected Outcome	Detail /Issues of Measures	Evaluation Criteria	Remark	
ATMl	⑯	Introduxtion of GBAS at TIA	Increase Service rates without introducing expensive equipment like ILS	✈ Analyze the ionosphere and build a model to correct for disturbances caused by the ionosphere. ✈ In order to build the model, a joint research project will be set up between research institutes in the two countries and Japanese research institutes. ✈ Since it is necessary to learn the basic concepts of GNSS, it is necessary to consider	Urgency/ Significance of the Task	A	In order to maximize TIA'sairport capacity, measure to reduce flight cancellation rate and delay are important.
					Coherence with Aviation Sector Policy	A	It will reduce flight cancellation and delay in bad weather, contributing to improved operational efficiency and safety.
					CAAN's Requirement	A	CAAN requested the introduction of GBAS to achieve precision approach from both sides of the runway.

Area	No	Short-term (~5yrs)	Expected Outcome	Detail /Issues of Measures	Evaluation Criteria		Remark
				implementing this program in conjunction with support by technical professionals. ✈ Need to consider the possibility of introducing SBAS using GAGAN in India. →Confirm communication with India. →Consider the possibility of introducing GAGAN ground stations	Technical Difficulty	A	Analysis of the current situation and development of a model through joint research between research institutes in Nepal and Japan is necessary and will take time. Human resource development is also necessary
					Cost	B	Operating costsand Equipment costs: 100 million
					Comprehensive Evaluation	A	CAAN requested the establishment of GBAS. Japan has an advantage in terms of technology for the installation of GBAS in low latitude regions.

(Source: JICA Study Team)

4) Measure to Improve Safety at Mountain Airporrt

In case of considering the impact of COVID-19, measurement for improvement of Mountain airport safety is required to proceed continuously. Therefore, those measurements should not be changed and the necessity of measurement are considered based on final criteria which is prioritized by comprehensive evaluation.

5) Measures to Improve Aviation Safety and Airport Security

In case of considering the impact of COVID-19, measurement for improvement of aviation safety and airport security is required to proceed continuously. Therefore, those measurements should not be changed and the necessity of measurement are considered based on final criteria which is prioritized by comprehensive evaluation.

6) Re-organization of Evaluated Result

In addition to the results of the evaluation on the future support of the aviation sector conducted in 7.4.2-5, the results of the evaluation as show in follows are reorganized which are based on section 8.4.1-2 considering the impact of COVID-19. As a result of the reassessment, there is a change from the previous study, the construction of Banepa Airport will be implemented as a medium-term and the project related to the introduction of GBAS will be started within 5 years. The period of exceeding runway processing capacity in TIA will shift around three years behind. Therefore, GBAS will be able to deploy in TIA based on following reasons.

a) Due to delay of exceeding runway processing capacity in TIA abour three years, GBAS installation project could proceed after technical assistance for GBAS introduction immediately.
b) It is expected that the rate of cancel and delay flight will decrese under low visibility conditions by introduction of GBAS. It means improvement of airport capacity, including terminal area of TIA.
c) The total airport capacity in Kathmandu metropolitan area will be able to increase by maximizing TIA airport capacity and Banepa airport construction.

Table 51 Evaluation Results of Future Cooperation in Aviation Sector

Area	No	Short term (~5yrs)	Evaluation Points					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
ATM	①	Construction of new control tower and MLAT at TIA (Aircraft Position monitoring)	A	A	A	A	B	A

Area	No	Short term (~5yrs)	Evaluation Points					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
	②	Improvement of airport capacity of TIA (ATS Improvement)	A	A	A	B	A	A
	③	Introduce airport CDM (A-CDM) at TIA (Considering some system introduction support)	A	A	A	B	A	A
Facility	④	Runway Extension	A	B	B	C	B	B
Communication	⑤	Introduction of RCAG (3 location)	A	A	B	B	B	A
	⑥	Introduction of Digital HF (6 Major Airports)	B	B	B	B	A	B
	⑦	Introduction of VSAT (5 airports, Lukla installed)	A	A	B	A	A	A
	⑧	Introduction of AMHS (5 airports, Lukla Installed)	A	A	A	A	B	A
Navigation	⑨	Recommendation of GPS equipped with RAIM function	B	B	C	A	B	C
	⑩	Design support for flight procedure (Cloud Break) for mountain airports	A	A	A	B	B	B
Surveillance	⑪	Satellite communication recommended for tracking device	A	B	B	B	B	B
	⑫	Introduction of MLAT (6 mountain airports)	A	A	C	C	C	C
Weather	⑬	Introduction of wind shear detector	A	A	A	B	A	A
	⑭	Introduction of ITV (around 6 major airports)	A	A	A	B	C	B
ATM	⑮	Assistance for introducing GBAS	B	A	A	A	C	A
		Introduction of GBAS in TIA	A	A	A	A	B	A
Surveillance	⑯	Introduction of air route monitoring radar (MSSR)	A	A	C	B	B	B
Weather	⑰	Introduction of weather radar (X-band radar)	A	A	A	B	A	A
ATM	⑱	Introduction of ATFM (Considering some system introduction support)	B	A	A	A	A	B

(Source: JICA Study Team)

(5) Review of Future Proposal for Support in Aviation Sector

1) Overview

Regarding the short-term measures necessary to address the issues in the aviation sector in Nepal, which were reviewed in 8.4 in consideration of the impact of COVID-19, the content of proposal for future support in the aviation sector is further summarized. However, the following measures are presented as proposals in this study, as they require consultation with the Japanese side.

Following table provides an overview of the proposed measures, including the changes made due to the review. As for the details, the capacity enhancement of the Kathmandu metropolitan area has been reviewed, and the description of the details will be discussed.

Table 52 Proposal For Future Cooperation in Nepal Aviation Sector

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
ATM	①	Construction of new ATC tower and introduction of MLAT at TIA (Aircraft position monitoring on airport surface)	Track the movement of aircraft and GSE around domestic terminal	✈ In consideration to airport master plan, the new ATC tower needs to be constructed at the height entire airport can be seen. ✈ Along with the the above, a management building and facility management building needs to be built. ✈ Necessary to carry out phase development in line with expansion of TIA →Phase1：Around domestic terminal →Phase2：entire airport	Grant Aid
	②	Improvement of airport capacity of TIA (ATS Improvement)	Increase aircraft movement in TIA	✈ 3 years of technical cooperation ✈ Reduce radar separation minima by improvement of radar control technique ✈ Design flight procedure to shorten separation minima ✈ Increase airport capacity by shortening the separation minima	Technical Cooperation
	③	Introduce airport CDM (A-CDM) at TIA (Considering some systems introduction support)	By sharing of necessary information between stakeholders will lead to smooth airport operation and reduce delay of flight	✈ Regarding A-CDM, technical assistance is provided to air traffic service provider (including TIA operation departments) and airlines. ✈ Support in development of operation manuals, considering that the operation will start in actual ✈ Introduce an evaluation system and conduct trial operation so that effect of operation can be sensed.	Technical Cooperation
Communication	⑤	Introduction of RCAG (3 locations)	Ground-to-air communication will be possible (eliminating blind spot)	✈ Install near Nepal Telecom's communication base stations (3 locations, on the mountain) near Lukla, Simikot/ Rara and Jomson Airport ※ Necessity to confirm the capability of continuous maintenance ※ It is necessary to check whether it can satisfy the coverage requirement for operation ※ Installation of solar panels as a back-up source is required	Grant Aid
	⑦	Introduction of VSAT (5 airports other than Lukla)	Redundancy in communication between mountain airports, ACC and hub airports	✈ AMHS is available by introducing VSAT to major mountain airports. ✈ Possible to Exchange information more reliably than digital HF. ※ Construction of ground equipment such as antennas is required ※In order to use a satellite communication line, it is necessary to pay a usage fee constantly.	Grant Aid
	⑧	Introduction of AMHS (5 airports other than Lukla)	Accelerate information sharing and exchange by data communication between airports	✈ Reliable information sharing platform by shifting from telephone and mobile phone communication to data base communication ✈ Huge amount of data exchange possible ✈ Redundancy of ground-to-ground communication can be ensured ✈ Automatic notice of weather information by linking with weather systems ※Moutainous airports except for Lukra and Jomsom are connected by microwave network, VSAT and optic fiber must be introduced	Grant Aid
ATM	⑮	Assistance for introducing GBAS	Increase Service rates without introducing expensive equipment like ILS	✈ GNSS education with two years of technical Assistance ✈ Education on GBAS theory, operation method and system configuration ✈ Training for airlines through stakeholder meetings.	Technical Cooperation
	⑯	Introduction of GBAS at TIA	Increase Service rates without introducing expensive equipment like	✈ Analyze the ionosphere and build a model to correct for disturbances caused by the ionosphere. ✈ In order to build the model, a joint research project will be set up between research institutes in the two countries and Japanese research institutes.	Grant Aid

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
			ILS	✈ Since it is necessary to learn the basic concepts of GNSS, it is necessary to consider implementing this program in conjunction with support by technical professionals. ✈ Need to consider the possibility of introducing SBAS using GAGAN in India. →Confirm communication with India. →Consider the possibility of introducing GAGAN ground stations	
Weather	⑭	Introduction of wind shear detector	The system will be able to detect dangerous sudden changes in airflow and notice it to landing aircraft.	✈ Introduced to four airports, Lukla, Jomsom, Simikot and Rara where have strong winds blow often and install near the end of the runway. ✈ Initially, it is installed at Lukla Airport only. ✈ For technical cooperation, CAAN will be the main counterpart, but it is considered that DHM staff will also participate in the training.	Grant Aid Technical Cooperation
	⑱	Introduction of weather radar (X-band radar)	Perform high-precision weather observations around airports and enroute to improve the accuracy of weather forecast	✈ Technical cooperation for enroute weather forecasts model development. ✈ Assuming gradual installation, in the first stage, it will be installed around TIA, hub airports, and some points where weather condition changes drastically on the routes of small aircraft. ※Need to consider on the coordination between DHM and CAAN. ※Necessary to discuss with DHM jointly with CAAN regarding type of weather data which is required to airlines. ✈ For technical cooperation, DHM will be the main counterpart, but it is considered that the training will also be attended by air traffic controllers.	Grant Aid Technical Cooperation

(Source: JICA Study Team)

(6) Measures for the enhancement of Aviation Capacity of Kathmandu Metropolitan Area

Grand Aid

In order to improve the safety and efficiency of aircraft operations at TIA, GBAS will be introduced in addition to the details described in 7.5.2. This will improve the on-time operation rate of aircraft. Furthermore, since the facility management building is scheduled to be established in conjunction with the construction of the new control tower, the timing of the project implementation will also be considered, such as the installation of new aircraft there.

Table 53 Project Outline for the Implementation of GBAS

4Subject	Improvement of Air Traffic Control Capacity in TIA
Implementation Period	3 years
Background of Project	At TIA, delays have become the norm as the airport capacity and the surrounding airspace capacity have become crowded due to the increase in air traffic demand. In addition, since TIA is not equipped with the necessary equipment for precision approach, delays and flight cancellations due to waiting and diverting of arriving aircraft occurs during bad weather. Under these circumstances, CAAN hopes to introduce GBAS for precision approach to reduce the flight cancellation rate and delay time and is requesting Japan to introduce the system.
Purpose	The introduction of GBAS in this project will enable precision approach at TIA, reduce the rate of aircraft cancellations and delays, and improve the on-time operation rate.
Project Content	1: GBAS Feasibility Study at TIA (⑯) Before GBAS implementation in TIA, research of technical validation and cost benefit for implementation of GBAS will be proceeded. 2: GBAS Implementation at TIA (⑯) To achieve precision approach at TIA, GBAS will be introduced in TIA.
Project Partner	CAAN, Airlines
Project Outcome	Quantitative effect ✈ Decrease in the number of flights delayed by 30 minutes or more in terms of scheduled departure and arrival times at TIA. (100% → 70%: over 30 minutes delayed flights decrease 30%) ✈ The cancellation rate of flights at TIA will be reduced during bad weather such as rain. (100% → 50%) Qualitative effect ✈ Reduce flight cancellation rates and delays at TIA, thereby improving the overall operational efficiency of TIA. ✈ Achievement of precision approach will improve the safety and efficiency of aircraft operations.
Prerequisite/External condition	■Prerequisite ✈ In the technical cooperation project, the effects of the ionosphere have been analyzed, and based on the results, model equations have to be developed to correct the effects of ionospheric disturbances.

(Source: JICA Study Team)

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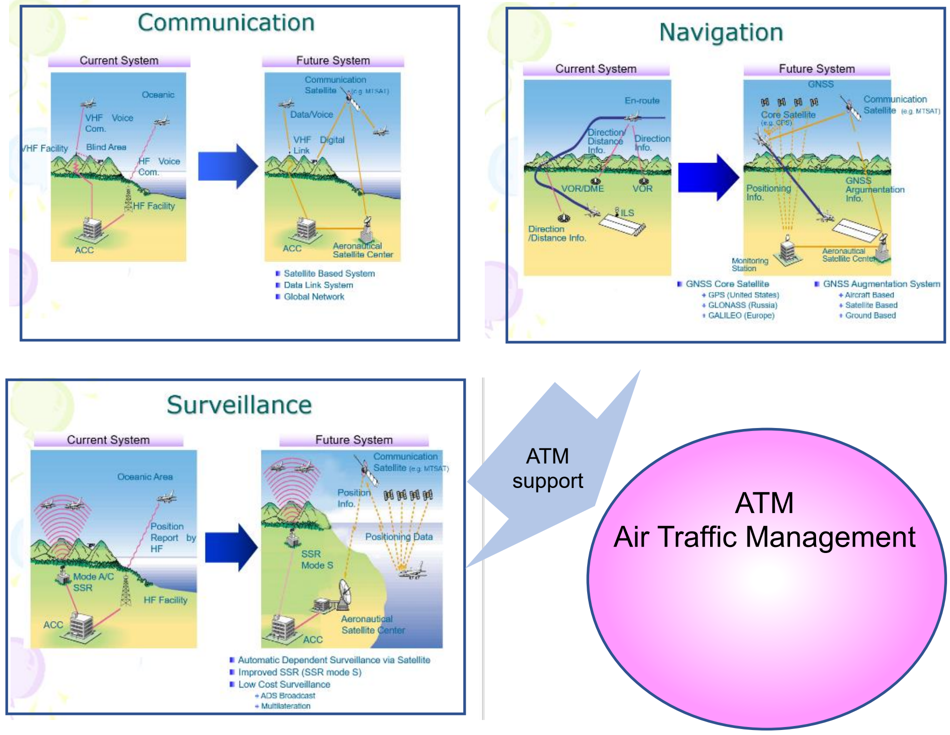
Abbreviations

ACC	Area Control Center
ADB	Asian Development Bank
ADS-B	Automatic Dependent Survillance-Boardcast
ANSSSD	ANS Safety Standards Department (CAAN)
A/P	Authorization to Pay
AP	Affected Person
APAPI	Abbreviated Precision Approach Path Indicator
APP	Approach / Approach Control
ATC	Air Traffic Controller
ATM	Air Traffic Management
B/A	Banking Arrangement
CAA	Civil Aviation Academy
CAAN	Civil Aviation Authority of Nepal
CAT	Category
CDC	Compensation Determination Committee
CDO	Chief District Officer
CNS	Communications, Navigation and Surveillance
CMV	Converted Meteorological Visibility
COTS	Commercial Off-the-Shelf
DAC	Development Assistance Committee
DA/H	Decision Altitude/Height
DGCA	Directorate General for Civil Aviation (France)
DME	Distance Measuring Equipment
DVOR	Doppler VHF Omnidirectional Range
EA	Executing Agency
EASA	European Union Aviation Safety Agency
EIA	Environmental Impact Assessment
FAF	Final Approach Fix
GAGAN	GPA-Aided GEO Augmented Navigation
GDP	Gross Domestic Product
GNI	Gross National Income
GP	Glide Path
GRC	Grievance Redress Committee
HF	High Frequency
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
ICAO	International Civil Aviation Organization
IEE	Initial Environmental Evaluation
IF	Intermediate Approach Fix
ILS	Instrument Landing System
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JST	JICA Survey Team
KIAS	Knot Indicated Air Speed
LAN	Local Area Network

LED	Light Emitting Diode
LOC	Localizer
MAPt	Missed Approach Point
MDA/H	Minimum Descending Altitude/Height
MOC	Minimum Obstacle Clearance
MoCTCA	Ministry of Culture, Tourism and Civil Aviation
MOSTE	Ministry of Science, Technology Environment
MSSR	Mono-pulls Secondary Surveillance System
NGO	Non-Governmental Organization
NPR	Nepal Rupee
OECD	Organization for Economic Co-operation and Development
OFID	OPEC Fund for International Development
PANS-OPS	Procedures for Air Navigation Services-Aircraft Operations
PAPI	Precision Approach Path Indicator
PBN	Performance Based Navigation
PD	Project Director
PMU	Project Management Unit
PV	Photovoltaic
RVR	Runway Visual Range
RWY	Runway
SAARC	South Asian Association for Regional Cooperation
SDS	Social Development Specialist
S.L.C.	School Leaving Certification
SOP	Standard Operating Procedure
SS	Suspended Solids
SSB	Single Side Band
T-DME	Terminal - Distance Measuring Equipment
TIA	Tribhuvan International Airport
TOR	Terms of Reference
TSP	Total Suspended Particle
VAGS	Visual Alignment Guidance System
VDC	Village Development Committees
VFR	Visual Flight Rule
VHF	Very High Frequency
VIS	Visibility
VOR	VHF Omnidirectional Range

Aviation Glossary

<table>
<tr><th>Terms</th><th>Description</th></tr>
<tr><td>CNS
/ATM</td><td>In 1988, it was concluded that satellite-based communications, navigation and surveillance systems will be the key to improvement of the navigation environment on global scale. It includes aeronautical mobile satellite service (AMSS), using global navigation satellite system (GNSS), Using automatic dependent surveillance (ADS) and air traffic management (ATM) respectively for each field. At present the acronym is called CNS/ATM.

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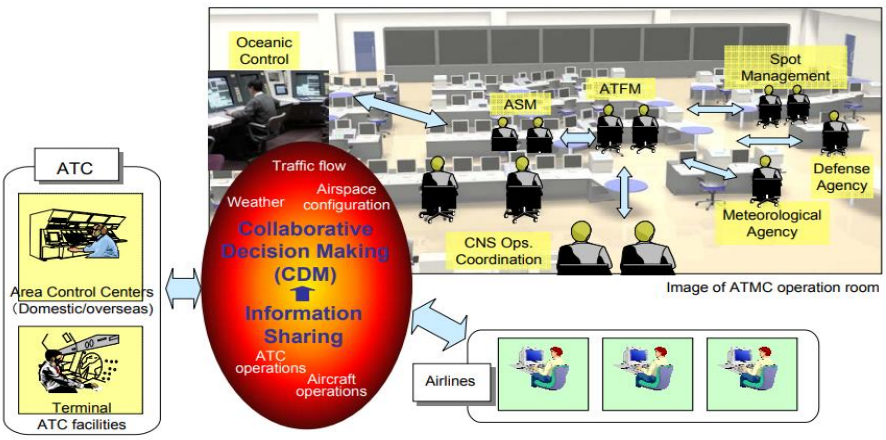
<tr><td>A-CDM</td><td>Airport Collaborative Decision Making
It enables ATM participants to make better decisions based on sharing the same information in order to derive successful achievement. ATM center builds up and develops CDM as effective operational procedures. Based on this mechanism, information sharing, and coordination are being done using systems with airlines


Source: Japan Civil Aviation Bureau homepage</td></tr>
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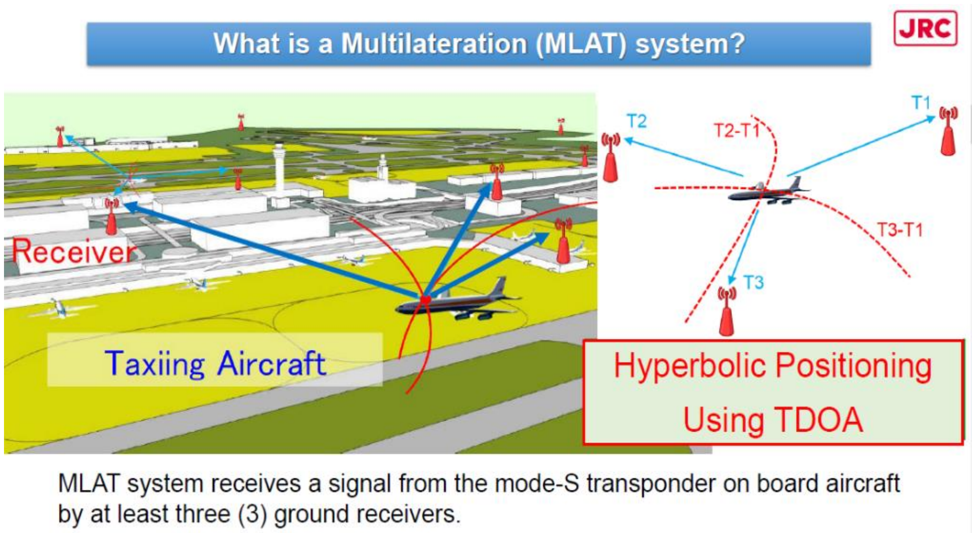
<table>
<tr><th>Terms</th><th>Description</th></tr>
<tr><td>MLAT</td><td>
Multilateration (MLAT) is an aircraft surveillance system that calculates the position of aircraft and display on screen. The signal transmitted from the transponder of the aircraft is received at three or more receiving station (four if altitude is required). It can eliminate blind spots compared to conventional ASDE and surveillance ability will not decrease even in bad weather. In Japan, New Chitose Airport, Narita, Haneda, Chubu, Kansai, Osaka, fukuoka and Naha airports have it installed.



Source: JRC
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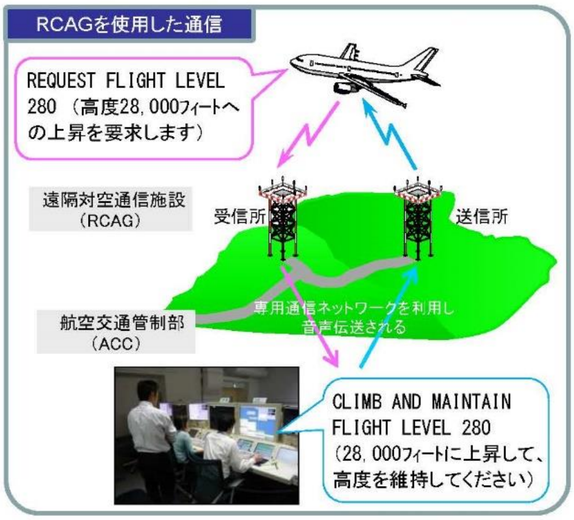
<tr><td>RCAG</td><td>
RCAG (Remote Center Air-Ground Communication)
An air traffic control facility used by the Area Control Centers (ACC) to carry out air traffic control operations, provide control operations, etc. for aircraft flying in the control airspace.
Area Control Center (ACC) controllers can use voice communication with aircraft by using a remotely located air-to-ground communication facilities. RCAGs located throughout the country are linked to the Area Control Centers (ACC) with the dedicated communication networks.



Source: Japan Civil Aviation Bureau homepage
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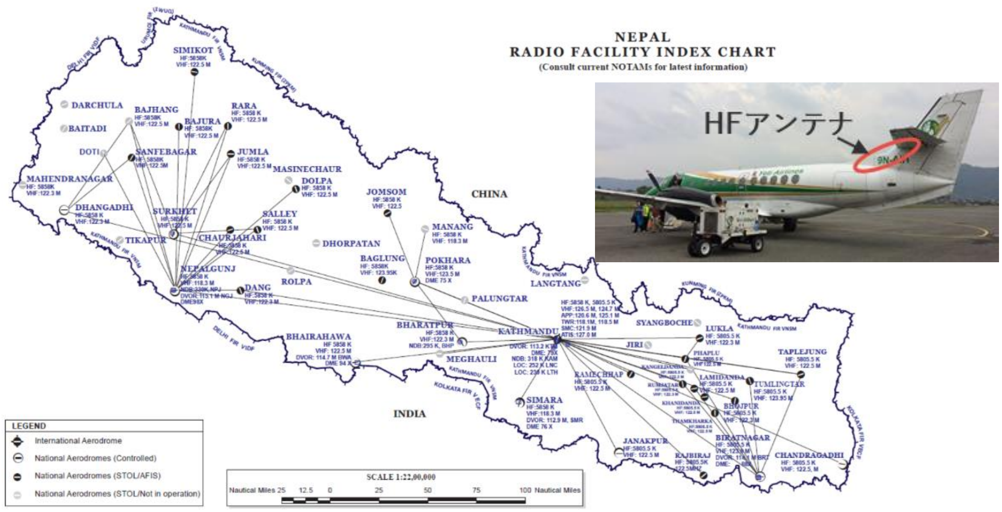
<table>
<tr><th>Terms</th><th>Description</th></tr>
<tr><td>Digital HF</td><td>

Normally, VHF, very-high frequency bands are used for communication between air traffic controllers and aircraft. VHF has the advantage of a small antenna and easy installation, but communication is limited to the line of sight. HF (shortwave) is excellent for long-distance communication, and in countries with airspace that cannot be covered by VHF (Nepal) communication network using HF is recommended to ensure communication with aircraft. Since HF telecommunications uses the refraction of radio waves in the ionosphere it is affected by seasons and solar activity, so communication is often interrupted or degraded.

Digital HF converts voice into digital signals and transmits them to solve the above-mentioned problems that occur in analogs and is known to improve signal quality.



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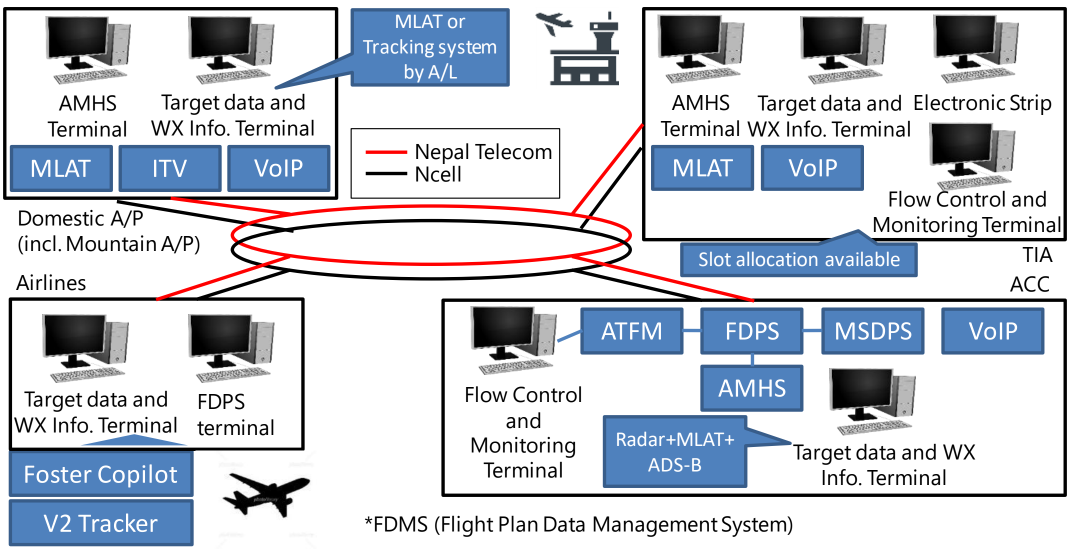
<tr><td>AMHS</td><td>

To ensure the safety and requirements of international civil aviation organization, ICAO has established operational procedure and technical standards for international aviation fixed communications for ICAO member countries. The airline fixed communication network called AFTN (Aeronautical Fixed Telecommunication Network) / AMHS (ATS Message Handling System) was set up.

AMHS links airports, air traffic control agencies, airlines, etc., and operates aircraft schedules including distress reports, emergency reports, flight plan reports, location reports, traffic reports, weather reports, weather information, and other essential information for operation. Information necessary for operation, such as information on service provision, supply of aircraft parts, refueling, etc., can also be exchanged.



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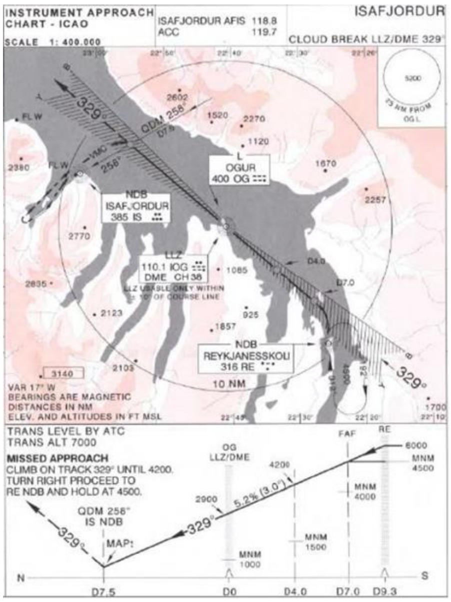
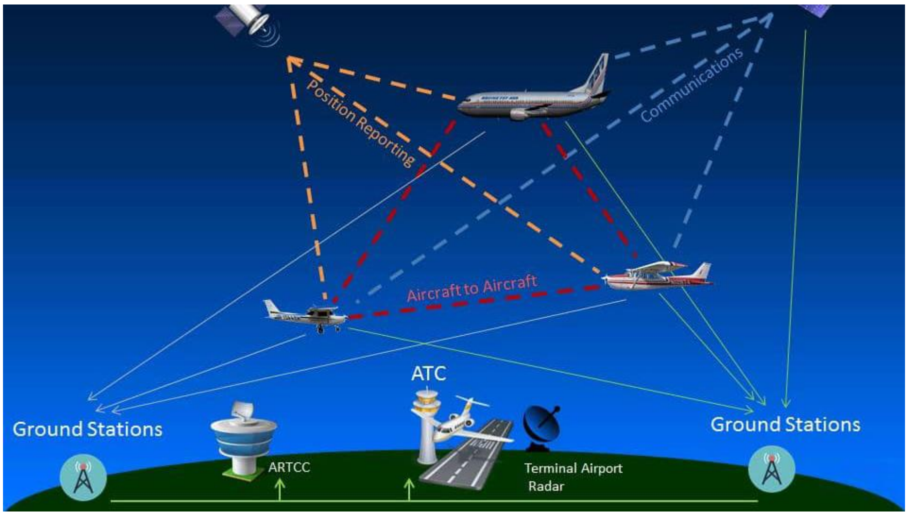
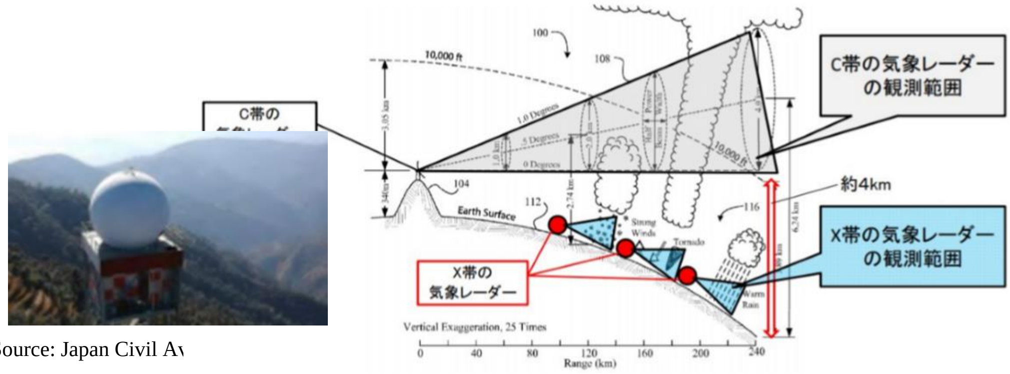
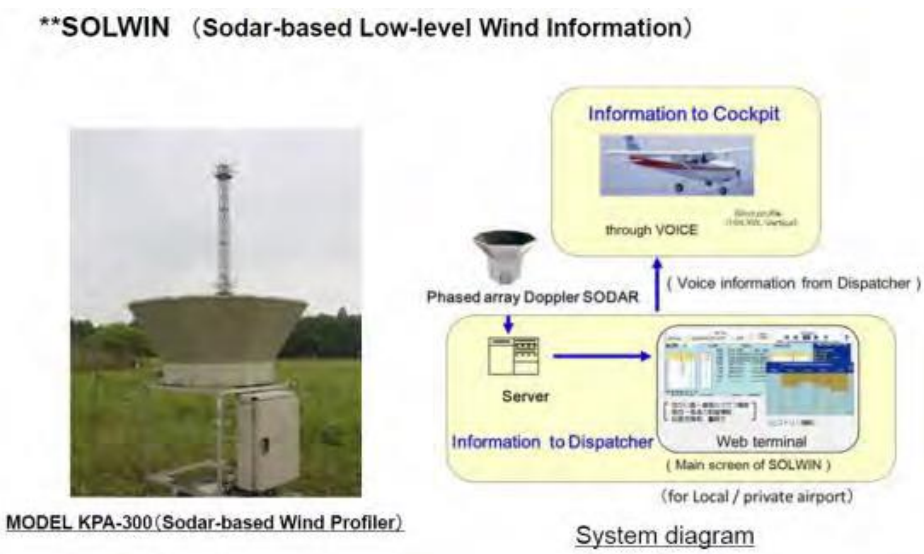
Terms	Description
Cloud Break Procedure	Aircraft flying in the VMC usually keep flying away from the clouds, but even if there is a cloud between the aircraft approaching the runway, it will temporarily pass through the clouds using radio navigation for landing safely. NDB or LOC is used for wireless navigation to assist landing, but the use of SBAS, which is satellite navigation, is also being considered. In addition, it is necessary to develop a flight procedure for landing.  
ADS-B	ADS-B is one of the monitoring functions in CNS / ATM, like radar. The transponder in is aircraft equipped with ADS-B receives the GPS signal, which accurately measures the position of the aircraft during flight, and uses it for other information (speed, direction, altitude, aircraft information). In addition, shares the information with other aircraft and controllers. GPS information is more accurate than radar, so it is safer and efficient. There is also a function that convey pilot various information such as the position and altitude of nearby flying, mountain information, obstacles, and positional relationship from bad weather. However, in order to utilize ADS-B, it is necessary to equip the aircraft with ADS-B devices and is necessary to implement mandatory ADS-B devices in the future. 

<table>
<tr><th>Terms</th><th>Description</th></tr>
<tr><td>X-band Radar</td><td>Radars for weather observation have been developed in two frequency bands, C-band and X-band. C-band radar observes a wide area mainly for the purpose of weather forecast and it may not be possible to perform enough local observation near the ground surface due to the curvature of the earth or topography conditions. The X-band radar requires to install multiple units locally, using high frequency and observe with higher accuracy.



Source: Japan Civil Av</td></tr>
<tr><td>Wind Shear detector</td><td>Wind shear refers to local changes in wind direction or speed in upward and downward direction, causing turbulence. In particular, the occurrence of wind shear at low altitudes affects safety.
The wind shear detection device (in the case of SOLWIN) uses the reflection of sound waves to read changes in airflow. Due to the characteristics of sound waves, the measurement range is up to 90m above the device.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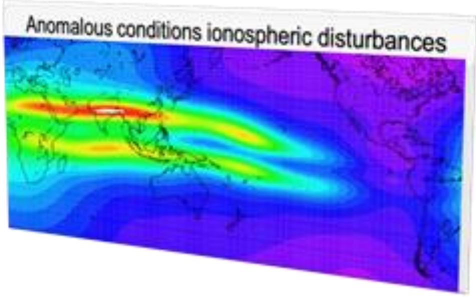
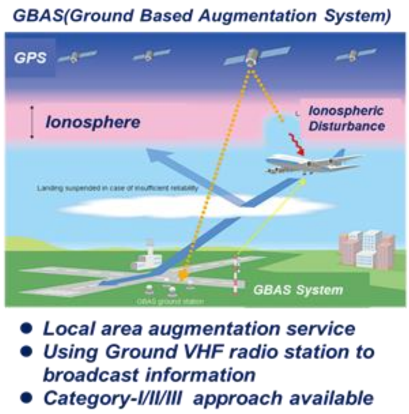
<table>
<tr><th>Terms</th><th>Description</th></tr>
<tr><td>GBAS</td><td>

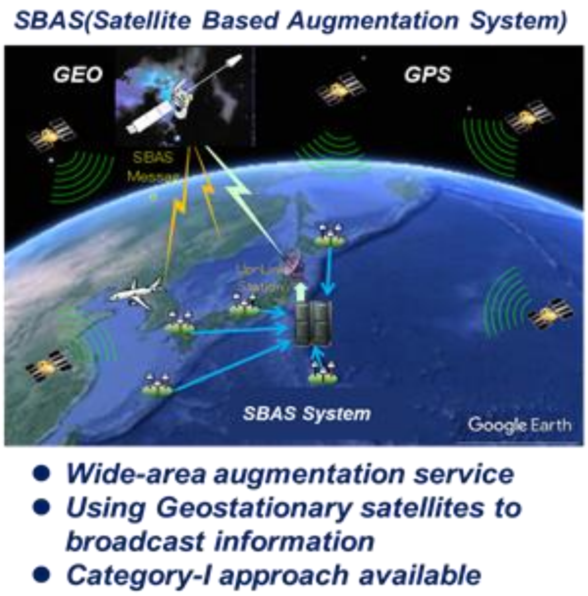
GBAS（Ground-Based Augmentation System) is a system that provides GPS reinforcement signals generated based on GPS signal obtained by monitoring station to aircraft in VHF waves.
The GPS augmentation signal is provided to the approaching aircraft, where the horizontal and vertical aircraft positions are determined, such as the ILS. It is known that the performance of GBAS depends on the effect of the ionosphere. Low-latitude regions in South Asia are affected.





</td></tr>
<tr><td>SBAS</td><td>

The SBAS (Satellite-Based Augmentation System) is a system that broadcast GPS augmentation signal from geostationary satellites. The augmentation signals are provided over wide range from air routes to terminal airspace.
SNAS includes a monitoring station that collects signals transmitted from the GPS, a control station that collects data obtained from the monitoring station to generate a GPS reinforcement signal and uplink station that transmit the GPS reinforcement signal to geostationary satellite. SBAS uses the same frequency as GPS but requires an SBAS receiver to use it.
Although the United States, Japan, Europe, and India had satellites for SBAS, China, Korea, Australia is also considering starting operations.



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Chapter 1 Basic Concept of The Project

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1 BASIC CONCEPT OF THE PROJECT

1.1 Background of the survey

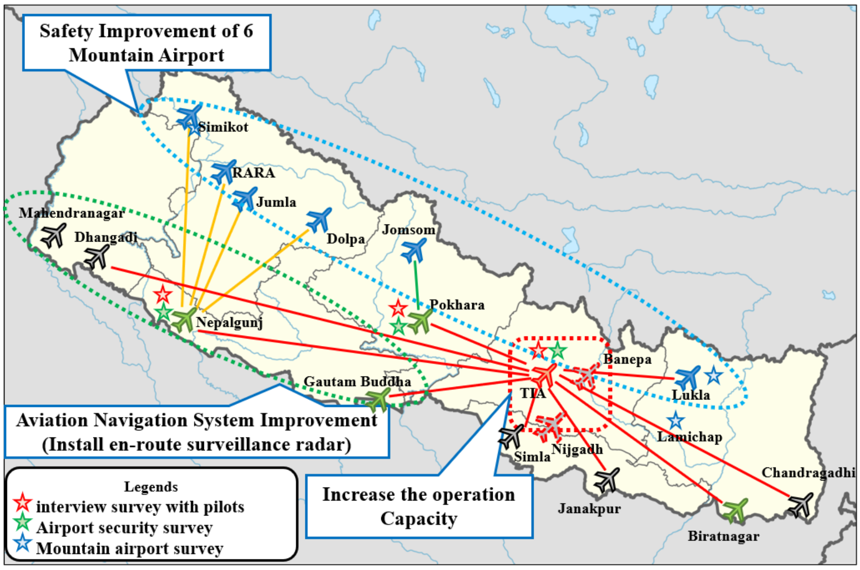
The Japanese government had provided various support in the aviation sector of Nepal since the 1990s through expert dispatch and grant aids in the installation and operation of air traffic control radar facilities, navigation equipments, etc. These contributed towards aviation safety and enhancing transportation capacity and had greatly improved the aviation sector; however, the following are the issues related to the current aviation sector in Nepal:

1) Insufficient handling capacity at the Tribhuvan International Airport (TIA),
2) Improvement in aviation safety (aircraft accidents still occur)
3) Airport security system does not meet the standards of the International Civil Aviation Organization (ICAO).

In response to this, the Civil Aviation Authority of Nepal (CAAN) has high prospect for cooperation in formulatingmaster plans for the entire aviation sector in Nepal.Based on this background, this project intends to examine the current situation and issues of the aviation sector in Nepal and to find out the future potential support policy of Japan in response to diversifying issues. The areas covered by this project include airports, airways, and air security facilities in the country, which are the subject of the field survey shown in Figure 1.1-1.

The aviation sector of Nepal has been impacted by global epidemicity of COVID-19 and the travel restriction, which causes international flight cancellation in TIA, since March 2020. However, since medium- and long-term impact on the aviation sector is not clear and the research and analysis including aviation demand forecast had been completed by March 2020, the impact of COVID-19 is not considered up to Section 7 in this report.

In addition, since April 2020 it is expected that the impact of COVID-19 affects demand forecast. Therefore, considering the long-term decline of aviation demand, the demand forecast up to 2050 had been reconsidered. Furthermore, based on the results of the demand forecast, the measures required for the aviation sector in Nationwide had been reviewed and modified for the implementation time and contents. Reconsidered measures required for aviation sector in Nepal are described in Section 8.



Scope of Survey
Capacity Enhancement of Kathmandu Region
-Tribhuvan International Airport (TIA) -Banepa Domestic Airport (Plan) -Nijgadh Second Intl. Airport (Plan)
Enhancement of Regional Air Transportation
-Gautam Buddha Airport (Expanding) -Pokhara Intl. Airport (Under Construction) -Tarai Region (Mahendra Nagar, Dangadi, Nepalgunj, Simara, Janakpur, Biratnagar, Chandragadi)
Safety Improvement of Mountain Airport
Target Airports (Six Airports) -Lukla, Jomsom, Jumla, Simikot, Dolpa, Rara Pilot Interview (Base Airport) -TIA, Pokhara, Nepalgunj
Airport Security
- TIA, Pokhara, Nepalgunj

(Source: Study Team)

Figure 1.1-1 Overview of the Survey

1.2 Scope of Survey

The scope of this survey is as follows:

- Research comprehensively and collect information necessary for understanding the current situation, issues and state at the aviation sector in Nepal.
- Consider the future support potentials of Japan International Cooperation Agency (JICA) for the aviation sector, including specific preliminary studies for each airport.

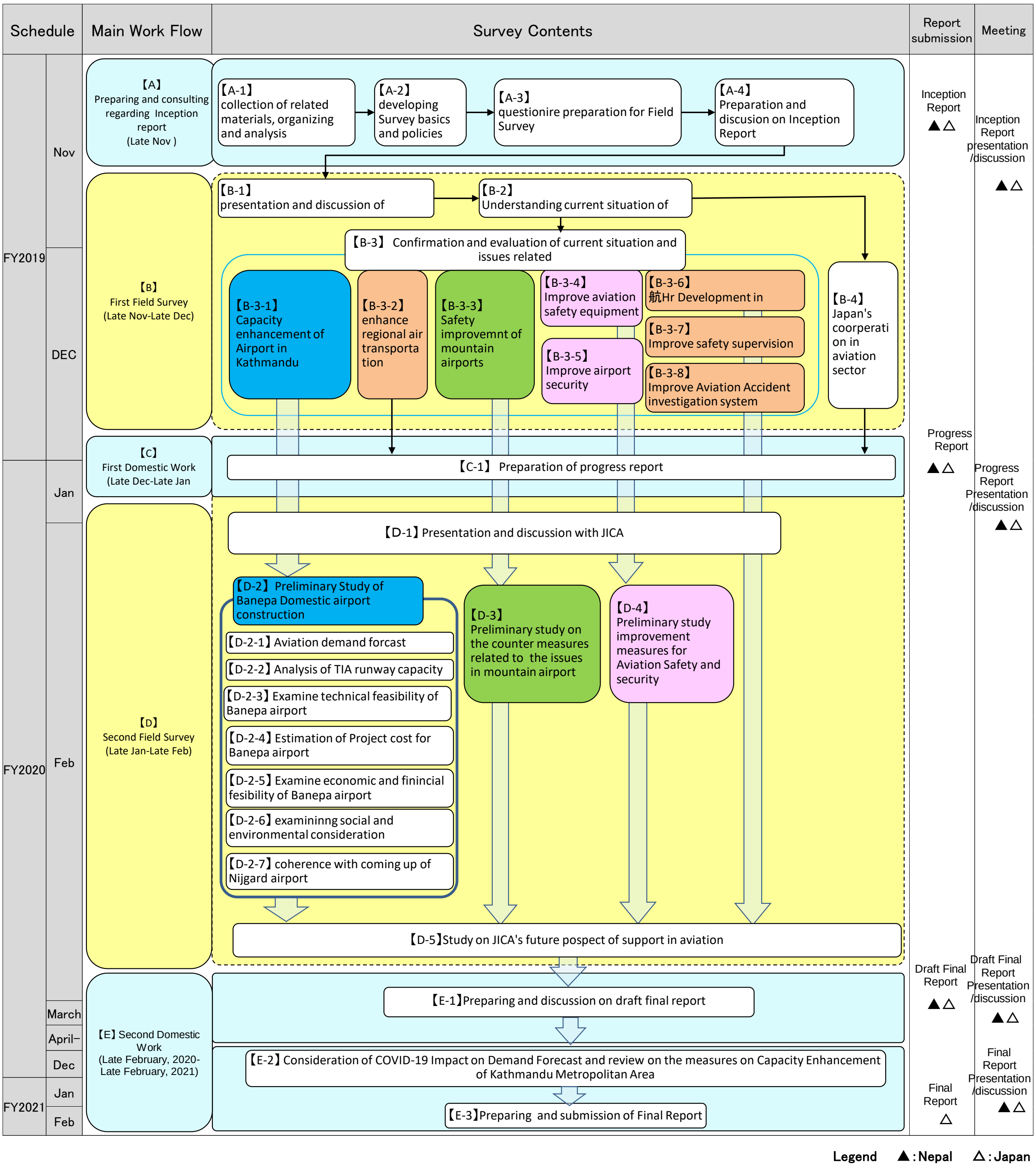
1.3 Executing Agency

(1) Implementing Agency: CAAN

(2) Executing Agency: Ministry of Culture, Tourism, and Civil Aviation (MoCTCA)

1.4 Srudy Flow Chart

The study flow chart is as shown in the Figure 1.4-1.



(Source: Study Team)

Figure 1.4-1 Representation of Survey Methodology

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Chapter 2 Current Status of Nepal

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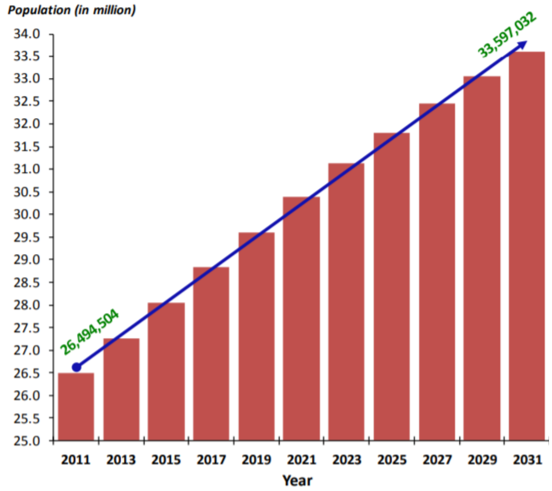
2 CURRENT STATUS OF NEPAL

2.1 Socio-economic and Development Plans

2.1.1 Population

As per the population projection for Nepal 2011-2031 by the Center Bureau of Statistics Nepal, the population in the year 2020 will be 29,609,623 (medium variant), based on the population census data of 2011, in which population was 26,494,504. The average population growth rate is assumed at around 1.35% a year. The population in urban and rural by percentage is about 21.4% and 78.6%, respectively. From the total number of populations, 65.09% are in between the age group of 15-64, with median age of 25 and sex ratio of 94.14 with female exceeding in number. Percentage population distributions in respect to the regions are 21.4% in Eastern Region, 37.5% in Central Region, 18% in Western Region, 13.5% in Mid-Western Region, and 9.6% in Far Western Region. The next population census in Nepal is planned in the year 2021.



(Source: CBS Nepal, 2011-2030 Population Projection)

Figure 2.1-1 Population Projection of Nepal (2011-2030)

2.1.2 Government of Nepal

The Federal Democratic Republic of Nepal consists of executive bodies where the President governs the states and the Prime Minister. The Prime Minister is elected from the Parliament and is the one managing the entire function of the government, whereas, the President's role is mainly ceremonial. The heads of the constitutional body are appointed by the President with the recommendations from the Constitutional Council, however, the Attorney General is appointed with the recommendation from the Prime Minister. The other ministries of the Nepalese government are as shown in Table 2.1-1. After the local, state and federal parliamentary elections held in 2017-2018, the introduction of federalism under the new government is in full swing.

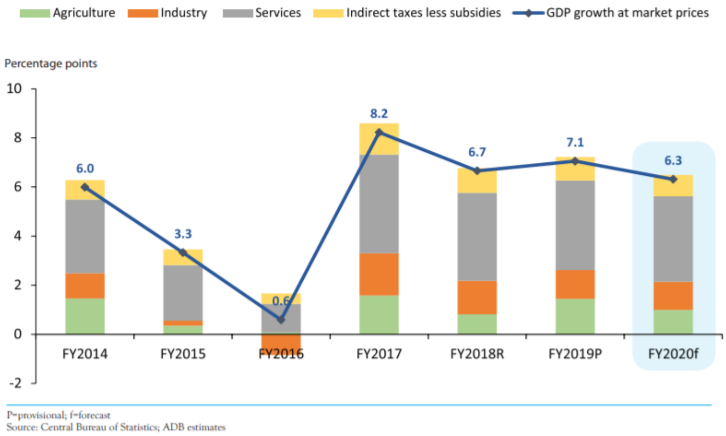
Table 2.1-1 Nepal Government Ministries and their Respective Ministers

Sl. no	Ministry	Minister		Ministry	Minister
1	Office of the Prime Minister	Khadga Prasad Oli	12	Ministry of Agriculture, Land Management and Cooperatives	Chakrapani Khanal
2	Ministry of Home Affairs	Ram Bahadur Thapa	13	Ministry of Labour, Employment and Social Security	Gokarna Bista
3	Ministry of Finance	Dr. Yuba Raj Khatiwada	14	Ministry of Urban Development	Mohammad Estiyak Rai
4	Ministry of Foreign Affairs	Pradip Kumar Gyawali	15	Ministry of Law, Justice and Parliamentary Affairs	Bhanu Bhakta Dhakal
5	Ministry of Defense	Ishwor Pokhrel	16	Ministry of Water Resources and Energy	Barsaman Pun
6	Ministry of Federal Affairs and General Administration	Lal Babu Pandit	17	Ministry of Women, Children and Senior Citizen	Tham Maya Thapa
7	Ministry of Education	Giriraj Mani Pokharel	18	Ministry of Health and Population	Upendra Yadav
8	Ministry of Physical Infrastructure and Transport	Raghubir Mahaseth	19	Ministry of Water Supply	Bina Magar
9	Ministry of Forest and Environment	Shakti Bahadur Basnet	20	Ministry of Youth and Sports	Jagat Bahadur Bishwakarma
10	Ministry of Industry, Commerce and Supplies	Matrika Prasad Yadav	21	Ministry of Culture, Tourism and Civil Aviation	Yogesh Bhattarai
11	Ministry of Information and Communication	Gokul Prasad Baskota			

(Source: JICA Study Team)

2.1.3 Macroeconomic Indicator

Nepal has a nominal gross domestic product (GDP) of USD 30.212 billion and nominal GDP per capita of USD 1,034 in the fiscal year 2018/19 from the National Accounts of Nepal, CBS. Accoding to the ADB Macroeconomic Update, the economic growth in FY2019 was 7.1%, which rose from 6.7% in FY2018. The rise was driven mainly by service and agricultural sectors. The number of tourists and higher remittance inflow were increased, and the service sector such as retail, real estate, transportation or hotels grew conclusively. As for the agricultural sector, the good monsoon and improved facilities initiated better production. In these figures, the provisional growths in each sector in FY2019 are 5% for agricultural sector, 8.1% for industrial sector, and 7.3% in service sector. It is forecasted that the GDP growth for the first term of FY2020 will be around 6.5% with higher projection of steady remittance inflow and higher tourist arrival. Some of the key factors towards the higher projection of remittance inflow and tourist arrival are: 1) Visit Nepal 2020 Initiative; 2) completion of second international airport; 3) increase in air connectivity from the establishment of new/revised air service agreement with Australia, Cambodia, China, UAE, and Vietnam; and 4) coming up of new hotels. On the other hand, new investments in hydropower and cement plants and improved capacity utilization could be positive side for the industrial growth.

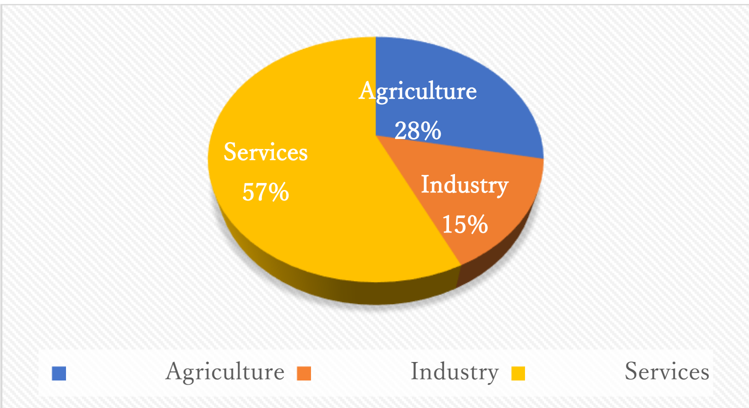


(Source: ADB Macroeconomic Update, September 2019)

Figure 2.1-2 GDP Trend of Nepal

2.1.4 GDP Distribution

In FY2018 the GDP share of by each sector is as shown in Figure 2.1-3, of the total agricultural makes 28%, Industrial sector make 15% and service sector makes 57%.

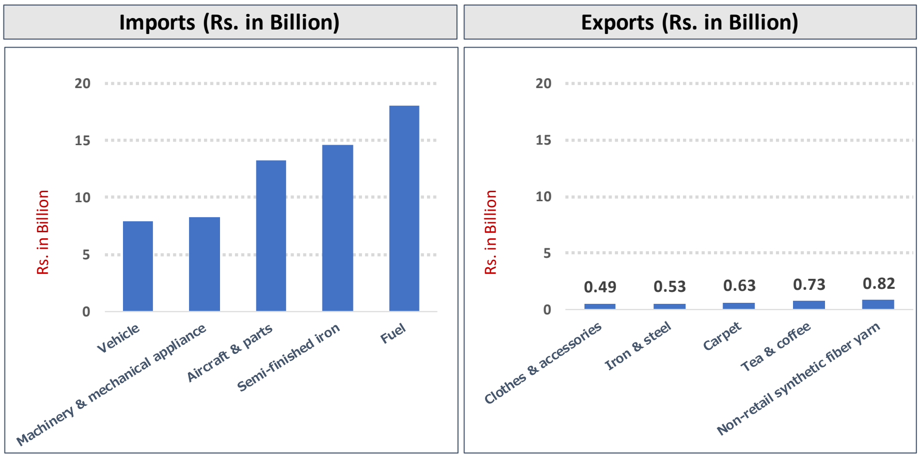


(Source: ADB Statistics)

Figure 2.1-3 GDP % from Major Sectors

2.1.5 Trade Amount by Export/Import

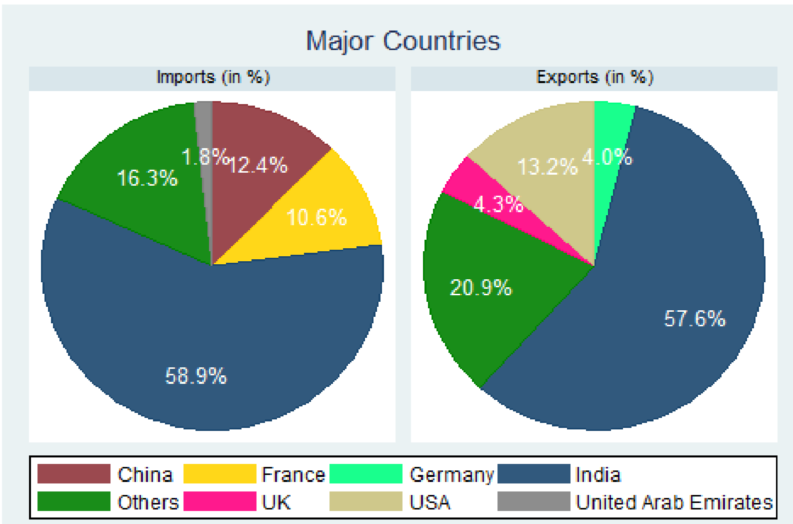
As per the data from the Department of Customs of Nepal, FY2018/19 for the Export/Import of commodities the amount of import in terms of cost is 1.06 billion USD and export is 60 million USD. This results in the negative trade balance of about 1 billion USD. The top exports of Nepal are Non-retail synthetic staple fiber yarn (7.2millionUSD), tea and coffee (6.4millionUSD), Carpet (5.5millionUSD), iron and steel (4.6millionUSD) and cloths and accessories (4.3millionUSD) as shown in the Figure 2.1-4 (right). For the case of import as shown in Figure 2.1-4 (left), top is fuel (160millionUSD), semi-finished iron (130millionUSD), aircraft and parts (120millionUSD), machinery and mechanical appliance (72millionUSD) and Vehicle(70millionUSD).



(Source: Department of Custom, Nepal)

Figure 2.1-4 Import (Left) and Export (Right) of Commodities

The top import/export destination of Nepal is as shown in Figure 2.1-5. For both export and import India is the leading country to trade with Nepal. For the export next country is USA followed by UK and then Germany. For the import next to India is China followed by France and then UAE.



(Source: Department of Custom, Nepal)

Figure 2.1-5 Major Trading Countries of Nepal

2.1.6 National Development Plan (15th Plan, 2019/2020-2023/2024)

Contents of National Development Plan (15^{th} Plan) are shown below.

(1) Background and Existing Condition

There are 28 airlines operating international flights in Nepal and 20 airlines operating domestic flights only. Nepal has bilateral agreements with 29 countries. Due to the complicated topography of Nepal, aviation is regarded as the most important sector of transportation in National Development Plan, but the following problems occur.

- Lack of latest technology and infrastructure
- Lack of personnel with knowledge related to aviation safety surveillance
- Lack of technical and management skills
- Restrictions on expanding international aviation services
- Lack of professional skills and capabilities of airline
- Lack of infrastructure and technology to handle increasing passenger volume
- Lack of aircraft

(2) Task and Goal

Key challenges related to aviation sector:

- Expansion of air routes to access Nepal airspace
- Development, expansion, and management of airport by Public Private Partnership (PPP)
- Self-reliant economical operation of domestic and international airports
- Expansion of international market share of Nepal Airlines Corporation

Key goals of aviation sector are as follows:

- Improve the reliability and safety of aviation services as noted by ICAO
- Enhance the capacity of TIA by operating 24 hours a day
- Starting operation of Gautam Buddha International Airport and Pokhara New international Airport
- Promotion of construction of Nijgadh Airport
- Attracting more private airlines to civil aviation

(3) Strategy and Work Policy

The long-term concept for achieving the above goals is "to ensure safe, reliable, and accessible air moving and transportation means", and for that purpose it is listed as a major goal to ensure air service and safety in accordance with international standards.
Strategy and work policy are shown in Table 2.1-2.

Table 2.1-2 Strategy and Work Policy for National Development Plan

Strategy	Working Policy
1. Adopting International safety standards and new technologies to increase the reliability and safety of aviation services	1. Installation of latest CNS equipment and facilities at the airport to improve air transport safety. Also, improve air safety monitoring and security to international level. 2. Making air accident investigation more systematic, effective, and scientific by establishing permanent and free mechanism. 3. Frequent maintenance and supervision of airport with more touristic and social importance. 4. Air insurance policy for its limit needs to be reviewed.

Strategy	Working Policy
2. Promotion of private sector partnership in the construction, development and management of airport infrastructure	1. Promote private sector collaboration for improving construction, development, and management of airport infrastructure 2. Strategic partnership will be put in place to improve efficiency, management, and competitiveness of Nepal Airlines Corporation. 3. Start the operation of GBA and Pokhara Airport within their construction duration 4. Infrastructure development and capacity enhancement of TIA based on international and domestic traffic demand 5. Begin construction of Nijgadh International Airport 6. Implementation of additional airport fot domestic airlines based on the studies. 7. Promote new airlines to airports that do not have scheduled airline. 8. Increase the number of Nepal Airlines Corporation's and domestic airlines' aiplanes based on the demand of both domestic and international tourists 9. Upgrading of domestic airport to enhance effectiveness of air transport 10. Improvement of accessibility of remote area by making use of Remote Area Air Transport Fund. 11.Construction of helipad in each ward for regional transportation.
3. Improve service provider's ability, competitiveness and effectiveness to make air transportation easier and more accessible	1. Interrelated air service will be operated among airports at the provincial capital. 2. Capacity of CAAN will be enhanced to make air transport service reliable and useful. 3. Higher seat capacity aircraft will be introduced to encourage improvement of domestic air services. Domestic airlines will be encouraged to outbound destinations.
4. Improve the organization of airlines and operator which manage and operate air transport services	1. Improving the organizational structure of Nepal airlines in terms of operational efficiency and professionalism. 2. Enact the Nepal Civil Aviation Act to separate CAAN into operator and regulator.
5. Make international destination accessible for Nepalese air carrier by promoting air routes and air agreements	1. Strategies for national air transport agreement will be formulated and accordingly air treaty/agreement will be done with new air destination countries. 2. Encourage Nepalese air carrier to enter the international market through diplomatic channels.

(Source: JICA Study Team)

2.1.7 National Pride Project Nepal

There are 21 projects selected for National Pride Projects of Nepal. Out of which, there are four irrigations, three hydropowers, three airports, two cultural heritages, six roads, one railroad and one nature conservation, shown in Table 2.1-3. There are 3 projects related to the aviation sector, namely, Gautam Buddha Regional International Airport project, Pokhara Regional International Airport project and Nijgadh Second International Airport project. Kathmandu-Terai Expressway project, which play a role as an access road for Nijgadh Second International Airport project, is also selected.

Table 2.1-3 List of 21 Project Under National Pride Project

	Project	Outline
1	Sikta Irrigation Project	Sikta irrigation project, as a national pride project, aims to provide irrigation facilities to 43,000 Hectare agricultural land of Banke district.
2	Babai Irigation Project	36,000 Hectare land of Bardiya district will be irrigated by Babai irrigation project.
3	Rani-Jamariya-Kularia Irrigation Project	This national pride project was started to provide irrigation facilities to 38,300 Hectare agricultural land of Kailali district.
4	Bheri-Babai Diversion Multipurpose Project	This national pride project is aimed to transfer 40 cubic meter/ sec water from Bheri river to Babai river under the head of 150 m to provide round the year irrigation to 51,000 Hectare cultivable land in Bardiya & Banke district. BBDMP includes three major components as: ・about 12.34 Km long & 4.2 m dia tunnel, ・headwork & desanding basin to be contstructed in Bheri river end ・& forebay, penstok, power house & electro-mechanical parts in Babai river end For tunneling purpose, TBM (Tunnel Boring Machine) is being used in this project for the first time in Nepal & in Siwalik geology.
5	Upper Tamakoshi Hydropower Project	It aims to produce 456 MW electricity & is located in Tamakoshi river of Dolkha district. It is run of river type of hydroelectric project.
6	Budhigandaki Hydropower Project	It has a power plant of 1200 MW capacity & the reservoir site is located in Gorkha & Dhading districts.
7	West Seti Hydropower Project	It aims to produce 750 MW electricity from the water current in Seti river & the project is located in Doti, Dadeldhura, Baitadi & Bajhang districts.
8	Gautam Buddha Regional International Airport	The current Gautam Buddha Airport in Rupandehi district is being upgraded into a regional international airport. Its runway will be upgraded from 1500 x 30 m to 3000 x 45 m.
9	Pokhara Regional International Airport	Under-construction airport in Pokhara, Gandaki Pradesh. It will have one 2500 x 45 m runway and will be able to handle one million passengers annually.
10	Second International Airport, Bara	Located in Bara district & has two parallel runways capable of handling 15 million passengers annually.
11	Pashupati Area Development Project	The main objective of this project is to plan and execute a development program for the Pashupati area in order to preserve this great world heritage site.
12	Lumbini Area Development Project	Lumbini is the birthplace of Gautam Buddha, the light of Asia & the founder of Buddhism. This project was founded for the purpose of restoring the Lumbini garden under the master plan of government of Nepal.
13	Mid-Hills Pushpalal HIghway	The highway which runs through mid-hill region of Nepal starting from Chiyabhanjyang of Panchthar district and ending at Jhulaghat of Baitadi district is known as Mid - Hill Pushpalal

	Project	Outline
		Highway.
14	East-West Railway	Realizing the importance of railways in carrying freight and passengers, Government of Nepal is planning to construct a railway line from east to west that connects the capital city, Kathmandu, with a total of 946 Km length.
15	Terai Hulaki Marg	Terai Hulaki Marga (Postal Highway) runs from Bhadrapur in east to Dodhara in west cutting across entire width of the country.
16	North-South Koshi Corridor	North - south highway which is known to be the shortest highway that connects India and China across the Himlayan mountains in Nepal.
17	North-South Kaligandaki Corridor	Kaligandaki corridor is a strategic project of length 435 Km which links Chinese border in north via Korala with Indian border in south via Bhairahawa. It includes Nawalparasi, Palpa, Tanahu, Syangja, Gulmi, Baglungm, Parbat & Myagdi districts.
18	North-South Karnali Corridor	Divided on two parts i.e. Khulalu - Simikot (196 Km) & Humla - Simikot (88 Km) connecting Khulalu in Kalikot to Hisla in Humla.
19	Kathmandu-Terai Expressway	Four-lane road of total length 76.4 Km linking Kathmandu with Nijgadh of Bara district. The Government of Nepal has handed this project to Nepal Army.
20	Melamchi Drinking Water Project	Designed to divert about 170 MLD (Million Liters Per Day) of fresh water to Kathmandu valley from Melamchi river in Sindhupalchowk district.
21	President Chure-Terai Madhesh Conservation Area Program	Chure is young mountain range situated between the Mahabharat range in north and the Terai plains in south. The range is mostly a long single file of mountain that runs continuously from Indus river in Pakistan in the west throughout the length of Nepal until it reaches Brahmaputra river in India in the east. The Government of Nepal has launched "Rastrapati Chure Terai Madhesh Conservation Program" in 2010.

(Source: Planning Commision, Nepal)

2.1.8 Visit Nepal 2020

Visit Nepal Year 2020(VNY2020) is a campaign conducted by Ministry of Culture, Tourism and Civil Aviation (MoCTCA) in order to achieve the government agenda, the National Tourism Strategic Plan 2016-2025, and to develop the tourism industry in the coming years. Moreover, it is recognized as national development strategy that brings together all the tourist stakeholders to collaborate closely with the government.

The VNY2020 Secretariat was established to coordinate the campaign that works under MoCTCA and in close collaboration with the Nepal Tourism Board and other tourism stakeholders. The office is located at Kaiser Mahal in Kathmandu. The formal grand inauguration of VNY2020 was done on 1 January 2020 by the President of Nepal at Dasharath Stadium in Kathmandu.

VNY2020 aims to improve its competitiveness through investment, innovation, infrastructure development, regulatory reform, new product offerings, environmental conservation, and quality services with the main objective of developing tourism industry as a key economic development strategy of Nepal.

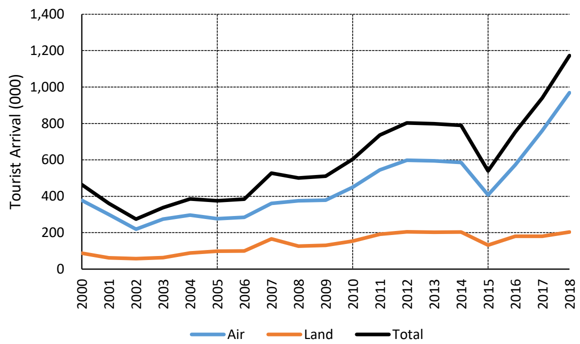
Two million tourists in 2020 is targeted, which is roughly twice that of 2019 (975,557 by October). Opening its door outside in the 1950s, Nepal has outstanding tourism assets like snowcapped highest mountains in the world, abundance of culture and heritage, adventure and recreation, spirituality, regional diversity, nature, and good hospitality. In order to enhance competitiveness of the tourism industry and grow its economic contribution, the government the government is developping road and rail networks, airports, and cable car, opening of new trekking routes, mountain engineering routes, air safety and aviation route, and stadiums and convention centers in all provinces.

VNY2020 Strategic Action Plan involves 20 various plans, such as opening of the Gautam Buddha Airport, organizing aerial sports competition, building on environmental and cultural sustainability, establishing brand of Nepal tourism board and enhancing destination marketing with digital innovations, and creating the Namaste Tourist Information Center. Additionally, in line with VNY2020 most of the airlines agreed to promote the campaign and increase the number of direct flights to Kathmandu. However, the planning was postponed due to infection spread of Covid-19

2.2 Present Status and Development Policy of Transportation and Tourism Sector

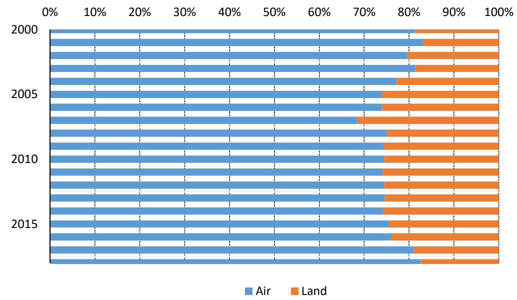
2.2.1 Historical Trend in Mode of Transportation for Tourists

The entry and exit to Nepal are either by air or land. The number of tourists by each mode has been varying as shown in Figure 2.2-1 and Figure 2.2-2 based on the Nepal Tourism Statistics published by the Department of Tourism under the Ministry of Culture, Tourism, and Civil Aviation.
The number of tourists visiting Nepal increased steadily until 2012 but decreased drastically in 2015 due to the earthquake. However, tourists began to expand again from the following year.
The use of transportation mode has remained almost constant at 75% by air and 25% by land since 2005, but the use of air transportation has exceeded 80% since 2017 and has increased further in 2018.



(Source: Nepal Tourism Statistics)

Figure 2.2-1 Historical Trend of Tourist



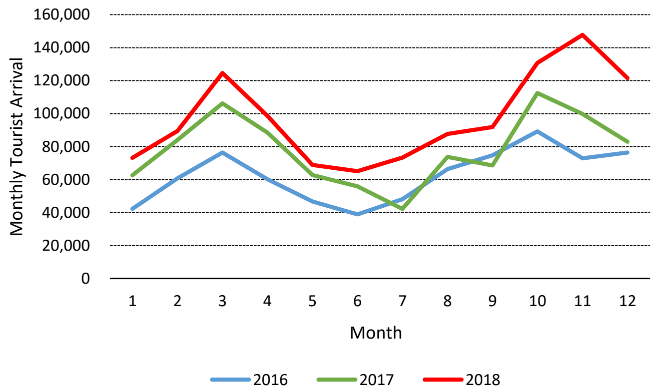
(Source : Nepal Tourism Statistics)

Figure 2.2-2 Mode of Transportation for Tourist Visiting Nepal

2.2.2 Feature of Tourist Visiting Nepal

(1) Seasonal Variation

Figure 2.2-3 shows the seasonal fluctuation of tourist visiting Nepal. There are two peak seasons, i.e., March and October to November, and the tourists during June, which is during off-season is less than 50% of the peak season in 2018.



(Source: Nepal Tourism Statistics)

Figure 2.2-3 Seasonal Fluctuation of Tourist

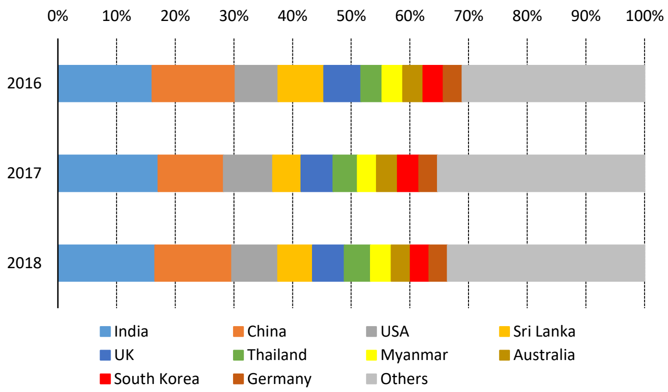
(2) Nationality

Table 2.2-1 shows the status of tourist arrival ranking by nationality. The first and second are unchanged for India and China, respectively, and the United States, Sri Lanka, and UK ranked from third to fifth places, although the rankings change every year.
The percentage distribution of tourist arrival from each country is shown in Figure 2.2-4. The top five countries accounted for about 50% of the total.
In 2018, there were 1.173 million tourists, with 200,000 in India, 153,000 in China, and 91,000 in the United States. Japan ranked 12th with 30,000 (2.6% of the total).

Table 2.2-1 Ranking of the Number of Tourist Arrival by Country

	2016	2017	2018
Rank 1	India	India	India
Rank 2	China	China	China
Rank 3	Sri Lanka	USA	USA
Rank 4	USA	UK	Sri Lanka
Rank 5	UK	Sri Lanka	UK

(Source: Nepal Tourism Statistics)



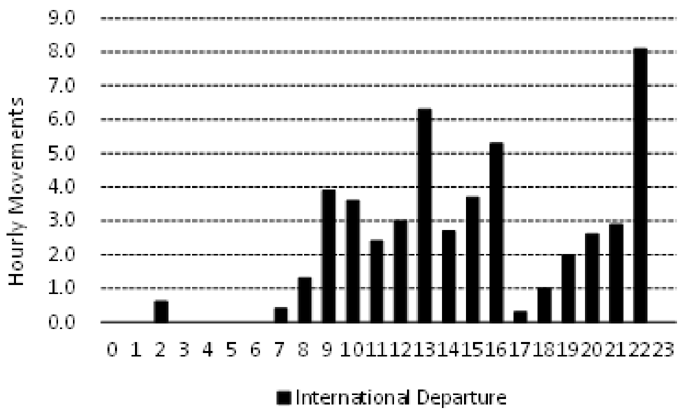
(Source: Nepal Tourism Statistics)

Figure 2.2-4 Nationality of Tourists

(3) Tourist Destinations in Nepal

Because there had been no data available on the destination of foreign tourists visiting Nepal, the interview survey had been conducted to understand the situation. The outline of the survey is as follows:

Survey method:	One day interview with departing passengers at TIA international check-in lobby.
Survey time:	Based on the international departure flight schedule shown in Figure 2.2-5, the survey time was set at eight hours from 8:00-13:00 and 18:00-21:00 considering the peak periods.

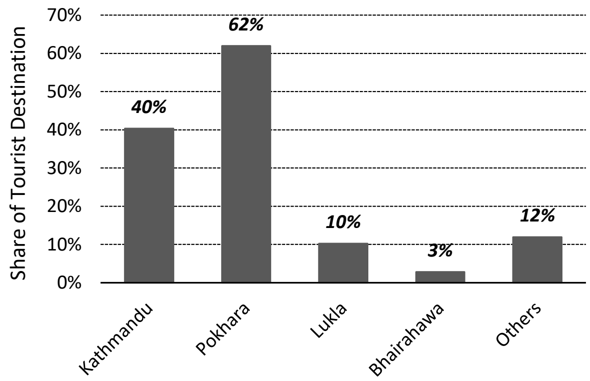


(Source: Flight Status, 1-7 October 2019)

Figure 2.2-5 Flight Schedule of International Departure

Question: Airline and destination of boarding flight, visit place in Nepal, current place of residence, etc.

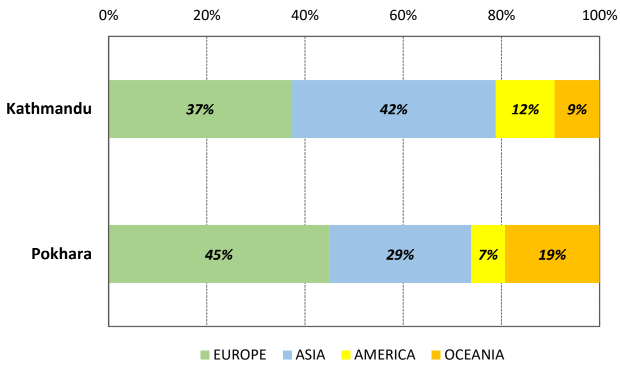
Survey result: About 60% of tourists visit Pokhara and 10% visit Lukla (Figure 2.2-6). Foreigners visiting Pokhara are more likely to live in Europe and Australia than those visiting Kathmandu (Figure 2.2-7).



Sample Number:352

(Source: JICA Study Team)

Figure 2.2-6 Destination of Foreign Tourists



Sample Number:352

(Source: JICA Study Team)

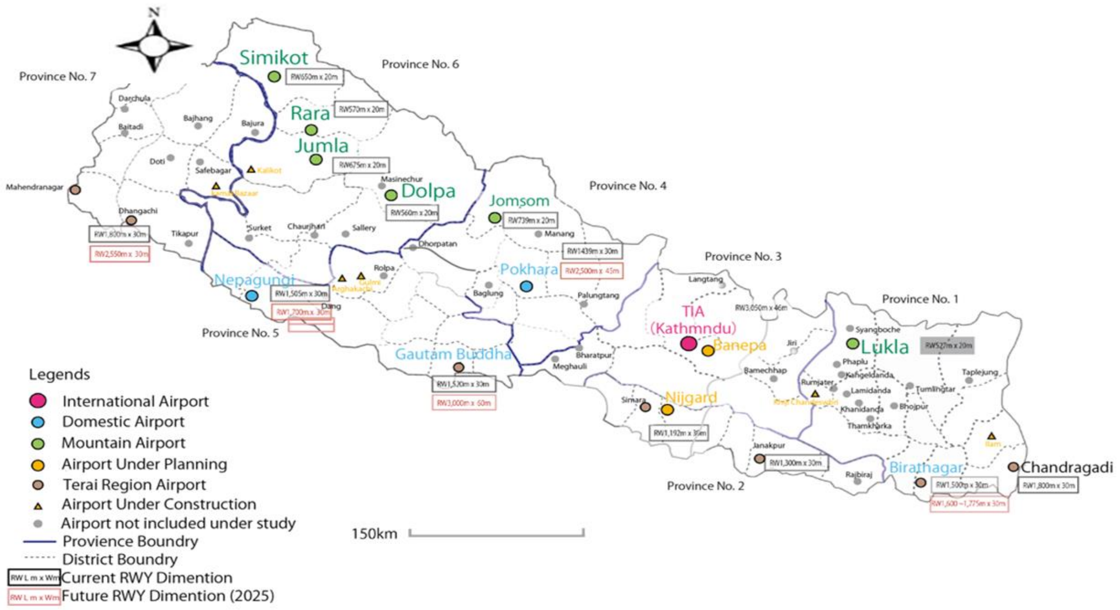
Figure 2.2-7 Residence of Foreign Tourists

2.3 Current Status of Aviation in Nepal

2.3.1 Airport Facilities (Overview of Major Airport Facilities)

(1) Status of Air Transportation

Air transportation is one of the important means of transportation in Nepal along with land transportation. Especially in the mountainous area, airports are the main means of transportation due to the difficult topography for constructing roads.
Nepal has one international airport, four domestic hub airports, and 44 domestic airports at present, a total of 49 airports.
Six domestic airports and three international airports are under construction together with one international airport under planning. Of the total 49 airports, 33 are in operation, and 16 are not operated.
Figure 2.3-1 shows the location of all airports while Table 2.3-1 shows a list of annual number of passengers at airports in operation.



(Source: JICA Study Team)

Figure 2.3-1 Airport Distribution Map of Nepal

Currently, all airports are operated by CAAN, but privatization of airport operations is under consideration. In 2010, the International Finance Corporation (IFC) is discussing providing technical assistance to the Government of Nepal for the privatization of Nepal Airlines and TIA international terminal.
In November 2017, at a stakeholder meeting at Gautam Buddha Airport, including NPC (Nepal Planning Commission), and was decided to conduct FS survey for operational privatization after completion of the airport construction. However, at that time in order to realize the privatization of the airport, it was necessary to develop new law. The Integrated civil aviation bill was proposed in August 2018, which allowed the private sector to enter the construction and operation of airports, but according to the NPC, when only the government's resources were insufficient after the completion of construction, the private sector will enter to operate the airport.
Even now, privatization of Gautam Buddha Airport and TIA is under consideration. In addition, the implementation based on the BOOT (Build, Own, Operate and Transfer) method is being considered for Nijgard second international airport project.

Table 2.3-1 List of Operating Airports in Nepal

No	Classification	Airport Name	Annual Passenger	Altitude (ft)	Runway Dimension

			(2018)		
1	International Airport	Tribhuvan International Airport	7,190,238	4394	3,050 m x 46 m
2	Domestic Hub Airport	Pokhara	609,975	2696	1,447 m x 30 m
3		Biratnagar	537,780	236	1,500 m x 30 m
4		Nepalgunj	426,661	518	1,524 m x 30 m
5		Gautam Buddha	377,692	344	1,500 m x 30 m
6	Tarai Region	Simara	231,291	445	1,192 m x 30 m
7		Bharatpur	229,495	679	1,200 m x 30 m
8		Chandragadi	228,128	312	1,500 m x 30 m
9		Dhangadhi	177,698	621	1,800 m x 30 m
10	Mountain Airport	Lukla	124,929	9337	527 m x 20 m
11	Tarai Region	Janakpur	79,296	233	1,300 m x 30 m
12	Mountain Airport	Simikot	54,261	9751	650 m x 20 m
13		Jomsom	46,401	8976	810 m x 20 m
14		Tumlingtar	30,998	1316	1,295 m x 30 m
15		Rara	19,360	8924	570 m x 20 m
16		Dolpa	19,352	8212	562 m x 20 m
17		Surkhet	15,547	2278	1,255 m x 30 m
18		Jumla	14,163	7792	675 m x 20 m
19		Bajura	11,807	4606	600 m x 20 m
20		Phaplu	10,603	8097	680`m x 30 m
21		Bhojpur	5,399	3962	545 m x 20 m
22		Salley	2,483	5184	580 m x 20 m
23		Taplejung	2,393	7936	900 m x 30m
24		Baglung		3248	608 m x 30 m
25		Chaurjhari		2431	600 m x 20 m
26		Dang		2080	750 m x 30 m
27		Khanidanda		4435	510 m x 27 m
28		Lamidanda		4025	516 m x 30 m
29		Ramechhap		1620	530 m x 20 m
30	Tarai Region	Rajbiraj		262	1,500 m x 30 m
31	Mountain Airport	Rumjatar		4498	549 m x 30 m
32		Sanfebagar		1959	550 m x 20 m
33		Thamkharka		5252	630 m x 20 m

(Source: JICA Study Team)

Tribhuvan International Airport in Nepal plays a vital role both as the only international airport in the country and as the hub for domestic airport networks.

Four of the domestic hub airports are Pokhara, Gautam Buddha, Nepalgunj, and Biratnagar. At present, three airports, i.e., Pokhara, Gautam Buddha and Nijgadh are under construction, which will be international airports in the future. The tentative completion date of the airport is in 2020 for Gautam Buddha and 2021 for Pokhara.

The main domestic routes in Nepal are those that connect, Kathmandu, Pokhara and Tarai Region. There are also air routes connecting, Kathmandu, Pokhara and Nepalgunj with mountain airports.

(2) Traffic Volume at Major Airports (Passenger, Flight Departure/Arrival, and Cargo Volumes)

Table 2.3-2 shows the number of air passengers and Table 2.3-3 shows number of aircraft takeoffs and landings at the domestic airport over the past ten years.

Table 2.3-2 Air Passengers in the Past Ten Years

Airport	Passengers									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tribhuvan - Int'l	2,027,147	2,436,558	2,700,027	2,925,175	3,140,302	3,511,647	3,217,162	3,510,742	3,887,845	4,342,486
Tribhuvan - Dom	1,377,868	1,554,701	1,583,845	1,575,059	1,542,604	1,450,558	1,364,048	1,757,596	2,451,390	2,847,752
Bajura						5,735	9,717	8,632	10,606	11,807
Bharatpur	41,506	45,131	51,126	52,709	57,695	53,861	54,238	150,345	257,709	229,495
Bhojpur						4,871	5,035	7,668	6,927	5,399
Biratnagar	408,576	364,949	372,045	358,742	292,538	311,368	340,202	377,077	455,284	537,780
Chandragadhi	135,466	154,687	154,882	150,264	129,768	120,408	164,891	162,153	192,584	228,128
Chaurjhari				4,353						
Dhangadhi	39,826	34,991	37,726	42,033		50,255	45,469	62,375	128,035	177,698
Dolpa						12,639	9,184	12,248	12,217	19,352
Gautam Buddha	87,727	84,349	119,508	118,367	119,994	109,731	107,914	168,421	300,393	377,692
Janakpur	55,899	66,506	62,113	72,356	51,792	60,384	44,655	53,283	64,703	79,296
Jomsom	24,014	70,834	65,527	57,592	34,542	48,949	35,766	39,715	41,634	46,401
Jumla	40,268	33,350	27,651	28,713	25,469					14,163
Kangeldada										
Khanidanda										797
Lamidanda				4,042	9,922					
Lukla	88,881	92,011	93,292	97,394	78,701	87,490	81,174	119,801	146,879	124,929
Manag										
Nepalgunj	140,045	143,456	142,869	178,049	171,012	165,867	176,372	233,533	369,355	426,661
Phaplu				18,819		1,483	36,928	11,811	11,007	10,603
Pokhara	301,475	360,610	370,493	379,503	359,899	368,880	274,550	328,031	446,024	609,975
Ramechhap				746						
Rara					5,981	3,780	4,078	13,700	18,651	19,360
Rumjatar										
Salley						1,200	2,350	1,824	2,577	2,483
Simara	83,012	82,431	70,745	60,051	38,760	50,868	45,525	78,756	107,154	231,291
Simikot	13,055	16,121	17,732	21,774	21,122	12,923	21,922	57,207	59,770	54,261
Surkhet	19,367	19,456	3,700	18,574	14,702	16,928	15,234	9,803	7,563	15,547
Taplejung						1,376	893	2,691	2,094	2,393
Thamkharka										
Tumlimgtar				3,037		28,227	34,913	31,834	33,210	30,998

(Source: CAAN)

Table 2.3-3 Aircraft Takeoffs and Landings over the Past Ten Years

Airport	Aircraft Mevements									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tribhuvan - Int'l	15,701	19,418	22,792	23,320	23,619	27,208	26,563	27,118	33,362	33,933
Tribhuvan - Dom	76,183	79,900	79,260	70,877	69,076	68,536	65,865	73,876	93,107	95,580
Bajura						756	1,500	966	1,068	1,092
Bharatpur	4,064	-	-	2,686	2,782	2,538	2,340	4,612	8,182	7,774
Bhojpur						368	348	526	444	372
Biratnagar	15,382	-	-	9,284	7,044	7,794	9,362	9,342	9,904	9,812
Chandragadhi	-	-	2,648	4,480	3,430	3,214	4,300	4,106	4,522	4,768
Chaurjhari				404						
Dhangadhi	1,176	-	-	1,364		1,208	1,150	1,086	2,530	3,076
Dolpa						1,517	1,274	1,638	1,200	1,556
Gautam Buddha	3,962	-	-	4,172	4,110	3,996	3,751	4,666	7,742	8,258
Janakpur	3,320	-	-	2,752	1,740	2,466	1,532	1,724	2,073	3,975
Jomsom	-	-	89	4,070	2,665	3,855	2,804	3,222	3,222	3,209
Jumla	-	-	10	2,140	2,132					1,588
Kangeldada										
Khanidanda										70
Lamidanda				412	642					
Lukla	12,300	-	-	16,936	23,363	16,802	16,767	20,418	27,292	31,636
Manag										
Nepalgunj	9,568	8,472	8,152	9,121	9,185	9,107	9,918	11,362	13,838	14,822
Phaplu				2,746		374	3,827	3,326	2,965	3,297
Pokhara	21,513	25,585	20,183	26,790	27,648	36,913	29,303	23,927	36,077	42,358
Ramechhap				1,736						
Rara					861	836	736	1,314	1,640	2,360
Rumjatar										
Salley						122	220	170	214	186
Simara	4,068	-	-	4,332	2,642	3,370	3,108	4,594	5,374	9,500
Simikot	-	-	4	2,524	5,856	4,082	6,470	13,368	14,725	13,960
Surkhet	12,049	-	-	6,570	4,475	5,620	5,363	5,099	3,765	4,567
Taplejung						180	90	334	334	299
Thamkharka										
Tumlimgtar				1,944		1,682	1,978	1,906	1,788	1,677

(Source: CAAN)

2.3.2 Air Transportation Services

(1) Air Passenger Transport

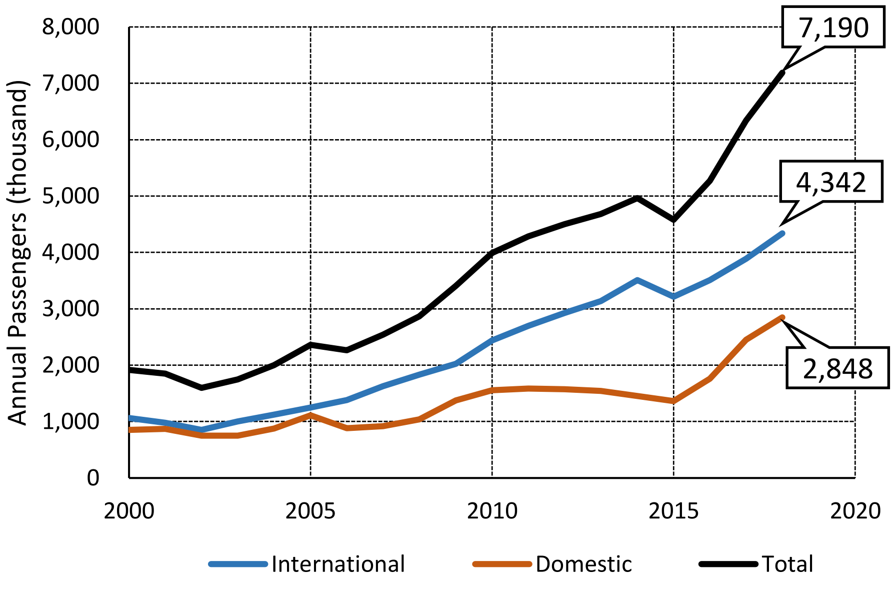
1) Kathmandu/Tribhuvan International Airport

The Tribhuvan International Airport (hereinafter, referred to as TIA) is the hub airport for the domestic airport network in Nepal and is the only airport to operate international flights. Figure 2.3-2 shows the historical trend of air passengers at TIA. In 2018, TIA handled 4.3 million passengers per annum (mppa) in international air service, 2.9 mppa in domestic air service, and 7.2 mppa in total.

The number of international passengers has shown a steady increase since 2002, despite a temporary decrease due to the impact of the 2015 earthquake.

On the other hand, the number of domestic passengers was found to be stagnant and does not increase during the five years period from 2010 to 2015. However, after 2015 the passenger movement rose sharply. In this regard, the comments by airlines are shown as follows:

- Regarding the increase after 2015, air service was used as the mode of transportation between Kathmandu and local cities, since roads were damaged by the 2015 earthquake and traffic was blocked in many places. In addition, it is also believed that air passengers have increased due to the increase in seat capacity and the drop-in air ticket prices. After 2015, major airlines have increased their aircrafts, and new airlines such as Shree Airlines have newly commenced their operation.
- Prior to 2015, there was a rise in air ticket prices due to the rise in crude oil prices. This is one of the reasons that the air passenger demand has not increased.



(Source: CAAN Annual Report, TIA data, CAAN and JICA Data Book)

Figure 2.3-2 Historical Trend of Air Passenger at TIA

2) Domestic Hub Airports

The four airports, namely; Pokhara, Biratnagar, Nepalgunj, and Bhairahawa function as hub airports in the domestic network, serving as bases for flights to the mountain airports or as relay points between Kathmandu and mountain airports.

Table 2.3-4 shows the number of domestic passengers handled at the four hub airports.

Table 2.3-4 Domestic Passenger at the Four Hub Airport

Airport		2014	2015	2016	2017	2018
Pokhara	(thousand)	369	275	328	446	610
Biratnagar	(thousand)	311	340	377	455	538
Nepalgunj	(thousand)	166	176	234	369	427
Bhairahawa	(thousand)	110	108	168	300	378

(Source: CAAN Annual Report, TIA data, CAAN and JICA Data Book)

3) Local Airport (1)

In addition to the four hub airports, there are five airports with the number of domestic passengers exceeding 100,000 in 2018. Lukla is included in these five airports. According to Lukla's passengers in 2018 which has fallen from the previous year, it is anticipated that transport capacity of Lukla does not meet the demand.

Table 2.3-5 shows the number of domestic passengers handled at the five airports.

Table 2.3-5 Domestic Passengers at the Five Local Airports

Airport		2014	2015	2016	2017	2018
Simara	(thousand)	51	46	79	107	231
Bharatpur	(thousand)	54	54	150	258	229
Bhadrapur	(thousand)	120	165	162	193	228
Dhangadhi	(thousand)	50	45	62	128	178
Lukla	(thousand)	87	81	120	147	125

(Source: CAAN Annual Report, TIA data, CAAN and JICA Data Book)

4) Local Airport (2)

Table 2.3-6 shows the number of domestic passengers at the airports where less than 100,000.

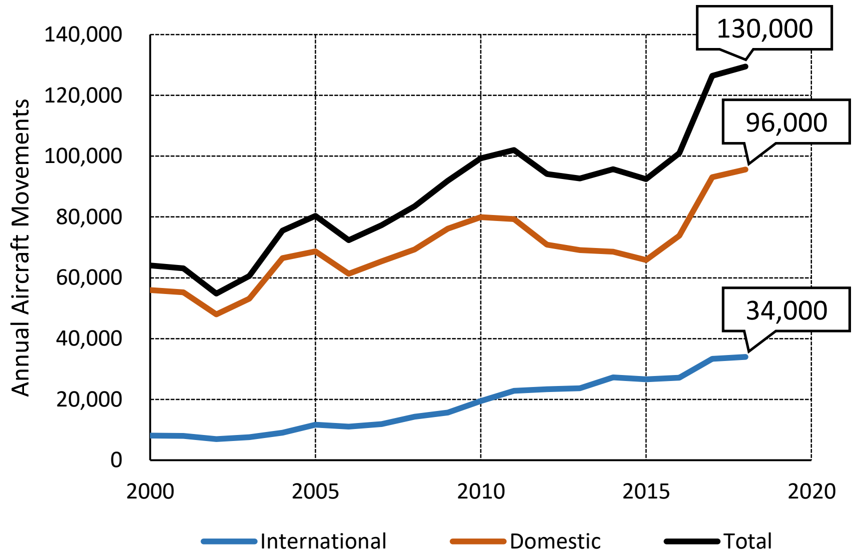
Table 2.3-6 Number of Passengers at the Local Airports-2

Airport		2014	2015	2016	2017	2018
Janakpur	(thousand)	60	45	53	65	79
Simikot	(thousand)	13	22	57	60	54
Jomsom	(thousand)	49	36	40	42	46
Tumlingtar	(thousand)	28	35	32	33	31
Rara	(thousand)	3.8	4.1	13.7	18.7	19.4
Dolpa	(thousand)	12.6	9.2	12.2	12.2	19.4
Surkhet	(thousand)	16.9	15.2	9.8	7.6	15.5
Bajura	(thousand)	5.7	9.7	8.6	10.6	11.8
Phaplu	(thousand)	1.5	36.9	11.8	11.0	10.6
Bhojpur	(thousand)	4.9	5.0	7.7	6.9	5.4
Salle	(thousand)	1.2	2.4	1.8	2.6	2.5
Taplejung	(thousand)	1.4	0.9	2.7	2.1	2.4

(Source: CAAN Annual Report, TIA data, CAAN and JICA Data Book)

(2) Aircraft Movement

The Figure 2.3-3 shows the historical trend of aircraft movements in TIA. In 2018, the aircraft movements were 96,000 for domestic flight and 34,000 for international flight making total of 130,000. International flights have been on a steadily increasing trend, while domestic flights have experienced a decrease in both passengers and aircraft movements due to the rise of fuel prices and airfare from 2010 to 2015. However, aircraft movements have increase as passenger increase after 2015.
The flight movement data obtained from the TIA includes all types of aircraft such as helicopters. In order to classify these data in terms of domestic flight, international flight, and helicopters, it is necessary to use flight log data. Since the peak season of aircraft movement at TIA was from October to November, the flight log data of late October (October 26) was collected.
As shown in Table 2.3-7, the number of daily flights (departure or arrival) on the subject day was 118, 55, 39 and 212, respectively, for domestic, international, helicopter, and total. Helicopters account for about 20% of the total flights during peak period.



(Source: CAAN Annual Report, TIA data, CAAN & JICA data book)

Figure 2.3-3 Historical Trend of Aircraft Movements in TIA

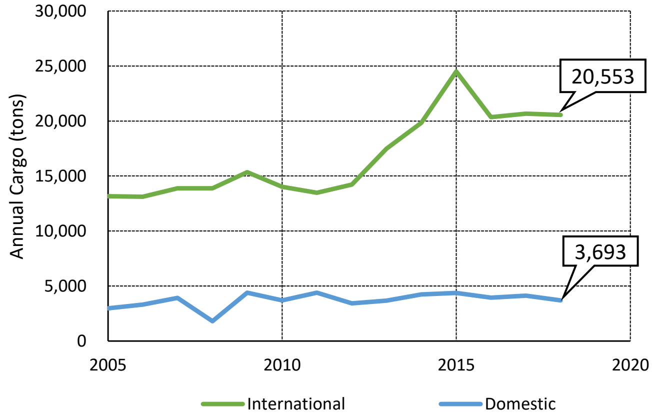
Table 2.3-7 Number of Flights Operated in TIA (26 October 2019)

	Domestic	International	Subtotal		Total	
19 seater (DHC6, Do228, etc.)	14	—	14	(8%)		
ATR42, B190,J41, etc.	37	—	37	(22%)		
ATR72, CRJ700/200, etc.	67	1	68	(39%)		
Jet (A330, A320, B737, etc.)	—	54	54	(31%)		
Subtotal	118	55	173	(100%)	173	(82%)
Helicopter	—	—			39	(18%)
Total					212	(100%)

(Source: TIA data)

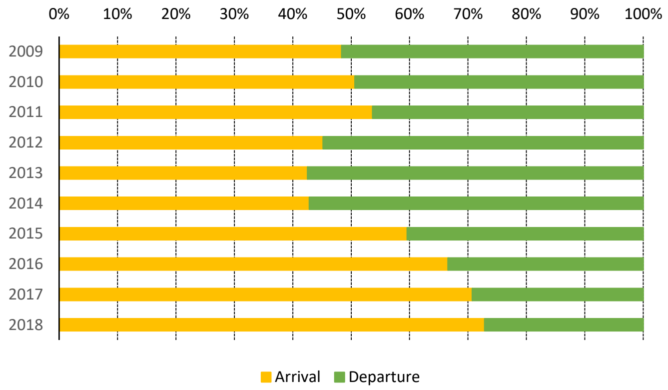
(3) Air Cargo Transportation

Figure 2.3-4 shows the historical trend of air cargo transportation in TIA. In 2018, international cargo volume was about 20.0 thousand tons and domestic cargo volume was 3.7 thousand tons.
Figure 2.3-5 shows the distribution of import and export of international air cargo. Figure 2.3-6 shows the distribution of domestic cargo arriving at and departing from TIA. International cargo had a peak in 2015 and the reason for this might that air cargo related to the earthquake increased. As for international cargo, in recent years, export cargo accounts for 30%-40% and import cargo accounts for 60%-70%. Regarding domestic cargo, the cargo departing from TIA accounts for 85%, and arriving at TIA as 15%.



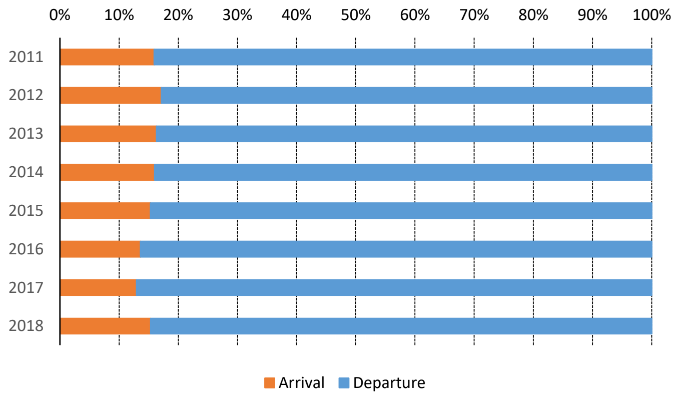
(Source: TIA data, CAAN and JICA Data Book)

Figure 2.3-4 Historical Trend of Air Cargo at TIA



(Source: TIA data)

Figure 2.3-5 Variation of Import and Export Cargo at TIA



(Source: TIA data)

Figure 2.3-6 Variation in Arriving and Departing Cargo at TIA

(4) Airline Operating Status and Future Trends

1) Airline Operating Status for Domestic Airlines

The airlines that operate domestic flight at TIA (excluding helicopter specialized companies) and the aircraft owned by each airline are as shown in
Table 2.3-8. Currently, nine airlines operate domestic flights at TIA. Of these, three companies, namely; Buddha Air, Yeti Airlines, and Shree Airlines own aircraft with the largest of 70-seater on domestic flights (ATR72, DHC8, and CRJ700).
The operating airlines, the number of flights, and aircraft on the routes connecting TIA and local airport are as shown in Table 2.3-9.

Table 2.3-8 Status of Domestic Flight Status at TIA

Airline		Equipment Operated
Buddha Air	(U4)	ATR72/42, Beechcraft 1900D
Nepal Airlines	(RA)	DHC6, Y12, MA60
Saurya Airlines	(S1)	CRJ200
Shree Airlines	(N9)	DHC8, CRJ700/200
Simrik Airlines	(RMK)	Beechcraft 1900D
Sita Air	(-)	Do228
Summit Air	(-)	L410
Tara Air	(-)	DHC6, Do228
Yeti Airlines	(YT)	ATR72, Jetstream41

(Source: Airline website, Airline interview)

Table 2.3-9 Operation Status of Domestic Airport

Route	Airline	Daily Frequency	Equipment	Runway Length
Biratnagar	Buddha	7	ATR72	1,505 m
	Nepal	1	MA60/DHC6/Y12	
	Saurya	2	CRJ200	
	Shree	5	CRJ700/200	
	Yeti	5	ATR72	
	Total	20		
Nepalgunj	Buddha	4	ATR72	1,504 m
	Nepal	3w	MA60/DHC6/Y12	
	Shree	4	CRJ700/200	
	Sita	3w	Do228	
	Summit	1w	L410	
	Yeti	2	ATR72	
	Total	10+7w		
Bhairahawa	Buddha	5	ATR72	1,510 m
	Nepal	2w	MA60/DHC6/Y12	
	Saurya	2	CRJ200	
	Shree	2	CRJ700/200	
	Yeti	3	ATR72	
	Total	12+2w		
Pokhara	Buddha	8	ATR72	1,439 m
	Nepal	1+3w	MA60/DHC6/Y12	
	Simrik	4	B1900	
	Yeti	12	ATR72/JS41	
	Total	24+3w		
Bharatpur	Buddha	5	ATR42	1,158 m
	Yeti	5	JS41	
	Total	10		
Janakpur	Buddha	3	ATR72	1,606 m
	Yeti	2	ATR72/JS41	
	Total	5		

Route	Airline	Daily Frequency	Equipment	Runway Length
Simara	Buddha	7	ATR42	1,192 m
	Nepal	1	MA60/DHC6/Y12	
	Total	8		
Chandragadhi	Buddha	3	ATR72	1,800 m
	Nepal	3w	MA60/DHC6/Y12	
	Saurya	1	CRJ200	
	Shree	3	CRJ700/200	
	Yeti	2	ATR72	
	Total	9+3w		
Lukla	Nepal	1	DHC6/Y12	527 m
	Sita	3	Do228	
	Summit	2	L410	
	Tara	4	DHC6, Do228	
	Total	10		
Dhangadhi	Buddha	2	ATR72	1,800 m
	Nepal	4w	MA60/DHC6/Y12	
	Shree	3	CRJ700/200	
	Total	5+4w		
Rajbiraj	Shree	1	CRJ700/200	1,700 m
Tumlingtar	Buddha	2	ATR42	1,220 m
	Yeti	2	JS41	
	Total	4		
Bhojpur	Nepal	1	DHC6/Y12	534 m
Rumjatar	Nepal	2w	DHC6/Y12	549 m
	Sita	1w	Do228	
	Total	3w		
Phaplu	Nepal	3w	DHC6/Y12	680 m
	Sita	1w	Do228	
	Summit	1w	L410	
	Tara	1	DHC6, Do228	
	Total	1+5w		
Salley	Nepal	4w	DHC6/Y12	535 m
Chaurihari	Nepal	2w	DHC6/Y12	487 m
Thamkharka	Nepal	2w	DHC6/Y12	549 m
Taplejung	Nepal	3w	DHC6/Y12	900 m
Ramechaap	Sita	1w	Do228	518 m
Lamidanda	Nepal	2w	DHC6/Y12	516 m
Surkhet	Buddha	1	ATR42	1,255 m
Baglung	Nepal	1w	DHC6/Y12	608 m
Dang	Nepal	1	DHC6/Y12	1,158 m
Total		129+42w		

(Source: CAAN data and JICA Data Book)

2) Airline Operating Status for International Airlines

Table 2.3-10 shows the international flight status operated by the Nepalese Airlines. Table 2.3-11 shows the international flight status operated by foreign airlines.
The number of flights operated by Nepalese Airlines is 97 flights/week and the number of flights operated by foreign airlines is 284 flights/week, 25% and 75%, respectively.

Table 2.3-10 International Flight Status Operated by Nepalese Airlines at TIA

(Nepalese Airlines)

Region	Country	Destination	Airline	Weekly Frequency	Equipment
Northeast Asia					
	Japan	Osaka	Nepal Airlines	3	A330
	China	Beijing	Himalaya Airlines	3	A320
		Changsha	Himalaya Airlines	1	A320
		Guangzhou	Nepal Airlines	3	A330
		Guiyang	Himalaya Airlines	1	A320
		Hong Kong	Nepal Airlines	3	A330
		Nanchang	Himalaya Airlines	1	A320
Southeast Asia					
	Thailand	Bangkok	Nepal Airlines	3	A330
	Malaysia	Kuala Lumpur	Nepal Airlines	7	A320
			Himalaya Airlines	5	A320
Southwest Asia					
	India	Bengaluru	Nepal Airlines	3	A320
		Delhi	Nepal Airlines	14	A320
		Kolkata	Buddha Air	3	ATR72
		Mumbai	Nepal Airlines	3	A320
		Varanasi	Buddha Air	2	ATR72
	Bangladesh	Dhaka	Himalaya Airlines	5	A320
Middle East					
	UAE	Abu Dhabi	Himalaya Airlines	7	A320
		Dubai	Nepal Airlines	7	A330
			Himalaya Airlines	2	A320
	Qatar	Doha	Nepal Airlines	7	A330
			Himalaya Airlines	7	A320
	Saudi Arabia	Dammam	Himalaya Airlines	7	A320
Total				97	

(Source: CAAN data (based on winter schedule 2019-2020)

Table 2.3-11 International Flight Status Operated by Foreign Airlines at TIA

(Foreign Airlines)

Region	Country	Destination	Airline	Weekly Frequency	Equipment
Northeast Asia					
	Korea	Seoul	Korean Air	4	B777
	China	Chengdu	Air China	7	A319/320
		Guangzhou	China Southern	14	A319/330
		Hong Kong	Cathy Dragon	5	A330
		Kunming	China Eastern	11	B737/A320
		Lhasa	Sichuan Airlines	4	A319
		Xian	Tibet Airlines	7	A319
Southeast Asia					
	Thailand	Bangkok	Thai International	7	B777
			Thai Lion Air	7	B737-900
	Malaysia	Kuala Lumpur	Malaysia Airlines	10	B737-800
			Malindo Air	14	B737-900
	Singapore	Singapore	Silk Air	7	B737/A320
Southwest Asia					
	India	Delhi	Air India	14	A320
			IndiGo Airlines	28	A320
			TATA SIA Airlines	7	B737/A320
		Kolkata	Air India	4	A319
	Bangladesh	Dhaka	Biman Bangladesh	7	B737-800
	Bhutan	Paro	Druk Air	5	A319
			Tashi Air	3	A319
Middle East					
	UAE	Abu Dhabi	Etihad Airways	14	A330/320
		Dubai	Fly Dubai	21	B737-800
		Sharjah	Air Arabia	21	A320
	Qatar	Doha	Qatar Airways	28	A350/B777
	Kuwait	Kuwait	Jazeera Airways	7	A320
	Oman	Muscat	Oman Air	14	B737
			Salam Air	7	A320
	Turkey	Istanbul	Turkish Airlines	7	A330
Total				284	

(Source: CAAN data (based on winter schedule 2019-2020)

3) Future trends of Airlines

Interviews were conducted with the four airlines, namely; Buddha Air, Nepal Airlines, Shree Airlines, and Yeti Airlines to understand the future prospects of airlines at this time.
The main questions in the interview are the current and future fleet plans, seat occupancy rate, prospects for operations at mountain airports and entry into international markets. Table 2.3-12 and Table 2.3-13 outline the answers to the questions.

Future fleet plan	Opinion differ by the airline regarding the introduction of jet aircraft ➢ One of the airlines does not consider it due to financial issues ➢ Another airline considers introducing it in about 10 years
Seat occupancy rate	During peak period ➢ Above 85% for international flights ➢ 80%-100% for domestic flights
Prospects for operation to Mountain airports	There are various ways for the operation at mountain airport, including ➢ Possess aircraft and operate as own flight ➢ Operation by subsidiary ➢ Some company does not consider operating to the mountain airport
Entry into international market	➢ Those currently operating international flight plan to expand routes ➢ Those not operating international flight consider operating from Pokhara and Bhairawa

Among these questions, "Trends of fleet mix" and "Intention to enter the international market" are important points in estimating future demand. In response to these questions, the possibility of future "introduction of jet aircraft" and "international flights to/from airports other than TIA" was answered, so it is considered to be reasonable to assume these movement.

Table 2.3-12 Fleet Plans of Major Airlines

Airline	Aircraft	Existing	Future	Seat Capacity
Nepal Airlines	A330	2	Intend to add	274
	A320	2	〃	158
	DHC6	2		19
	Harbin Y-12	4		19
	Xian MA60	2		56
Buddha Air	ATR-72	8	1	72
	ATR-42	3		42
	Beechcraft 1900D	2		18
	Cesna Skycourier		1	19
Yeti Airlines	ATR-72	5	2	72
	Jetstream 41	5		30
	DHC6 (Tara Air)	4	1	19
	Do228 (Tara Air)	2		18
Shree Airlines	DHC8-Q400	2		80
	CRJ700	2		70
	CRJ200	2		50
	A220-300 (CS300)		2～3	130

(Source: Airline website, Airline interview)

Table 2.3-13 Summary of Interview Result with Major Airlines

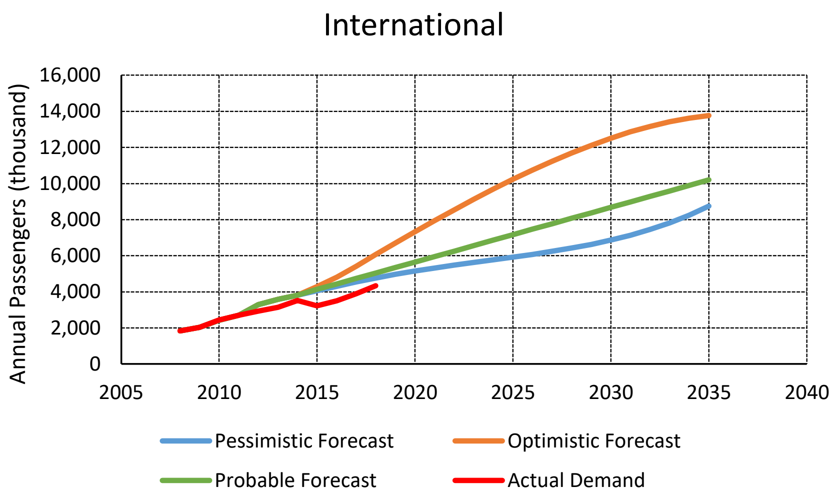
Airline	Nepal Airlines	Buddha Air
Fleet Plan		
Expand current fleet	Addition of A330/320 type	Introduce STOL aircraft that can take off and land on runway of 1000 m or less
Introduce jet aircraft		Will not introduce due to possibility of financial loss
Seat Occupancy	85% or more	
Mountain Airport Flight	Available with existing 19-seater	Plan to operate with newer aircraft
International Flights	Plan flights from TIA to Narita, Riyadh and Guangzhou (3 flights/week)	Plan operation of short-haul international flight from TIA (ATR72 operable routes)

Airline	Yeti Airlines	Shree Airline
Fleet Plan		
Expand current fleet	Add ATR72	
Introduce jet aircraft	Plan to introduce after 10 years from now	Plan to introduce a 130-seater type jet
Seat Occupancy	Almost 100% for TIA and 80-90% for the rest depending on temperature	
Mountain Airport Flights	Coordinated by the subsidiary company	Does not plan to operate at the mountain airport
International Flights	Plan to operate from Pokhara, Bhairahawa to India, Bangkok, etc.,	Plan to operate from Pokhara, Bhairahawa to South Asia (India, Bangladesh, Sri Lanka etc.,

(Source: Airline website, Airline interview)

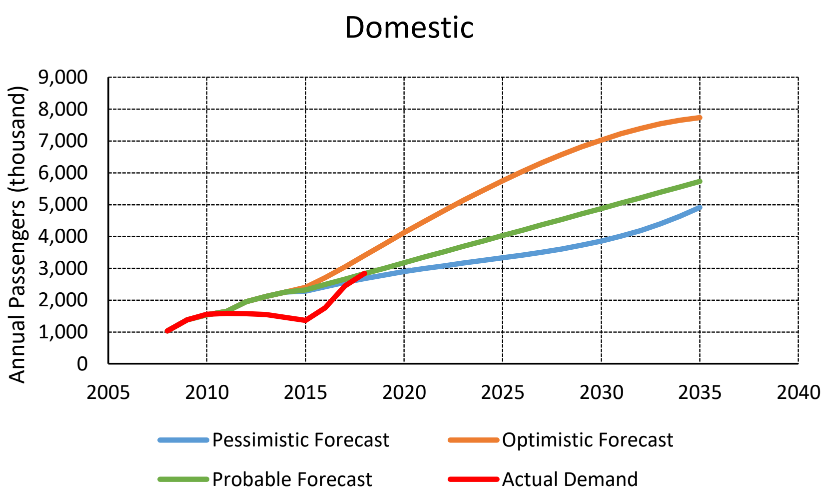
(5) Aviation Demand Forecast Conducted in the Past

In 2012, CAAN published the result of its aviation demand forecasting survey (TIAIP) for TIA. The survey was conducted by an ERM-PROINTEC-INECO consortium funded by ADB and examined the demand for domestic and international for approximately 20 years up to 2035, respectively.
Figure 2.3-7 shows the international demand while Figure 2.3-8 shows the domestic demand based on forecast results and actual result at this time.



(Source: ERM-PROINTEC-INECO, Air traffic demand forecast draft, September 2012)

Figure 2.3-7 TIAIP Result for International Demand Forecast



(Source: ERM-PROINTEC-INECO, Air traffic demand forecast draft, September 2012)

Figure 2.3-8 TIAIP Result for Domestic Demand Forecast

2.3.3 Aviation Safety Facilities (Communication, Navigation, Surveillance, and Aviation Weather)

(1) International Standard Conditions in ICAO and their Operation Status in Nepal

1) Direction of ICAO Consideration

ICAO describes the international vision of aviation facility development and its application in the Global Air Navigation Plan (GANP Rev.4). The aviation facilities described in this plan include ground-based and airborne-based and those are expected to be installed to contribute to international civil aviation safety from now up to the future. Such modernization framework for integrated planning based on performance is shown as the Aviation System Block Upgrade (ASBU) framework in GANP.

ASBU framework describes the applicable or considered applicable CNS/ATM systems and services with their enablers in four timeframes. Those are “from year 2013 to 2018”, “from 2019 to 2023”, “from 2024 to 2028” and “after 2029”. The CNS/ATM systems, relating services and applied enablers in each time frame are described as “BLOCK 0”, “BLOCK 1”, “BLOCK 2”, and “BLOCK 3”. For example, “BLOCK 0” (from 2013 to 2018) includes CNS/ATM systems, services, and enablers described in Table 2.3-14. ICAO’s each office organize introducing plan in its member countries, coordinate between concerned countries and monitor the progress of installation in order to achieve the GANP vision.

Table 2.3-14 Example of Aviation Services, Enablers in “BLOCK 0” Based on GANP (Rev.4.0)

Classification		Services	Enablers
C	A/G Data Communication	CPDLC & ADS-C	HF (ACARS), VDL Mode 0/A (ACARS VHF), VDL Mode 2 (ACARS), Satellite communication
	G/G Communication	AMHS, AIDC	VoIP (IPV4, IPV6)
	A/G Voice Communication	ATC voice communication	VHF (25 kHz, 8.33 kHz), HF, Satellite communication
S	Airport Surface Surveillance	SMGCS	MLAT
	Ground based Surveillance	Ground based surveillance Surveillance data fusion	PSR, SSR/Mode-S, WAM, ADS-B In/Out
	A/A Surveillance	AIRB, VSA	ADS-B In/Out
N	Conventional	PBN Operations CAT-I/II/III Landing	ILS/MLS, DME, VOR/NDB Core GNSS Constellation GNSS Augmentation
	PBN	En-route oceanic and remote control En-route continental Terminal airspace: Arrival and departure Approach	RNAV 10 (RNP 4 , RNP 2) RNAV 5, RNAV 2, RNAV 1 Basic RNP 1, RNP APCH (SBAS, BARO VNAV, Basic GNSS) RNP AR APCH
Information Management	SWIM	SWIM CONOPS	-
	AIS/AIM Enhanced quality	Paper → Digital data availability	eAIP, Aeronautical Information Exchange Model (AIXM)
	Meteorology	Traditional alphanumerical codes replaced by digital data; Enhanced quality	Weather Information Exchange Model (WXXM)
Avionics	Communication	Com/Nav Integration	FANS 1/A, FANS 2/B
	Surveillance	-	Traffic Computer, ADS-B In/Out
	Navigation	-	INS, Multi-Sensor Navigation Management FMS (supporting PBN)
	Airborne Safety Nets	ACAS	Topography Awareness and Warning System (TAWS)
	Onboard Systems	-	Weather Radar, Airport Moving Map Electronic Flight Bags

(Source：Global Navigation Plan：2013-2028 4th Edition)

2) Direction of APAC Consideration

The Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) under the ICAO Asia Pacific Office is the main body responsible for reflecting ICAO directions in Asia Pacific Region. APANPIRG was established by ICAO Council in 1991 in charge for planning aviation safety relating matters in the Asia Pacific Region. It has been conducting the following works with its contributory bodies such as subgroups. The works include organizing the implementation of air navigation systems and services recommended by ICAO (including ones described in GANP), coordinating between concerned countries for their implementation, and monitoring the implementation progress of such systems and services in member countries including Nepal. Both the declaration stated in Asia/Pacific Ministerial Conference on Civil Aviation and Action Items from regular DGCA Conference are delivered to APANPIRG and they have been followed also by the group.

The First Asia/Pacific Ministerial Conference on Civil Aviation was held in 2018 January in Beijing and stated the adopted result as Beijing Declaration. Regarding air navigation services, the necessary follow up action was requested for PBN, Common Ground/Ground Telecommunication Network and Enhanced Surveillance Capability including ADS-B Implementation Achievement by 2022. Stated services are ones included in GANP BLOCK 0 described in Table 2.3-14.

The 54th DGCA Conference was held in 2017 in Ulaanbaatar. In this conference, the action items include AIDC implementation, managing interference to GNSS, Performance-based Communication and Surveillance (PBCS) in Asia Pacific, preparing for interoperability of ATMS, and set up 2020 as the target for CRV implementation for all ANSP.

The conditions of Beijing Declaration and Action Items of DGCA Conference have been followed up in APANPIRG Conference and DGCA Conferences afterwards.

3) Operation Conditions in Nepal

The operation conditions in Nepal is shown in Table 2.3-15, referring the report by CAAN in the 55th DGCA Conference held in October 2018.

Since Nepal is the country which has complex topography with the Himalayan Mountains, it is difficult to supply CNS/ATM services to each location and airspace of the country by existing ground-based CNS system. To improve these conditions, CAAN has taken various actions for aviation safety to equip the airports with necessary communication, navigation, and surveillance facilities together with the development of aerodrome and airfield infrastructure, receiving development assistance from other countries and international organization in some cases. The details of CAAN initiatives are described in Table 2.3-15.

Table 2.3-15 Operation Conditions in Nepal

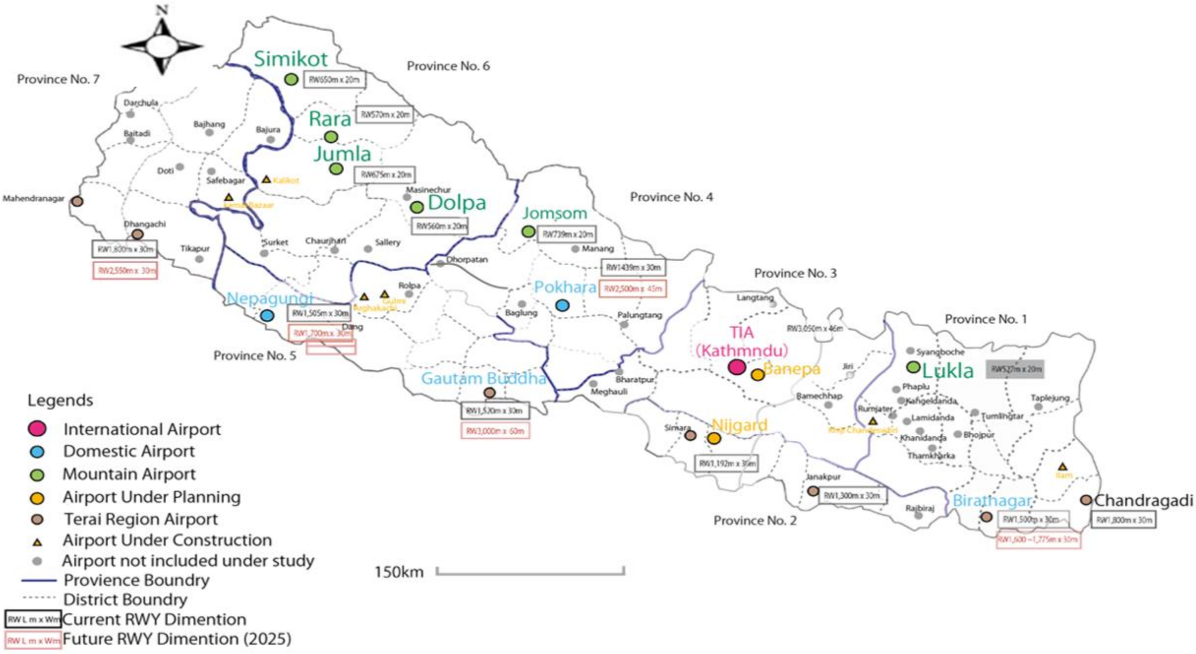
Item		Operation Status
ATM Field	Air Traffic Services (ATS) related	✈ Introduced the PBN concept and ATFM concept for the reorganization and management of existing airspace and ATC operation. ✈ Expanded radar vectoring service to airspace (up to now only terminal airspace).
	Airspace Organization and Management (AOM)	✈ Development of new air routes and terminal procedures and revise the existing domestic routes based on the Nepal PBN Implementation Plan. ✈ The RNP AR APCH system designed at TIA (2012) is used by 11 international airlines for landing at TIA. Additional RNP AR SIDs and additional approach procedures in TIA are planned in the future. ✈ RNP 1 SIDs, STARs and RNP APCH methods have been implemented for the three major regional airports (Biratnagar, Dhangadhi, Chandragadhi), and work is underway to establish settings for the other three regional airports. ✈ Introduced the software for the flight procedure design automation.
CNS Field	Communication （C）	✈ In addition to the existing RCAG in Kathmandu (Mount Pulchokki), RCAG was newly installed in Nepalgunj and Biratnagar, and VHF communication coverage in Nepal was improved.

Item		Operation Status
		✈ ATS voice / data network enhancements and AMHS node upgrades are planned in 2019.
	Navigation（N）	✈ Considering that the flight system by PBN will be the main facilitator in the airspace where the main navigation system is GNSS, CAAN planned to acquire a GNSS signal monitor system in the near future. ✈ To improve flight safety at the airports, it was planned to install DVOR / DME at Dhangadhi and Chandragadhi in 2019 and Localizer / T-DME at TIA in 2020.
	Servillence（S）	✈ For safer and more efficient aircraft operation, radar surveillance coverage in the Nepal FIR was expanded by introducing MSSR for en-route surveillance (E-MSSR), MSSR for airport survillance (T-MSSR) and Multi Sensor Data Processing System (MSDPS). ✈ ADS-B is planned to provide surveillance service in western part of the country as well as a backup to existing MSSR system by (*) ✈ * Four ADS-B ground stations are already installed, as of December 2019.
	Automation system	✈ E-Strips, AMHS, and MSDPs have been effectively implemented at TIA as part of the ATC Automation. ✈ CAAN has allocated programmed budget for the implementation of AIDC for the improvement of present ATM system ✈ Coordination with KUNMING FIR/ATMB China to establish bi-lateral technical interoperability relations
AIS Field		✈ CAAN is in the initial process of phase-wise implementation of AIS to AIM transition. ✈ The preparation of design and specification for AIS automation project is in progress. The project is supported with necessary budgetary and resources.
SAR Field		✈ New SAR regulation has being formulated. ✈ Revision of existing SAR manual is in progress to make it more compliant to ICAO SARPs. ✈ Discussion on equipment, trainings, and infrastructure development is in progress in order to improve RCC (Rescue Co-ordination Centre) functions.
Aviation Weather		✈ An agreement was signed between CAAN and Department of Hydrology and Meteorology (DHM) to ensure the smooth provision of weather information services. Based on this, DHM dispatched staffs to TIA and medium-sized airports like Pokhara and Nepalgunj to observe weather around airport and provide weather information to ATC and airlines. ✈ DHM is currently planning to: ● Install RVR for RWY 20 and AWOS at TIA; ● Introduce Aviation Weather Radar System in the western part of the country (Completed in December 2019) ● Expand the scope of Aviation MET Services to 20 more additional domestic airports with modern meteorological equipment. ✈ In addition, SIGMET (Significant Meteorological Information) services are regularly provided to airlines and airspace users.

(Source: JICA Study Team)

(2) Existing Aviation Safety Related Equipment under CAAN

Aviation safety related equipment are basically installed in or near the airports in Nepal. There are 33 operating airports of which one is TIA. Figure 2.3-9 shows the location of airports around Nepal.



(source: CAAN)

Figure 2.3-9 Airport Locations in Nepal

1) Installed Aviation Safety Related Equipment Category (By Airport)

The categories of aviation safety facilities at each airport are shown in Table 2.3-16. Aviation safety related facilities include CNS/ATM related facilities as well as weather facilities and security related facilities.

Table 2.3-16 Installed Aviation Safety Related Equipment by Airport

No	Airport Name	C		N			S		ATM、AIS		MET	X-Ray	PWR	RFF
		HF/ VHF	RCAG	VOR	DME	NDB	PSR/ SSR	ADS-B	MSDPS	AMH S				
1	Tribhuvan International A/P	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	（Bhattedanda）						✓ E-MSSR							
2	Gautam Buddha A/P	✓		✓	✓					✓		✓	✓	✓
3	Biratnagar A/P	✓	✓	✓	✓	✓				✓		✓	✓	✓
4	Nepalgunj A/P	✓	✓	✓	✓	✓		✓		✓		✓	✓	✓
5	Pokhara A/P	✓			✓					✓		✓	✓	✓
6	Baglung(Balewa) A/P	✓										✓	✓	
7	Bajura A/P	✓										✓	✓	
8	Bharatpur A/P	✓				✓						✓	✓	
9	Bhojpur A/P	✓										✓	✓	
10	Chandragadhi A/P	✓		✓	✓					✓		✓	✓	
11	Dang A/P	✓										✓	✓	
12	Dhangadhi A/P	✓		✓	✓					✓		✓	✓	
13	Dolpha(Juphal) A/P	✓										✓	✓	
14	Janakpur A/P	✓				✓				✓		✓	✓	
15	Jomsom A/P	✓										✓	✓	
16	Jumla A/P	✓										✓	✓	
17	Khanidanda A/P	✓										✓	✓	
18	Lamidanda A/P	✓										✓	✓	
19	Phaplu A/P	✓										✓	✓	
20	Rumjatar A/P	✓										✓	✓	
21	Rara A/P	✓										✓	✓	
22	Ramechhap A/P	✓										✓	✓	
23	Rajbiraj A/P	✓										✓	✓	
24	Rukum Chaurjhari A/P	✓										✓	✓	
25	Rukum Salle A/P	✓										✓	✓	
26	Simara A/P	✓		✓	✓					✓		✓	✓	
27	Surkhet A/P	✓								✓		✓	✓	
28	Simikot A/P	✓										✓	✓	
29	Sanfebagar A/P	✓										✓	✓	
30	Lukla (Tenzing-Hillary) A/P	✓								✓		✓	✓	
31	Tumlingtar A/P	✓										✓	✓	
32	Taplejung A/P	✓										✓	✓	
33	Thamkharka A/P	✓										✓	✓	

(Source: CAAN)

2) Details of Aviation Related Equipment (By Airport)

Among the aviation safety related equipment at each airport shown in Table 2.3-17, specific models, manufacturer, and installation year for different equipment are listed in Table 2.3-18 to Table 2.3-20.

Table 2.3-17 Details Regarding Safety Equipment by Airport

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
1. Tribhuvan International Airport	VHF Receiver (Main/Standby)	126.5 MHz	40 W	ACC/WEST	Park Air	T6R	2013
	〃	124.7 MHz	40 W	ACC/WEST	Park Air	T6R	2013
	〃	120.6 MHz	40 W	Approach	Park Air	T6R	2013
	〃	125.1 MHz	40 W	Approach	Park Air	T6R	2013
	〃	118.1 MHz	40 W	Ground	Park Air	T6R	2013
	〃	118.5 MHz	40 W	TWR	Park Air	T6R	2013
	〃	121.9 MHz	40 W	TWR	Park Air	T6R	2013
	〃	121.5 MHz	40 W	Emergency	Park Air	T6R	2013
	VHF Transmitter (Main/Standby)	126.5 MHz	50 W	ACC/WEST	Park Air	T6T	2013
	〃	124.7 MHz	50 W	ACC/WEST	Park Air	T6T	2013
	〃	120.6 MHz	50 W	Approach	Park Air	T6T	2013
	〃	125.1 MHz	50 W	Approach	Park Air	T6T	2013
	〃	118.1 MHz	50 W	Ground	Park Air	T6T	2013
	〃	118.5 MHz	50 W	TWR	Park Air	T6T	2013
	〃	121.9 MHz	50 W	TWR	Park Air	T6T	2013
	〃	121.5 MHz	50 W	Emergency	Park Air	T6T	2013
	VHF Set (Main/Standby)	118.1 MHz	10 W	TWR	Jotron	TR-810LR	2013
	VHF Set (Emergency)	121.5 MHz	10 W	TWR	Jotron	TR-810LR	2013
2. Gautam Buddha Airport	HF Main	5805.5 & 5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	25 W	TWR	Jotron	TR-7725	2013
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	2013
	VHF Emergency	121.5 MHz	10 W	TWR	Telerad	ER-846	2015
3. Biratnagar Airport	HF Main	5805.5 & 5858.0 KHz	125 W	TWR	JRC	JSB-196	2005
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-7725	2005
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-7750	2010
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	2005
4. Nepalgunj Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2001
	HF Standby	〃	150 W	〃	THM	CSF-950	2001
	VHF Main	118.3 MHz	25 W	TWR	Jotron	TR-7725	2013
	VHF Standby	118.3 MHz	25 W	TWR	Jotron	TR-7725	〃
	VHF Standby	126.5 MHz		TWR	RBT	TR-846A	2001
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	2015
5. Pokhara Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
	HF Standby	〃	〃	〃	〃	〃	2017
	VHF Main	122.5 MHz	25 W	TWR	Jotron	TR-7725	2011
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-7725	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Telerad	ER-846B	2000
6. Bajura Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2017
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	2017
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
7. Bharatpur Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.3 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.3 MHz	10 W	TWR	Telerad	ER-846A	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
8. Bhojpur Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2012
	VHF Main	122.3 MHz	10 W	TWR	Jotron	TR-810	2012
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	2012
9. Chandragadhi Airport	HF Main	5805.5&5858.0 KHz	125W	TWR	Vertex Standard	VX-1700	2010
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-7725	2010
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-7725	〃
10. Dhangadhi Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-7725	2013
	VHF Standby	122.5 MHz	10 W	TWR	JCOM	IC-A110	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
11. Dolpa Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
12. Janakpur Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-7725	2010
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-7725	〃
	VHF Set Portable	-	10 W	TWR	ICOM	IC-A110	
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	2014
13. Jomsom Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	20111
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-7725	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	2014
14. Jumla	HF Main	5805.5&5858.0	125 W	TWR	Vertex	VX-1700	2012

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
Airport		KHz			Standard		
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.5MHz	10 W	TWR	Jotron	TR-810	〃
15. Khanidanda Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2017
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	25W	TWR	Jotron	TR-7725	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
16. Lamidanda Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2012
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	2015
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
17. Phaplu Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
20. Rara Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2015
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	2017
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	2015
21. Ramechhap Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2012
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Emergency	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
22. Rukum Chaurjahari Airport	HF Main	5805.5&5858.0 KHz	100 W	TWR	Icom	IC-78	2012
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	2012
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
23. Rukum Salley Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
24. Simara Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2012
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	118.3 MHz	25 W	TWR	Jotron	TR-7725	2016
	VHF Standby	118.8 MHz	25 W	TWR	Jotron	TR-7725	2012
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
25. Surkhet Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2010
	HF Standby	〃	〃	〃	〃	〃	〃
	VHF Main	122.5 MHz	25W	TWR	Jotron	TR-7725	〃
	VHF Standby	122.5 MHz	25 W	TWR	Jotron	TR-7725	〃
	VHF Standby	118.3 MHz	10 W	TWR	ICOM	IC-A110	〃
26. Simikot Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2013
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	2013
	VHF Standby	122.5 MHz	10 W	TWR	ICOM	IC-A110	〃
27. Lukla Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Barret	BARRET-950	2001

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
	HF Standby	〃	150 W	〃	Thomson	THOMSON-CSF950	〃
	VHF Main	122.5 MHz	40 W	TWR	PAE	T6TR	2019
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-7725	2018
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	2017
28. Tumlingtar Airport	HF Main	5805.5&5858.0 KHz	125W	TWR	Vertex Standard	VX-1700	2011
	VHF Main	123.95 MHz	25 W	TWR	Jotron	TR-7725	2010
	VHF Standby	123.95 MHz	10 W	TWR	Jotron	TR-810	2011
29. Taplejung Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2017
	VHF Main	122.5 MHz	25 W	TWR	Jotron	TR-7725	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Emergency	121.5 MHz	10 W	TWR	Jotron	TR-810	〃
30. Kaangeldanda Airport	HF Main	5805.5&5858.0 KHz	125 W	TWR	Vertex Standard	VX-1700	2014
	VHF Main	122.5 MHz	10 W	TWR	Jotron	TR-810	〃
	VHF Standby	122.5 MHz	10 W	TWR	Jotron	TR-810	〃

(Source: CAAN)

Table 2.3-18 Details of Aviation Safety Equipment for Wireless Navigation Aid

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
1.Tribhuvan International Airport	DVOR	112.3 MHz	50 W	KTM	Selex		2010
	DME	124.7 MHz	1000 W	KTM	Selex		2010
	NDB LOCATOR(South)	230 KHz	100 W	LTH	SAC		2004
	NDB LOCATOR(East)	252 KHz	125 W	LNC	SAC		2010
2.Gautam Buddha Airport	DVOR	114.7 MHz	50 W	BWA	Indra		2013
	DME	CH76X	1000 W	BWA	Indra		2013
3.Biratnagar Airport	DVOR	114.1 MHz	50 W	BRT	Selex		2010
	DME	CH88X	1000 W	BRT	Selex		2010
	NDB	358 kHz		BRT	Terelad		1992
4.Nepalgunj Airport	DVOR	115.1 MHz	50 W	NGJ	Indra		2013
	DME	CH98X	1000 W	NGJ	Indra		2013
	NDB	330 kHz	100 W	NGJ	Terelad		1992
5.Chandragadhi Airport	DVOR/DME	-	-	-	-	-	-
6.Dhangadhi Airport	DVOR/DME	-	-	-	-	-	-
7.Pokhara Airport	DME	CH75X	50 W	PKR	AWA		2013
8.Simara Airport	DVOR	118.3 MHz	50 W	SMR	Indra		2013
	DME	CH76X	1000 W	SMR	Indra		2013
Bharatpur Airport	NDB Transmitters	295 kHz	-	BHR	Telerad		2000
Janakpur Airport	NDB Transmitters	295 kHz	-	JKR	SAC		2000

(Source: CAAN)

Table 2.3-19 Details of Aviation Safety Equipment for Aircraft Monitoring

Airport Name	Equipment List	Frequency	Output	Network ID	Manufacturer	Type	Installation Year
1.Tribhuvan International Airport	ASR	S-band	500 kW	-	Toshiba		1996
	SSR	1030/1090MHz		-	NEC		1996
	Radar System Control (LOCAL)	-	-	-	Toshiba		1996
	Surveillance Monitor	-	-	-	Toshiba		1996
	Radar System Control (REMOTE)	-	-	-	Toshiba		1996
	MSSR-T	1030/1090 MHz		-	NEC		2016
	ADS-B Ground station	1090 MHz	-	-	ERA		2019
（Mt. Battedanda）	MSSR-E	1030/1090 MHz		-	NEC		2016
2. Nepalgunj Airport	ADS-B Ground station	1090 MHz	-	-	ERA		2019
3. Gautam Buddha Airport	ADS-B Ground station	1090 MHz	-	-	ERA		2019
4. Dhangadhi Airport	ADS-B Ground station	1090 MHz	-	-	ERA		2019

(Source: CAAN)

Table 2.3-20 Details of ATM and AIS Related Equipment

Airport Name	Equipment List	Contents	Nos	Manufacturer	Installation year
1.Tribhuvan International Airport	DPS	INFMAX	1	Avibit	2013
	DPS	DIFLIS	1	Avibit	1996
	DPS	RDPS	8	Toshiba	1996
	DPS	SLEP	6	Toshiba	1996
	DISPLAY	DEDS	3	Toshiba	1996
	DISPLAY	BD DISPLAY	2	Toshiba	1996
	Converter	DIGITAL SCAN CONVERTER	1	Toshiba	1996
	LINK	Apraisa XE U-LINK	2	Apraisa XE	2013
	LINK	VSAT Link-Beijing	1	COMTEC	2015
	LINK	VSAT Link-Lhasa	1	COMTEC	2015
	LINK	VSAT LINK-KEP	1	Merchantile	2009
	AMHS	AMHS	1	COMTEC	2012
	MSDPS	MSDPS	1	NEC	2016
	RDD	Configuration of MSDPS	4	NEC	2016
	FDD	〃	4	NEC	2016
	ATC Simulator	〃	1	NEC	2016
2. Gautam Buddha Airport	AMHS	AMHS	1	COMTEC	2013
3.Biratnagar Airport	AMHS	AMHS	1	COMTEC	2012
4. Nepalgunj	AMHS	AMHS	1	COMTEC	2013
5.Pokhara Airport	AMHS	AMHS	1	COMTEC	2012
6.Chandragadhi Airport	AMHS	AMHS	1	COMTEC	2012
7.Dhangadhi Airport	AMHS	AMHS	1	COMTEC	2012

Airport Name	Equipment List	Contents	Nos	Manufacturer	Installation year
8.Simara Airport	AMHS	AMHS	1	COMTEC	2014
9.Surket Airport	AMHS	AMHS	1	COMTEC	2014
10.Lukla Airport	AMHS	AMHS	1	COMTEC	2012

(Source: CAAN)

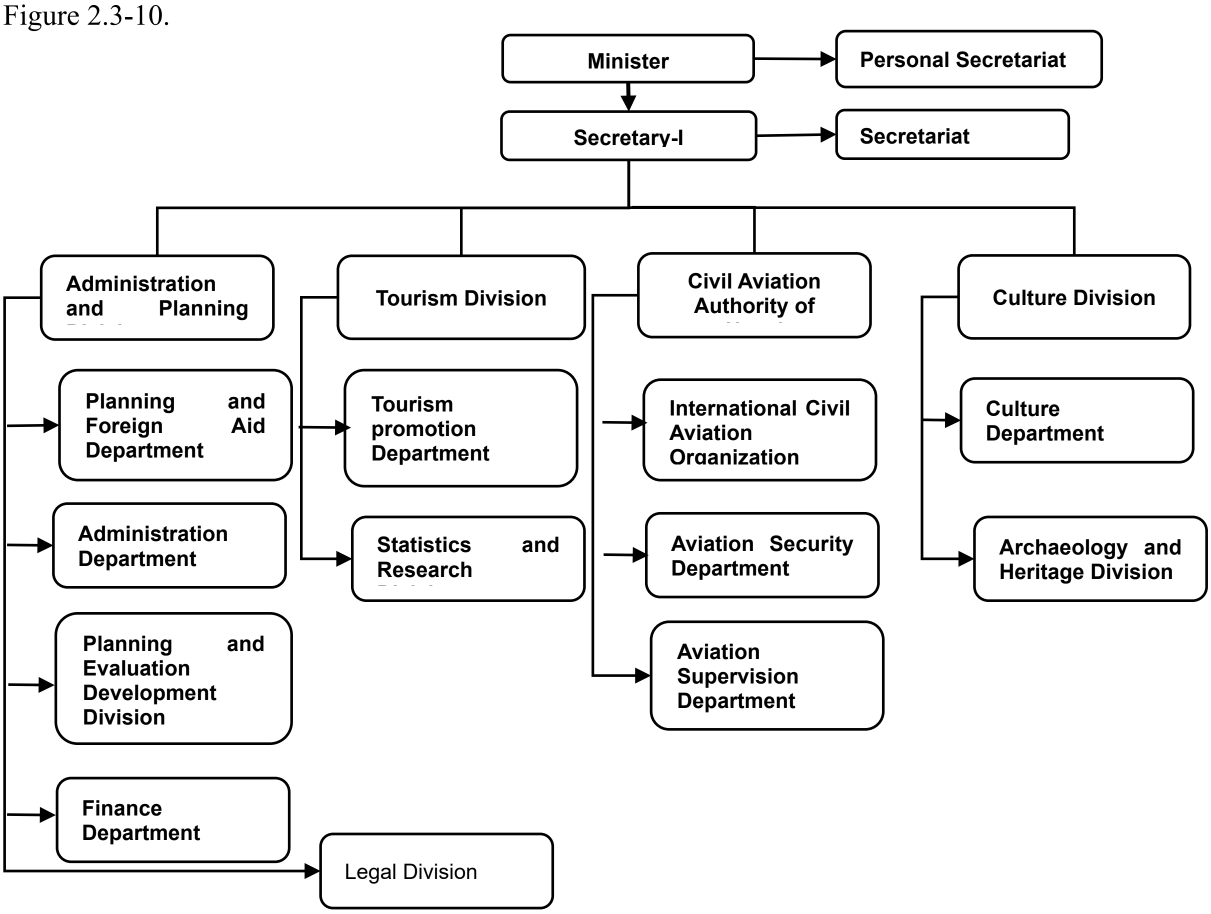
2.3.4 Ministry of Culture Tourism and Civil Aviation

(1) Role

Ministry of Culture Tourism and Civil Aviation is one of the ministries under Government of Nepal, that promotes tourism, culture and private sector involvement. It also serves as the civil aviation regulatory body of Nepal. In addition, this ministry has a vital role in contribution for Nepal's economy and at the same time preservation of the culture and heritage of the country.
The Ministry was previously established in 1978 as a Ministry of Tourism but later civil aviation and culture was also incorporated under it in 1982 and 2000 respectively. However, it was again dissolved into Ministry of Tourism and Civil Aviation and Ministry of Culture and State Restructuring in 2008. In 2012, ministry was brought to its current form as the Ministry of Culture, Tourism and Civil Aviation.

(2) Organization

The Ministry of Culture, Tourism and Civil Aviation is headed by Minister who has been elected from the member of the ruling Political Party. The highest position from the bureaucracy is the Secretary who manages all the department under the ministry. The organization chart of MoCTCA is as shown in Figure 2.3-10.



(Source: MoCTCA)

Figure 2.3-10 Organizational Chart of MoCTCA

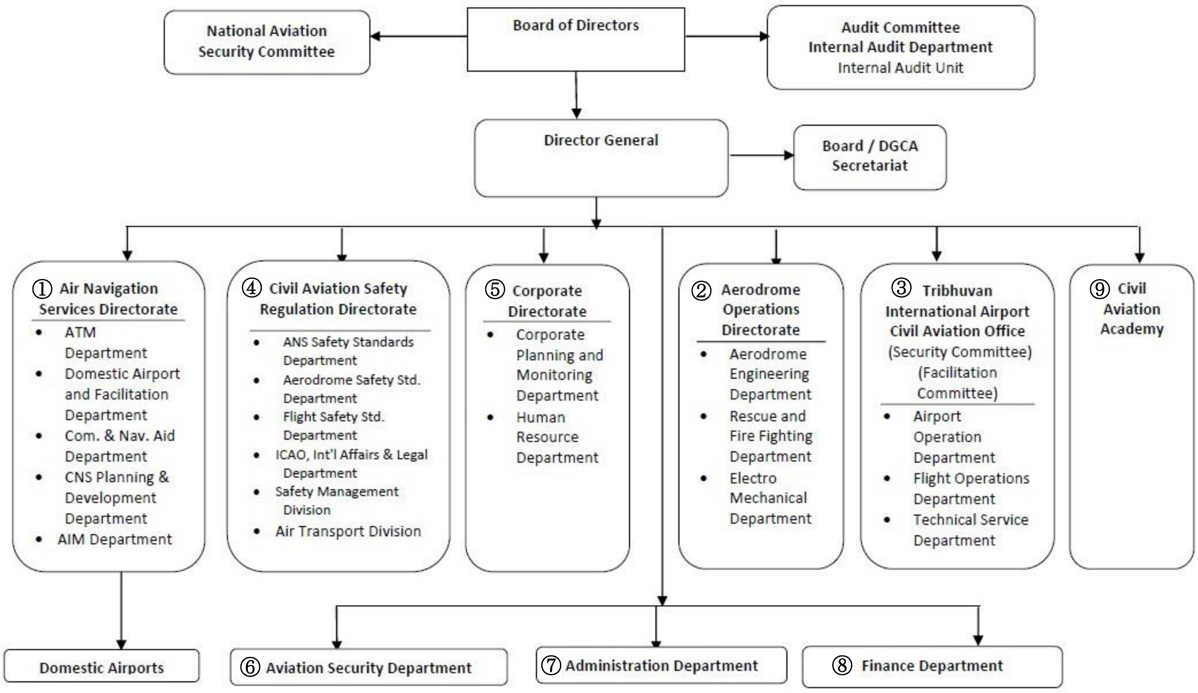
2.3.5 Civil Aviation Authority of Nepal (CAAN)

(1) Role

The Nepal Civil Aviation Authority (CAAN) is an autonomous regulatory body established on December 31, 1998 under the Civil Aviation Act 1996. The main mission of CAAN is to ensure safe, secure, efficient, standard, and quality service in civil aviation and airport operation.

(2) Organization

Under the Board of Directors, which is chaired by the Minister of MoCTCA, CAAN is managed by the Director General who is also a member of the Board with the support by the Deputy Director Generals. The organization of CAAN is as shown in Figure 2.3-11 and Table 2.3-21. It consists of four Directorate, three non-afflicted departments, Tribhuvan International Airport Civil Aviation Office (TIACAO) and Civil Aviation Academy (CAA).



(Source: CAAN)

Figure 2.3-11 Organizational Chart of CAAN

Table 2.3-21 CAAN Organizational Branch

①	**Air Navigation Service Directorate**
	ATM Department
	Domestic Airport and Facilitation Department
	Com. & Nav. Aid Department
	CNS Planning & Development Department
	AIM Department
②	**Aerodrome Operations Directorate**
	Aerodrome Engineering Department
	Rescue and Fire Fighting Department
	Electro Mechanical Department
③	**Tribhuvan International Airport Civil Aviation Office**
④	**Civil Aviation Safety Regulation Directorate**
	ANS Safety Standards Department
	Aerodrome Safety Standards Department
	Flight Safety Standard Department
	ICAO, International Affairs & Legal Department
	Safety Management Division
	Air Transport Division
⑤	**Corporate Directorate**
	Corporate Planning and Monitoring Department
	Human Resource Department
⑥	**Aviation Security Department**
⑦	**Administration Department**
⑧	**Finance Department**
⑨	**Civil Aviation Academy**

(Source: CAAN)

There are two Deputy Director General (DDG) and their functions are divided for Air Navigation Service Directorate (ANSD)/Aerodrome Operation Directorate and Civil Aviation Safety Regulation Directorate (CASRD)/Corporate Directorate.

In CAAN organization, although there is a safety regulation directorate that sets standards, there is no department that checks or do the auditing. For the proper implementation of safety management, ICAO has proposed for the establishment of a regulator, which will carry out the audits for the safety management, in addition to the service provider that will control air traffic controls. Currently, MoCTCA and CAAN are newly set for Air Service Authority of Nepal (ASAN), whch will be in charge for providing ATC service. On the other hand, the functions of a regurator and a provider are to be discussed in the future.

(3) Employees

CAAN has a total staff of 1,065 and the number of employees by their job/designation is as shown in Table 2.3-22.

Table 2.3-22 Specification of Different Designations and Levels in CAAN

Group	Sub Group		Code	Number	Level											
					DG	12	11	10	9	8	7	6	5	4	3	2
Administration	Administration	Administration	A/A/A	70			1	1	5	12	18	21	11	17	2	2
		Legal	A/A/L	3						1	1	1				
		Business Administration	A/A/BA	13			1	1	2	2	3	4				
		Library	A/A/Lib	4						1	1	1	1			
		Statics	A/A/Stat							1	1	1				
		Open	A/Open	3				2	1							
	Financial Admin.	Chartered Accountant	A/FA/CA	32					2							
		Account	A/FA/Acc	47					4	7	10	12	10	4		
		Revenue	A/FA¥Rev	27					1	2	5	9	6	4		
		Open	A/FA/Open	4			2	2								
Technical	Civil Aviation	ATS	T/CA/AT	295			10	25	63	85	112					
		Aviation Fire Services	T/CA/AF	189			1	3	6	7	14	22	46	90		
		Flight Operation Service	T/CA/FO	11				1	3	3	4					
	Aeronautical Engineering		T/AE	11				1	3	3	4					
	Civil Engineering		T/CE	66			1	3	5	9	18	11	19			
	Electrical Engineering		T/EE	45				2	2	3	5	13	14	6		
	Mechanical Engineering		T/ME	53				2	2	4	7	13	16	3	6	
	Electrical Communication Eng.		T/ET	97			2	7	14	17	24	15	18			
	Miscellaneous		T/Misc	22							1	16	13	3		
Technical			Open for all	13	1	3	1	2	5	1						
			Tech. Open	44		3	1	5	3	6				6		20
			CE; EE; ME CA/AF	4			1	1	1	1						
			CA/AF	1					1							
			CE; EE; ME	1				1								
			EE; ME	7			1	1						5		
			AE; CA/FO	1			1									
			CA/AT; ET	3			1	2								
			ET; EE; ME	4			1	1	2							
Total				1,065	1	6	25	63	125	166	228	129	154	138	8	22

(Source: CAAN)

(4) Functions

The main functions and departments in-charge of CAAN are as shown in Table 2.3-23.

Table 2.3-23 Responsibilities and Departments In-charge of CAAN

Functions	Departments In-charge
Airline operation permission	Air Transport Division
Airworthiness certificate of aircraft, license, and airman rating	Flight Safety Standard Department
Supervision of air operation based on ICAO standards and recommendation	
Supervision of aviation safety operation based on ICAO standards and recommendation	ANS Safety Standards Department
Aerodrome supervision based on ICAO standards and recommendation	Aerodrome Safety Standards Department
Construction, operation, and maintenance of airport	Aerodrome Operations Directorate TIA Civil Aviation Office
Installation and maintenance of aviation security facilities and provision for aviation safety service	Aviation Security Department TIA Civil Aviation Office

(Source: JICA Study Team)

(5) Financial Status

Since CAAN acts as an autonomous body, it performs its own independent accounting and is subjected to value added tax (VAT) and income tax. The main source of revenue for CAAN is the service fees collected from the operation side of the airport and air safety facilities.

Overview of CAAN's financial status is as shown in Table 2.3-24. Although, for the first five year of establishment, the income falls in the red line. Thereafter, except for FY2008/2009 the net income turnout to be positive and from FY2011/2012 the cumulative losses have also recorded in positive value. The deficit in FY2008/2009 was temporal because the shares held by Nepalese government were transferred into loans (interest rate 10.5% per annum), and the interest from the time of establishment was paid in lumpsum. In FY2014/2015, the company recorded net income of NRS 2,562 million and cumulative earning of NRS 6,756 million. However, after considering repayment of debts the net profit turnout to be NRS 219 million. As for the income statement of FY2016/2017, the net profit was NRS 113 million, and it is not that they are well funded.

Table 2.3-24 Financial Summary of CAAN (in NPR Million)

Fiscal Year	Income	Expenses	NPBIDT	Interest	Depreciation	Extraordinary Items	Income Tax	Net Profit	Cummulative Loss
1998/1999	418.34	89.86	328.48	106.01	568.96	0.00	0.00	-346.49	-346.49
1999/2000	912.44	293.44	619.00	222.81	1046.44	0.00	0.00	-650.25	-996.74
2000/2001	1177.61	276.75	900.86	259.54	1028.51	0.00	0.00	-387.20	-1383.94
2001/2002	1235.60	357.04	878.56	306.61	871.73	0.00	0.00	-299.78	-1683.71
2002/2003	1162.10	399.07	763.03	308.73	743.10	0.00	0.00	-288.80	-1972.51
2003/2004	1258.20	401.64	856.56	121.90	629.33	-651.98	0.00	757.30	-1215.21
2004/2005	1375.59	425.79	949.80	287.42	537.34	-35.81	0.00	160.85	-1054.35
2005/2006	1551.82	485.38	1066.44	262.77	464.46	-3.19	0.00	342.40	-711.95
2006/2007	1567.04	545.42	1021.62	169.99	404.88	357.57	45.64	43.55	-668.40
2007/2008	1952.88	545.51	1407.37	153.98	611.90	73.00	152.00	416.49	-251.91
2008/2009	2339.31	1441.41	897.90	237.09	782.40	1318.42	-338.41	-1101.60	-1353.51
2009/2010	2444.83	1007.54	1437.29	219.07	714.77	310.45	-14.19	207.20	-1146.31
2010/2011	2738.06	1100.45	1637.61	152.17	651.87	-20.46	156.99	697.05	-449.27
2011/2012	3365.44	1157.83	2207.61	154.85	615.67	38.91	-44.91	1443.10	993.83
2012/2013	3546.14	1405.39	2140.76	146.64	566.90	-913.77	392.02	1948.97	2942.81
2013/2014	4047.51	1722.10	2325.41	96.06	603.25	-42.24	417.08	1251.25	4194.05
2014/2015	4426.03	2128.82	2297.21	56.92	666.58	-1381.88	393.43	2562.15	6756.20

(Source: CAAN)

(6) Development Policy

The future development policies of CAAN in relation to the National Development Planning (15th Plan) are as shown in Table 2.3-25.

Table 2.3-25 Development Policy of CAAN

Items	Policies as per CAAN Civil Aviation Annual Report 2018
1. Application of international standards for aviation sector	✈ Developing Nepal Aviation Safety Plan (2018-2022) in accordance with ICAO Global Safety Plan and proceed with related measures at faster pace. ✈ Coordination among CAAN and airlines to reduce the number of accident due to climate and geographical conditions. ✈ Updating air Navigation services by introducing latest equipment ✈ Introduce e-bidding process to automate airport operations
2. Airport Infrastructure Development	✈ Three international airports are under construction to meet increasing demand - Gautam Buddha Intl. Airport: Scheduled to be in operation by 2020 - Pokhara Intl. Airport: Scheduled to be in operation by July 2021 - Nijgardh Intl. Airport: Scheduled to be in operation in 2025, currently acquiring land
3. Airline Company Improvement	✈ 27 international airline (including Nepalese company) connects TIA to 14 countries. 19 domestic airlines are in operation. ✈ By March 2019, 75 aviation recreational club (4 ultralight aviation, 1 balloon, 70 paragliders) have been registered.
4. Organization Improvement (Aviation Bureau, Airline)	✈ CAA Seminars, Workshops, Field trainings. ✈ Attend training and seminars by international organizations including ICAO and CANSO ✈ CAAN is working with airlines to promote the ICAO Next Generation Aviation Professional (NGAP) program and Global Plan. The construction of aviation museum (Kathmandu) is an example of such activities.
5. Air Route Negotiation (Bilateral)	✈ Signed bilateral Air Service Agreement with Cambodia (November29, 2019). Nepal has signed ASA with 39 countries since 1963 and Cambodia is most recent example.

（Source：CAAN Report 2018）

2.3.6 Trends of Support Received from the International Organization or Other Donors in Aviation Sector

Table 2.3-26 shows the overview of the funding support received from the international organizations or other donors in the aviation sector.

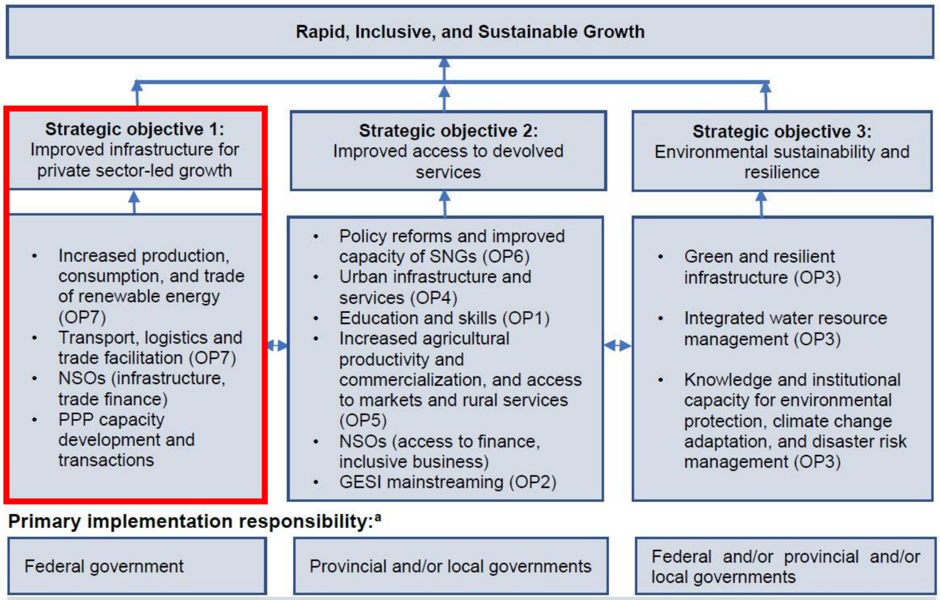
Table 2.3-26 Assistance from Donor Countries

Implementation Year	Institution	Project Title	Amount（USD）	Scheme	Overview
FY1996	France	French Seventh Protocal: Rehabilitation of Airport Equipment for Hub and STOL Airports	2.5/13.0 (₣)	Loan, Grant	
FY1997～FY2002	Asian Development Bank (ADB）	Tribhuvan International Airport Improvement Project	27(USD)	Loan	
FY2007～2010	Asian Development Bank (ADB）	Civil Aviation Airport project	0.75Million	Technical Cooperation	Study on the necessity of existing airports improvement, TIA Master Plan (2010-2023)
FY2009～ongoing	Asian Development Bank (ADB）	Air Transport Capacity Enhancement Project for TIA, 3 Domestic Airports (Lukla, Rara, Simikot)	About 80Million	Loan	**TIA:** Runway and Parallel Taxiway Extension, PTB and Apron Expansion, Utility Works, ATC and Weather Observation Facilites Update **Simikot&Rara:** Airport Lighting, ATC and Weather Observation Facilities
Cancelled	Asian Development Bank (ADB）	Tribhuvan International Airport Capacity Enhancement Investment Program	240Million	Loan	Airside maintenance in accordance with TIA master plan.
FY2014～ongoing	Asian Development Bank (ADB） OPEC International Development Fund	Gautam Buddha Airport Project	About 97Million	Loan, Grant	Construction of Runway, PTB, Apron and control tower Improve existing domestic runway into parallel taxiway
FY2017～ongoing	Export-Import Bank China	New Pokhara International Airport Project	Project cost 216Million Loan 145Million	Loan	Construction of new international Airport with runway length of 2,500m, located 3km southeast of present Pokhara Airport.
FY2017～ongoing	French Civil Aviation Authority（DGAC）	Improvement of Safety management function	N/A	Grant	Technical Assistance incorporated between CAAN and DGAC with MoU signing in 2017 to provide support in airworthiness certification and audit systems for airlines.
Proposed	Asian Development Bank (ADB）	Civil Aviation Sector Improvement Program	50Million 0.5Million	Loan/Technical Assistance	Organizational Strengthening of CAAN (TIA airside maintenance, New ITB at GBIA, CAAN organizational restructuring (regulator, operator))
FY2019～ongoing	Asian Development Bank (ADB）	Preparing the South Asia Sub-regional Economic Cooperation Airport Capacity Enhancement Sector Development Program	1Million	Technical Cooperation	Support civil aviation sector reforms in restructuring and strengthening (TIA hanger relocation, investment for ITB at GBIA, construction of Domestic apron at TIA)

（Source: JICA Study Team）

From 1969 to 2015, ADB has provided Civil Aviation sector of Nepal with 7 loans and 5 technical cooperation.

Since 1996, ADB assisted with the TIA development projects (loans), which includes expansion of international terminal building, construction of cargo handling facilities, improvement of safety-related roads and advisory consulting service. In the Civil Aviation Airport Project from 2007, a master plan of TIA airport was prepared. The Air Transport Capacity Enhancement Project (grant/loan) has being carried out since 2009 to support the extension of runway and maintenance of airside in accordance with the master plan. From 2014, the support for the construction of Gautam Buddha Airport was also initiated.



(Source: ADB)

Figure 2.3-12 ADB's Nepal Country Partnership Strategy, 2020-2024

In the Nepal Country Partnership Strategy (2020-2024) by ADB, they have three strategic objectives: (i) improved infrastructure led by private sector, (ii) improved access to various services, and (iii) environmental sustainability and resilience (Figure 2.3-12). Improvement work for civil aviation sector is included in objective (i), and ADB will assist with the enhancement of Tribhuvan International Airport's infrastructure and operational capacity, together with operational improvement in Civil Aviation Authority of Nepal to increase air safety. In their strategy framework, key outcomes that ADB contributes to are "More reliable, sustainable and resilient transport", and International air passengers will be increased 25% by 2024 (2018 baseline: 4.34 million) due to their work.

In addition, institutional development and strengthening of new regulatory bodies are also mentioned as an issue for the civil aviation sector. ADB will work closely with the government to provide relevant knowledge. They will also proactively engage in providing policy advice to the government and strengthen institutional capacity. This will include development and implementation of appropriate systems, such as asset management systems and e-government procurement systems.

2.3.7 Overview of Japan's Cooperation in Nepal 's Aviation Sector

The Table 2.3-27 shows the summary of Japan's previous cooperation in Nepal's Aviation Sector.

Table 2.3-27 Summary of Japan's Previous Cooperation

Implementation Year	Project Title	Grant Amount (Yen)	Project Overview
1994-2002	Dispatch of JICA Expert Aviation safety and Radar control		Conduct training for the operation and maintenance of equipment delivered during "Kathmandu International Airport Development Project".
1995-1997	Grant Aid Kathmandu International Airport Development Project	3.6 billion	Preparation of airport surveillance radar and conduct necessary training
1999-2001	Grant Aid ATC facility improvement project in TIA modernization project	1.2 billion	To enhance the effectiveness of radar installed during "Kathmandu International Airport Development Project" and perform safe ATC operation, carry out maintenance of ATC equipment and update radio equipment together with installation of new weather observation facilities.
2006-2008	Follow-up project on ATC system improvement		System improvement project for delivered equipment.in "Air Traffic Control Improvement Project in the TIA Modernization Program"
2009-2014	ATC Technology Senior volunteer		—
2013-2015	Grant Aid Tribhuvan International Airport Modernization Project (ATC Radar)	989 million	Installation of secondary radar system and replacement of existing surveillance radar in TIA.
2014-2018	Technical cooperation Project for development of spare parts management center and en-route radar control service	-	Develop capacity related to spare parts management of aviation safety equipment throughout Nepal and operation and maintenance of en-route air radar control services.
2016-Present	Grand Aid Improvement of aviation safety facility project	1.4 billion yen	Improvement of aviation safety equipment at eight major airports in Nepal (TIA, Danghadi, Chandragadi, Lukla, Jomsom, Jumla, Rara, Simikot).
2018-Present	Technical Cooperation Project Capacity development in operation and Maintenance of aviation safety equipment		Technical support for operation and management of localizer and IFR design system provided by "Improvement of aviation safety facility project". Technical support for expansion of equipment provided by "Development of spare parts management center and en-route radar control service"

(Source: Study Team)

Through grant aids and technical cooperation projects, CAAN's ability to ensure aviation safety has been improving steadily mainly through installation and maintenance of equipment and capacity development of CAAN staff. Seeing the achievement, Japan forms strong presence among development partners and government of Nepal and CAAN expect further continuing cooperation in aviation sector. Although, CAAN has proper organizational structures as one of the governmental agencies, it has issues related to insufficiency of controllers and technicians at local airports.

Therefore, in future along with development of air traffic control services and expansion of aviation safety equipment to meet increasing demand for air traffic, Japan look forward to assisting in enhancement of necessary personals through trainings and improving the training contents to meet required positions.

Chapter 3 Status And Issues in Nepal Aviation Sector

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3 STATUS AND ISSUES IN NEPAL AVIATION SECTOR

3.1 Improving Airport Capacity in Kathmandu Region

This chapter summarizes the current situation and issues regarding the four airports including planned airports in the Kathmandu area, Tribhuvan International Airport, Ramechhap Airport, Banepa Domestic Airport, Nijgadh Second International Airport.

3.1.1 Tribhuvan International Airport

(1) Current Status of Facilities

The Tribhuvan International Airport (TIA) is located in the capital city of Kathmandu. It is currently the only international airport in Nepal and also a domestic hub airport. In 2018, it handled 4 million international passengers annually, 2.9 million domestic passengers annually, totaling 7.2 million passengers annually. In addition, the number of takeoffs and landings of aircraft was 34,000 a year for international flights and 96,000 for domestic flights, for a total of 130,000. Table 3.1-1 shows the airport specifications of TIA and Figure 3.1-1 shows the current airport plan.

Table 3.1-1 Overview of TIA

4 Letter Code	VNKT
Aerodrome Referencet Code	4’D’
Airport Coordinate	270 41’ 49.72764” N／0850 21’ 28.52718” E
Province／District	3／Kathmandu
Operation Hours	Jan－Feb, Nov－Dec： 6：30－24：30 Feb－Nov： 6：00－24：30
Operation Start Year	1951
Airport Area	Approx. 1,785,160,05 ㎡
Runway	3,050 m x 46 m (02/20) Bituminous Paved (Asphalt Concrete)
Apron	Int’l - 9 Medium and Wide Boby, Domestic – 17 Small Aircrafts, Helipad - 13 Helicopters
Runway Strip	3,140m x 150m
International Passenger Terminal Building	30,000m^2（3 stories）2000 year operation start
Cargo Terminal Building	10,000m^2（2 stories）2000 year operation start
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	A333, B777, IL76, MD10, DC10, ATR72, CRJ200/700, MA60, ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	Category Ⅸ

（Source：CAAN）

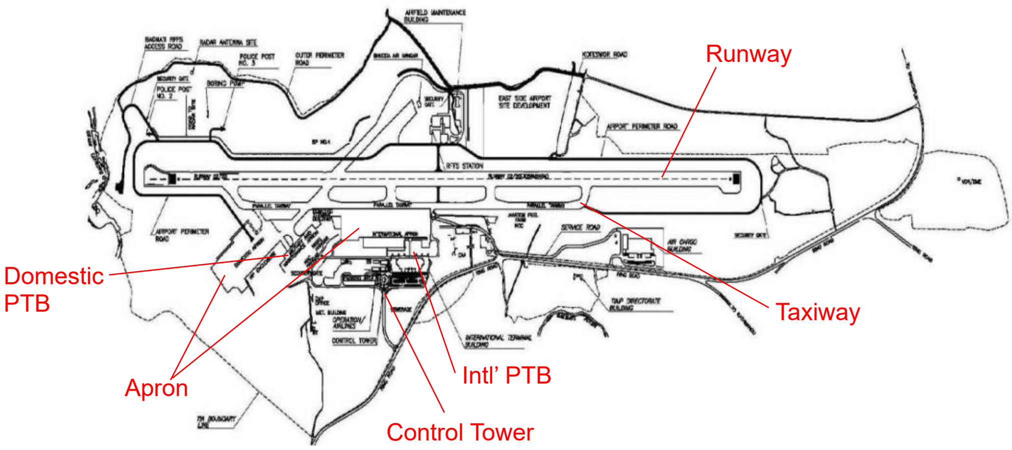
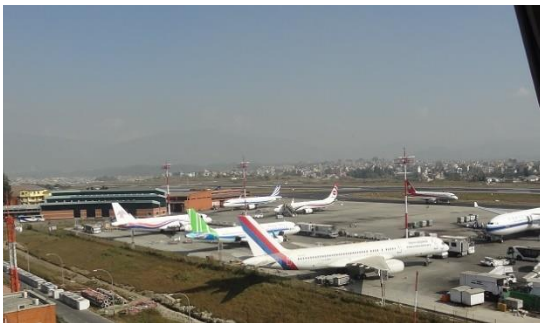


Figure 3.1-1 Plan View of TIA

(Source: CAAN)

Photo 3.1-1 View of the Tribhuvan Airport Terminal Area (View from the Northern Side)

	
Photo 3.1-2 Control Tower, International Passenger Terminal	**Photo 3.1-3 Domestic Passenger Terminal**
	
Photo 3.1-4 International Passenger Terminal Entrance	**Photo 3.1-5 International Apron**

(Source: JICA Study Team)

Table 3.1-2 shows the current status and future plans of major facilities of TIA studied in 2008. The international passenger terminal building is currently undergoing renovation. The domestic building was renovated in 2016.

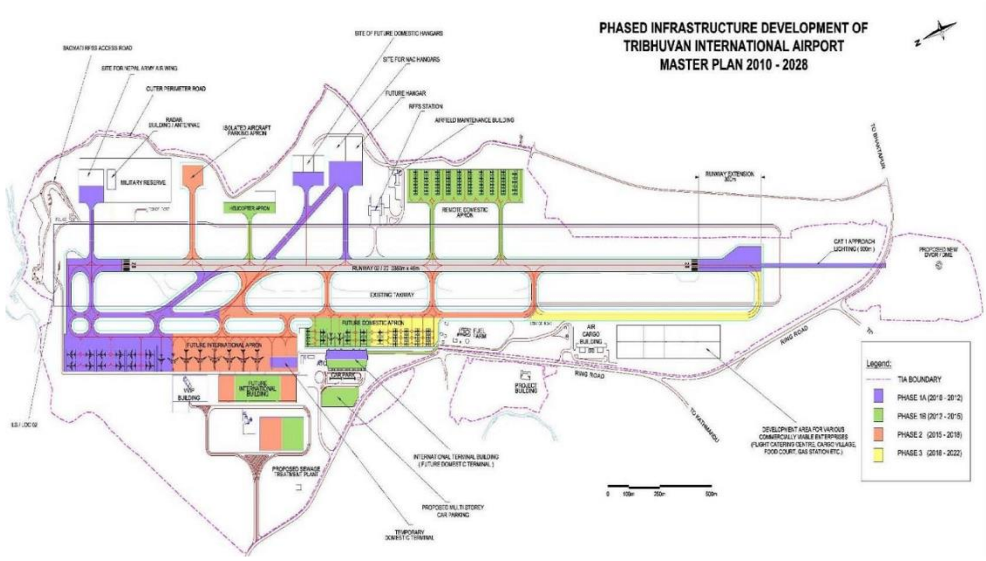
Table 3.1-2 Current Status and Future Plans of Major Facility of TIA (2008)

	Current Status	Future Plans
Runway	・3050m x 45m ・There is cross runway in north edge of main runway but not in use. ・RESA of northern side is only 90m and it is not sufficient for ICAO recommendation(240m) ・Runway Strip length is not enough for ICAO Annex 14.	・Extend 300m to southern direction.（Shoulder extend 7.5m each side.） →Extend RESA of northern side to240m and keep appropriate distance from SALS and ILS/LOC antenna. ・150 m Runway strip width for both side fromrunway center line. ・Establish turning pad that meet ICAO Annex 14.
Taxiway	・The distance from runway centerline to parallel taxiway is 109m and is not enough for Code 4C,4D,4E standard of ICAO Annex 14.	・Establish the parallel taxiway where centerline locates 182.5m apart from runway centerline.
Apron	・International aprons are too close to the runway and depending on the size of aircraft, parking aircraft may interfere the transitional surface.	・Domestic：Appropriate review, as capacity is not sufficient but further expansion is limited. ・International：New international apron recommended in front of new international PTB and northwest of existing ATC Tower
Control Tower	・Height:30 m ・VFR room Size:36 ㎡ ・Domestic apron cannot be seen due to expansion of airport in the past	N/A
Internationa l PTB	Terminal Area: 32,000 m^2 2008 Demand: 1.76 mppa ・Operation with almost maximum capacity, congestion also occurs. ・No space for pick-up and drop-off for both departure and arrival. ・No extensibility in the existing layout.	Terminal Area: 90,000 m^2 in 2028 6.3 mppa in 2028
Domestic PTB	Terminal Area: 4,000 m^2 2008 Demand: 1.08 mppa ・Already handling more passengers than capacity ・Immediate expansion of domestic PTB is required, but existing domestic PTB does not meet ICAO Annex 14, so it is desirable to relocate.	Terminal Area: 10,560 m^2 in 2028 2.98 mppa in 2028

（Source: ADB）

(2) Expansion Plan

Currently, the Air Transport Capacity Enhancement Project (ATCEP) and Transport Project Preparatory Facility (TPPF) project are in progress. The figure below shows the master plan of TIA from 2010 to 2028 which has been formulated in 2008. It includes runway extension, runway safety area extension, parallel taxiway and apron expansion.



(Source: CAAN)

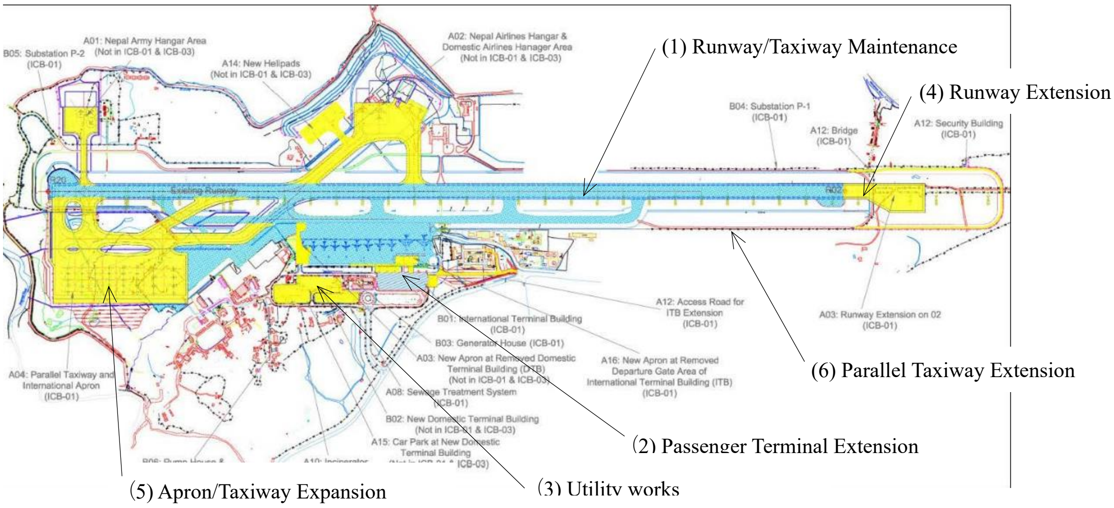
Figure 3.1-2 Master Plan from 2010 to 2028

Initially, ATCEP was initially planned to be entirely funded by ADB, but the construction of No. 2 to 5 in Table 3.1-3 was awarded by a Spanish company through an international bidding for a single package, but the contract was canceled in 2016. After that, it will be carried out with the funds of CAAN, and it will be divided into 4 packages. The construction of 2 to 4 will proceed with domestic competitive bidding and 5 will proceed with international bidding. No. 6 is not included in ATCEP, but the procedure for development with ADB funds is in progress.

Table 3.1-3 Work Items of ATCEP

No.	Contract No. Progress	Contract Value	Contractor
7. Rehabilitation of Runway and Taxiways of TIA (Runway and taxiway repair work)	TIA/CED/ICB/01/2016-2017 Construction start date: 2018/11/12 Completion date: 2020/5/5	4.27 Billion NPR	China National Aero-Technology International Engineering Corporation
8. ITB Expansion, Reconfiguration and Associated Works at TIA （ITB expansion/renovation, new apron construction due to relocation of departure gate)	NCB-02 On progress Progress Rate 50% （2019/12）	0.77 Billion NPR	M/s Sharma-Prera-Ashish JV
9. Utility Works at TIA	NCB-03 On Progress	0.19 Billion NPR	M/s Ashish-Prera JV
10. Runway Extension Works at TIA (Runway extension work)	NCB-02 Surface Course remain	0.84 Billion NPR	Kalika-Tundi JV
11. Apron and Taxiway Expansion Works at TIA (Apron and taxiway expansion work)	ATCEP/ICB-01R 2020/2Contract Preparation work		China National Aero-Technology International Engineering Corporation
12. Parallel Taxiway Extension Works (parallel taxiway extension work)	On progress of selection of ADB review Consultant		Under PQ evaluation

(Source: JICA Study Team)



(Source: ADB)

Figure 3.1-3 ATCEP Work Plan

The TPFF is a review of master plan as shown in Table 3.1-4 and implementation of design development of international terminal building and others. The design items of TPFF are shown in the table.

Table 3.1-4 Work Item of TPPF

Work Item	Situation
1. Master plan review	Designed by the Airport De Paris Ingenierie (ADPI)
2. New international passenger terminal building design development	
3. New VVIP building design development	
4. Design of hangars, Nepal Army Complex for relocation, expansion of air cargo complex	
5. Detailed engineering design of airside infrastructure per ultimate master plan	

(Source: JICA Study Team)

The master plan updated in 2016 is shown in the Figure 3.1-4. The master plan concept to relocate the current Nepalese airlines hangar and military apron to the east side of the runway and build a new international passenger terminal building is maintained, updated more in detailed.

(Source: CAAN)

Figure 3.1-4 Updated Master Plan (2016)

(3) Issues to be solved

As per the TIA master plan, the facility development includes the construction of new international passenger terminal building and renovating current international terminal building for the use as domestic passenger terminal. However, for that relocation of existing facilities, including military facilities which falls in the planning premises has not progressed. The present control tower is almost 30years or more since its construction and its height is not enough to observe current domestic apron which is blocked by the domestic terminal. Therefore, it is difficult to keep operational safety for aircrafts which move on ground. At the same time, The VFR room is also cramped with a mix of old and new equipment, and the administrative offices in the Administration Building are not large enough. As per the newspaper, the initial cost of the TIA expansion work was initially planned at USD 600 million but it is expected to increase to USD 1000 million and the plan will be reviewed considering the economic situation.
With the situation above, the Asian Development Bank (ADB) has sent out the expression of interest for the consulting services in reviewing the master plan on September 19, 2019. This work is planned to be executed in 4 months.

3.1.2 Ramechhap/Manthali Domestic Airport Development

(1) Overview of Current Situation and Development Plans

Ramechhap Airport is a domestic airport located in Mantari, Ramechhap District, Province 3, 150 km road distance from Kathmandu.

In 2015 at Tribhuvan Airport, asphalt paving work was carried out on the runway, and from 2019, flights to Lukla Airport had been moved to Ramechhap Airport due to reduced operating hours caused by runway repair work and as well increase in the aircraft movement in Tribhuvan International Airport. Except for the first and last flight, there were 100 flights a day during the busy season in 2019, with flights from Ramechhap Airport to and from Lukla Airport. The current airport specifications of Ramechhap Airport are shown in Table Table 3.1-5.

Table 3.1-5 Overview of Ramechhap Airport

Location Indicator	VNRC
Aerodrome Reference Code	1'A' Type 3
Aerodrome Coordinates	27^0 23' 38" N／86^0 3' 41" E
Province/ District	3／Ramechhap
Operation Hours	Jan－Feb、Nov－Dec： 6：45－12：30 March－April、Sept－oct： 6：15－12：30 May－Aug： 6：00－12：30
Operation Start Year	October 1979
Airport Area	Approx. 102,510,61 ㎡
Runway	530 m x 20 m (03/21) Bituminous Paved (Asphalt Concrete)
Apron	3 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	D228, DHC6, L410, Y12, C208
RFF Category	None

(Source: CAAN)

The Civil Aviation Authority of Nepal (CAAN) is currently planning to upgrade the Ramechhap Airport. Some of the planned development works include river rehabilitation work towards the runway 03 side, extension of runway edge until the fencing area on both sides as an immediate solution for improving runway safety, and plans to extend further in the future to at least 1,000 m.

(Source: CAAN)

Figure 3.1-5 Provisional Draft Airport Development Plan

In the future, for the purpose of improving the safety, the plan is to develop a runway length compatible with ATR42 considering the acquisition of land is unnecessary. As per CAAN, the Lamechhap Airport will be used mainly to serve Lukla Airport, and also intends to plan for regional airport routes as such as Biratnagar Airport.

(2) Airport Access

The Ramechhap/Manthali Airport is 150 km away from the capital city of Kathmandu which takes about 4 hours by drive. Although the road throughout is paved, it will take 4 hours by car even during early morning when there is no traffic. From Kathmandu to Bhaktapur the road is 2-lane, thereafter, until Dhulikhel the road is single lane, then the sindhuli road from Dhulikhel has 1.5-lane, which causes difficulties for large vehicle to pass each other. The access road to Ramechhap is as marked in Figure 3.1-6.

(Source: JICA Study Team)

Figure 3.1-6 Condition of Access Road to the Ramechhap Airport

(3) Issues

The airlines operate Lukla flights starting early in the morning, as the weather condition become worse in the afternoon and there is a high possibility of flight cancels. Therfore, it is necessary to leave Kathmandu at 2:00 am to catch an early morning flight.

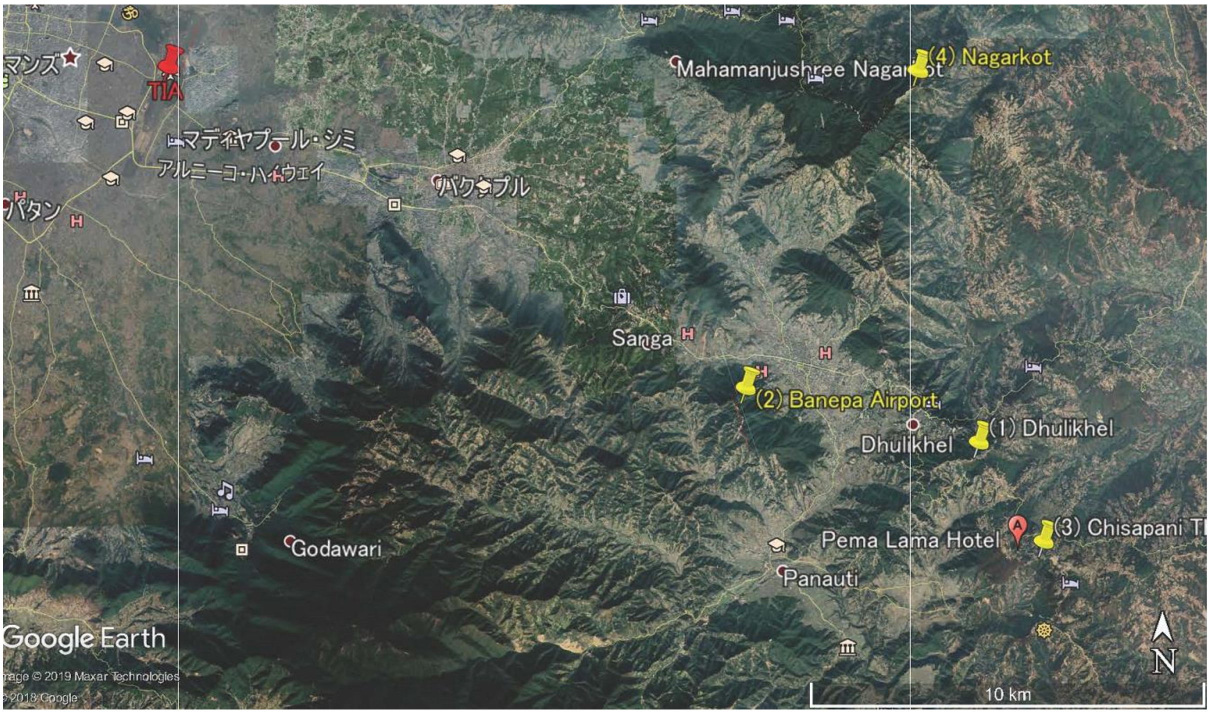
In addition, if it is found that there is a delay or cancellation after arrival at Ramechhap airport in the early morning, the airport terminal building is poor and there are not enough facilities for passengers to wait for the departure flight, so the response to passengers is not sufficient.

CAAN is planning to extend the runway and improve the airport facilities in the future, but since it is difficult to shorten the access time from the current 4 hours, Ramechhap Airport will not correspond to the alternative airport of TIA.

3.1.3 Banepa Domestic Airport Plan

(1) Background of the Site Selection of Banepa Airport

The Banepa Airport was planned in order to ease the traffic congestion at the Tribhuvan International Airport by diverting the domestic short takeoff and landing (STOL) aircraft to this airport.
A suitable site was further selected by CAAN in 2018 from the four selected sites based on the comparison carried out with the list of 34 points on technical, social, environmental and biological shown in Table 3.1-6. The Banepa site was the most suitable amongst the four. A score of 1 to 10 was given, with 0 being the lowest and 10 being the highest, and Banepa was selected as the most suitable site for airport construction.



(Source: JICA Study Team)

Figure 3.1-7 Location of Suitable Selected Sites for the Alternate Domestic Airport for TIA

Table 3.1-6 Site Selection Result

SL no.	Comparison Points	(1) Dhulikhel	(2) Banepa	(3) Chisapani	(4) Nagarkot
1	Access and accessibility cost	8	6	4	3
2	Distance from highway and TIA	7	8	6	5
3	Meteorological conditions	5	5	5	5
4	Approach and obstacles (ICAO Annex 14)	8	6	5	3
5	Adequacy of land for developing airport facilities	6	7	5	4
6	Installation of air navigational/lighting facilities	5	5	5	5
7	Procedural conflict with TIA traffic	8	6	9	5
8	Air traffic management	8	6	9	5
9	VHF Omnidirectional Range (VOR)/DME, radar coverage from KTM	7	8	7	7
10	Availability of construction materials	7	8	6	5
11	Stability of ground, geological conditions	7	7	7	6
12	Deforestation	7	7	5	8
13	Acquisition of government land	7	7	8	5
14	Loss of vegetation, forest and forest products due to site	7	7	6	5

SL no.	Comparison Points	(1) Dhulikhel	(2) Banepa	(3) Chisapani	(4) Nagarkot
	clearance				
15	Relocation of existing infrastructures like view tower, transmission line, public road	6	7	8	8
16	Relocation of a temple which is of religious, historical and cultural value	6	8	6	8
17	Riddance of space that people have been using from decades	7	8	8	8
18	Acquisition of land and buildings	6	7	9	9
19	Change of topography and land-use	7	7	7	7
20	Disposal of soil	7	7	6	8
21	Loss of top soil	7	8	7	8
22	Change in hydrology and drainage system	7	7	7	6
23	Air, noise, sanitation and water quality degradation	7	7	7	7
24	Impacts on flora, fauna, vegetation, wildlife, bird's habitat	7	7	6	6
25	Exposed social issue opposing the construction of airport	5	8	8	5
26	Pressure on existing road	7	8	7	5
27	Change in the noise pollution levels by operation activities	6	6	6	6
28	Operation related solid and other waste (in-flight waste, office waste, sanitary waste, etc.) discharges and associated pollution of land	6	6	6	6
29	Operation related engine emission	6	6	6	6
30	Ease in conducting construction activities	8	8	8	6
31	Ease in acquisition of land and buildings	6	7	8	6
32	Ease of water supply	7	7	7	5
33	Ease in obtaining separate dedicated feeder line	6	6	6	6
34	Easy storm and sub-surface water management	6	6	6	6
	Total	**208**	**215**	**211**	**190**

(Source: Banepa Site Selection Report, Ministry of Culture, Tourism and Civil Aviation (MoCTCA))

(2) Overview of Development Plans

CAAN has prepared a detailed feasibility study (FS) for the Banepa Airport construction. The report consists of comparison of the two options for the runway length of 1200 m and 800 m. The summary of comparison of the two options (Option-1 and Option-2) is shown in Table 3.1-7.

Table 3.1-7 Summary of the Two Options

Characteristics	Option-1	Option-2
Runway dimensions	1,200 m x 30 m	800 m x 20 m
Airport area	34.84 ha（Approximate）	24.15 ha (Approx.)
Target aircraft	ATR-42/ Jetstream-41	DHC-6 Twin Otter
Airport code	2'C'	1'B'
Runway orientation	16/34	16/34
Future extension	Not possible	Not possible
Approach	Two ways	Two ways
Obstacles	No prominent obstacles	No prominent obstacles
Nearest airport	TIA（approx. 9 nmi）	TIA（approx. 9 nmi）
Runway longitudinal slope	1%	1%
Transvers slope	1% from RWY centerline	1% from RWY centerline
Apron area	31,540 m^2	21,170 m^2
Number of bays	16 for DHC 5 for ATR-42	20 for DHC-6
Boundary fence length	3,970 m	2,810 m
Maximum excavation depth	50 m	21 m
Excavation complexity	Hard rock may be encountered	Hard rock may be encountered

Earthwork excavation (total)	5,394,000 m^3	699,000 m^3
(Hard rock volume)	2,138,000 m^3	13,000 m^3
Earthwork in filling	108,000 m^3	457,000 m^3

(Source: Banepa Detailed FS)

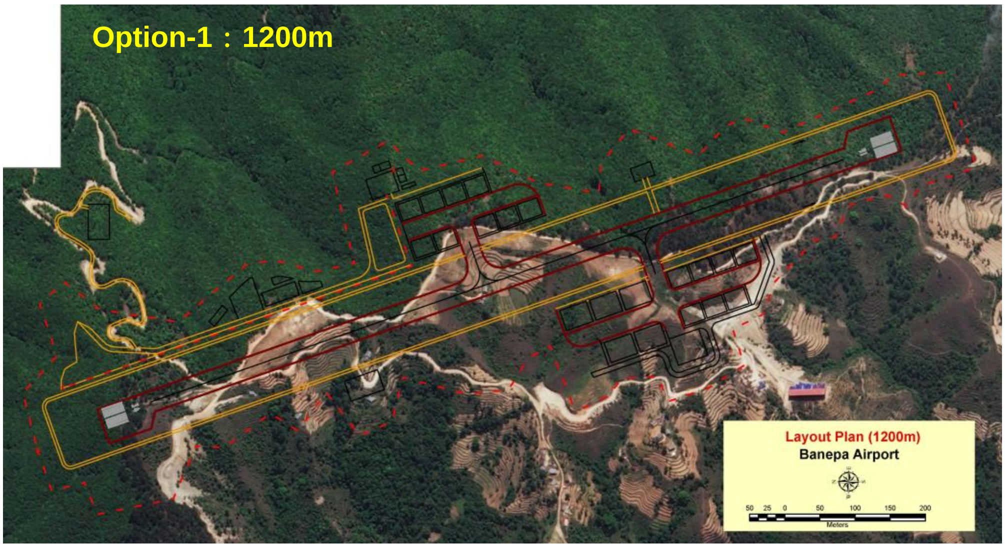
The soil that may be encountered during the excavation is shown in Table 3.1-8:

Table 3.1-8 Types of Soils that can be Encountered

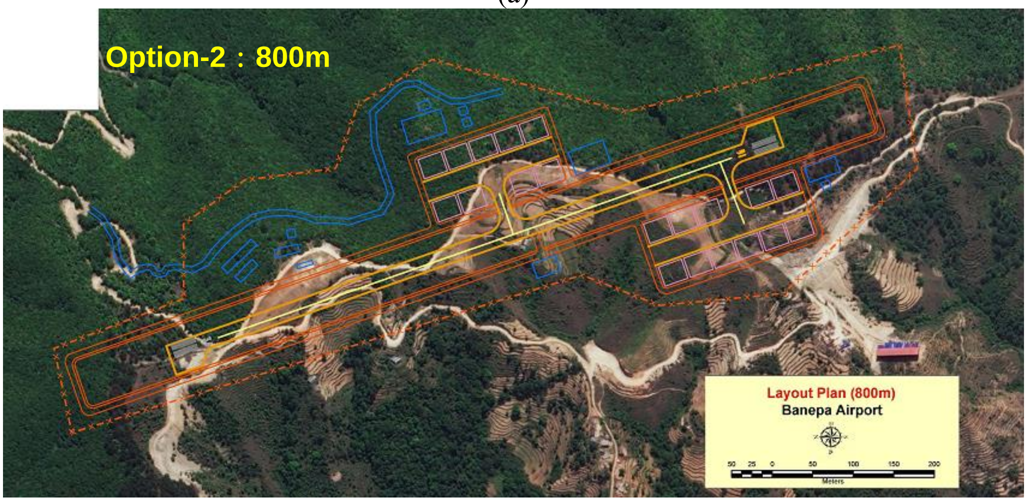
Soil type	Option-1	Option-2
Soft soil (residual and colluvium deposits)	24%	53%
Hard soil/gravel/B.M.S	20%	32%
Soft rock	16%	13%
Hard rock	40%	2%

(Source: Banepa Detailed FS)

The plans for the two options are shown in Figure 3.1-8 (a) and (b).



(a)



(b)

(Source: Banepa Detailed FS)

Figure 3.1-8 (a) Plan of Option-1 (1200 m) (b) Plan of Option-2 (800 m)

The planned site of Banepa airport is a mountain ridge, and there is built area in the part of the ridge, but there are no settlements. A dirt road is sewn on the mountain and can be accessed by car from the foot to the candidate site.

Photo 3.1-6 Approach Road to the Banepa Airport Planned Site

Photo 3.1-7 View of Banepa Airport Planned Site

Photo 3.1-8 View at the Planned Site

Photo 3.1-9 View of the Nearby Village from the Planned Site

(Source: JICA Study Team)

The cost estimates for the construction of the Banepa Airport for the two options are shown in Table 3.1-9.

Table 3.1-9 Cost Estimates for the Two Options

	Features of Airport Facilities	Option-1 (Million NPR)	Option-2 (Million NPR)
A	General item	50.37	15.85
B	Earthwork	2,792.30	155.54
C	Pavement structural work	707.64	475.52
D	Drainage works	38.54	24.01
E	Chain-link fence work	37.17	26.33
F	Miscellaneous work	15.92	10.99
G	Roads and parking	570.00	498.30
H	Buildings and utilities	1,176.70	709.50
	Total Estimated Cost	5,388.64	1,916.03
	10% Cost inflation	538.86	191.60
	10% Physical contingency	538.86	191.60
	VAT（13%）	700.52	249.08
	Grand Total with VAT	7,166.89	2,548.32
	Grand Total with VAT(JPY)	68.8 Billion	24.5 Billion

(Source: Banepa Detailed FS)

(3) Issues

In relation to the construction of the Banepa Airport, the following issues need to be addressed well for it to be more reliable:

- Improvement of access road from Kathmandu to the Banepa Airport site.
- Access road along the mountain route towards the site from the Arniko Highway needs to be maintained since the refueling vehicle will be relying on it.
- Needs to balance cut and fill volume at the site, especially option-1.
- Environmental impact assessment needs to be studied.
- Possibility of land acquisition
- Relocation of residents
- Look for solution of water at the proposed site like rainwater harvesting, regulating ponds, etc.,

The feasibility of construction of Banepa domestic airport project will be examined in Chapter 4.

3.1.4 Nijgadh International Airport Project

(1) Overview of Development Plans

The Nijgadh Second International Airport is a project to build a second international airport in Nijgadh municipality, Bara District, about 60 km south-southwest of Kathmandu. In 2010, a FS was conducted by a Korean company (Landmark Worldwide Company). The airport construction plan is shown in Table 3.1-10 and the planned view after construction is shown in Figure 3.1-9. Completion date is not fixed.

Table 3.1-10 Overview of Airport

Aerodrome Reference Code		4'E'
Airport Area		40km^2 (4,000ha)
Runway		4,000m x 60m x 2sets, Bituminous Paved (Asphalt Concrete)
Stage Development	**Phase-Ⅰ**	Passenger 15mppa、Project Cost 650 million USD, Construction Period 4years
	Phase-Ⅱ	Passenger 30mppa、Project Cost 3,200 million USD, Construction Period 5years
	Phase-Ⅲ	Passenger 67mppa, Project Cost 6,700million USD, Construction Period 5years

(Source: CAAN)

(Source: CAAN)

Figure 3.1-9Aerial View of the Nijgadh Airport

The progress status of the current project is as follows, but the completion date is undecided.

Table 3.1-11 Work Progress of Nijgadh International Airport Project

Item	Work Progress	Note
Environmental Impact Assessment	Approved in May 2018	
Land Aquisition	On Progress （60%）	✈ Project Cost：NRs. 1.555 billion ✈ MoCTCA request Ministry of Land Management, Cooperatives and Poverty Alleviation for Resettlement Program, responding to 1495 squatters in the vicinity（5 January, 2020）
Civil Work	On Progress	✈ Project Cost：NRs. 150 billion ✈ MoCTCA request MOFE to take necessary measures for felling trees around the airport due to the construction of the airport. (28 November, 2019) ✈ Department of Forest and Soil Conservation request Division Forest Office to estimate felling tree numbers due to the

Item	Work Progress	Note
		construction of the airport. (12 January, 2020)
River Training Work	On Progress (60%)	✈ Project Cost：NRs. 250 million
Fonce Work	Complete	✈ Project Cost：NRs. 39.9 million

(Source: CAAN)

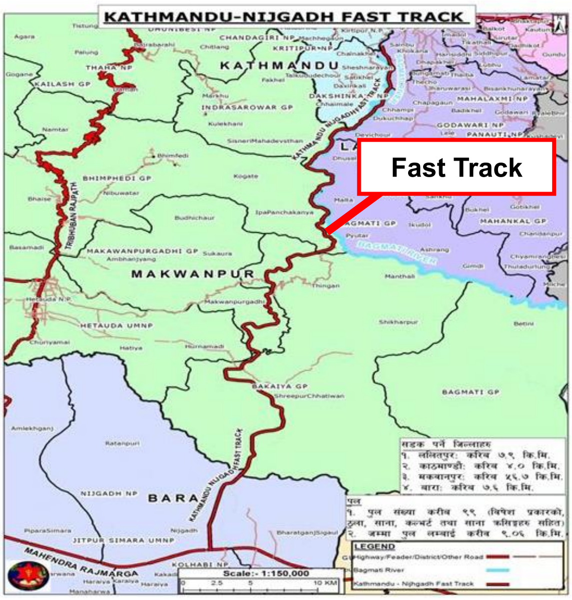
(2) Overview of the Fast Track Project

Fast Track project is part of National Pride Project of Nepal, which consist of construction of highway linking Kathmandudistrict and India. The Project will also serve as an access road connecting Nijgadh Airport with Kathmandu. The overview of the Project is shown in Table 3.1-12. The total length of fast track is 72.5 km (the original proposed was 76.2km). It includes construction of 87 bridges and 3 tunnels.

Table 3.1-12 Overview of the Fast Track Project

Features	Contents
f) Carriageway and length	The expressway consists of a dual carriageway with double lane high design speed highway. Overall length is 72.5 from Khokana (Lalitpur) to Nijgadh (Bara) which interconnect the Kathmandu and Makwanpur districts in between.
g) Tunnel	The expressway also includes a 1.35 km long twin tube tunnel. The proposed width of the tunnel is 11 m and 22 m in 2-lane and 4-lane, respectively.
h) High bridges	The expressway consists of many high-rise concrete bridges connecting steep mountains in order to achieve a smooth gradient and gentle curve sustaining high design speed. This work makes use of the latest technology in bridging, tunneling, and highway construction engineering.
i) EIA	A strict environmental consideration was implemented from the start of the project during planning, preliminary design, and alignment. Significant and frequent environmental impacts were examined in order to achieve dynamic output in environmental protection and impact mitigation measures.
j) Status	Although the overall length had been calculated previously it is expected that a minor deviation could arise with the exact length, numbers and length of tunnels because of geographical, financial and technical factors during the final stages of detailed planning/DPR and during the implementation phase of the project. It is predicted that the travel time could be reduced to over an hour after completion.

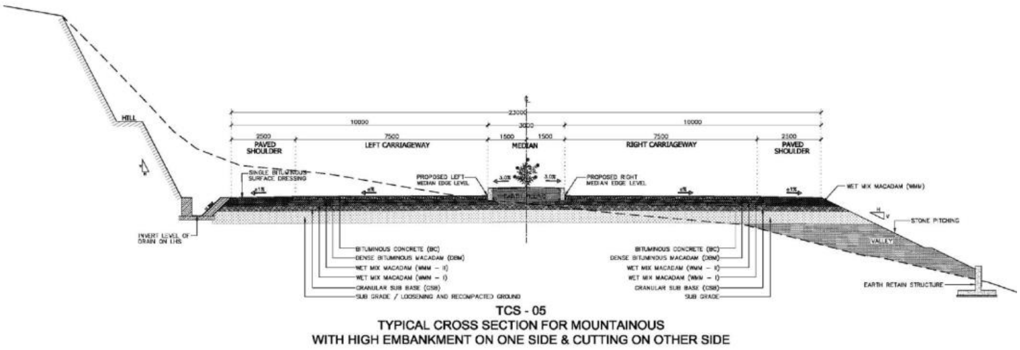
(Source: Nepal Army (https://www.nepalarmy.mil.np/fasttrack/home)



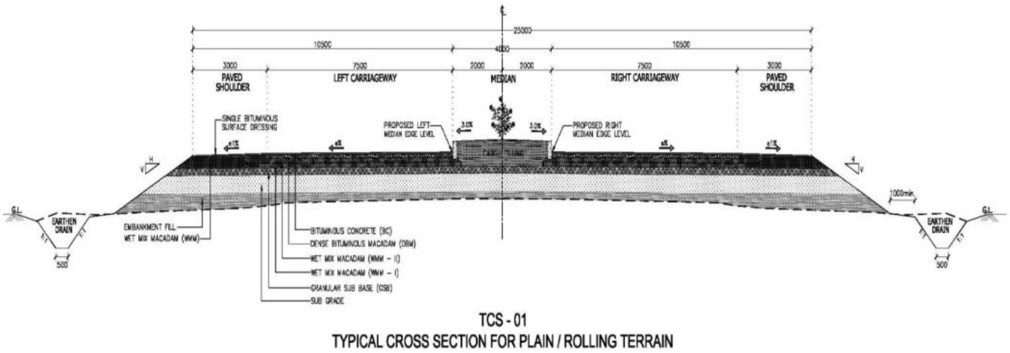
(Source: Nepal Army (https://www.nepalarmy.mil.np/fasttrack/home)

Figure 3.1-10 Representation of Fast Track Route

The design of road is based on the “Asian Highway Class-I” standard and cross-section detail of the road is as shown in Figure 3.1-11.



(a)

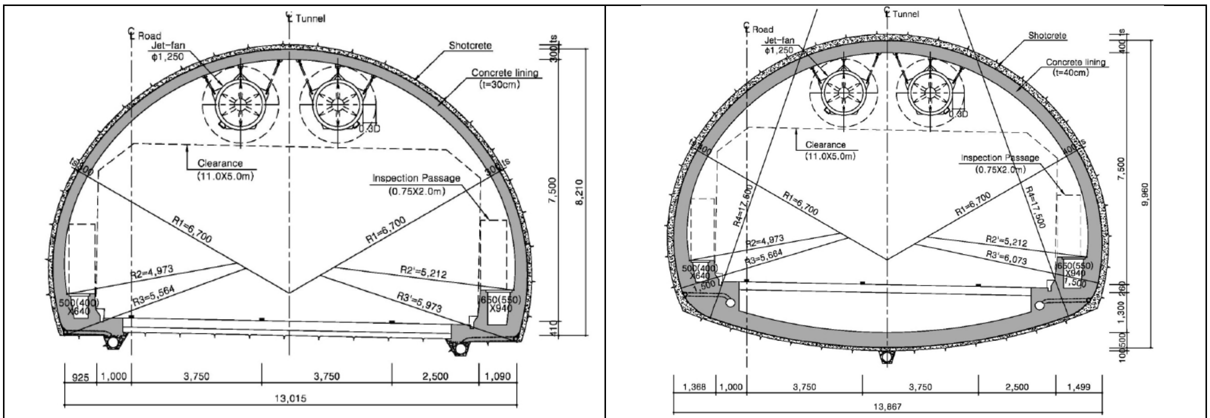


(b)

(Source: Promoting PPP in Nepal, unescap.org)

Figure 3.1-11 Cross-sectional Detail of Fast Track Road

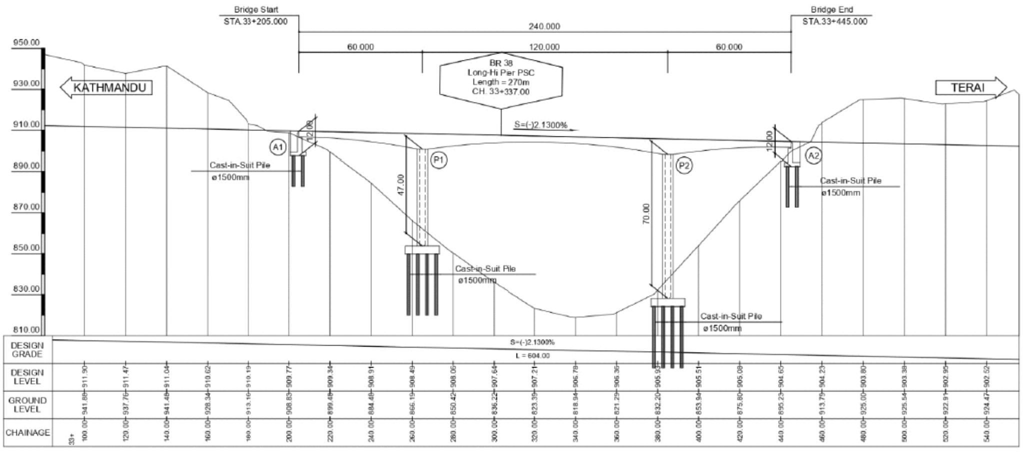
The typical cross-sectional detail of twin tunnel and bridges are as shown in Figure 3.1-12 and Figure 3.1-13 respectively.



Without Invert	With Invert

(Source: Procurement Document, KTFT/ICB/PQ/TUNNEL/076/077-1)

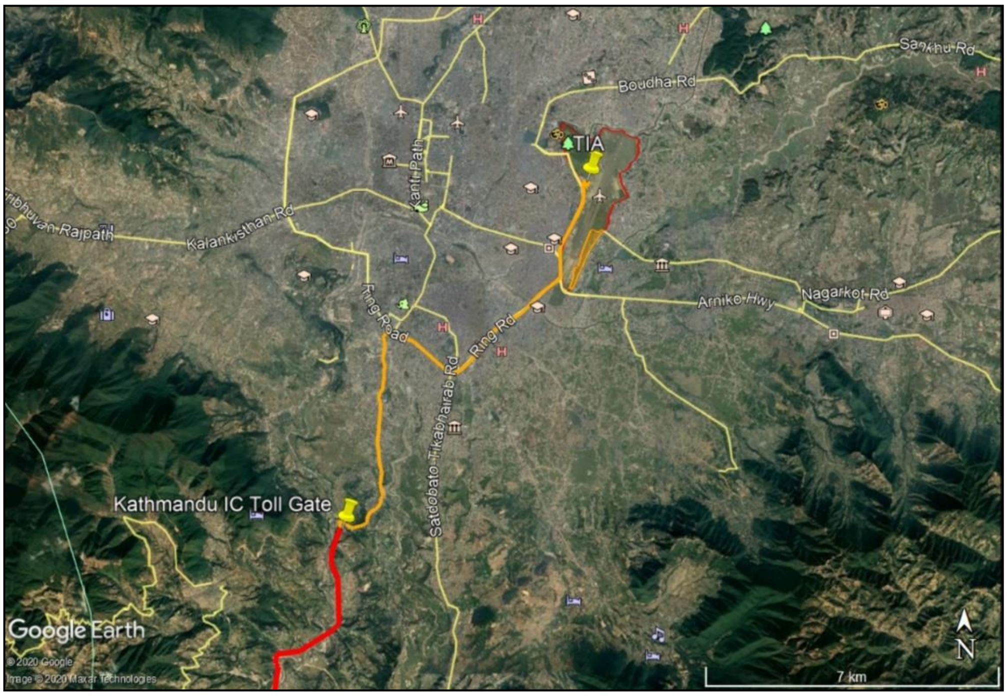
Figure 3.1-12 Cross-sectional Detail of Tunnel



(Source: Procurement Document, KTFT/ICB/PQ/TUNNEL/076/077-1)

Figure 3.1-13 Cross-sectional Detail of bridge No.38

The starting point of Kathmandu fast track road is roughly located in place called Khokana (Laliput) which is about 15Km from TIA and around 4-5km from the Kathmandu ring road. The location is as indicated in Figure 3.1-14, with coordinate of 27°37'26.30"N and 85°17'44.84"E, however it has been decided based on the point where the construction of road has begun.



(Source: JICA Study Team)

Figure 3.1-14 Location of Starting Point of Fast Track

Some of the photo that has been taken at the starting point of the fast track in Kathmandu are as below;

	
Photo 3.1-10 Site Photo of Fast Track starting Point	**Photo 3.1-11 Earthwork Implementation Status**
	
Photo 3.1-12 Earthwork Implementation Status	**Photo 3.1-13 Construction is suspended where some structures are required.**

(Source: JICA Study Team)

As per the press conference of December 9th, 2019, Nepal Army Headquarter (NAHQ) mentioned that construction of Kathmandu-Madhes/Terai Fast Track Project will be completed by March, 2024. The Project was handed over to Nepal Army on August 11th, 2017 by the previous government. The progress of the project in the last two year was about 6%, however, Nepal Army plans to develop holistic project plans and work to complete it by 2024. The cost of the project was estimated at 175billion NPR including VAT from the initial estimate of 155 billion NPR. For the current fiscal year the allocated budget was about 15billion NPR and it was decided by the government to give project five years implementation period.

(3) Issues

Under the scheme of Build, OWN, Operate and Transfer (BOOT) for the Nijgadh Airport, there were seven companies that submitted their expression of interest for the project to the Investment Board of Nepal (IBN). Among them, only one will be selected and will be asked to do the detailed design. IBN is requesting that a detailed proposal be submitted to the only eligible Zurich Airport out of the seven companies that expressed interest in the BOOT scheme of the Nijgadh Second International Airport Development Project.

However, it is not definite that the project will be carried under the BOOT scheme.

Regarding the Fast Track project, although the military has begun the construction, the construction for bridges and tunnel has not started so it is difficult to decide the construction completion date.

3.1.5 Issues

Although the runway capacity at the peak of TIA is approaching the limit, the number of runways remains one even after the completion of the master plan which is updated on 2016. It is difficult to construct a second runway at TIA because the airport land is limited, and the problem of airspace congestion cannot be solved. Therefore, the development of TIA is not the only solution for capacity enhancement of airport in Kathmandu metropolitan area.
Ramechhap airport is located 150 km away from Kathmandu and the access time from kathmandu will not be shortened from 4 hours in case of access road improved. It is difficult for Ramechhap airport to serve as an alternative airport of TIA.
Nijgadh Second International Airport is an international airport with two runways and an annual operation capacity of 67 million passengers, but the construction of a fast track, which is an access road from Kathmandu to the airport and connect between Khokana (Lalitpur) and Nijgadh (Bara), is not progressing well. If both the airport facility and the fast track are completed, it is considered that they will function as an alternative airport of TIA. However, since the fast track includes a 1.35 km tunnel and bridge, and if they are not completed soon it will endup taking time.

As mentioned above, as capacity enhancement of airport in Kathmandu metropolitan area, it is difficult to deal with the development of Ramechhap airport and other airports such as TIA and Nijgadh Second International Airport and Banepa domestic airport may be a valid solution.
On the other hand, as there are issues for development of Banepa domestic airports as described in 3.1.3, in Chapter 4, capacity enhancement of airport in Kathmandu metropolitan area is studied including measures for Banepa domestic airport development projects.

3.2 Development Status of Major Domestic Airport

In order to enhance air transportation in Nepal, CAAN is proceeding with a project to develop Gautam Buddha airport and Pokhara airport as international airports and develop the airport facilities of domestic airports in the Terai region. CAAN is also constructing a new airport in order to improve access to the airport vacant land. In this chapter, the development status of those airports and future development plans are summarized.

3.2.1 Gautam Buddha International Airport Development Project

The Gautam Buddha (Bhairahawa) Airport (GBA) is in the Rupandehi District in the western part of the Terai Region in Nepal. It is located about 2 km west of Siddhartha Nagar/Bhairahawa, it is situated at an altitude of 109 meter above mean sea level. Lumbini, which is the birthplace of Gautam Buddha and a famous tourist place of the area, is 20 km towards the west of GBA. It has been a famous pilgrimage destination for the Buddhist people after visiting Bodhgaya, which is 6 hours by bus.

(1) Current Situation

Table 3.2-1 shows the airport specification of GBA, as of December 2019

Table 3.2-1 Overview of the Domestic GBA Airport

Location Indicator	VNBW
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	27^0 30' 26" N／83^0 25' 05"E
Province/ District	5／Rupandehi
Operation Hours	Jan-Feb, Nov-Dec: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	4 July1958
Airport Area	Approx.1,040,311,08 ㎡
Runway	1,520 m x 30 m (10/28) Bituminous Paved (Asphalt Concrete)
Apron	2 Medium/ 4 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	ATR72, CRJ200/700, MA60, ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	Category V

(Source: CAAN)

GBA currently operates the domestic flight between Kathmandu and Pokhara with around 30 daily scheduled flights. The current runway length is 1,520 m and width 30 m. The new runway and apron are being constructed and included in the current GBA development projects. It is also being planned that the current runway may be used as a parallel taxiway in the future.

(Source: JICA Study Team)

Figure 3.2-1 Overall View of GBA

(2) GBA Development Project

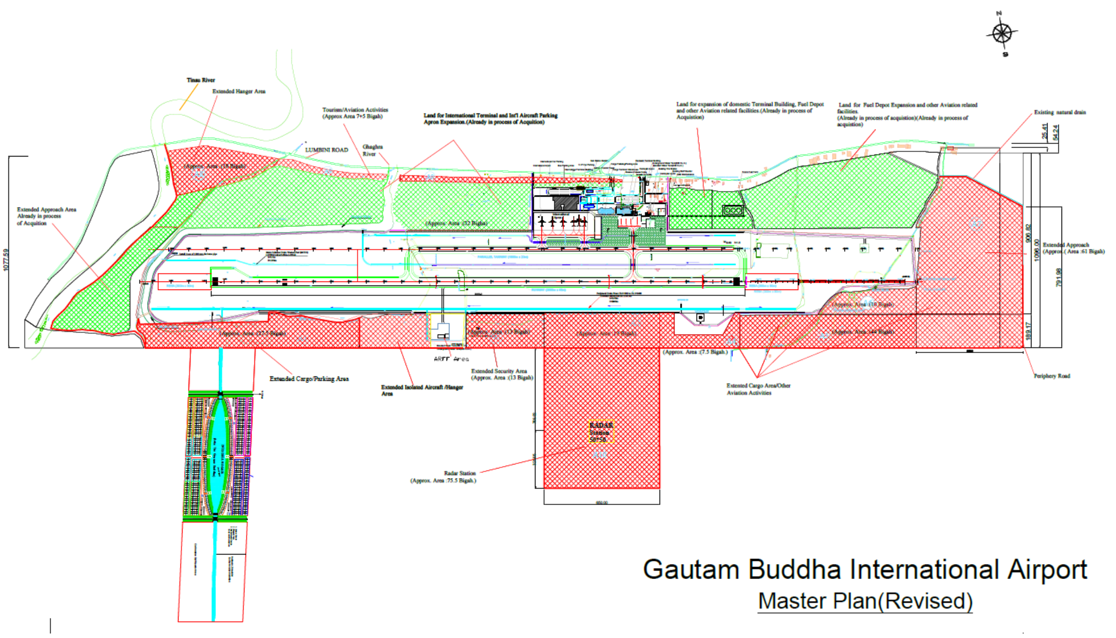
The current GBA development project is included under the National Pride Project of Nepal, which includes the construction of a new 3,000 m long runway and transforming it as an international airport. The overview of the facilities after the project is completed and is shown in Table 3.2-2.
The source of the project fund includes ADB loan (USD 30 million) and Grant aid (USD 3 million) and OPEC International Development Fund (OFID) loan (USD 15 million) making the total budget of about USD 97 million.

Table 3.2-2 Overview of the GBA International Airport Project

Aerodrome Reference Code	4'E'
Runway	3,000 m x 45 m （Shoulder width 7.5 m）
Runway Strip	3,202 m x 300 m
Taxiway	1,900 m x 23 m
Runway/Parallel Taxiway C/C Spacing	182.5 m
Runway End Safety Area（RESA）	300 m x 90 m （both sides）
Int. Terminal Building Area	15,169 m^2
Control Tower and Management Bldg Area	2,141 m^2
Fire Department	1,608 m^2
Main Construction	Airside, landside construction、utilities (water and sewage), terminal equipment, mechanical, electrical

(Source: CAAN)

The master plan of the airport that has been obtained from the National Pride Project Office is as shown in Figure 3.2-2.



(Source: CAAN)

Figure 3.2-2 Master Plan of the GBA Project

Photo 3.2-1 New Passenger Terminal Building under Construction

Photo 3.2-2 Current Passenger Terminal Building

(Source: JICA Study Team)

The work is divided into two packages (ICB-01 and ICB-02), the details of each work are shown in Table 3.2-3 and Table 3.2-4 below.

Table 3.2-3 ICB-01 Airside and Landside Construction Details

Features	Contents
Contractor	M/S Northwest Civil Aviation Airport Construction Group, China (NCAACG)
Commencement	November 2014
Contract completion	28 June 2019（EOT2）
Contract Price	NPR 6.22 billion
Airside and Landside Works	Completed: Runway, apron Ongoing: Taxiways, passenger terminal building, control tower

(Source: National Pride Project Office)

Table 3.2-4 ICB-02 Metrological Equipment Procurement Details

Features	Contents
Contractor	Aeronautical Radio of Thailand Limited
Commencement	7 March 2019
Contract Price	USD 4.77 million and NPR 7.88 million
Airside	CNS/ATM, Metrological equipment

(Source: National Pride Project Office)

As per the interview with the project chief, the construction is delayed from its initial planned completion, which is June 2019, however, 70% of the construction is completed and it is targeted to be completed by March 2020.

(3) Issues

The issues related with the airport are dense fog coverage of the airport in the morning during winter (from December to February), which affect the scheduled flight operation. Also, since the airport does not have a radar installed, VHF communication is used as the primary communication facility.

3.2.2 Pokhara International Airport Development Project

(1) Current Situation

Table 3.2-5 shows the current specification of the Pokhara Domestic Airport. The airport alone in FY2018 has handled over 609,000 domestic passengers, the second airport to handle the largest number of domestic passengers next to Tribhuvan International Airport. In addition to passenger flights, recreational flights and helicopters play a major part in the traffic of the airport. During the peak season, there will be around 200 flights a day. The flight operation utilizes both the direction for takeoff and landing.

Table 3.2-5 Overview of Pokhara Domestic Airport

Location Indicator	VNPK
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	28^{0} 11' 56" N／83^{0} 58' 42"E
Province/ District	4／Kaski
Operation Hours	Jan-Feb, Nov-Dec: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	4 July 1958
Airport Area	Approx. 588,426 ㎡
Runway	1,444 m x 30 m (04/22) Bituminous Paved (Asphalt Concrete)
Apron	4 Medium/ 6 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	Category V

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-3 Plan View

Photo 3.2-3 Photo View of Apron

Photo 3.2-4 Photo Control Tower and Passenger Terminal

(Source: JICA Study Team)

(2) Pokhara New International Airport

The Pokhara International Airport construction is also part of the National Pride Project, which includes the construction of 2,500 m long runway located about 3 km southeast of the current domestic airport. In 2014, turnkey agreement is made between the China CAMC Engineering company for approximately 216 million USD with more than 145 million USD of the project funding from China Exim Bank. The outline of the project is shown in Table 3.2-6.

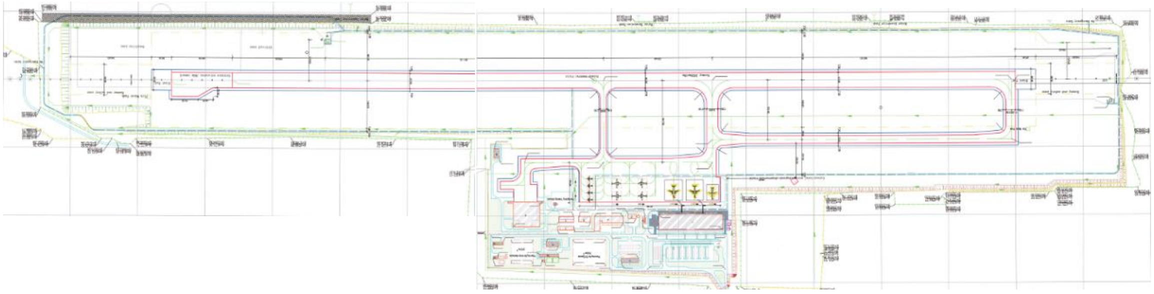
Table 3.2-6 Overview of Pokhara International Airport

Location Indicator	4'D'
Runway	2,500 m x 45 m
Parallel Taxiway	900 m x 23 m
Number of Taxiway	3 Nos（142 m x 28.5 m, 208.5 m x 34 m, 208.5 m x 18 m）
Surrounding Road	Road width 3 m
Airport Access Road	Road width 20 m (4-Lane)
Apron	417 m x 129 m、（Future plan 150 m x 152.5 m）
Passenger Terminal Bldg.	14,643 m^2
Hanger	6,055.95 m^2
Control Tower	1,117.58 m^2
RFF Category	Category Ⅷ

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-4 Plan View



(Source: CAAN)

Figure 3.2-5 Master Plan of Pokhara International Airport

Photo 3.2-5 Passenger Terminal Building under Construction

Photo 3.2-6 Status of Runway Construction (pavement work completed)

(Source: JICA Study Team)

The outline of the construction and the schedule for the completion date are shown in Table 3.2-7.

Table 3.2-7 Outline of the New Pokhara Airport Project

Features	Contents
EPC Contractor	M/S China CAMC Engineering Co,. Ltd.
EPC Commencement	11 July 2017
Contract Completion	10 July 2021
EPC Contract Price	USD 215.96 million
Milestones in FY2019	Completed runway, taxiway, apron, drainage facilities and other building facilities
Milestones in FY2020	Completion of passenger terminal building and equipment installation
Milestones in FY2021	Project completion and flight test

(Source: National Pride Project Office)

(3) Issues

Pokhara airport is a popular tourist destination visited by more than half of the foreign tourists visiting Nepal. It is expected that some passengers currently passing through TIA will directly use Pokhara airport, after the international flight starts operation in Pokhara airport.

There are topographical barriers (hills) on the eastern side of the new airport which will restrict takeoff from the east side. Thus, it should only allow unidirectional takeoff from the western side for the large jets.

This leads to reduced runway handling capacity for the large jet aircraft since it can land and takeoff only in one direction. The international destination will include south Asia, Southeast Asia and also short distance international flight to east Asia.

3.2.3 Airport Development/Planning in Terai Region

The Terai region is a narrow plain extending from east to west in southern Nepal, occupying 17% of the total land area, and 11 million people inhabits, which is 48% of the population of Nepal. Airports are established in cities in the Terai region (Mahendranagar, Dhangadhi, Nepalganj, Narayanghat, Birganj, Janakpur, Biratnagar, Badrapuru).

(1) Mahendranagar Airport

Mahendranagar Airport is located in Mahendranagar (population 106,000 (2011)) in western Nepal. Table 3.2-8 shows the current facilities at the Mahendranagar Airport.

Table 3.2-8 Overview of Mahendranagar Airport

Location Indicator	VNMN
Aerodrome Reference Code	1'A' Type2
Aerodrome Coordinates	28^0 57' 48" N／80^0 09' 53" E
Province/ District	7／Mahendranagar
Operation Hours	Nov-Jan： 10：00－16：00 Feb-Oct： 10：00－17：00
Operation Start Year	30 December 1973
Airport Area	Approx. 355,766 ㎡
Runway	884 m x 30 m (17/35) Grass
Apron	2 Small Aircrafts
Re-fueling Facility	None
Type of Aircraft	DHC6, Y12, C208
RFF Category	None

（Source: CAAN）

At the request of the local government, CAAN is planning to develop a runway (884 m x 30 m) at the Mahendranagar Airport for ATR72, CRJ (1800 m x 30 m) as an alternative airport during the renovation of the Dhangadhi Airport. The current airport site is adjacent to the national park so the planning for the runway extension should not fall under the national park.

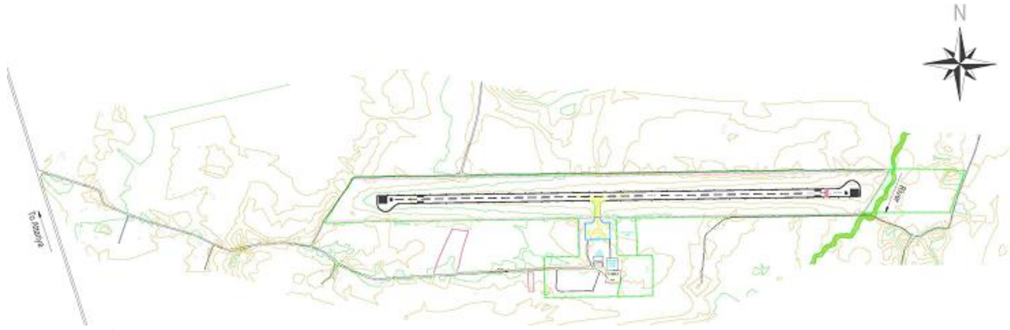
(2) Dhangadhi Airport

Dhangadhi Airport is located in Dhangadhi (population 147,000 (2011)). Table 3.2-9 shows the current facilities at the Dhangadhi Airport.

Table 3.2-9 Overview of the Dhangadhi Airport

Location Indicator	VNDH
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	28^0 45' 12" N／80^0 34' 59"E
Province/ District	7／Kailali
Operation Hours	Nov-Jan： 10：00－16：00 Feb-Oct： 10：00－17：00
Operation Start Year	26 December 1964
Airport Area	Approx. 301,246.94 ㎡
Runway	1,670 m x 30 m (09/27) Bituminous Paved (Asphalt Concrete)
Apron	1 Medium/ 2 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	ATR72, CRJ200/700, MA60, ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	None

（Source: CAAN）



(Source: CAAN)

Figure 3.2-6 Master Plan of the Dhangadhi Airport

	
Photo 3.2-7 Apron View	**Photo 3.2-8 Control Tower and Passenger Terminal Building**

(Source: JICA Study Team)

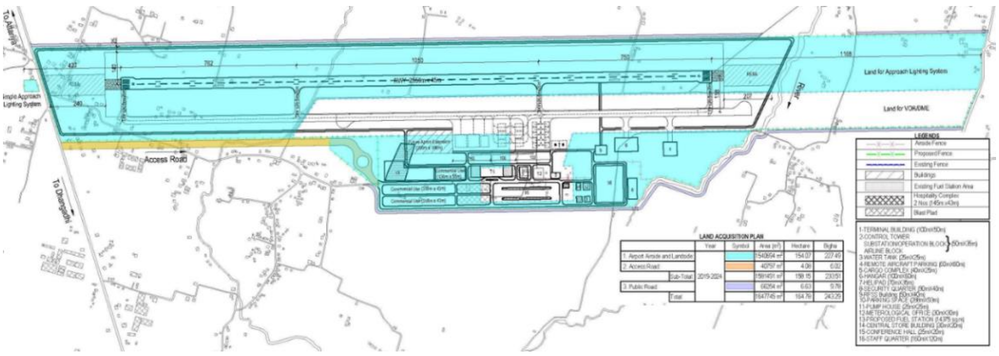
The master plan for the Dhangadhi Airport was prepared in 2018 and the details of the construction work for each phase are shown in Table 3.2-10.

Table 3.2-10 Overview of the Airport Development Plan

Work Stage（Working period）	Components of Work
Phase-1 (2019-2024)	Apron extension to the east side (22,200 m^2), VOR/DME
Phase-2 (2025-2040)	New runway construction 2550 m x 45 m Apron extension to the west side (15,700 m^2) New passenger terminal building and control tower
Phase-3 (2040-2045)	Parallel taxiway construction

(Source: CAAN)

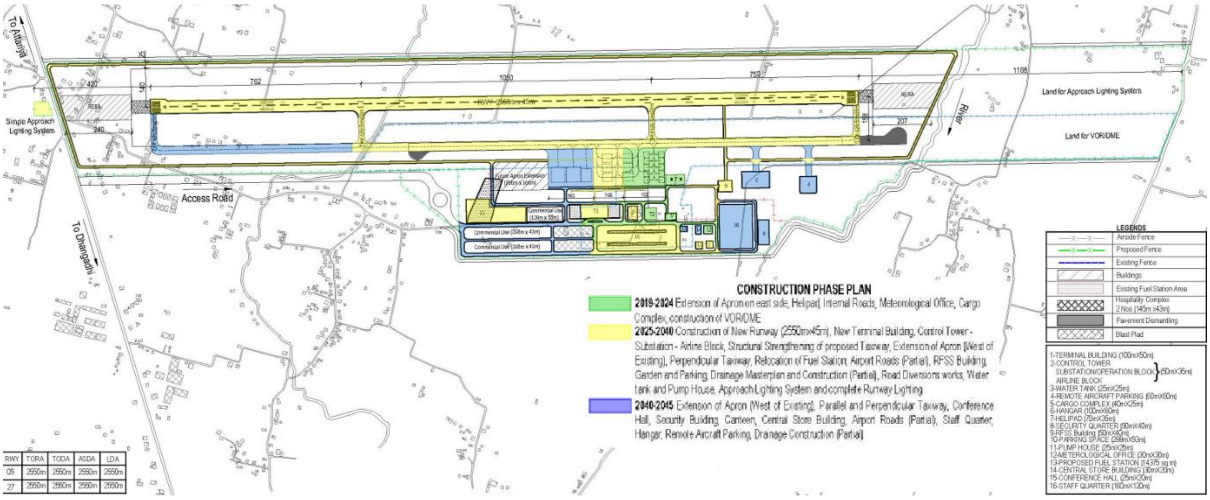
The land acquisition plan for the airport development work is represented by colored portion in Figure 3.2-7.



(Source: CAAN)

Figure 3.2-7 Land Acquisition Plan for Airport Development

Plan showing the work components of each phase is shown in Figure 3.2-8.



(Source: CAAN)

Figure 3.2-8 Representation of Different Work Phases

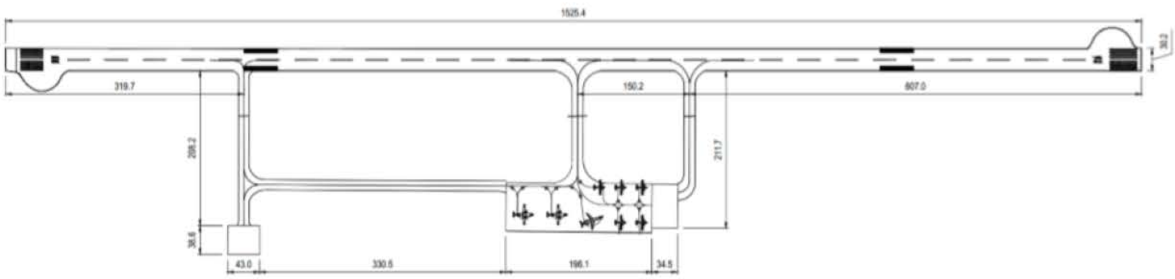
(3) Nepalgunj Airport

Table 3.2-11 shows the current facilities at the Nepalgunj Airport.

Table 3.2-11 Overview of the Nepalgunj Airport

Location Indicator	VNNG
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	28^0 6' 5" N／81^0 40' 3" E
Province/ District	5／Banke
Operation Hours	Jan-Feb, Nov-Dec: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	15 March 1961
Airport Area	Approx. 921,078.80 ㎡
Runway	1,505 m x 30 m (08/26) Bituminous Paved (Asphalt Concrete)
Apron	3 Medium/ 6 Small Aircrafts
Re-fueling Facility	Available, provided by Nepal Oil Corporation
Type of Aircraft	ATR72, CRJ200/700, MA60, ATR42, JS-41, B190, D228, DHC6, L410, Y12, C208
RFF Category	Category V

(Source: CAAN)



(Source: CAAN)

Figure 3.2-9 Plan of the Nepalgunj Airport

Photo 3.2-9 Entrance to the Terminal	Photo 3.2-10 Apron View

(Source: JICA Study Team)

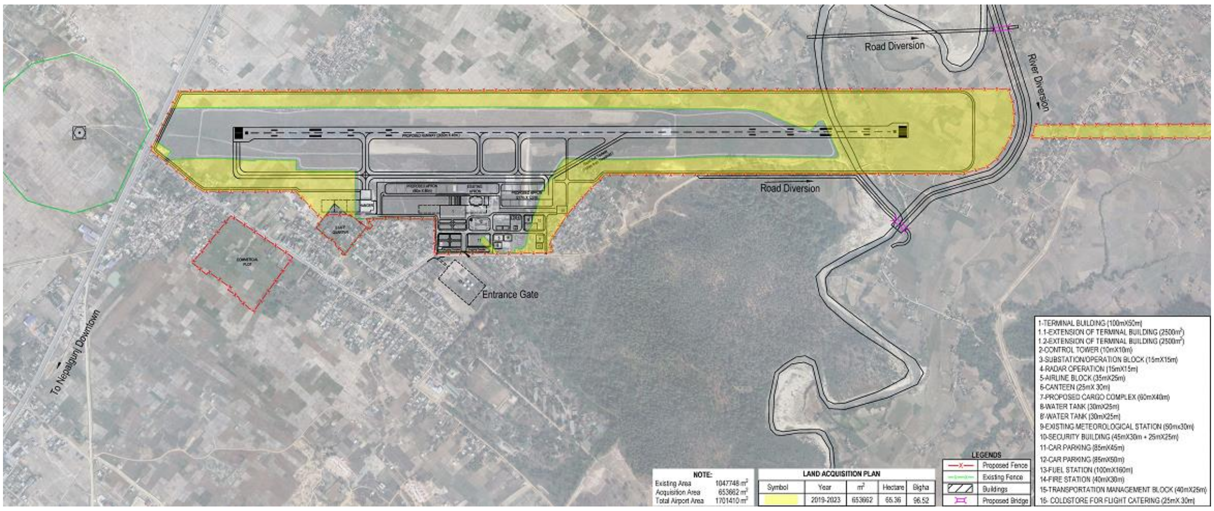
The master plan for Nepalgunj Airport was prepared in 2018 and implementation work has begun in 2019. As of 2019, expansion of apron (code C-7spot) is underway and is scheduled to be completed by June 2020. The runway extension work (200 m) has already been designed and is under the process of evaluation, as of December 2019.

Table 3.2-12 Overview of Working Plan

Work Stage（Working Period）	Components of Work
Phase-1 (2019-2021)	Runway extension on the western side (1,700 m x 30 m) Apron extension (31.5 m x 35.5 m, 7 spots) Passenger terminal building (one floor, floor area-5,000 m^2) Control tower
Phase-2 (2022-2025)	Apron extension
Phase-3 (2026-2032)	Extension of runway on the eastern side and widening (2,250 m x 45 m) Taxiway widening Domestic passenger terminal building (additional 2,500 m^2)
Phase-4 (2033-2040)	Extension of runway on the eastern side (2,650 m x 45 m) Parallel taxiway and rapid exit taxiway construction

(Source: CAAN)

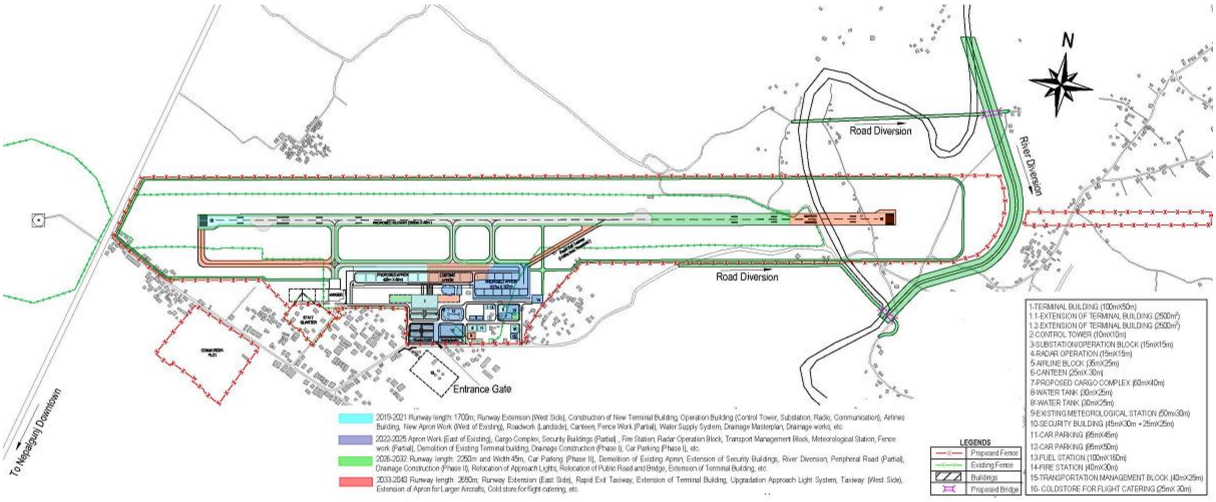
A new passenger terminal building and control tower will be built during 2019-2021, for which the CAAN is designing the passenger terminal building.
The land acquisition plan for the airport development work is represented by the colored portion in Table 3.2-10.



(Source: CAAN)

Figure 3.2-10 Land Acquisition Plan for Airport Development

Plan showing the work components of each phase is shown Figure 3.2-11



(Source: CAAN)

Figure 3.2-11 Nepalgunj Airport Master Plan

(4) Simara Airport

Table 3.2-13 shows the current facilities at the Simara Airport. According to CAAN, there is no development plan currently for this airport.

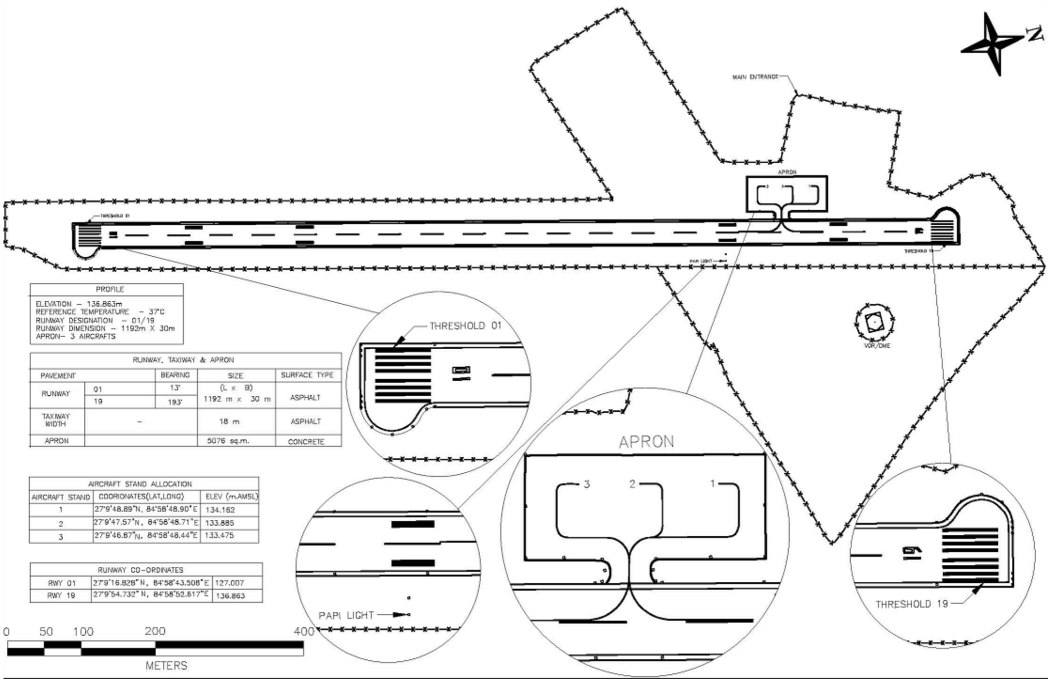
Table 3.2-13 Overview of the Simara Airport

Location Indicator	VNSI
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	27^0 9' 45" N／$84^0$58'54" E
Province/ District	2／Bara
Operation Hours	Jan-Feb, Nov-Dec: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	4 July 1958
Airport Area	Approx. 428,301.65 ㎡
Runway	1,192 m x 30 m (01/19) Bituminous Paved (Asphalt Concrete)
Apron	1 Medium/ 4 Small Aircrafts
Re-fueling Facility	none
Type of Aircraft	JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	none

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-12 Overall Arial View



(Note: AIP Nepal)

Figure 3.2-13 Plan of the Nepalgunj Airport

(5) Janakpur Airport

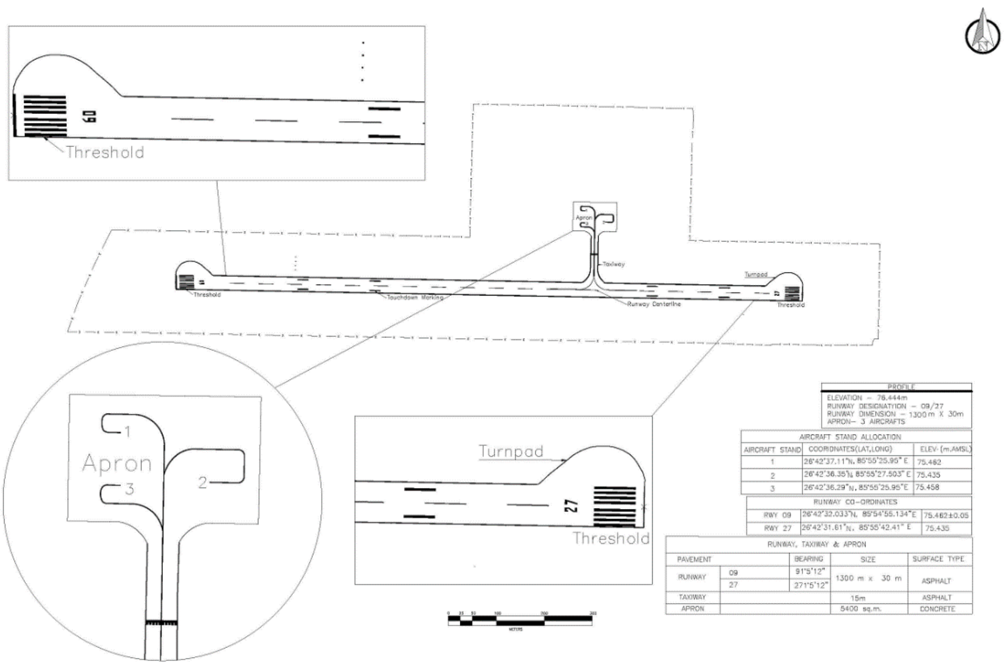
Table 3.2-14 shows the current facilities at the Janakpur Airport. Currently, the apron expansion work is underway.

Table 3.2-14 Overview of the Janakpur Airport

Location Indicator	VNSI
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	26^0 42' 38.44" N／85^0 55' 28.32" E
Province/ District	2／Bara
Operation Hours	Jan-Feb, Nov-Dec.: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	4 July 1958
Airport Area	Approx. 428,301.65 ㎡
Runway	1,192 m x 30 m (01/19) Bituminous Paved (Asphalt Concrete)
Apron	1 Medium/ 4 Small Aircrafts
Re-fueling Facility	None
Type of Aircraft	JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	None

（Source: CAAN)

(Source: Google Earth)



(Note: AIP Nepal)

Figure 3.2-14 Plan of the Airport

(6) Biratnagar Airport

Table 3.2-15 shows the current facilities at the Biratnagar Airport. In 2018, the airport handled around 573,000 domestic passengers and is the third largest airport that handles domestic passengers next to TIA and Pokhara.

Table 3.2-15 Overview of the Biratnagar Airport

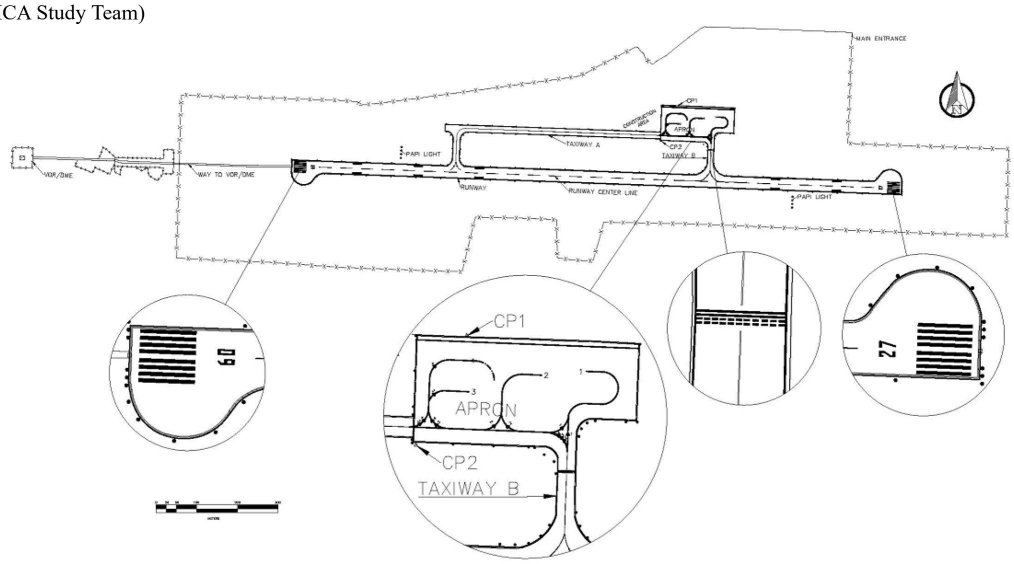
Location Indicator	VNVT
Aerodrome Reference Code	3'C'
Aerodrome Coordinates	26^0 29' 03" N／87^0 15' 52"E
Province/ District	1／Morang
Operation Hours	Jan-Feb, Nov-Dec.: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	6 July 1958
Airport Area	Approx. 773,706.18 ㎡
Runway	1,500 m x 30 m (09/27) Bituminous Paved (Asphalt Concrete)
Apron	3 Medium/ 4 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	ATR72, CRJ200/700, MA60, ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	Category V

(Source: CAAN)

Photo 3.2-11 Passenger Terminal Building

Photo 3.2-12 Apron View

(Source: JICA Study Team)



(Source: CAAN)

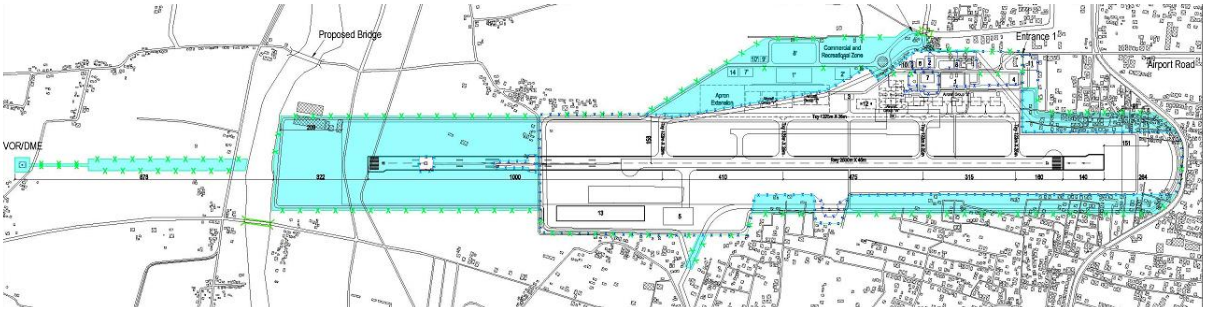
Figure 3.2-15 Plan of the Airport

Table 3.2-16 Overview of the Working Plan

Work Stages（Working Period)	Work Components
Phase-Ⅰ (2019-2025)	Runway extension on eastern side (1,640 m x 30 m) New parallel taxiway Apron expansion (existing and new construction, total 13,998 m^2) Domestic passenger terminal building (100 m x 50 m), control tower
Phase-Ⅱ (2026-2030)	Apron extension
Phase-Ⅲ (2031-2040)	Runway extension and widening (2,500 m x 45 m) New parallel taxiway New international passenger terminal building (120 m x 50 m)

(Source: CAAN)

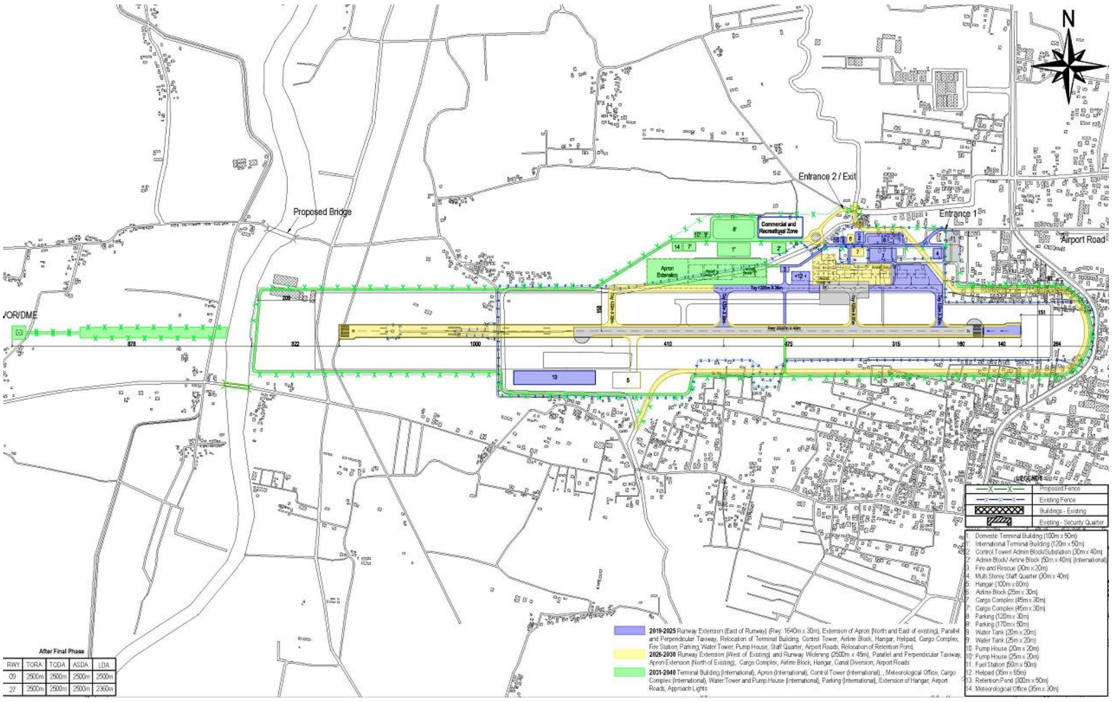
The land acquisition plan necessary for the airport development works is represented by the colored portion in Figure 3.2-16.



(Source: CAAN)

Figure 3.2-16 Land Acquisition Plan for Airport Development

Plan showing the work components of each phase is shown in Figure 3.2-17.



(Source: CAAN)

Figure 3.2-17 Biratnagar Airport Master Plan

(7) Chandragadi Airport

Table 3.2-17 shows the current facilities at the Chandragadi Airport.

Table 3.2-17 Overview of the Chandragadi Airport

Location Indicator	VNCG
Aerodrome Reference Code	3’C’
Aerodrome Coordinates	26^0 34’ 11” N／88^0 4’ 38” E
Province/ District	1／Jhapa
Operation Hours	Jan-Feb, Nov-Dec.: 6：45－18：00 March-April, Sept-Oct: 6：15－18：30 May-Aug: 6：00－18：45
Operation Start Year	November 1963
Airport Area	Approx. 233,656.02 ㎡
Runway	1,500 m x 30 m (10/28) アスファルト舗装
Apron	1 Medium/ 2 Small Aircrafts
Re-fueling Facility	Available, Provided by the Nepal Oil Corporation
Type of Aircraft	ATR72, CRJ200/700, MA60, ATR42, JS41, B190, D228, DHC6, L410, Y12, C208
RFF Category	none

(Source: CAAN)

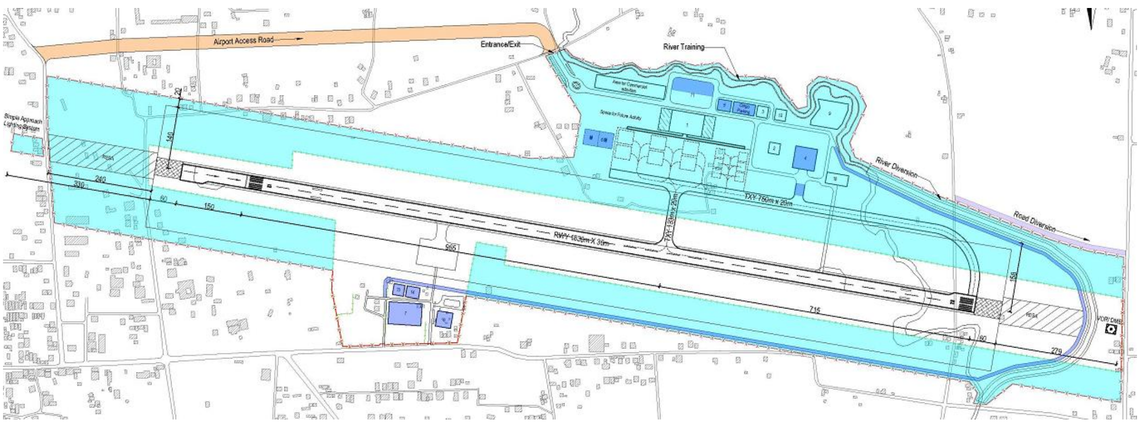
Table 3.2-18 shows the development plans that have been set in the master plan.

Table 3.2-18 Overview of the Working Plan

Work Stages（Working Period)	Work Components
Phase-Ⅰ (2019-2024)	VOR/DME Runway light maintenance
Phase-Ⅱ (2025-2035)	Runway extension on western side (1,830 m x 30 m) New parallel taxiway (900 m x 20 m) New apron (24,238 m^2) New Passenger Terminal Building (75m x 50m) Control Tower/Administration Building, Fire Station and Fueling Facility
Phase-Ⅲ (2036-2040)	New hanger New airport related facilities

(Source: CAAN)

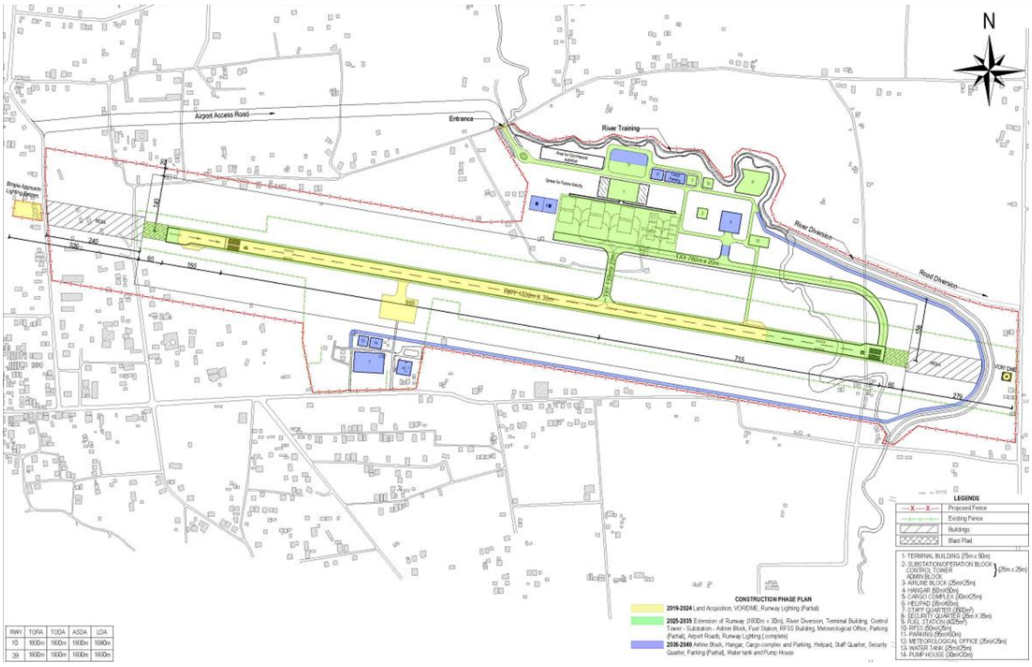
The land acquisition plan for the airport development work is represented by the colored portion in Figure 3.2-18.



(Source: CAAN)

Figure 3.2-18 Land Acquisition Plan for Airport Development

The plan showing the work components of each phase is shown in Figure 3.2-19.



(Source: CAAN)

Figure 3.2-19 Chandragadi Airport Masterplan

3.2.4 Other Airport Development Plans

The CAAN Annual Report 2018 shows six airports under construction: Arghakhanchi Airport, Gulmi Airport, Ilam Airport, Kalikot Airport, Kamal Bazaar Airport, and Khiji Chandeshwori Airport. In this chapter, the locations of the 6 airports and runway specifications are summarized. All six airports are airports for STOL aircraft with runway lengths of 400 to 700 m in the mountains of the airport blank areas.

(1) Arghakhanchi Airport

Table 3.2-19 shows the current facilities at the Arghakhanchi Airport.

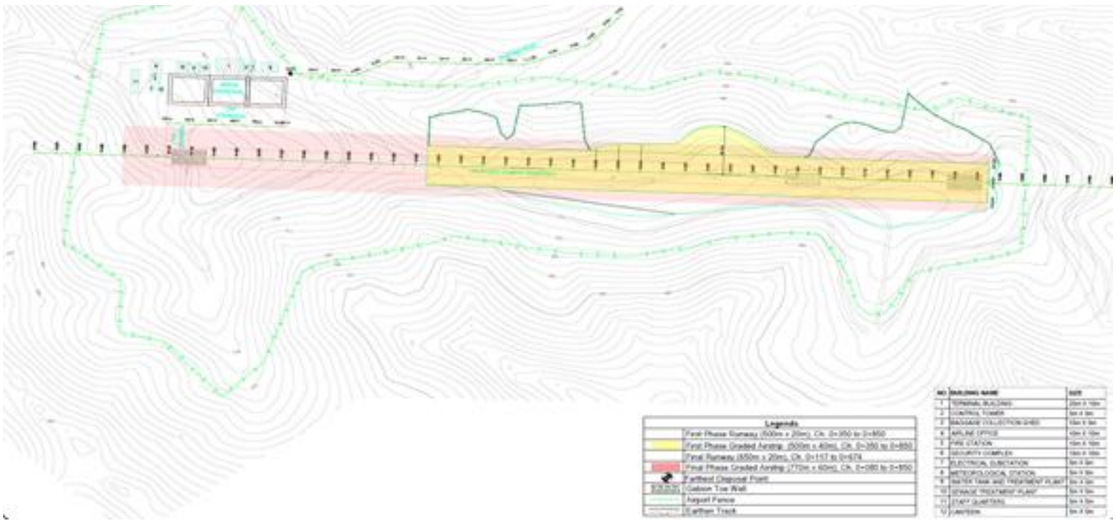
Table 3.2-19 Overview of the Arghakhanchi Airport

Aerodrome Coordinates	27^{0} 59’ 39” N／83^{0} 7’ 1” E
Province/ District	5／Arghakhanchi
Runway	500 m x 20 m (16/34)

(Source: CAAN)

(Source: CAAN)

Figure 3.2-20 View of the Arghakhanchi Airport Location



(Source: CAAN)

Figure 3.2-21 Arghakhanchi Airport Exisiting Plan

(2) Gulmi Airport

Table 3.2-20 shows the current facilities at the Gulmi Airport.

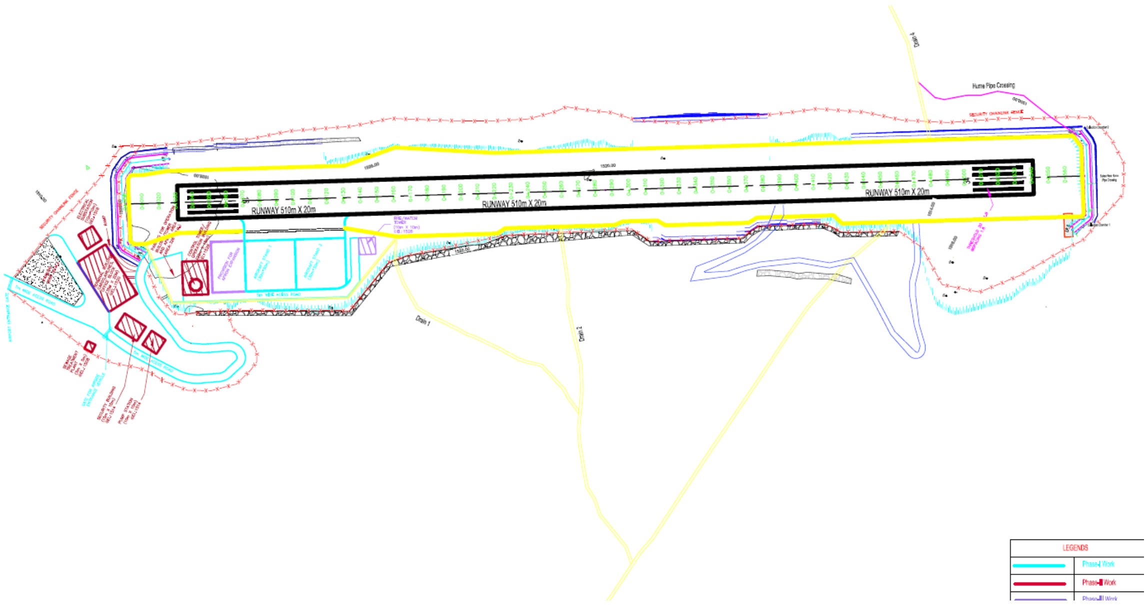
Table 3.2-20 Overview of the Gulmi Airport

Aerodrome Coordinates	28^0 1' 26" N／83^0 15' 14" E
Province/ District	5／Gulmi
Runway	510 m x 20 m (16/34)

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-22 View of the Gulmi Airport Location



(Source: CAAN)

Figure 3.2-23 Gulmi Airport Existing Plan

(3) Ilam Airport

Table 3.2-21 below shows the current facilities at the Ilam Airport.

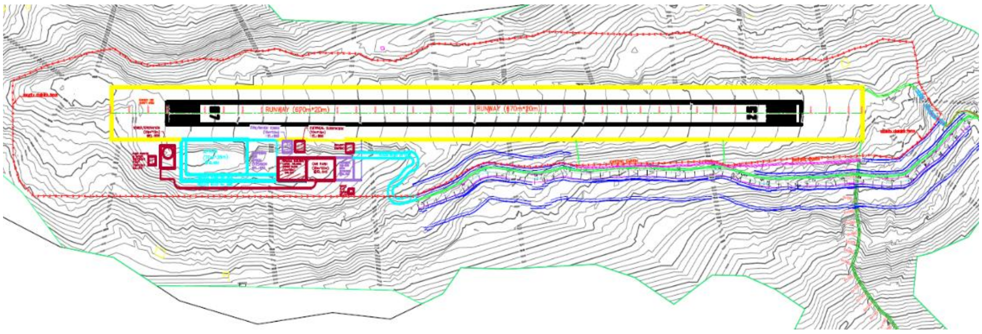
Table 3.2-21 Overview of the Ilam Airport

Aerodrome Coordinates	26^0 52’ 38” N／87^0 54’ 19” E
Province/ District	1／Ilam
Runway	670 m x 20 m (07/25)

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-24 View of the Ilam Airport Location



(Source: CAAN)

Figure 3.2-25 Ilam Airport Existing Plan

(4) Kalikot Airport

Table 3.2-22 shows Kalikot Airport which is a domestic airport under construction in province 6.

Table 3.2-22 Overview of the Kalikot Airport

Aerodrome Coordinates	29^0 10’ 20” N／81^0 34’ 31” N
Province/ District	6 Karnali／Kalikot
Runway	700 m x 30 m (14/32) from Google Earth

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-26 View of the Kalikot Airport Location

(5) Kamal Bazaar

Table 3.2-23 shows Kamal Bazaar Airport which is a domestic airport under construction in province 7.

Table 3.2-23 Overview of the Kamal Bazaar Airport

Aerodrome Coordinates	29^0 3' 11" N／81^0 20' 33" E
Province/ District	7／Achham
Runway	530 m x 30 m (12/30) from Google Earth

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-27 View of the Kamal Bazaar Airport Location

(6) Khiji Chandeshwori

Table 3.2-24 shows the current facilities at the Khiji Chandeshwori Airport.

Table 3.2-24 Overview of the Khiji Chandeshwori Airport

Aerodrome Coordinates	29^0 3' 11" N／81^0 20' 33" E
Province/ District	1／Okhaldhunga
Runway	430 m x 20 m (14/32) from Google Earth

(Source: CAAN)

(Source: Google Earth)

Figure 3.2-28 View of the Khiji Chandeshwori Location

	
Photo 3.2-13 Runway Construction Status	**Photo 3.2-14 Runway Construction Status**

(Source: JICA Study Team)

3.2.5 Issues

After starting operation of Pokhara International Airport and Gautam Buddha International Airport, it is expected that some passengers currently using TIA will use those airports. In addition, it is expected to open new flight route from China etc. It is thought to have the effect of stimulating the demand for air travel to Nepal.

Airports in the Terai region are being developed according to the airport master plan prepared for each airport, and it is expected that domestic flight aircraft will larger in size as domestic demand increases. The airport under construction by CAAN is an airport in the mountains, and the runway length is 700 m or less. Even if a regular flight is in service, it is a STOL aircraft.

When considering capacity enhancement of airport in Kathmandu Metropolitan Area, the above conditions should be reflected.

3.3 Safety Improvement of Mountain Airports

In Nepal, about one to two aircraft accidents (fixed-wing aircraft/ rotary-wing aircraft) occur every year. Most of these aircraft accidents occur at the mountain airports. Taking this in consideration, the study also includes safety improvement of the mountain airports, whereby the current status of airport facilities and aviation safety system at the six major airports were examined and based on that, issues are identified. In the process of the study, interviews were conducted with airline pilots, dispatchers, and traffic controllers of CAAN, and current situation and issues were grasped based on the results of the survey. Accordingly, four airports were prioritized among other six airports and field surveies were conducted at those four airports.

Ultimately, after analyzing the results of the field survey and interviews relating to the airport facilities and aviation safety systems, considerations for the improvement of mountain airport safety systems will be done.

3.3.1 Airports to Study

In this survey, targeted mountain airports for grasping current situation and issues are shown in Figure 3.3-1.

(Source: JICA Study Team)

Figure 3.3-1 Targeted Mountain Airport Location

Table 3.3-1 shows the number of passengers handled ateach of six mountain airports as of FY2018.

Table 3.3-1 General Features of TargetedSix Airports

Airport Name	Simikot	Rara	Jumla	Dolpa	Jomsom	Lukla
Annual passenger numbers (person)	54,261	19,360	14,163	19,352	46,401	124,929
Number of takeoff and landing (times)	13,960	2,360	1,588	1,556	3,209	31,636
Altitude (m)	2,971	2,720	2,375	2,804	2,736	2,846

(Source: CAAN)

3.3.2 Evaluation of Past Works on Safety Improvement

At mountain airports, CAAN has been working to improve safety so far. The efforts are summarized below.

(1) Measures taken by CAAN for Safety Improvement

1) Asphalt Pavement of Runway

CAAN is carrying out asphalt concrete pavement work of runway at mountain airports. Rara Airport was carried out asphalt pavement work for runways in 2015 and Dolpa Airport in 2017. As for runway overlay work, asphalt overlay work to correct runway slope has been carried out at Jomson Airport, and asphalt overlay for pavement repair is being planned at Simikot Airport.

2) Installation of Airport Lighting

CAAN has installed runway threshold lighting at the Lukla Airport, Jomsom Airport, and Jumla Airport with the support of JICA's grant aid for the improvement of runway visibility in adverse weather.

Photo 3.3-1 Jomsom Airport Threshold Lighting

Photo 3.3-2 Jomsom Airport Threshold Lighting(close-up)

(Source: JICA Study Team)

3) Installation of Solar Power System

Solar power systems have been installed at Lukla, Jomsom, Jumla, Rara, and Simikot to stabilize power supply to the airport and secure the alternate source.

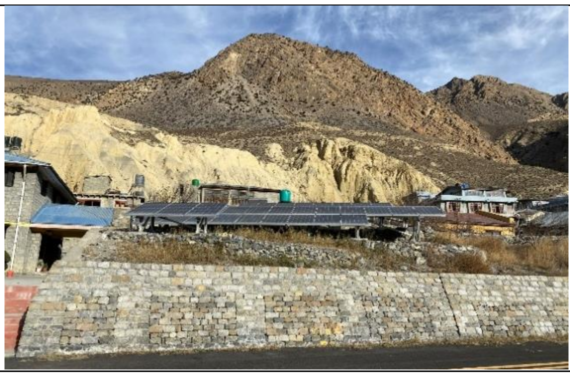


Photo 3.3-3 Jomsom Airport Solar Panel

(Source: JICA Study Team)

4) Installation of ADS-B

As per the ICAO Study conducted in 2011, recommendation for installation of MLAT and ADS-B to 12 locations to improve monitoring capacity of Kathmandu FIR was made. Based on that recommendation, CAAN under its own financing is undertaking to install ADS-B receiving stations. These 12 locations include Lukla and Simikot which are targeted mountain airports. However, ADS-B receiving stations are installed only at Phulchoki, Dhangadhi, Nepalgunj, and Bhairahawa airport for air route monitoring, and further installation plans are not decided.

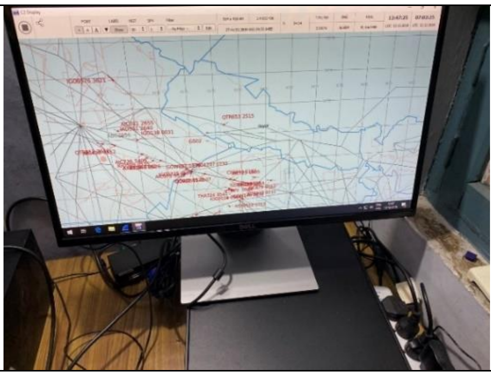


Photo 3.3-4 Monitoring Display in Nepalgunj Airport Radio Equipment Room

Photo 3.3-5 ADS-B Processing Unit in Nepalgunj Airport Radio Equipment Room

(Source: JICA Study Team)

5) Mandatory Mounting of GPS Receiver on the Aircraft for Mountain Flights

Since 2007, CAAN has made it mandatory for the small mountain aircrafts to mount with GPS receiver. However, no verification/calibration on GPS accuracy was performed, and also not performed those vertification/calibration using GAGAN or other means.

(2) Measures Taken by Airlines for Safety Improvement

1) Confirmation of Weather Condition around destination airports

Airline companies which provide mountain flights have contracted private metrological firms, like Weather News to monitor weather condition around mountain airports. Some of airlines, such as Buddha Air, select fuel efficient altitude zone, confirm weather condition along the flight route, and try to improve flght efficiency and safety the through high-level weather/wind data provided by Weather News.

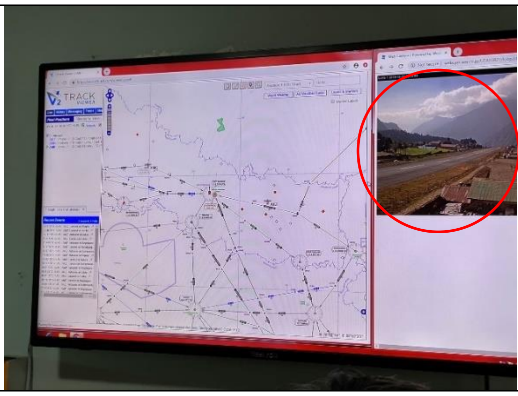


Photo 3.3-6 Summit Air Operation Room, Monitor displays an image from the weather observation camera

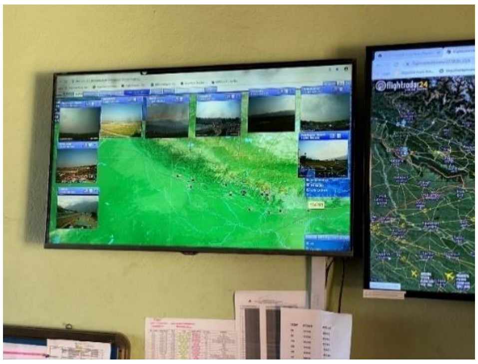


Photo 3.3-7 Buddha Air Operation Room, Monitor displays an image from the Weather News' weather observation camera

(Source: JICA Study Team)

2) Acquisition of Aircraft Position Information

Airlines that operate mountain flights have equipped aircraft with tracking system such as V2 trackers and Foster Co-Pilot to track aircraft position information. With these tracking systems, airlines can obtain position information of its own aircraft and estimate the arrival time at destinations.

However, the V2 tracker used by airlines except for the Nepalese airline could choose both mobile phone network and communication satellite (Iridium) network based on their equipment specification, but since the usage fee of satellite communication network is very expensive, majority uses mobile phone network. Therefore, aircraft that flies outside of the reach of the mobile network, issues such as delay in updating location information or failure to report a location when aircraft accident occurs.

In addition to the Nepalese Airlines, for the case of Buddha Air, since they operate flight to major domestic airports using ATR72 and have ADS-B on their aircrafts, they use Flightradar24 to grasp position of aircrafts. They have independently installed ADS-B receivers in the area where the signal of ADS-B could not reach for the effort to grasp location information.

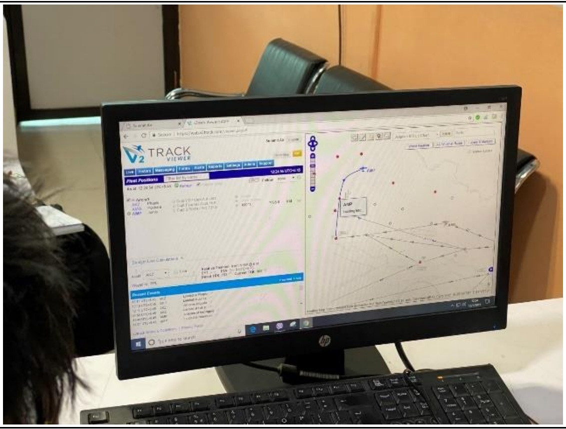


Photo 3.3-8 Summit Air Operation Room, Monitor displaying position of aircraft	**Photo 3.3-9 Summit Air, L410 Cockpit V2 tracker transmitter installed**

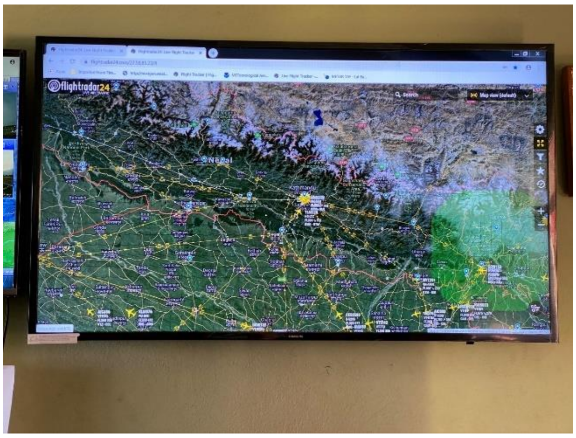
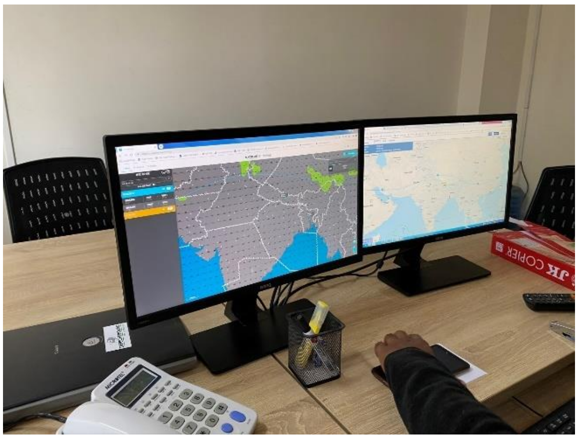

	

Photo 3.3-10 Buddha Air Operation Room, Monitor displaying the position information of aircraft	**Photo 3.3-11 Nepal Airline Operation Room, NavBLUEAircraft position information service**

(Source: JICA Study Team)

3) Position Information using GPS

Under the guidance of CAAN, small aircrafts and helicopters operating mountain flights have been equipped GPS receiver so that the pilot can get position information of their aircrafts. However, since position information from the GPS is not guaranteed and it is not backed by reliable navigation satellite system, those information serves just as a reference during visual flight.

	
Photo 3.3-12 Tara Air DHC 6 Cockpit, Navigation Display	**Photo 3.3-13 Air Dynasty Airbus AS350b3 Cockpit Use of tablet to show position**

(Source: JICA Study Team)

(3) Measures Taken by the Department of Hydrology and Metrology (DHM) for Safety Improvement

1) Arrangement of Weather Observation System and Personnel at Mountain Airports

At DHM, staff are assigned to the meteorological office (Met Office) of TIA and major hub airports. They create METAR (Aviation Routine Weather Report), and information is distributed from AMHS to each airports and airlines. In addition, in order to confirm and measure the current weather conditions more accurately at mountain airports, where the weather changes drastically, consideration for the installation of automatic weather observation systems at mountain airports and the allocation of personnel for weather experts are being carried out. However, due to budget and human resources shortage, the implementation timing has not been decided.

2) Installation of X-band Radar for Regional Weather Observation

DHM is planning to install X-band radar in various parts of the country including Kathmandu Valley to observe regional weather condition changes. But decisions for the financial source are not made.

3.3.3 Compilation of Related Issues

In the course of this study, various interviews were conducted with the airline pilots and dispatchers and ATC from CAAN, through which the issues related to the mountain airports are identified and compiled. Based on the survey result covering the six mountain airports, different issues that are being faced and recommendations for the improvement relating to airport facilities, aviation safety, and ATC are being addressed.

(1) Issues Related to Airport Facilities

1) Runway Extension and Widening

Since most of the runway length at the mountain airport are very short, use of every bit of runway length becomes very vital for the pilots. In that line, most of the pilot recommended for the extension of runway even though the extension is very short, as it gives them more space during landing and takeoff.
In addition, since there is not enough area of runway strip, there was a request to take measures such as expanding runway strip as much as possible from the perspective of improving safety.

2) Aircraft Overrun Prevention

In relation to the short runway of the mountain airport, there were many cases of runway overrunning causing plane to crash. For instance, there were collision of plane nose on the wall at runway end at Lukla and cases where aircraft fell off from the runway because of overrun.
To counter those issues, there were recommendations such as setting up overrunning zone or installing cushion material to stop the aircraft.

(Source: Sita Air)

Figure 3.3-2 Case of Aircraft Nose Collision in Lukla

(The strong impact of such accident could cause injury or death of the pilots)

3) Increase the Parking Spots

At the mountain airport, because of rapid weather change time when the operation is stably possible is limited. However, in high demand airports, such as Lukla Airport, which have 100 flights incluging helicopters a day during the peak season, frequent piston transport occurs. The reason for this is that the number of the parking spots is not enough.

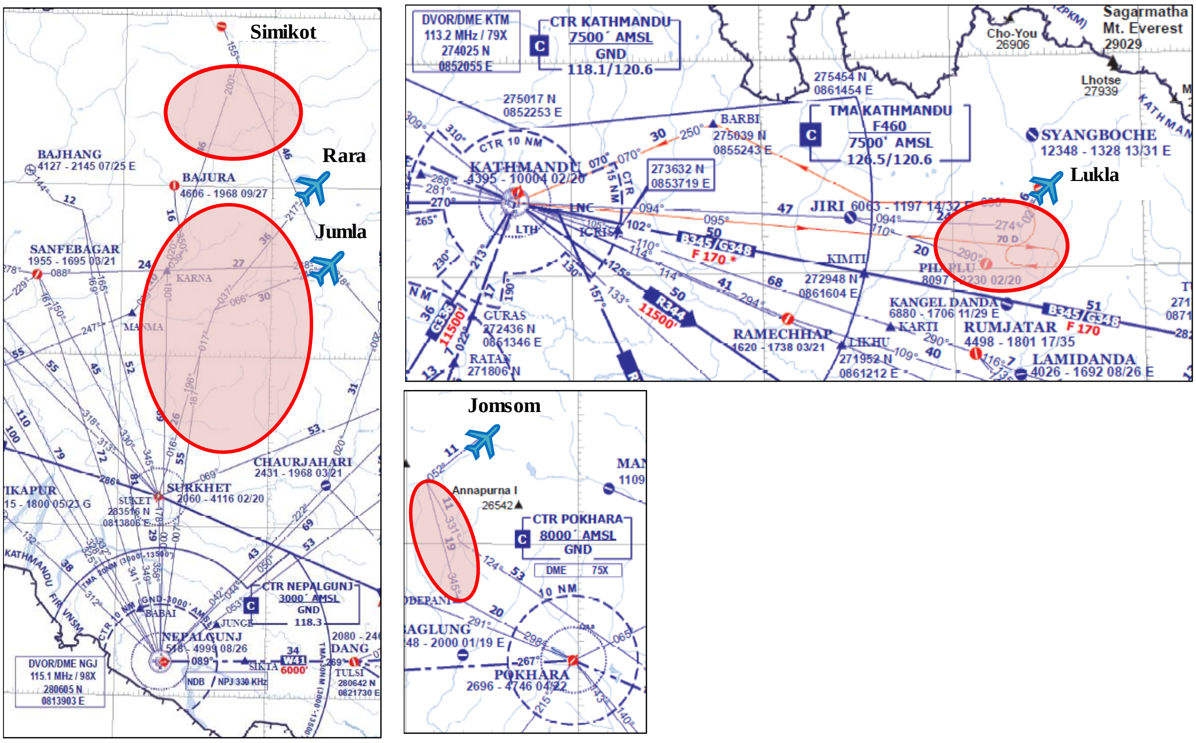
(2) Issues Related to Air Navigation System

1) Communication

(A) Ground-to-air communication

In relation to communication at the mountain airport, both pilots and ATC pointed out problems on Ground-to-air communication.

Firstly, regarding the VHF, there is a dead zone in the existing RCAG, where it is impossible to receive information necessary from ACC base airport and destination airports. The major problem is that information that may cause accidents, such as rapid weather change, cannot be obtained in real time.



(Source: JICA Study Team)

Figure 3.3-3 Dead Zone of VHF for Ground-to-Air Communication

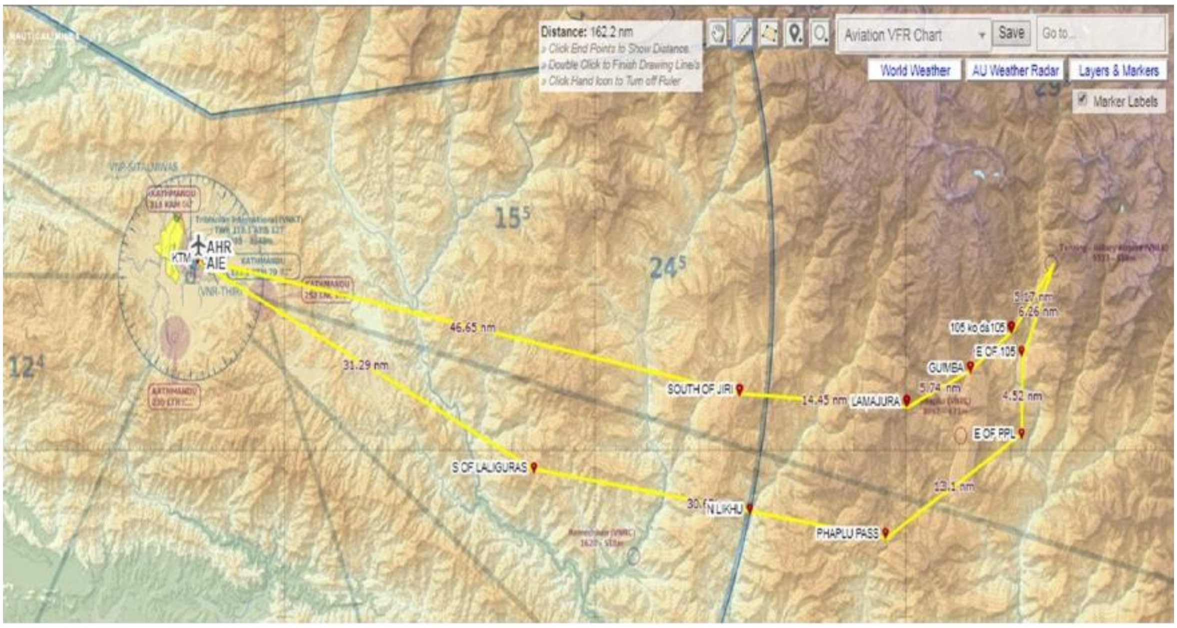
(B) Ground-to-ground communication

For the ground-to-ground communication the HF is not used for the normal business because the sound quality is very poor and almost inaudible. Additionally, AMHS lines and terminals for the exchange of flight information and weather information are not installed at all mountain airports. Therefore, the information lack accuracy and timeliness.

2) Navigation

Aircrafts are equipped with GPS and airline companies are taking measures such as creating their routes themselves. However, those routes are not officially announced by CAAN nor the aircraft positions are monitored. This causes problem regarding the safety of operation.

Therefore, CAAN needs to establish and announce the navigation data together with topography data and VFR routes in the mountainous area.



(Source: Sita Air)

Figure 3.3-4 VFR Route Proposal between TIA and Lukla by SITA Air Pilot

There is also a recommendation on the installations of GBAS Landing System (GLS) and Transponder Landing System (TLS) to support landing during bad weather.

3) Surveillance

In the mountainous area, air traffic is out of radar coverage and air-to-air communication is inadequate, so controllers are unable to know the aircraft position. Therefore, it is very important to introduce a system for monitoring the aircraft position around the mountain airport.

4) Meteorology

Issue on flight operation in the mountainous area is the inability to accurately know the information related to weather conditions on its route before arriving at the destination airport. Therefore, the provision and utilization of weather forecast information along the air route are very essential for safe operation. Moreover, installation of weather observation device and specialized weather observation by DHM needs to be applied to the mountain airport for operation based on weather conditions at the destination airport.

(3) Issues Related to Air Traffic Control Services

1) Provision for Air Traffic Control Service for VFR

In Nepal, Class-C is only set for TIA and major domestic airports, Class-G is set for other domestic airports including mountain airports. Therefore, only Aerodrome Flight Information Service (AFIS) is provided for VFR aircraft.
The general trend in the VFR flight operation is that only necessary information is provided without giving controlled instruction. In the mountain airport it is difficult for the pilot to obtain enough visual information due to topography restriction and weather conditions, also information obtained by the controller through communication may not be appropriate. Additionally, since all the flights are concentrated at the same period, as there is no allocation for fixed wing and rotary wing, it is difficult to ensure safety of operation just by the responsibility of the pilot.
From the above, the pilot requests for setting the control zone (CTZ) around major mountain airport in order to serve location information of surrounding aircraft, weather update and control instruction when necessary.

2) Setting VFR Routes

Currently, only the route between TIA and Lukla Airport has been announced to AIP as VFR route. For the other routes, the outbound route and inbound route are not separated. Since communication with neaby airport is not available, when the aircraft flies at the same time on the same route, communication between the pilots adjust the flight altitude of the aircraft. In case during the low visibility weather, the safety could be impaired.

3) Mixed Operation of Fixed Wing and Rotary Wing Aircraft

For the mountain flight operation due to mixture of demanded activities by the tourist, like transportation to base camps for mountaineering or tourist spots, and sightseeing, fixed wing aircraft and rotary wing aircraft are mixed. In some cases, during the busy hours the controlled interval of those two types of aircraft is not enough.

4) Formulating STOL Specification

Currently, there is no standard specification for STOL airport in Nepal. It is important that Nepal should develop its own specification for STOL airports that would comply with its situation, as the STOL specification specified by ICAO cannot be applied in Nepal because of its topographical constraints.

3.3.4 Current Situation at the Mountain Airports (Including Interviews)

In this survey, based on the evaluation of current situation of aviation sector of Nepal and interview with pilots at TIA, Pokhara, Nepalgunj, which are the bases from where the mountain flights are being operated, four sites that may require safety system development are selected and survey was conducted. The process by which the selection of these airports was made, and the result is shown below.

(1) Methodology of Mountain Airport Selection

As to the approach towards the selection of mountain airport field survey, interviews were conducted with CAAN's ATC and engineers, airline dispatchers and pilots, thereafter, the results were summarized as described in the above paragraphs.
Moreover, interviews were also conducted with the Director General of CAAN and Joint Secretary of MoCTCA from which the prioritization was made from the viewpoint of aviation policy in Nepal.
Results of interview with stakeholders are summarized in Table 3.3-2.

Table 3.3-2 Summary of Interview Result

<table>
<tr><th colspan="2"></th><th>Simikot</th><th>Rara</th><th>Jumla</th><th>Dolpa</th><th>Jomsom</th><th>Lukla</th></tr>
<tr><td rowspan="4">ATC & Engineers</td><td>Communication</td><td colspan="6">・No coverage of RCAG
・Flight between two airports could experience communication interruption of around 5-15 min.
・Congestion of network in the western part due to use of same frequency
・Poor quality HF makes it unusable</td></tr>
<tr><td>Navigation</td><td colspan="6">・No navigation support facilities
・No survey regarding the validation of GPS and absence of backup</td></tr>
<tr><td>Surveillance</td><td colspan="6">・Mountain airports are out of coverage of the airline surveillance radar (monitoring by ADS-B/ WAM/MLAT required)</td></tr>
<tr><td>Metrological</td><td colspan="6">・Require high accuracy weather forecast equipment</td></tr>
<tr><td rowspan="7">Pilot</td><td>Airport facility</td><td>・Runway extension</td><td>・Runway extension
・Overrun measures</td><td>・Runway extension</td><td>・Runway slope improvement
・Overrun measures</td><td>・Runway extension</td><td>・Runway extension
・Overrun measures
・Apron expansion</td></tr>
<tr><td>Communication</td><td colspan="6">・Need of reliable and un interrupting communication</td></tr>
<tr><td>Navigation</td><td colspan="6">・Provide navigation data including topography information
・VFR flight route to be developed by CAAN
・Landing assistance facilities are required</td></tr>
<tr><td>Surveillance</td><td colspan="6">・Mountain airports are out of coverage of the airline surveillance radar (monitoring by ADS-B/ WAM/MLAT required)</td></tr>
<tr><td rowspan="2">Metrological</td><td colspan="6">・Airport weather forecast required</td></tr>
<tr><td>—</td><td>—</td><td>—</td><td>・Metrological forecast equipment
・Weather forecast information</td><td>・Metrological forecast equipment (esp. wind)</td><td>・Weather forecast information
・Metrological forecast equipment (esp. wind)</td></tr>
<tr><td>Others</td><td></td><td>Difficulty in direct approach</td><td>Guidance light required</td><td></td><td></td><td>Guidance light required</td></tr>
<tr><td>CAAN DG, Dy. DG</td><td>Aviation policy</td><td>High tourist demand</td><td>High tourist demand</td><td>—</td><td>—</td><td>High tourist demand</td><td>High tourist demand</td></tr>
<tr><td colspan="2">Number of Accident (cases)</td><td>7</td><td>1</td><td>3</td><td>3</td><td>2</td><td>8</td></tr>
<tr><td colspan="2">Casualties (person)</td><td>7</td><td>—</td><td>18</td><td>3</td><td>18</td><td>32</td></tr>
</table>

(Source: JICA Study Team)

As per the result of the interviews, there were many common points with respect to recommendation made for airport facilities and aviation safety system made by ATC, engineers, and pilots. Those points are on the improvement of communication, installation of monitoring system, and provision for weather forecasting system.

On the other hand, from the perspective of aviation policy, airports in hinterlands with high tourism demand should be prioritized for improvement of airport facilities and implementation of safety improvement measures.Additionally, looking at the history of aircraft accidents and number of casualties, Lukla, Jomsom and Simikot excluding Jumla, have high number of tourist arrival.

Based on this evaluation, the following are the four airports, where site survey will be conducted for examining the safety improvement measures:

- Simikot Airport
- Rara Airport
- Jomsom Airport
- Lukla Airport

For Jumla Airport and Dolpa Airport, where the field survey was not conducted, the materials obtained from CAAN had been summarized.

(2) Simikot Airport

1) Overview of the Airport

Overview of Simikot Airport is shown in Table 3.3-3. Simikot Airport is the gateway for pilgrims to Mt. Kailash and is used especially by many Indian tourists. Among the Indian tourists, the wealthy ones often travel by small aircraft to Simikot airport, then transfer to helicopter from there and head directly to nearby Mount Kailas.

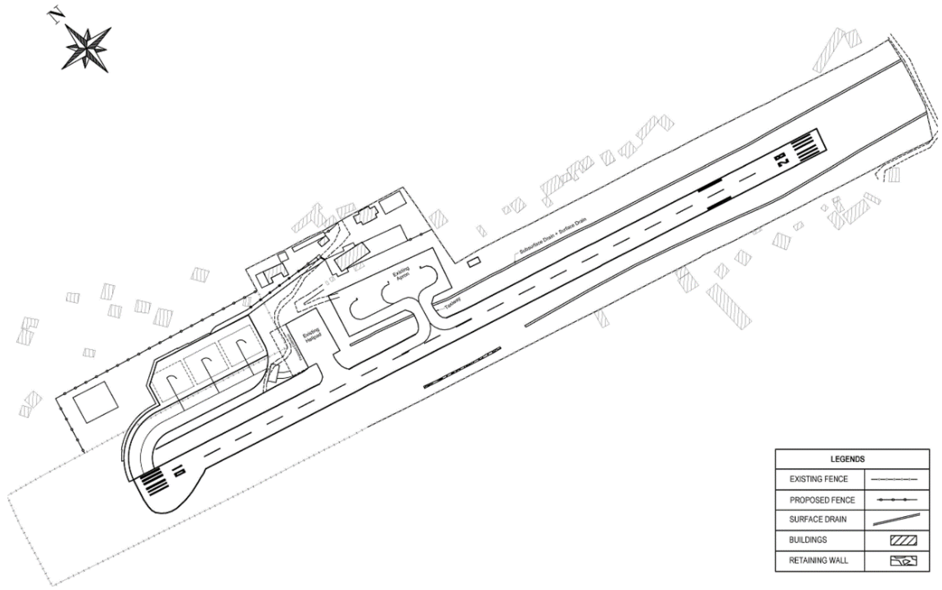
Since Simikot has bad accessability by car, the primary means of transportation is by air for people and goods.

Table 3.3-3 Overview of the Simikot Airport

Location Indicator	VNST
Aerodrome Reference Code	1’A’ Type 3
Aerodrome Coordinates	29^0 58’ 16” N／81^0 49’ 8” E
Altitude	2,971 m
Province/ District	6／Humla
Operation Hours	Jan-Feb, Nov-Dec.: 6：45－12：30 March-April, Sept-Oct: 6：15－12：30 May-Aug: 6：00－12：30
Operation Start Year	18 March 1977
Airport Area	Approx. 67,992.77 ㎡
Runway	650m x 20m (10/28) Bituminous Paved (Asphalt Concrete)
Apron	3 Small Aircrafts, 3 Small Aircraft expansion planning
Re-fueling Facility	None
Type of Aircraft	D228, L410, DHC6, Y12, C208
RFF Category	None
Air Control Service	AFIS and warning report
Communication Equipment	HF, VHF
Navigation Aid	N/A
CAAN staff	Staff Number: 20persons, Watch: 4persons
Tenant	N/A
Other facilities	N/A

(Source: CAAN)

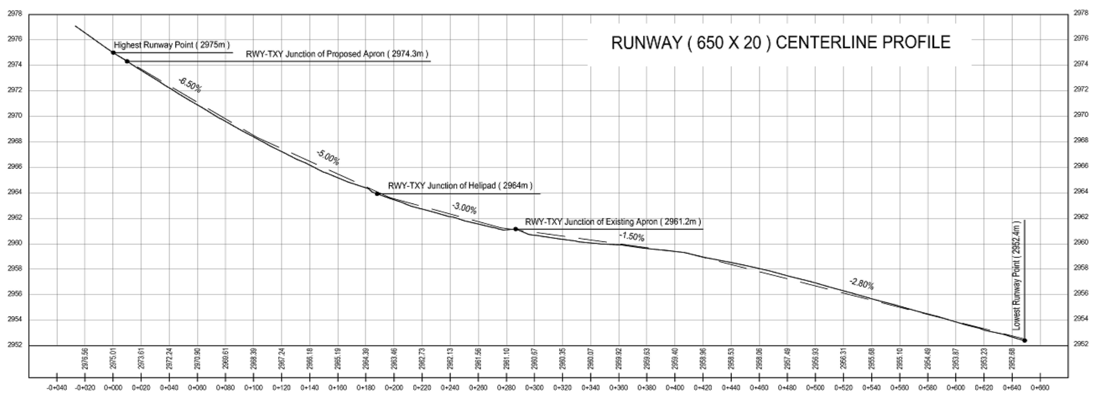
The plan view of the airport is shown in Figure 3.3-5. The plan includes newly constructed parking spot for small aircrafts for three aircrafts.



(Source: Google Earth)

Figure 3.3-5 Plan View of the Simikot Airport

The landing is from side RWY 28 to side RWY 10 and the takeoff from side RWY 10 to side RWY 28, both one direction. A longitudinal view of the center of the runway is shown in Figure 3.3-6. There is an uphill slope from RWY 28 to RWY10, with a maximum slope of 6.5%.



(Source: CAAN)

Figure 3.3-6 Longitudinal Section of the Simikot Airport

	
Photo 3.3-14 Overall Airport View	**Photo 3.3-15 Runway View**

(Source: JICA Study Team)

Figure 3.3-7 shows the 3-D image of the airport with 3-spot apron for DHC-6 aircraft after construction.

(Source: CAAN)

Figure 3.3-7 Aerial view of the Simikot Airport after Apron Development Plan

2) Current Status of Airport Facilities and Aviation Safety Systems

The current status of airport facilities and aviation safety system is shown in Table 3.3-4.

Table 3.3-4 Status of Airport Facilities and Aviation Safety System at the Simikot Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	650 m x 20 m
	Orientation	10 / 28
Parking Spot	3	
Aviation Safety System	Communication	VHF (122.5 MHz), HF (5858 kHz)
	Navigation	None
	Monitoring	None
	Metrological	MET display, Wind Sensor, Data Logger
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal Detector	Manual type
	CCTV	Available
	UHF communication system	None
	FIDS	None
Airport Lighting	Runway end lighting	
Backup Power Supply	Solar Power System	

(Source: CAAN)

3) Field Survey Result

(A) Passenger Terminal Building

Photo 3.3-16 Passenger terminal building

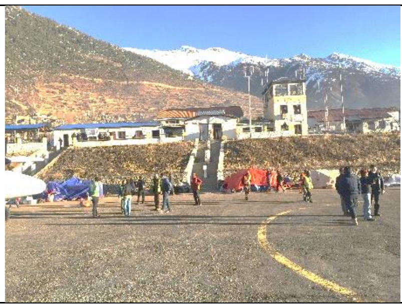


Photo 3.3-17 Passenger terminal building, control tower exterior

Photo 3.3-18 Check -in counter

(Source: JICA study Team)

The airport operation hours are limited from early morning to around 12:00, the most probable cause of disturbance for the operation of flight is the route weather conditions, since the flight must cross over many passes and must fly visually. The departure and arrival of flights is congested during the peak season, because many pilgrims and tourist from India and trackers towards Mt. Kailash, making airport facilities such as check-in counter and departure lobby congested.

In terms of security, passenger is scanned with metal detector and then security personnel perform body checks. On the other hand, there is no X-ray inspection for the baggage, insteadmanual security check up is performed. CCTV is not installed and surveillance in the restricted area is performed by the Nepalese police. The military personnel perform exterior patrolling.

The luggage is being transported to aircraft using cart.

(B) Airside facilities (Runway, apron, etc.)

Photo 3.3-19 Apron

Photo 3.3-20 New apron site

Photo 3.3-21 Runway damage

Photo 3.3-22 RWY28 Side

Photo 3.3-23 RWY10 Side

Photo 3.3-24 Helipad beside the apron

(Source: JICA study Team)

The current runway length is 650m with 20m width. For Simikot Airport of 100m extension on both sides may be possible. On RWY10 side it will be mainly cutting and towards RWY28 it will be filling up soil. There had been patches of pavement peeling over several points mainly at the touch down point of aircraft during landings observed and was understood that the asphalt pavement was constructed 3-4 years ago, and pavement maintenance procedure is undergoing by CAAN.
From the pilots view the need for the leveling of runway is also required as the longitudinal transition slope along the length of runway cause difficulties for the pilots during landing and departure.

(C) Air Navigation system

		
Photo 3.3-25 VHF terminal	**Photo 3.3-26 Weather observation camera**	**Photo 3.3-27 Weather information monitor**

(Source: JICA study Team)

The aviation safety system installation at the Simikot Airport consists of communication equipment and weather observation equipment. There is no navigational supporting equipment and monitoring system.

For air-to-air communication pilot uses VHF, while HF is used for the ground-to-ground communication however due to its poor sound quality it's not in use. Similarly, HF is not used for air-to-air communication. For the transmitting of flight plan information between control tower of Simikot Airport and Nepalgunj Airport communication is made by telephone lines.

The communication range of VHF is limited to an area of radius of 10-15NM because of surrounding mountains. According to the controllers and pilot, during the flight between Nepalgunj and Simikot airport, the only point where Simikot Airport can be reached is between Simikot Pass and Simikot airport. On the outbound flight to Nepalgunj Airport, VHF communication with Nepalgunj tower can be reached only on the western part of Virgin Pass, so in between the Simikot pass and west virgin pass communication can be made with Bajura Airport tower to receive flight information services.

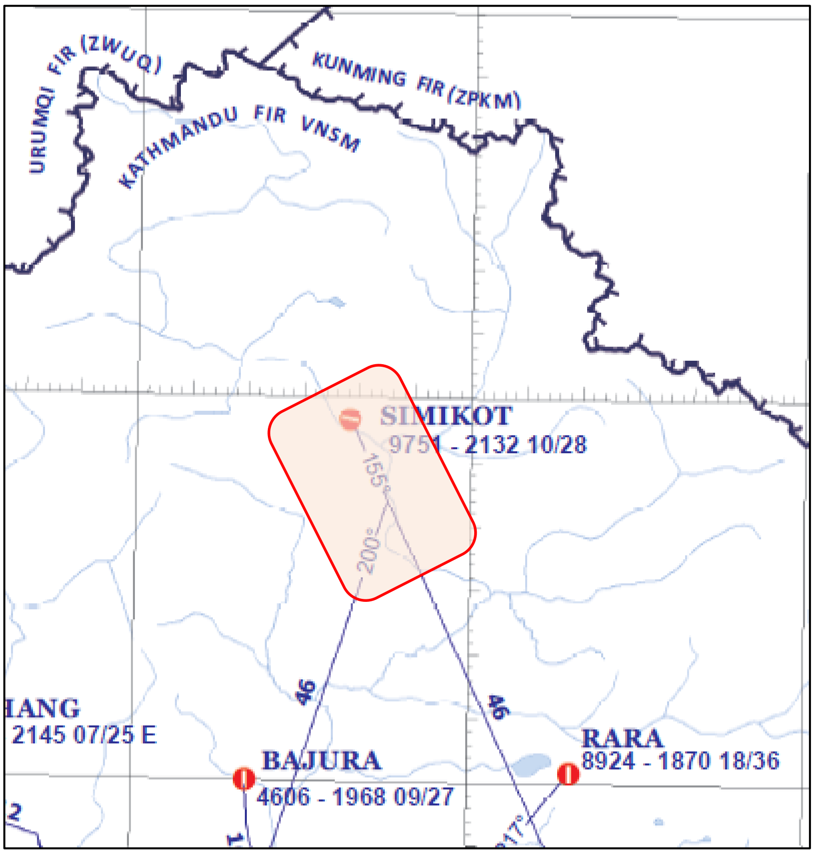


Figure 3.3-8 Simikot Airport VHF Coverage

As for the metrological observation devices, wind direction/wind speed, thermometer and barometer are installed on the eastern slope about 150m from the end of RWY28 and the display device is installed in the VFR room. At the same time, the air traffic controller visually observes the surrounding cloud conditions, cloud height, rain and snowfall, and visibility, and notifies the air traffic controller and pilots at Nepalgunj Airport of this information.

(3) Rara Airport

1) Overview

The Rara Airport is the gateway for tourists visiting Rara Lake, which is the largest lake in Nepal, or national park surrounding the lake. It is projected that the number of tourists visiting Rara Lake will increase. The general overview of the airport is shown in Table 3.3-5.

Table 3.3-5 Overview of the Rara Airport

Location Indicator	VNRR
Aerodrome Reference Code	1'A' Type 3
Aerodrome Coordinates	29^0 31' 00" N／82^0 09' 00" E
Altitude	2,971 m
Province/ District	6／Mugu
Location Indicator	VNRR
Operation Hours	Jan-Feb, Nov-Dec.: 6：45－12：30 March-April, Sept-Oct: 6：15－12：30 May-Aug: 6：00－12：30
Operation Start Year	19 October 2003
Airport Area	Approx. 92,407.088 ㎡
Runway	570 m x 20 m (18/36) Bituminous Paved (Asphalt Concrete)
Apron	2 Small Aircrafts (DHC-6, D228)
Re-fueling Facility	None
Type of Aircraft	D228, L410, DHC-6, Y12, C208
RFF Category	None
Air Control Service	AFIS and warning report
Communication Equipment	HF、VHF
Navigation Facility	N/A
CAAN staff	Staff Number： 20persons、Watch：4persons
Tenant	N/A
Other facilities	N/A

(source: CAAN)

The runway slope increases 6.5% from RWY18 towards RWY36, the runway operation is only in one direction where the landing takes place from RWY18, and takeoff from RWY36. Since the airport is built over the mountain slope, there arepossibilities oflandslide occurrence around the turning pad and apron, for which the measures are being considered.

(Source: Google Earth)

(a)

(Source: CAAN)

(b)

Figure 3.3-9 (a) Aerial View of the Rara Airport (b) Master Plan of the Airport

(Source: Nagarik H.P)

Photo 3.3-28 General Overview of the Rara Airport

	
Photo 3.3-29 View of the Airport Location	**Photo 3.3-30 View at End of RWY36**

(Source: CAAN)

2) Current Status of the Airport Facilities and Aviation Safety Systems

The summary of current status of airport facilities and aviation safety systems at the Rara Airport is as shown in Table 3.3-6.

Table 3.3-6 Status of Airport Facilities and Aviation Safety System at the Rara Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	570 m x 20 m
	Orientation	18 / 36
Parking Spot	2	
Aviation Safety System	Communication	VHF (122.5 MHz), HF (5858 kHz)
	Navigation	None
	Monitoring	None
	Metrological	Anemometer
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal Detector	None
	CCTV	None
	UHF communication System	None
	FIDS	None
Airport Lighting	None	
Backup Power Supply	Solar Power System	

(Source: CAAN)

3) Field Survey Result

(A) Passenger Terminal Building

The airport operation hours are limited from early morning to around noon. Since the flight has to cross over many passes and has to fly visually, the issue for the operation of flight is tail wind and the route weather conditions.
Currently there is no terminal building, airline uses temporary shed to check in. The new passenger terminal is under construction.
In terms of security nothing is in place as the airport itself is an open area with local habitants crossing runway and viewing the aircraft takeoff and landings. The military personnel perform exterior patrolling.
The luggage is being transported to aircraft using carts.

(B) Airside facilities (Runway, apron, etc.)

Photo 3.3-31 Apron

Photo 3.3-32 Landslide above apron

Photo 3.3-33 Runway view

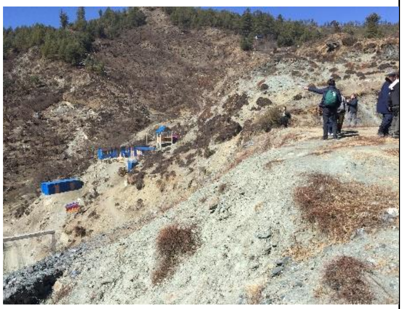


Photo 3.3-34 RWY36 Side Steep slope	**Photo 3.3-35 RWY18 Side Landslide Condition**	**Photo 3.3-36 Erosion on RWY18 side drainage**

(Source: JICA study Team)

The current runway length is 570m and 20m wide. The runway extension may not be possible because of the topography of the airport location. As per the hearing from the pilots and airport staff safety can be improved if they could level the runway so that both ends of runway can be used for take-off and landing, which currently is restricted to only RWY18 side.
Moreover, airport has many landslides that occured around RWY18 end, which may have caused due to improper drainageand near the apron almost half of the apron area is covered with sediment.
Currently, renovation work for the landslide is under process around the airport runway.

(C) Air Navigation system

		
Photo 3.3-37 Control tower exterior	**Photo 3.3-38 VHF Equipment**	**Photo 3.3-39 Wind direction and anemometer**

(Source: JICA study Team)

Lara Airport does not have a control tower and operates its control operations in a temporal building. The only air security systems in place are communication equipment and weather observation equipment. No navigational aid facilities or surveillance systems have been installed.
For air-to-air communication pilot uses VHF, while HF is used for the ground-to-ground communication however due to its poor sound quality it's not in used. Similarly, HF is not used for air-to-air communication. For the transmitting of flight plan information between control tower of Rara Airport and Nepalgunj Airport communication is made using telephone lines.
The communication range of VHF is limited to an area of radius of 10-15NM because of surrounding mountains. According to the controllers and pilot, during the flight between Nepalgunj and Rara airport, the only point where Rara Airport can be reached is between Rara pass and Rara airport. When flying on other segments, VHF communication from Nepalgunj Airport can only reach the virgin pass, so flight information services are not available while flying between Rara pass and virgin pass.

(4) Jomsom Airport

1) Overview of the Airport

The Jomsom Airport is located along the trekking route around the Annapurna Mountain and is near the Kali Gandaki River. The airport is used by many climbers to Dhaulagiri, Annapurna, Nilgiri, etc. The general overview of the airport is as shown in Table 3.3-7.

Table 3.3-7 Overview of the Jomsom Airport

Location Indicator	VNJS
Aerodrome Reference Code	1'A' Type 3
Aerodrome Coordinates	28^0 46' 53.4" N／83^0 43' 22.69" E
Altitude	2,736 m
Province/ District	4／Mustang
Operation Hours	Jan-Feb, Nov-Dec.: 6:45－12:30 March-April, Sept-Oct: 6:15－12:30 May-Aug: 6:00－12:30
Operation Start Year	March 1976
Airport Area	Approx. 119,197.20 ㎡
Runway	815m x 20 m (06/24) Bituminous Paved (Asphalt Concrete)
Overrun	RWY 24: 50 m, RWY 06: 25 m
Apron	4 Small Aircrafts, 2 Helicopter
Re-fueling Facility	None
Type of Aircraft	D228, L410, DHC6, Y12, C208
RFF Category	None
PTB operation capacity	60 passengers per hour
Air Traffic Control Service	AFIS and warning report
Communication Equipment	HF, VHF
ILS	N/A
Surrounding population（inside Approx.5km）	Approx. 1,500 persons
Passenger	20 passengers per hour
CAAN Staff	CAAN Staff: 7 persons, Watch: 7persons
Airport Security (Nepal Police)	Staff： 20persons, Watch： 15persons
Tenant	Yes
Other facility	WIFI router for Passenger

(Source: CAAN)

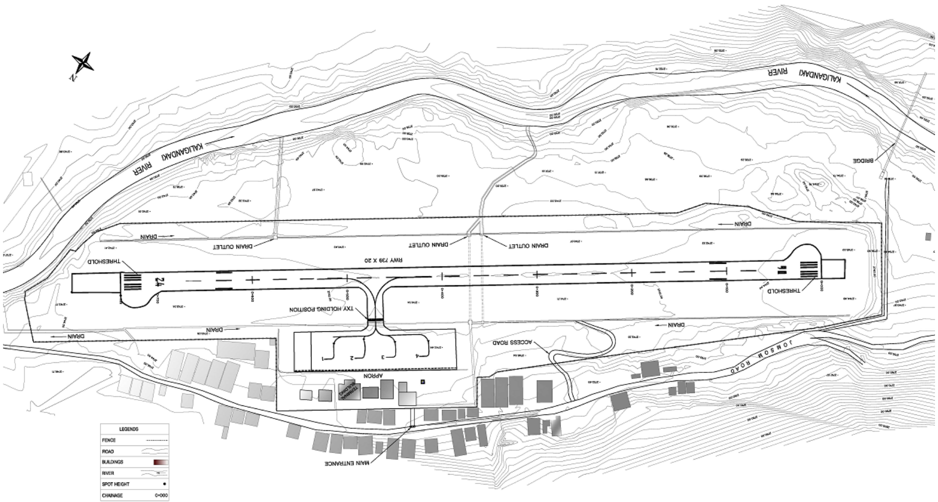
(Source: Google Earth)

Figure 3.3-10 View of the Jomsom Airport Location

	
Photo 3.3-40 View of the Runway from RWY24 Side	**Photo 3.3-41 RWY06 Extendable Site**

(Source: CAAN)

The current airport plan is shown in Figure 3.3-11.



(Source: CAAN)

Figure 3.3-11 Current Plan of the Jomsom Airport

2) Current Status of Airport Facilities and Aviation Safety Systems

The current status of airport facilities and the aviation safety system is shown in Table 3.3-8.

Table 3.3-8 Status of Airport Facilities and Aviation Safety System at the Jomsom Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	815 m x 20 m
	Orientation	06 / 24
Parking Spot	3	
Air Navigation System	Communication	VHF (118.3 MHz), HF (5858 kHz)
	Navigation	None
	Surveillance	None
	Metrological	MET display, Anemometer
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal detector	Stationary type, Handy type
	CCTV	None
	UHF Communication System	None
	FIDS	None
Airport Lighting	Runway threshold lighting	
Backup Power Supply	Solar Power System, Generator	

(Source: CAAN)

3) Field Survey Result

(A) Passenger Terminal Building

		
Photo 3.3-42 Outer view of the terminal building	**Photo 3.3-43 Check -in counter**	**Photo 3.3-44 Departure lounge**
		
Photo 3.3-45 Baggage claim	**Photo 3.3-46 Metal detector**	

(Source: JICA study Team)

The airport operation hours are limited from sunrise to around 12:00, so the departure and arrival flights may be congested during the peak season, when it is highly probable that airport facilities such as check-in counter and departure lobby will be crowded. For the terminal building capacity, it corresponds to the present requirement.

In terms of security, passenger is scanned with metal detector and then security personnel perform body checks. On the other hand, there is no X-ray inspection for the baggage, in case manual security check up is performed. CCTV is not installed and security check in the restricted area is performed by the Nepalese police. The military personnel perform patrolling around the airport.

The luggage is being transported to aircraft by staffs using cart and CAAN official in charge is requesting for the conveyor installation. It is planned to introduce Digital Flight Information Display to improve passenger convenience.

(B) Airside facilities (Runway, apron, etc.)

		
Photo 3.3-47 Apron (From control tower)	**Photo 3.3-48 Boarding at apron**	**Photo 3.3-49 Drainage channel (outlet in the river)**

		
Photo 3.3-50 RWY06 Side (construction work)	**Photo 3.3-51 RWY24 Side (River side)**	**Photo 3.3-52 Helipad beside the apron (Scheduled for future maintenance)**

(Source: JICA study Team)

The current runway length is 815 m but there is a space for expansion to the southern side (RWY06) and is planned to extend in the future. For the extension work, it could be extended for at least 50 m and at most 200 m.

The aircraft accident of Nepal Airline DHC-6 during landing occurred in 2013. It overrun the runway and fell into the river towards the north side of the airport. The tail wind at the time was 8-12 knots. Although there were no casualties reported, it would point out the requirement for runway extension for safe operation.

Specifically, at the Jomsom Airport, strong wind tends to constantly blow which could cause airport closure if the tail wind exceeds 15 knots in order to avoid accidents, however, it could be of help if it has longer runway.

In addition, there is a concern for the requirement of GPU introduction. Flights to the Jomsom Airport are operated by aircraft based in Pokhara Airport, and the parking at Jomson Airport is about 15 mins required for disembarking and embarking. Therefore, the engine is started with the battery of the aircraft when departing from the airport, but there is a risk that the engine cannot be started I the engine or battery has some trouble. Also, since the GPU socket differs for four types of aircraft which is used for flights to Jomsom Airport, it is required to introduce GPU that could be used for multiple aircrafts.

(C) Air Navigation system

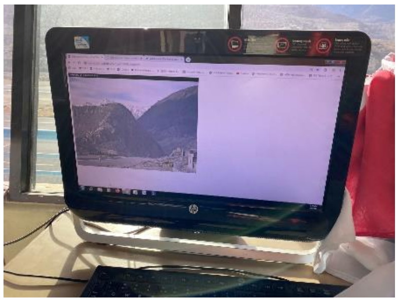
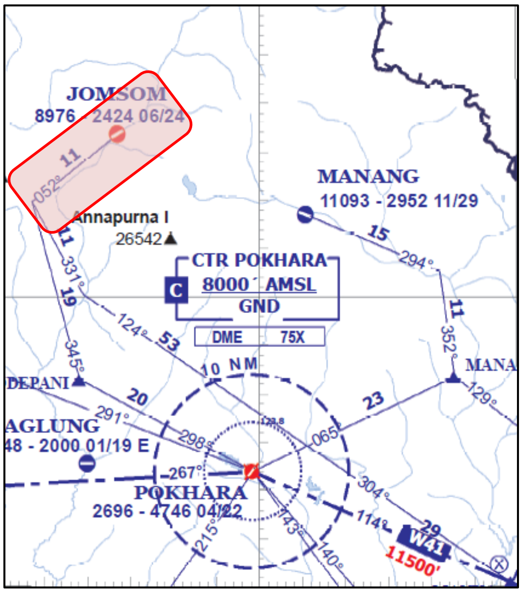
		
Photo 3.3-53 VFR room at the control tower (One controller in operation)	**Photo 3.3-54 Console (HF/VHF Terminal and weather monitoring)**	**Photo 3.3-55 Image of weather observation camera (Weather News)**

		
Photo 3.3-56 Image of weather observation camera (Weather News)	**Photo 3.3-57 VHF and HF antenna**	

(Source: JICA study Team)

The air navigation system installed at the Jomsom Airport consists only of communication equipment and weather observation equipment and has no navigational support facilities and surveillance systems.
VHF is only used to communicate with the pilot and HF is not in use for ground-to-ground communication because of its poor quality and for the same reason it is not used for surface-to-air communication.
VHF has a limited range, and pilots cannot communicate with controllers either at Jomsom or Pokhara airports while flying between north and south routes along Mt. Ghodepani.



(Source: JICA study Team)

Figure 3.3-12 Jomsom Airport VHF Coverage

Therefore, in the dead zone of VHF ground-to-air communication, communication between the pilots is made directly so that they can adjust the flight altitude to avoid collision and share weather information.
For sharing flight information such as flight plans, the AFTN line is used, and when transferring necessary information to and from the Pokhara Airport, a landline telephone line (Hotline) is used.
As for the weather observing devices, wind direction/ wind speed, thermometer and barometer are installed at the top of the control tower and display device is in VFR room. The weather condition at the airport is being studied through display devices together with

visual observing the surrounding cloud condition, rainfall/snowfall, and visibility then notify the controller at Pokhara and pilots just before landing/ takeoff. The airline decides whether to operate flight or not based on the weather information provided by the destination airport. Especially at the Jomsom Airport, strong wind blows often due to its topographical characteristics. Since almost 90% of the takeoff and landing take place to the south, there have been cases where takeoff and landing take place in the course of receiving tail wind. After the accident in 2013, since the Accident Investigation Commission issued a recommendation to halt operation if the tail wind exceeds 5 knots, both controller and pilot are complying with wind condition at landing/ takeoff.

(5) Lukla Airport

1) Overview of the Airport

The Lukla Airporthandles the maximum number of passengers becauseit is the gateway to Mt. Everest climbers and trekkers. Overview of the Lukla Airport is as shown in Table 3.3-9. According to the December 2019 Survey, the operation time for Lukla from TIA is reduced due to the construction of parallel taxiway causing heavy traffic. So, in order to satisfy the peak season demand, the Ramechhap Airport is preferred as an alternative airport, which in a day handles around 100 flights.

Table 3.3-9 Overview of the Lukla Airport

Location Indicator	VNLK
Aerodrome Reference Code	1'A' Type 3
Aerodrome Coordinates	27^0 41' 16" N／86^0 43' 53" E
Altitude	2,846 m
Province/ District	1／Solukhumbu
Operation Hours	Jan-Feb, Nov-Dec.: 6:45－18:00 March-April, Sept-Oct: 6:15－18:30 May-Aug: 6:00－18:45
Operation Start Year	September, 1971
Airport Area	Approx. 81,509.93 ㎡
Runway	527 m x 20 m (06/24) Bituminous Paved (Asphalt Concrete)
Apron	4 Small Aircrafts
Re-fueling Facility	None
Type of Aircraft	D228, L410, DHC6, Y12, C208
RFF Category	Small Fire Truck (1 no)
Air Traffic Control Service	AFIS and warning report
Communication Equipment	HF, VHF, AMHS
ILS	N/A
CAAN Staff	CAAN Staff: 5 staff, Watch: 5 staff
Tenant	Yes
Other facility	WIFI router for Passenger, Cable Television, Restaurant

(Source: CAAN)

(Source: Google Earth)

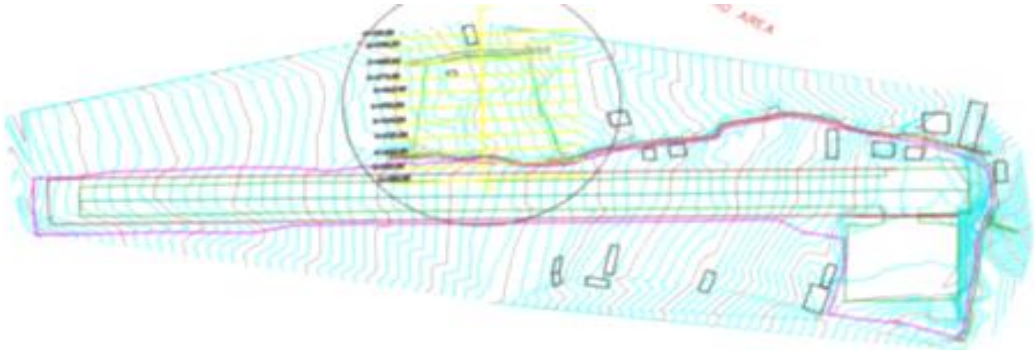
Figure 3.3-13 View of the Lukla Airport Location

The runway is operated in one direction only landing takes place from RWY06 and takeoff from RWY24. Due to presence of mountain slope on RWY24 side, the extension on this side is difficult.

	
Photo 3.3-58 View of RWY06 Side	**Photo 3.3-59 View of RWY24 Side**

(Source: CAAN)

Currently, the new helipad (five spots) is undergoing construction.



(Source: CAAN)

Figure 3.3-14 Current Plan of Lukla Airport

2) Current Status of Airport Facilities and Aviation Safety Systems

The current status of airport facilities and aviation safety system is shown in Table 3.3-10

Table 3.3-10 Status of Airport Facilities and Aviation Safety System at the Lukla Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	527 m x 20 m
	Orientation	06 /24
Parking Spot	4	
Air Navigation System	Communication	VHF (122.3 MHz), HF (5805.5 kHz), VSAT, AMHS
	Navigation	None
	Surveillance	None
	Metrological	MET display, Anemometer
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal detector	Handy Type
	CCTV	None
	UHF Communication System	None
	FIDS	None
Airport Lighting	Runway threshold light, APAPI（※1）	
Backup Power Supply	Solar Power System	

(Source: CAAN)

(※1: APAPI was installed once but removed at the request of the pilot, since actual approach angle and reading indicated by PAPI does not match)

3) Field Survey Result

(A) Passenger Terminal Building

		
Photo 3.3-60 Outer view of the terminal building	**Photo 3.3-61 Check -in counter**	**Photo 3.3-62 Departure lounge**
		
Photo 3.3-63 Baggage claim	**Photo 3.3-64 Security Check**	**Photo 3.3-65 Check-in baggage**

(Source: JICA study Team)

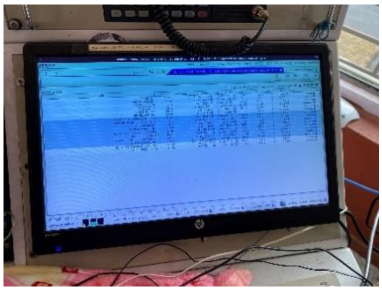
(B) Airside facilities (Runway, apron, etc.)

		
Photo 3.3-66 Apron	**Photo 3.3-67 View of upslope of RWY**	**Photo 3.3-68 Runway**
		
Photo 3.3-69 RWY06 Side (1)	**Photo 3.3-70 RWY06 Side (2)**	**Photo 3.3-71 Heliport under construction**

(Source: JICA study Team)

The current runway length is 527m with 20m width and gradient of 11.7%. From the site visit it was found that the runway extension towards RWY24 is not possible due to mountain and toward RWY06 presence of cliffs and steep rugged mountain could pose difficulty for the extension. Although there is possibility of construction with steel stractures, difficulties in transportation of material and equipment could cost huge amount for the project.
Due to short runway length and adverse weather conditions precision is necessary for the pilots to operate at Lukla Airport to avoid accidents However, huge number of passengers per annum and very huge number of traffic during peak season cause problem for the parking area for aircraft. During a meeting with MoCTCA, a site for a new airport on the ridge opposite Lukla Hospital was mentioned. In that site a longer runway can be constructed, and it can contribute to make approach of flights easier.

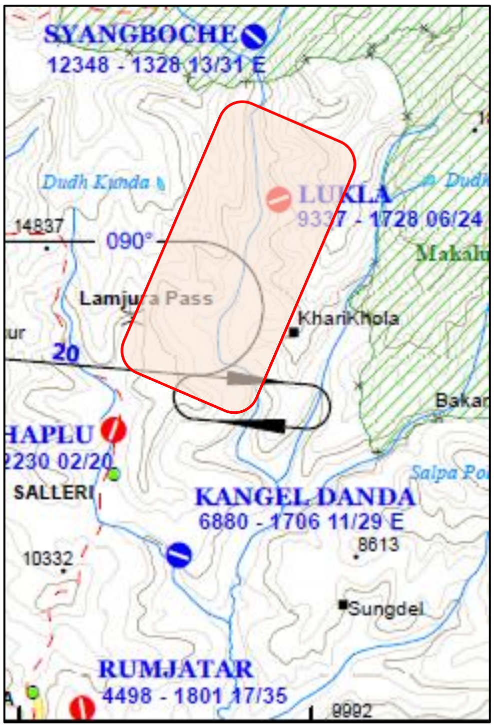
(C) Air Navigation System

		
Photo 3.3-72 VHF Antenna	**Photo 3.3-73 Weather Information Screen and VHF terminal**	**Photo 3.3-74 AMHS Terminal**
		
Photo 3.3-75 HF Terminal	**Photo 3.3-76 VSAT Antenna**	**Photo 3.3-77 Solar panel (For control tower)**

(Source: JICA study Team)

The air navigation system installed at the Lukla Airport consists of communication equipment (HF & VHF), AMHS terminal and weather observation equipment. There is no navigational supporting equipment and monitoring system. In addition, there is ground station antenna (VSAT, 4GHz) for satellite communication for AMHS.
For ground-to-air communication with pilot VHF is used, while HF for the ground-to-ground communication is not used due to its poor sound quality. Similarly, HF is not used for ground-to-air communication. If there is need to contact between Lukla airport and near-by airport or the ATC, hotline, regular telephone or mobile is used.

The communication range of VHF is limited to an area of radius of 15NM because of surrounding mountains. According to the interview with pilots and controllers, on the flight between TIA and Lukla airport, the only point where communication with Lukla Airport is available is between Lamjura Pass and Lukla airport.



(Source: JICA study Team)

Figure 3.3-15 Lukla Airport VHF Coverage

Therefore, in the dead zone of VHF ground-to-air communication, communication between the pilots is made directly so that they can adjust the flight altitude to avoid collision and share weather information.

The Flight information such as flight plan information is transmitted and received by AMHS. For the flight departing from TIA, flight plan information can be confirmed with AMHS terminal. For the flight departing from Lukla Airport, flight controller receives the flight plan information, inputs it to the AMHS terminal and reports it to ACC.

As for the weather observation devices, wind direction/wind speed, thermometer and barometer are installed at the end of the runway and the weather condition can be confirmed on the display device in VFR room. Moreover, the monitor for weather information display also shows the amount of stored solar power generated by the solar panel, so that it is possible to check and secure the buckup power supply. In addition to checking the current weather condition at the airport form display device, controllers visually observe surrounding cloud condition, height, rainfall/snowfall and visibility. These information is reported to ACC, controllers in TIA and pilots just before takeoff/ landing.

The airline company decides whether to operate based on the images from the ITV cameras installed by Weather News. The operational weather conditons of Lukla Airport are visibility of 5 km for fixed wings or 1,500 m for rotally wing, and when wind speed exceeds 10 knots, operation of the airport is suspended.

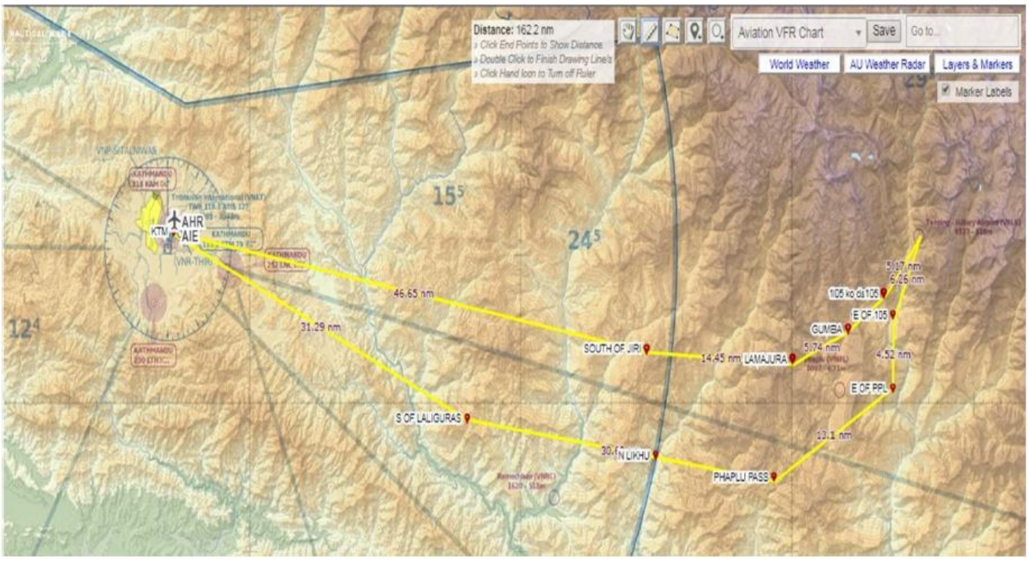
(Source: CAAN)

Figure 3.3-16 Estimated visibility at Lukla Airport

Lukla Airport is in a narrow valley and landing approach is only in single direction. In addition, it is difficult for aircraft to go-around once ready for landing. Therefore, the number of aircraft flying in the valley around the Lukla Airport is limited to one aircraft. Moreover, when the arrivals are consecutive, the aircraft needs to hold around designated area to adjust the interval between the arrival and departure aircraft.

(D) Others

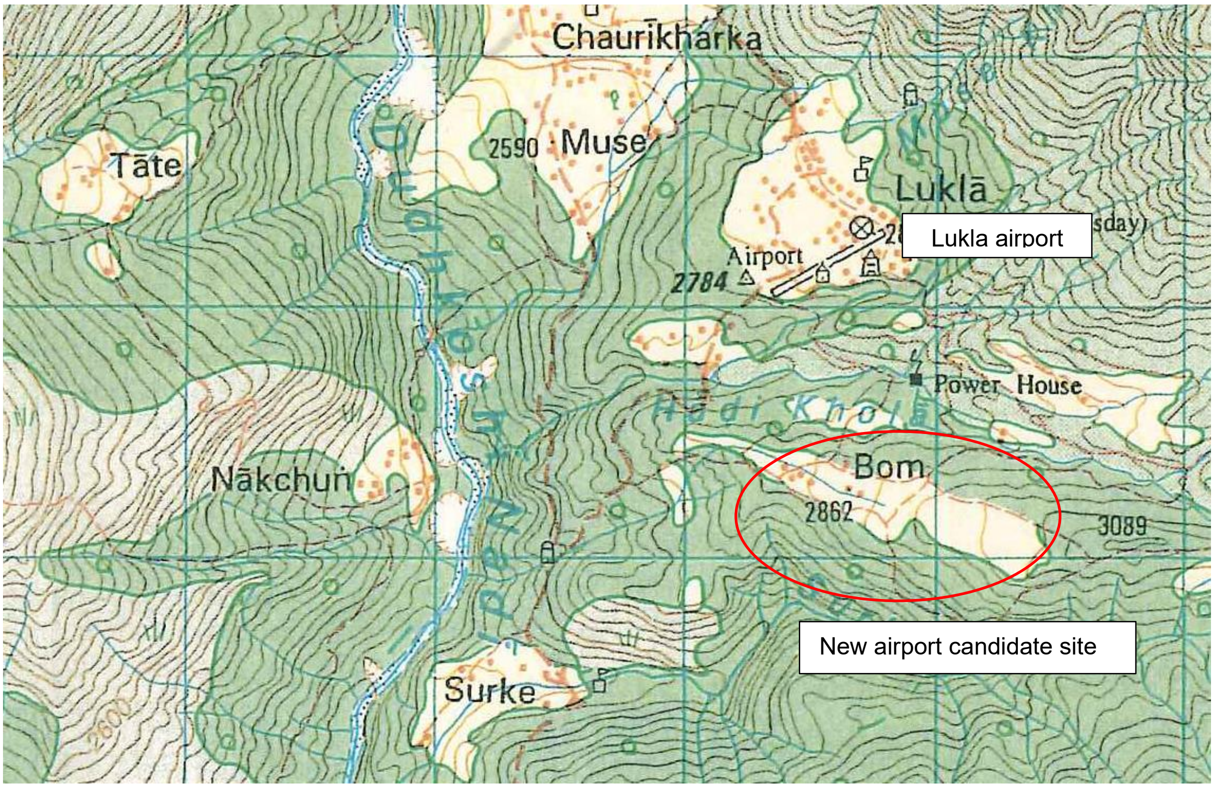
There are flights from not only TIA but also Phaplu or Ramechhap to Lukla, and during the peak season, the number of flights in Lukla Airport reaches 100 a day. In order to ensure safety, pilots proposed separate outbound and inbound routes between Lukla and other airports.



(Source: Sita Air)

Figure 3.3-17 Sita Air pilot's separated route proposal between TIA and Lukla Airport (outbound: south Inbound: north)

Figure 3.3-18 shows the new airport candidate site that CAAN staff referred to. This site is located on the opposite ridge from Lukla airport across Lukla hospital, and according to the figure, the runway may be longer than the current airport. Although there is a problem that need to cross the valley from the village of Lukla to the site, it is difficult to expand the present airport and it is desirable to develop a new airport in the future, so the site is considered to be a candidate for new airport construction.



(Source: JICA Study Team)

Figure 3.3-18 New Lukla Airport Candidate Site CAAN staff referred

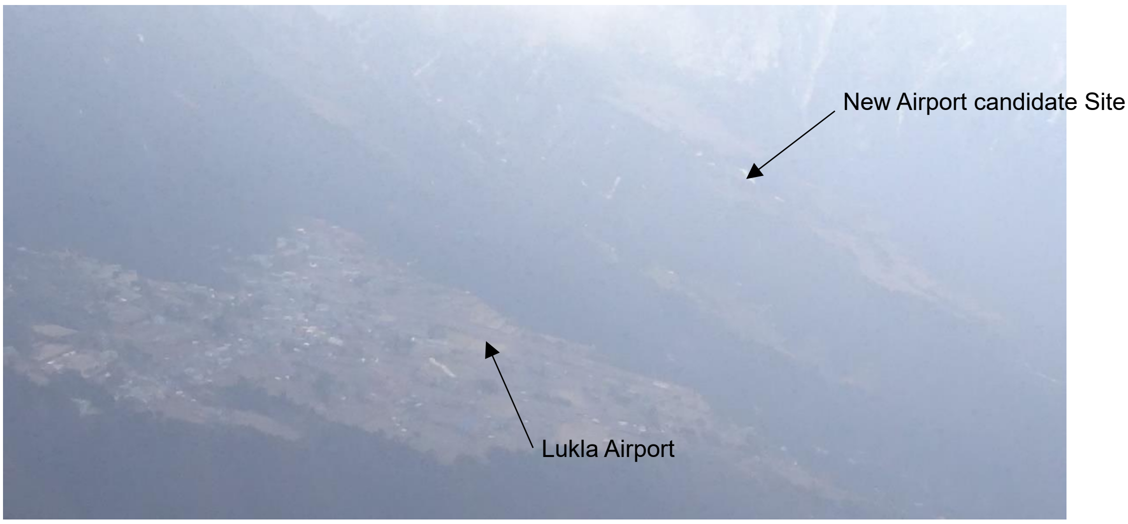


Photo 3.3-78 New Airport Candidate Site

(Source: JICA Study Team)

(6) Jumla Airport (Review Data)

1) Overview of the Airport

The Jumla Airport is located in Jumla Bazaar and plays vital role in the transportation of people and goods in the area. Although the airport is located at high altitude, it is surrounded by cultivable land, thus, it has a flat surface compared with other mountain airports.

Table 3.3-11 Overview of the Jumla Airport

Location Indicator	VNJL
Aerodrome Reference Code	1’A’ Type 3
Aerodrome Coordinates	29^0 16’ 26” N／82^0 11’ 23” E
Province/ District	6／Jumla
Operation Hours	Jan-Feb, Nov-Dec.: 6:45－18:00 March-April, Sept-Oct: 6:15－18:30 May-Aug: 6:00－18:45
Operation Start Year	1 October 1972
Airport Area	Approx. 81,509.93 ㎡
Runway	675 m x 20 m (09/27) Bituminous Paved (Asphalt Concrete)
Apron	3 Small Aircrafts
Re-fueling Facility	None
Type of Aircraft	D228, L410, DHC6, Y12, C208
RFF Category	None

(Source: CAAN)

(Source: Google Earth)

Figure 3.3-19 View of the Jumla Airport Location

Photo 3.3-79 View of the Airport	**Photo 3.3-80 Terminal Area During Snowfall**

(Source: CAAN)

2) Current Status of the Airport Facilities and Aviation Safety Systems

The summary of current status of airport facilities and aviation safety system at Jumla Airport is as shown in Table 3.3-12.

Table 3.3-12 Status of the Airport Facilities and Aviation Safety System at the Jumla Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	675 m x 20 m
	Orientation	09 /27
Parking Spot	3	
Air Navigation System	Communication	VHF (122.5 MHz), HF (5858 kHz)
	Navigation	None
	Surveillance	None
	Metrological	MET display, Wind sensor
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal detector	Handy type
	CCTV	None
	UHF communication System	None
	FIDS	None
Airport Lighting	PAPI, Runway Threshold light	
Backup Power Supply	Solar Power System	

(Source: CAAN)

(7) Dolpa Airport (Reviewed Data)

1) Overview of the Airport

The Dolpa Airport serves as an important transportation means for persons and goods in Dolpa District. Additionally, it serves as a gateway for tourist visiting the lake Phoksundo in Shey Phoksundo Natioanl Park listed as a world heritage site in 2007. The general overview of the airport is as shown in Table 3.3-13.

Table 3.3-13 Overview of the Dolpa Airport

Location Indicator	VNDP
Aerodrome Reference Code	1’A’ Type 3
Aerodrome Coordinates	28^0 59’ 09” N／82^0 49’ 09” E
Province/ District	6／Dolpa
Operation Hours	Jan-Feb, Nov-Dec.: 6:45－12:30 March-April, Sept-Oct: 6:15－12:30 May-Aug: 6:00－12:30
Operation Start Year	1975
Airport Area	Approx. 59,659.65 ㎡
Runway	560 m x 20 m (16/34) Bituminous Paved (Asphalt Concrete)
Apron	3 Small Aircrafts
Re-fueling Facility	None
Type of Aircraft	L410, DHC6, Y12, C208
RFF Category	None

(Source: CAAN)

The runway is operated in one direction only, the landing is from RWY16 and takeoff is from RWY34. The gradient of the longitudinal slope is 8% with an upward from RWY16 to RWY34.

(Source: Google Earth)

Figure 3.3-20 View of the Dolpa Airport Location

	
Photo 3.3-81 Airport Runway View	**Photo 3.3-82 Terminal Area**

(Source: CAAN)

2) Current Status of the Airport Facilities and Aviation Safety Systems

The current status of the airport facilities and aviation safety systems at Dolpa Airport is as shown in Table 3.3-14

Table 3.3-14 Status of Airport Facilities and Aviation Safety Systems at the Dolpa Airport

Runway	Pavement	Bituminous Paved (Asphalt Concrete)
	Runway dimension	560 m x 20 m
	Orientation	16 /34
Parking Spot	3	
Air Navigation System	Communication	VHF (122.5 MHz), HF (5858 kHz)
	Navigation	None
	Surveillance	None
	Metrological	MET display, Anemometer
ATC Services	AFIS for VFR aircraft (Airport Flight Information Services)	
Security	X-Ray	None
	Metal detector	Handy Type
	CCTV	None
	UHF communication system	None
	FIDS	none
Airport Lighting	None	
Backup Power Supply	Solar Power System	

(source: CAAN)

3.3.5 Issues

Based on the results of field surveys and interviews, the issues and countermeasures for airport facilities and aviation security facilities at mountain airports are described below.

(1) Issue of Airport Facilities

CAAN is discussing issues of mountain airport facilities with ICAO, and the first meeting of the Asia / Pacific Aerodrome Design and Operation Task Force was held in September 2019. There is a debate on the necessity of establishing guidance material to planning, design, construction and safe operation of ALTIPORTS.
The specifications of 44 domestic airport runways are summarized in Table 3.3-15.
35 of the 44 airports are located in mountainous areas, and most of the airports with a runway slope of 2% or more are classified as ALTIPORT in the ICAO STOLPORT Manual. It means that the airport is (1) in a mountainous area, (2) uses an uphill slope for landing with a tight runway slope, and uses a downhill slope for takeoff, and (3) takes off / landing in only one direction.

Table 3.3-15 Domestic Airport Specification in Nepal

<table>
<tr><th rowspan="2">Runway Length(m)</th><th><400</th><th>400<800</th><th>800<1200</th><th>1200<1600</th><th>>1600</th></tr>
<tr><td>2 airports</td><td>31 airports</td><td>4 airports</td><td>6 airports</td><td>1 airport</td></tr>
<tr><th rowspan="2">Altitude(m)</th><th>60-305</th><th>305-1000</th><th>1000-2000</th><th>2000-3000</th><th>>3000</th></tr>
<tr><td>9 airports</td><td>9 airports</td><td>11 airports</td><td>12 airports</td><td>3 airports</td></tr>
<tr><th rowspan="2">Runway Slope（%）</th><th>0-2%</th><th>2-5%</th><th>5-10%</th><th colspan="2">>10%</th></tr>
<tr><td>24 airports</td><td>13 airports</td><td>5 airports</td><td colspan="2">1 airports</td></tr>
</table>

(Source: JICA Study Team)

Table 3.3-16 shows the specifications of the major facilities of the mountain airport under consideration.

Table 3.3-16 Specification of Major Mountain Airport

Airport	Simikot	Rara	Jumla	Dolpa	Jomsom	Lukla
Annual Passengers (Numbers）	54,261	19,360	14,163	19,352	46,401	124,929
Annual Takeoff and Landing	13,960	2,360	1,588	1,556	3,209	31,636
Runway	650 x 20m	650 x 20m	675 x 20m	560 x 20m	815 x 20m	527 x 20m
Runway Slope	Max6.5%	Max6.5%	Plane	Max8%	Riverbed	Max11.7%
Runway Strip Width（Distance from Runway centerline to Runway Strip）	25m	20m	30m	20m	40m	15m
Apron Spot	STOL 3spots + 3spots under construction	STOL2spots	STOL 3spots	STOL 3spots	STOL 4spots	STOL 4spots

(Source: CAAN)

Because mountain airports are constructed on limited land, some airports do not meet the necessary criteria for runway length / gradient and runway strips length/ width as indicated by ICAO. At some airports, the number of apron spots are not sufficient for the required number of spots during peak hours. Regarding the runway length, the aircraft operating at the mountain airport are short take-off and landing aircraft (STOL aircrafts), that can take off and land at shorter run-distance compared to ordinary planes. Table 3.3-17 and Table 3.3-18 show the take-off and landing performance specifications of the DHC-6 Twin Otter (19 passengers), which is a representative model of STOL aircraft.

Table 3.3-17 DHC-6 STOL Landing and Takeoff Distance

Item	Distance
Takeoff Distance to 15.2m	366m
Landing Distance from 15.2m	320m

STOL landing distance assumes retardation with wheel brakes and both engines reversed.
All takeoff distances are based on both engines operating at takeoff power throughout. The takeoff and landing distances are given at sea level, zero wind and from a dry concrete level surface.
(Source: Technical Specification)

Table 3.3-18 DHC-6 SFAR 23 Landing and Takeoff Distance

Item	Distance
Takeoff Distance to 15.2m	454m
Landing Distance from 15.2m	460m
Accelerate Slow Distance to 35 kt	623m
Accelerate - Stop Distance	675m

The CAR 3 and SFAR 23 landing distances and accelerate stop distance assume retardation with wheel brakes only.
The takeoff and landing distances are given at sea level, zero wind and from a dry concrete level surface.
(Source: Technical Specification)

According to the ICAO standard, the required runway length is calculated by correcting the standard runway length (runway length in standard atmosphere with altitude at sea level, zero wind, 0% runway slope), with corrections for altitude, temperature, etc. Each 300 m above sea level increases, the runway length increase by 7%, and each airport temperature increases 1 ℃ above the standard atmospheric temperature at the airport altitude, the runway length increase by 1%.

At an altitude of 2,700m, a runway length is required 1.63 times of standard runway length (1 + 2,700 / 300 x 0.07). And the airport temperature is 21 ℃ like Jumura, Rara, Simikot (at the average maximum daily temperature of the maximum temperature month) and the altitude is 2,700 m (standard atmospheric temperature -2.55 ℃), 1.23 times (1+ (21-(-2.55) / 100) runway length is required.

According to the ICAO standard, if the altitude and temperature corrections exceed 1.35 times, a separate study is required, and the above calculation results are only rough estimate. In many mountain airports, the runway length is not sufficient even when considering the STOL takeoff and landing distance. At mountain airports, it is difficult to extend the runway due to topographical conditions, but it is desirable to extend the runway as much as possible.

At some airports, in order to secure the runway length as long as possible, the distance from runway thresholds to runway strip cannot be secured. At such airports, it is advisable to consider ways to prevent airplanes from hitting slopes or falling onto cliffs or rivers.

Apron spots are lacking at high season of Lukla and Simikot airports. Simikot airport is currently being constructed with three STOL (DHC-6) spots with CAAN funding, but Lukla airport is difficult to expand due to site condition.

(2) Issues in Aviation Safety Facilities

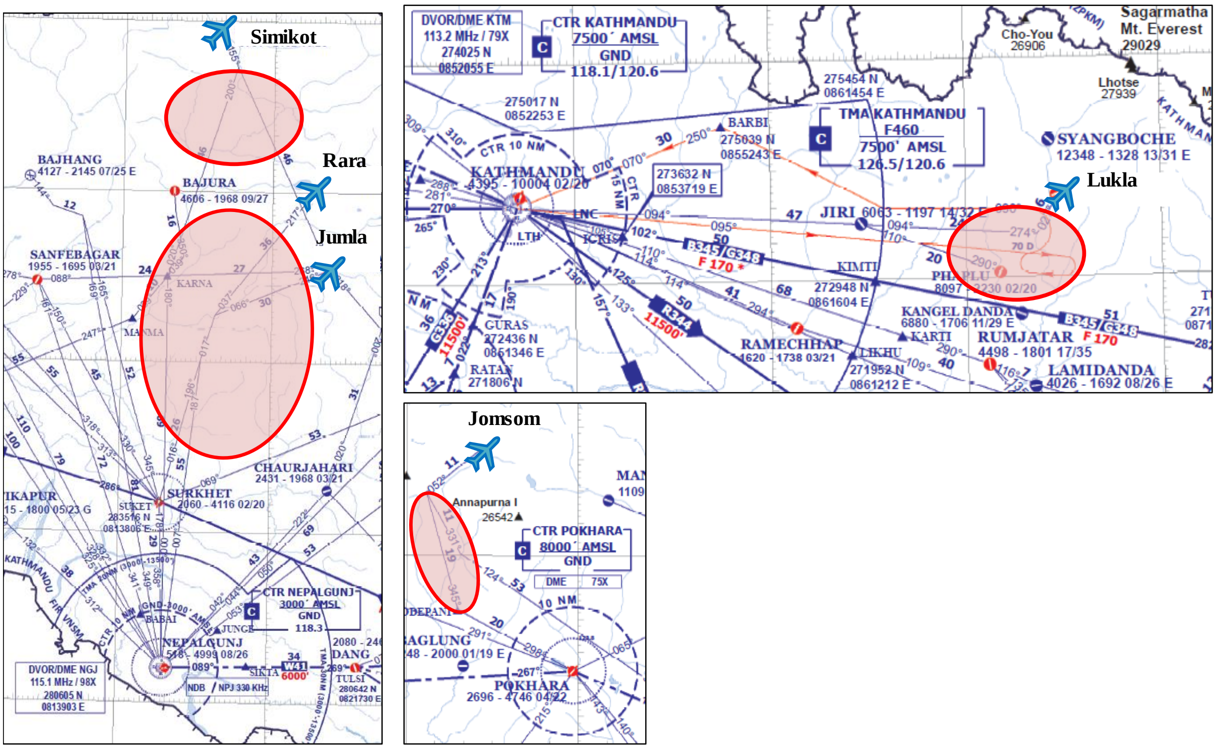
1) Communication

(A) Issues

The issues related to communication at mountain airports are the existence of dead zones for VHF communication and the lack of communication lines to mountain airports.

a) VHF Communication Dead Zone

There aredead zones of VHF communication between Nepalganj-Simikot, Pokhara-Jomsom, and Kathmando-Lukla, where ground-to-air communication cannot be performed. Therefore, the pilot cannot acquire the weather information and the information on the surrounding aircraft, which are necessary to ensure the safety during flight and landing.

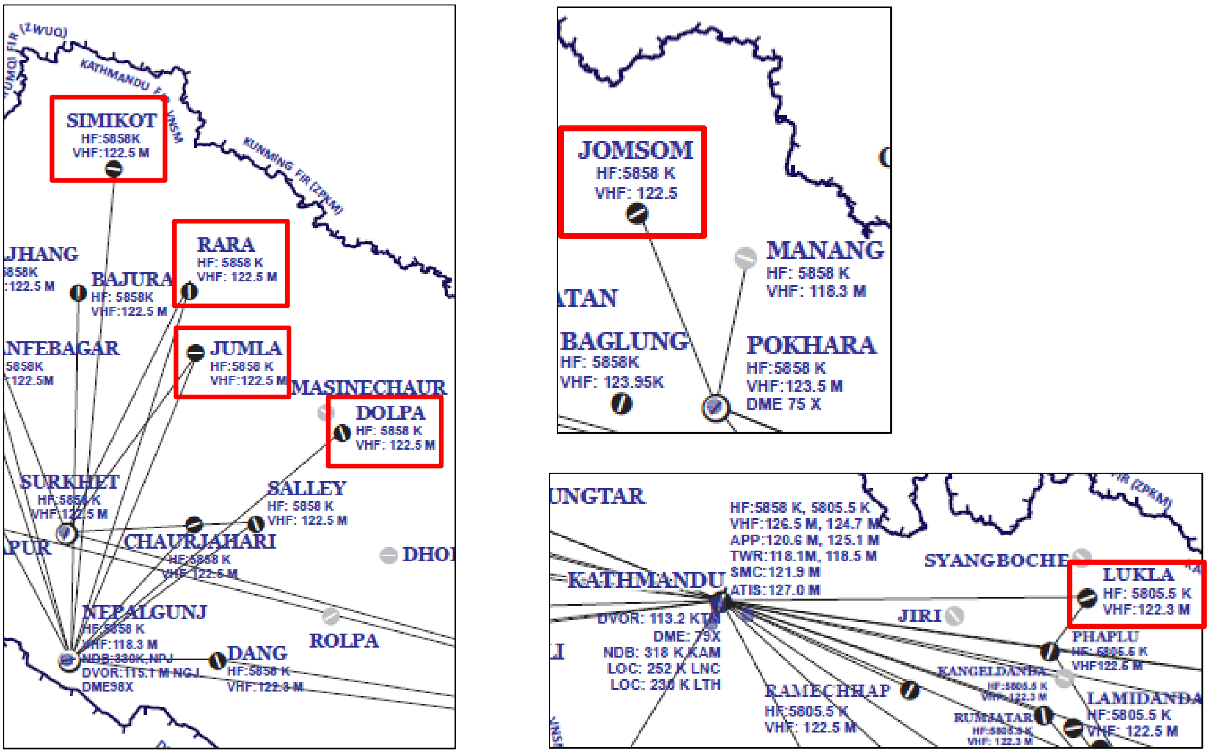


(Source: JICA Study Team)

Figure 3.3-21 VHF Communication Dead Zone

b) Lack of Communication Line to Mountain Airport

Currently, information exchange between mountain airports and base airports is carried out with poor quality HF communication and telephone lines. Since HF communication has poor voice quality, necessary information is notified and acquired via telephone lines.
Also, at mountain airports, AMHS lines are not available except for some airports. Therefore, the flight information and weather information are reported only by voice, and the amount of information is limited, at the same time, accuracy and timeliness are lacking.
In addition, as a backbone network infrastructure, only microwave line is installed between Simikot, Rara, Jumula, Dolpa and Nepalgunj, and between TIA and Lukla. Optical line is installed only between Jomson and Pokahara.



(Source: JICA Study Team)

Figure 3.3-22 Status of Existing Communication Lines at Mountain Airport

(B) Countermeasures

a) Elimination of VHF Communication Dead Zone

The solution for this issue includes installation of RCAG to cover major mountain airport. Two sites for installation of RCAG have been selected in the preparatory survey of grant aid project "Main Airport Aviation Safety Equipment development plan". Although, it was not adopted, it was confirmed that the two sites are suitable for RCPG installation in order to eliminate current dead zone.

Therefore, in this study as well, proposals for installing RCAG will be considered in order to improve VHF communication conditions at mountain airports and the surrounding airspace.

b) Securing Alternatives for Grund-to-Ground Communication

Currently, there is no communication line other than telephone lines for communication between airports. Therefore, proposal will be considered to ensure a backup communication line firstly. In addition, depending on communication conditions, introduction of digital HF, which is assumed that it will also be used for ground-to-air communication as necessary will be considered.

2) Navigation

(A) Issues

Since radio waves do not reach the mountainous areas, navigation assistance facilities, such as VOR / DME cannot be used, and it is difficult to install similar ground navigation assistance facilities.

Therefore, VFR aircraft uses GPS information as a reference. However, the GPS accuracy in Nepal is not guaranteed to be applicable at a level for aircraft navigation. Therefore, it is necessary to verify the GPS accuracy and introduce auxiliary system for GPS aircraft position estimation.

(B) Countermeasures

GPS position information has some errors, and further accuracy is required for it to be used in flight operations. Therefore, it is necessary to introduce SBAS, which has the function of supplementing GPS accuracy. If GPS has an auxiliary system, it can perform as well as VOR / DME.

From the above, it is possible to fly in a mountainous area by ensuring a safe distance between the aircraft and the topographys. In the future, it is necessary to consider the possibility of introducing PBN in mountainous areas.

3) Surveillance

(A) Issues

The current surveillance radar in operation is known to have no coverages in the northern mountainous area. Regarding the installation of ADS-B under guidance of ICAO, most of the aircraft operating in the mountainous airport are not equipped with ADS-B related systems, so, at present it is difficult to use ADS-B for aircraft surveillance in the northern mountainous areas.

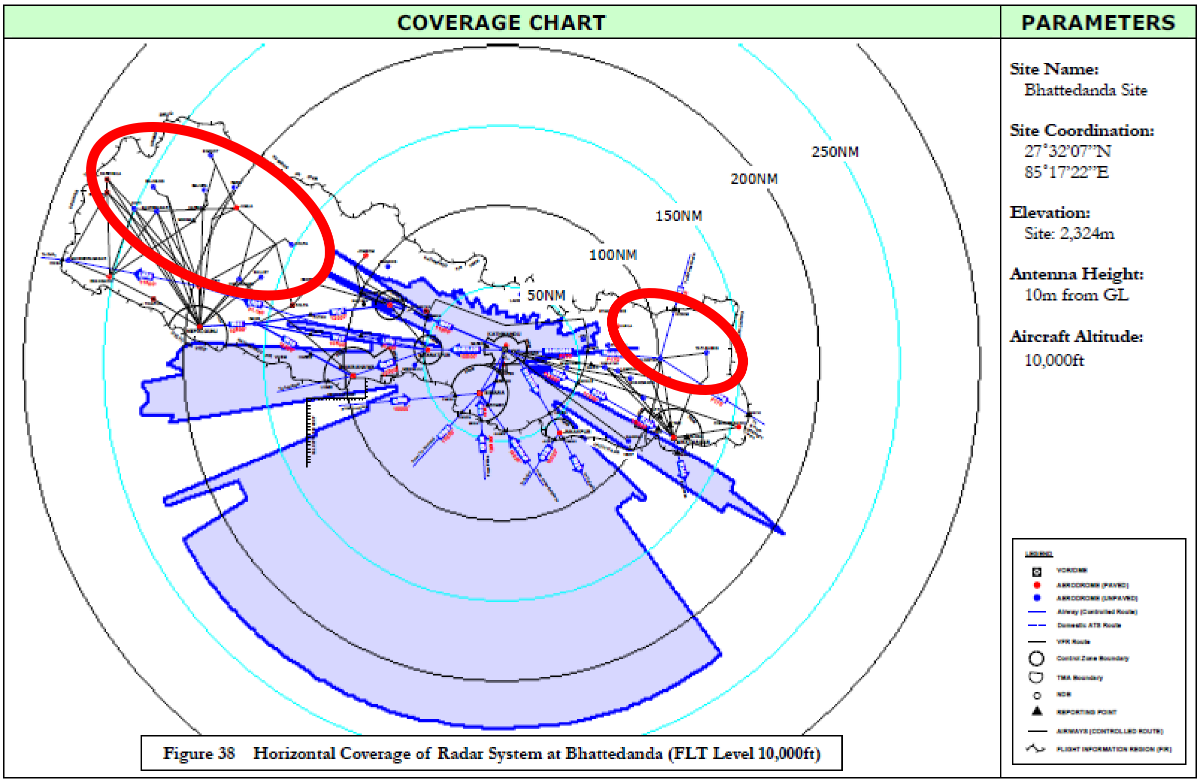


Figure 38 Horizontal Coverage of Radar System at Bhattedanda (FLT Level 10,000ft)

(Source: JICA Study Team)

Figure 3.3-23 Coverage of Mt. Bhattedanda Surveillance Radar

(B) Countermeasures

There are steep mountains around the mountain airports, which makes the visibility range often limited. In addition, the introduction of the conventional monitoring system is not considered realistic because there are problems in acquiring a place to install airport radars, transporting equipment and materials for installation work, and staffs for maintenance.

Therefore, consideration needs to be made for introducing a surveillance system that also has WAM functions, such as MLAT in Japan, to mountain airports where aircraft surveillance is required.

4) Metrology

(A) Issues

The following three points can be considered as the issues of weather at mountain airports.

① Shortage of Human Resources

Currently, DHM has assigned its staff at TIA to observe weather and provide weather information. However, due to the lack of personnel, it is difficult for DHM to assign weather observer at mountain airport, so air traffic controller provides the data obtained from metrological equipment. Since, DHM has dispatched personnel to only some airport it is difficult to observe weather from specialized point of view.

② Lack of Metrological Equipment

At the mountain airports, wind direction / wind speed anemometer, thermometer, and hygrometer are installed, but other observation devices are not installed. In addition, no device is installed to observe changes in weather conditions around the airport. Therefore, the change in weather conditions is confirmed by airline company through the current situation of the destination airport based on the ITV image set up by a private company (Weather News Co., Ltd.) and decides its operation.
Therefore, the change in weather around destination airport or the actual flight route causes flight accidents or cancellation of flights.

③ Lack of Weather Forecasting Technology

Due to the lack of data from the weather observation equipment around the mountain airports, it is difficult for DHM to construct a weather forecast model. Above all, at mountain airports, it is very difficult to predict the weather due to the unique topographical characteristics around the airports.
To develop a unique weather forecast model it requires a large amount of data collection and a research period.

(B) Countermeasures

Currently, DHM is introducing weather observation systems at 88 locations nationwide. The system is planned to be installed at some airports, but in the future, it will be necessary to install these systems at mountain airports to acquire weather data around the airport automatically.
Additionally, for the airport where the weather condition changes drastically, a small doppler radar or wind shear sensor installation needs to be considered to detect changes in weather condition and inform pilot about the condition to improve safety.
Introduction of such system will help in the collection of data necessary to develop forecast model around mountain airport, so that the operation service could be improved by knowing whether, by determining to take flight in advance, thereby improving the safety.

3.4 Improvement of Air Navigation System

3.4.1 Efforts to Improve Air Navigation Systems (Communication, Navigation, Surveillance and Metrological)

(1) Communication

1) Development of information network

At present, 18 airports have established an AFTN network and exchange the minimum necessary operational information by teletype. On the other hand, some airports are switching to AMHS, and the introduction of AMHS, including at major mountain airports, is under consideration.
It is also considering using a backbone network of a telecommunications company such as Nepal Telecom or Ncell to build an exclusive aviation network managed by CAAN.
System to share necessary information for aircraft operation and air traffic control, flight plan information, aircraft position information, weather information, etc. on IP-VPN network among related parties will be built in the future, similar to CAS.net in Japan.

(2) Navigation

1) Introduction of navigation facilities

In Nepal, DVOR and DME have been set up for TIA and major domestic airports (Gautam Buddha, Biratnagar, Nepalgunj, Simara and Pokhara airports). On the other hand, NDB, which had been used in the past, was retired at Chandragadhi, Dhangadhi, Jumla, Largevillage, Simikot and Tumlingtar in 2010, and no alternative equipment has been installed.
Therefore, for airports where NDB has retired, it is desirable to install VOR / DME at airports with relatively heavy traffic and at points where air routes are required to enable instrument flight in bad weather based on Grand Aid Improvement of aviation safety facility project (JICA Grand Aid). Rfter the project, the Government of Nepal requested that VOR / DME be installed at Chandragadi, Tumlingtar, Janakpur, and Dhangadhj airports.
As a result, agreements have been reached at two airports, Chandragadi and Dhangadhi airports, and development is currently underway.

2) Introduction of instrument landing system

At present, there is no Instrument Landing System (ILS) at TIA, and during bad weather, the aircraft frequently waits over or diverts to alternative airports nearby, resulting in frequent flight schedule delays and cancellations. To improve the situation, the installation of localizers and terminal distance measuring equipment (T / DME) is being promoted at TIA.
ILS will be installed at Gautam Buddha International Airport and Pokhara International Airport currently under construction. ILS Cat-II will be introduced at Gautam Buddha International Airport.
At this time, CAAN has no plans to introduce ILS for other airports, but there are airports other than the above listed airports where frequent flight delays due to poor visibility occur. therefore, so as air traffic demand increases in the future, there is a possibility that introduction of ILS may be considered for the purpose of improving the cancellation rate.

3) Introduction of GPS facilities

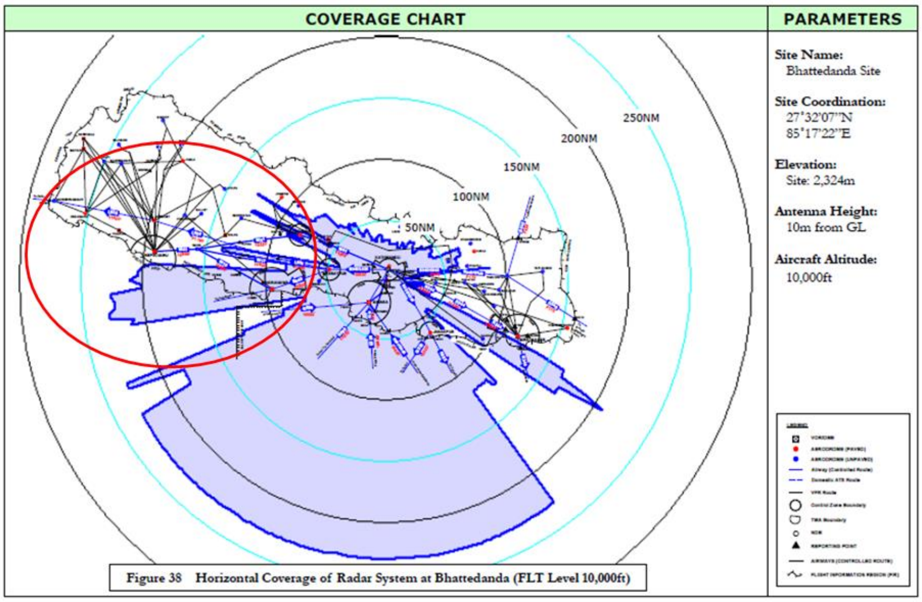
CAAN has mandated the installation of GPS receivers on aircraft since 2007 and is gradually introducing Performance Based Navigation (PBN) flight methods. In 2012, the RNP AR approach was set up at TIA, and about 10 of the international airlines are already operating compatible aircraft.
Meanwhile, major domestic airports are also planning to introduce the RNP GNSS approach.

Due to geographical constraints, it is difficult to introduce ground navigation aid facilities in the northern mountainous area. Therefore, there is a possibility that the introduction of a PBN flight system may be considered widely in the future.

(3) Surveillance

1) Introduction of Enroute Surveillance radar

Surveillance radar installed on Mount Bhattedanda can cover almost the entire area of the Kathmandu FIR at an altitude of 40,000 feet, while for lower altitudes below 12,000 feet, western Nepal becomes a blind area.
In the western part of Nepal, there is a domestic hub airport, Nepal Gunji Airport, and flights to mountain airports in the northwestern part of Nepal are based on Nepal Gunji Airport.
CAAN is considering the introduction of ADS-B to cover the current blind area of surveillance radar, but all aircraft used on domestic IFR flights are not compatible with ADS-B. Moreover, most fixed-wing and rotary-wing aircraft in Nepal, including flights to mountain airports, do not support ADS-B.
Therefore, it is estimated that the existing surveillance system should be introduced continuously until CAAN obliges airlines to equip ADS-B and it is spread.



(Source: JICA Study Team)

Figure 3.4-1 Coverage of Radar from Bhattedanda (altitude of 10,000 feet)

2) Introduction of ADS-B

CAAN is promoting the introduction of ADS-B based on the recommendations of the ICAO's report on the survey results (ATS Surveillance and TIA Approach and Landing Systems, 2011). The ICAO report recommends that a monitoring system be implemented phase by phase, with MLAT in Phase 1, WAM in Phase 2, and ADS-B in Phase 3.
It is recommended to install ADS-B receiving stations near the airport. CAAN has completed installation at four locations indicated by read circles in Figure 3.4-2 as of December 2019. In addition, according to the plan of CAAN, ADS-B receiving stations will be continuously installed, finally installed total in 9 places.

(Source: JICA Study Team)

Figure 3.4-2 Airports with ADS-B receiver

3) Introduction of WAM

WAM is planned to introduce in the new Pokhara International Airport currently under construction instead of airport surveillance radar.

The ICAO report also recommends installing WAMs at four locations around the Kathmandu Valley and five locations at TIA gradually for surveillance function.

However, according to the current CAAN policy, it is assumed that the development of ADS-B is basically proceeding, and the introduction of WAM is just ragarded as a substitute for usage of the airport radar from the viewpoint of cost effectiveness.

(4) Metrological

The Department of Hydrology and Meteorology (DHM) has been developing the following systems in the Building Resilience to Climate Related Hazards (BRCH) Project, which is supported by the World Bank.

1) Overview of Projects Related to Weather

Table 3.4-1shows an overview of the projects that DHM is currently carrying out with the support from World Bank.

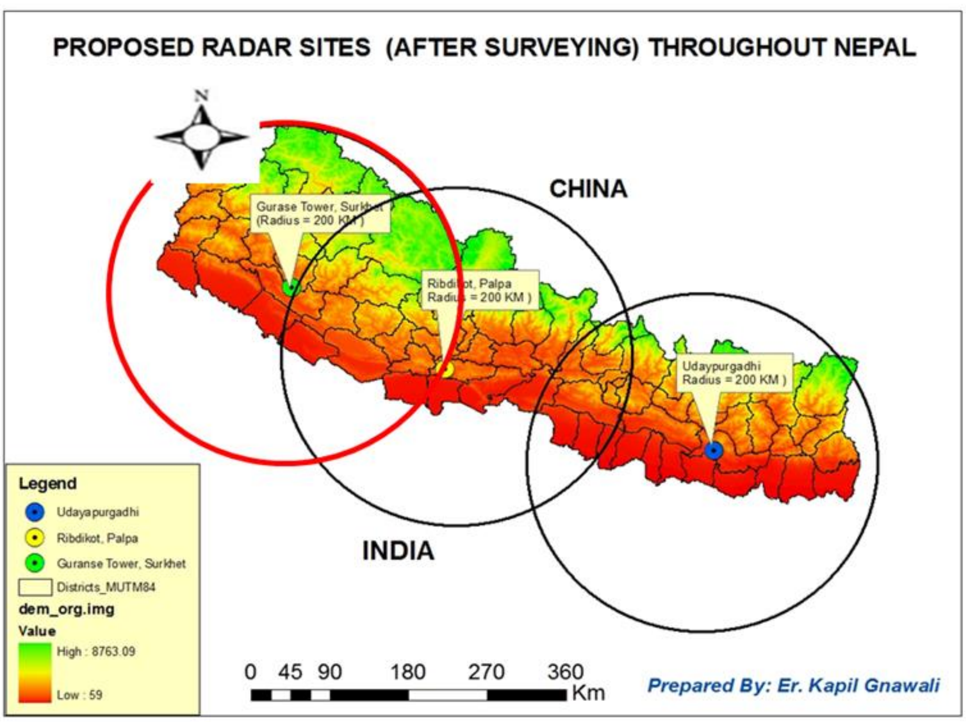
Table 3.4-1 Status of DHM Project Related to Weather

Project Name	Building Resilience to Climate-Related Hazards (BRCH) Project
Cost	31Million USD (Grant: 16Million USD、Loan: 15Million USD)
Duration	June 2013－November 2018 (5 and Half Years)
Revised Duration	December 2019
Completion Date	December 2020
Purpose	Strengthen the following field to mitigate damage related to weather, ➢ Improve accuracy and rapid weather and flood forecast ➢ Warning to weather-sensitive communities ➢ Construction of agricultural management information system to support farmers producing agricultural products affected by weather

(Source: DHM)

2) Acquisition of high-level weather data by installing weather radar

As a part of upgrading weather observation network under BRCH Project, the installation of weather observation radar (C-band radar) is underway. The plan includes installation of three radars of which one is currently installed at Surkhet. All the radars have a 200 km radius coverage but can cover only the southern part of Nepal and cannot cover the northern mountainous area.

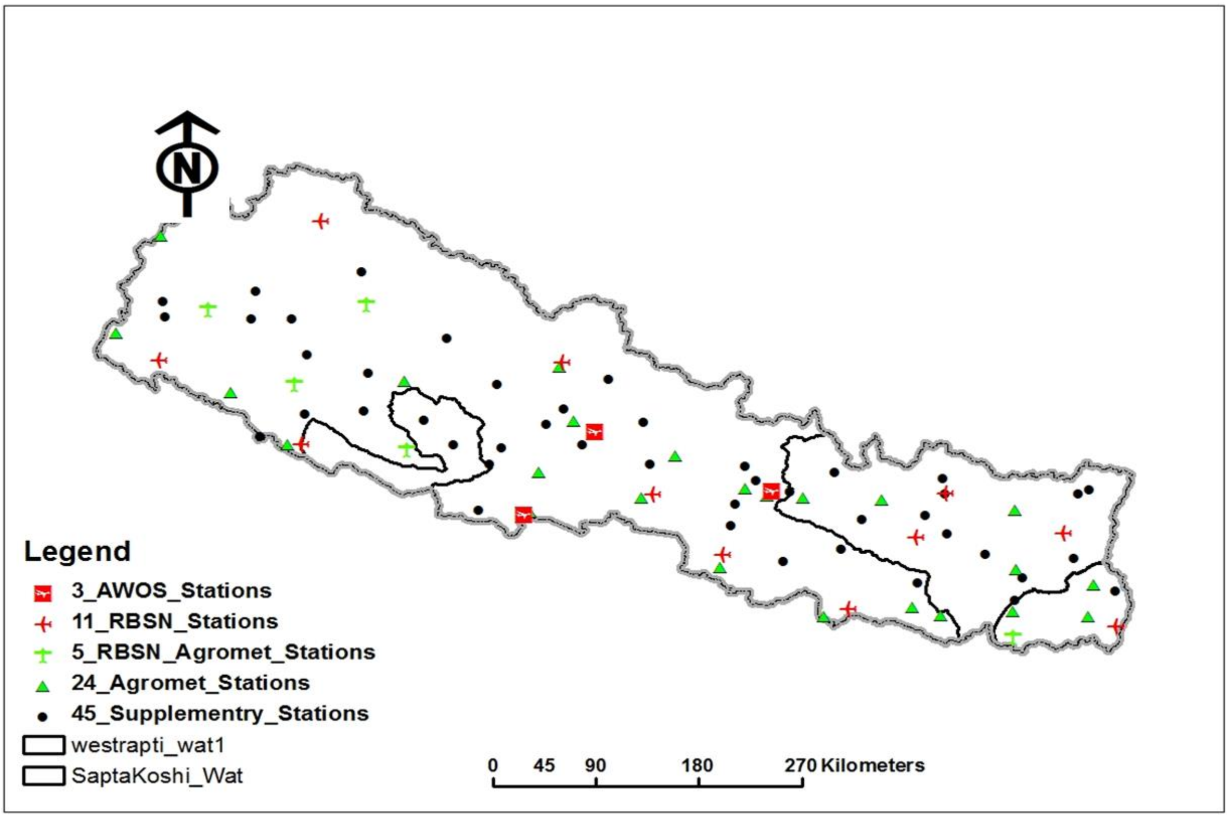


(Source: DHM)

Figure 3.4-3 Planned Location of Weather Radar in Nepal (Red circle indicates one already installed)

3) Acquisition of ground weather data by installing an automatic weather observation system

The BRCH Project also includes plans to install systems for observing and recording weather conditions in real time on the ground in 88 locations nationwide.
Of the 88 systems, 22-25 are planned to be installed near the airports or air routes. Currently, 74% of 88 systems have been installed.



(Source: DHM)

Figure 3.4-4 Planned Location of Weather Station

4) Construction of airline weather forecast model

DHM believes that airline weather forecasting models are indispensable in improving the safety of aircraft operations thus making the project as high-priority. Currently, the project for building a model is being done with the support of Finland.

3.4.2 Issues

Regarding the development of air navigation systems, it is necessary to consider facilities and systems that not only improve safety but also contribute to improve efficiency of air traffic control and the capacity of TIA.

(1) Expanding Radar Coverage in Western Nepal

At present, most of the central Nepal is within the radar coverage but the mountainous area and the western part of Nepal (Terai Plain) falls in blind area.The problem is that some areas are not within the radar coverage area because there are main routes for international flights and domestic flights in this area. Regarding the monitoring of high-altitude enroutes in the area, there are currently four ADS-B stations installed, and it is considered that there is no problem because all aircraft flying the enroutes are equipped with ADS-B. However, due to mixed operation of ADS-B equipped aircraft and smaller low altitude aircraft with no ADS-B, it causes the surveillance ineffective.

To solve this problem, it is necessary to install ADS-B on all aircraft operating over this region, so that even low altitude around the airport and western part can be monitored. If it's the issues with the cost, other means needs to be considered.

(2) Improving Information Network

Currently, the Civil Aviation Authority of Nepal does not have a network that centrally manages information necessary for air traffic control such as flight plan information, weather information, and aircraft position information. For this reason, the ACC (Area Control Centre) and the controllers at each airport cannot share the necessary information, and the controllers cannot provide the necessary information to pilots and airlines.

Obtaining weather information during flight is an important issue, but lack of appropriate weather information before flight is a big problem. It is necessary to take some measures to reduce error of judgements by pilots. Therefore, measures to make it easier to obtain weather information by connecting each airport in Nepal should be examined.

(3) Visibility from ATC Tower at TIA

One of the issues faced at TIA is that, the ATC tower lack visual coverages at domestic apron. If the controller lacks visibility, it will be difficult to guide when traffic is crowded, which will affect arrivals and departures. In addition, it is important for the controller to confirm the position of the aircraft, which leads to not only improvement in efficiency but also improvement in safety.

The improvement of efficiency could help in enhancement of TIA capacity, because it is expected to improve the flight delay which is caused by congestion on domestic apron, so it is important to consider measures to address this issue.

3.5 Improving Airport Security

3.5.1 List of Airport Security Equipment Owned by CAAN

Table 3.5-1 shows the list of security equipment possessed by CAAN. This table is based on the data obtained from the DATA Book-Air Transportation in Nepal on 30 October 2019 and updated through the first field survey.

Table 3.5-1 List of Security Equipment under CAAN

Location		EQP.Name	EQP. Code	Type*1)	Installed Date
Tribhuvan International Airport	1	Hold Baggage X-ray A1	ITB-A1	HS 100100T-2is	2019
	2	Hold Baggage X-ray A2	ITB-A2	HS 100100T	2017
	3	Hold Baggage X-ray B1	ITB-B1	HS 100100T-2is	2017
	4	Hold Baggage X-ray B2	ITB-B2	HS 100100T-2is	2019
	5	Hold Baggage X-ray SS A1	ITB	HS 100100T-2is	2014
	6	Hold Baggage X-ray SS Jet	ITB	HS 100100T-2is	2014
	7	Hold Baggage X-ray SS	ITB	CX100100D	2019
	8	Hold Baggage X-ray SS	ITB	CX100100D	2019
	9	Hold Baggage X-ray Dom	DTB	HS 100100T	2010
	10	Hold Baggage X-ray SS Dom1	DTB	HS 100100T	2013
	11	Hold Baggage X-ray SS Dom 2	DTB	HS 100100T-2is	2014
	12	Domestic Cargo X-ray	DTB	HS 130100T	2016
	13	Hand Baggage X-ray 1	ITB-S1	HS-6040-2is	2018
	14	Hand Baggage X-ray 1	ITB-S1	HS-6040-2is	2018
	15	Hand Baggage X-ray 2	ITB-S2	HS-6040-2is	2018
	16	Hand Baggage X-ray 3	ITB-S3	HS-6040-2is	2019
	17	Hand Baggage X-ray 4	ITB-S4	HS-6040-2is	2019
	18	Hand Baggage X-ray VIP	ITB-SV	HS-6040-2is	2019
	19	Hand Baggage X-ray Dom1	DTB	HS-6046si	2016
	20	Hand Baggage X-ray Dom2	DTB	HS-6046si	2010
	21	Hand Baggage X-ray RFF	RF-1	HS-6046si	2017
Biratnagar Airport	1	Hold Baggage X-ray	SMT	HS 9075 HR	2006
	2	Hand Baggage X-ray	SMT	HS 6040 i	2005
Gautam Buddha Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2015
	2	Hand Baggage X-ray	SMT	HS 6040 2is HR	2016
Nepalgunj Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2013
	2	Hand Baggage X-ray	SMT	HS 6040 2is HR	2016
Pokhara Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2010
	2	Hand Baggage X-ray	SMT	HS 6046si	2013
Simara Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2017
Chandragadhi Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2017
Dhangadhi Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2017
Bharatpur Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2019
Janakpur Airport	1	Hold Baggage X-ray	SMT	HS 100100T	2019

*1) Type: HS: Smiths Detection, CX: NUCTECH
(Source: CAAN)

3.5.2 Efforts in the Improvement of Airport Security of TIA and Other Airports

CAAN is updating its X-ray inspection equipment in line with the expansion of TIA's international passenger terminal. The upgrading of equipment includes introduction of dual-view X-ray inspection equipment (HS 100100T-2is, HS-6040-2is) that automatically detects explosives and liquids, which improves the security of airport.

3.5.3 Field Survey at Major Airports

Field surveys were conducted at different airports in Nepal; TIA on 8 December, Pokhara Airport on 4 December, and Nepalgunj on 12 December.

(1) TIA

International departing passengers' baggages are inspected through X-ray machine at the entrance (2 No.) of the international terminal building. After that the check-in passenger must go up to the second floor. Nextly, passing through the immigration control, carry-on baggage is inspected by X-ray machine and passenger must pass on the walk-through metal detector together with manual check performed by police personnel. The security checkpoint also have a liquid inspection device and explosive inspection devices. After passing the security checkpoint, passengers must wait in the departure lobby in front of the gates.

	
Photo 3.5-1 X-ray Machine at the Entrance of Passenger Terminal	**Photo 3.5-2 X-ray Machine for Carry-on Baggage**

(Source: JICA Study Team)

Currently, TIA has installed belt conveyor and X-ray machine for the check-in baggage behind the check-in counter inline with check-in counter area renovation work. Previously, check-in baggare were inspected by X-ray machine installed at the baggage identification area. Two X-ray machines are in operation now and two is in prepararion to install. When the renovation work is completed, there will be four x-ray machines to inspect passengers' check-in baggages.

	
Photo 3.5-3 Newly Installed X-ray Machine	**Photo 3.5-4 Old X-ray Machine before Renovation**

(Source: JICA Study Team)

For the international arrival passengers, they have to pass through the security check up before entering the baggage claim area, the security check includes carry-on baggage inspection and scanning by handy metal detector.

Towards the domestic terminal, departing passengers' baggage are inspected through an X-ray at the entrance. After the check-in, carry-on baggage inspection is carried by an X-ray machine and passenger is also inspected by a walk-through metal detector and manual check by police personnel. Check-in baggage is inspected by the X-ray machine, which is located the passage behind check-in counter.

(2) Pokhara Airport

The departing passengers are checked by a walk-through metal detector and police personnel manually. Carry-on baggage is scanned through X-ray machine.
The checked-in baggage is being inspected through X-ray machine placed next to the check-in counter.

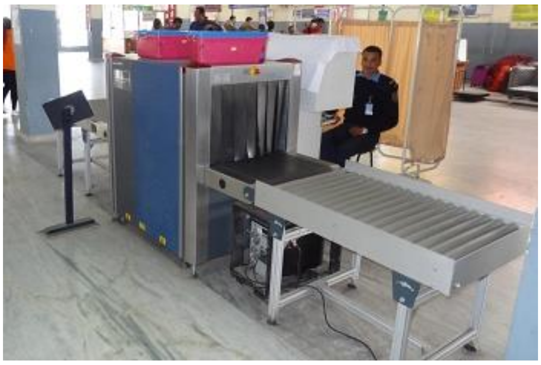


Photo 3.5-5 Checked-in luggage X-ray scanner	Photo 3.5-6 Carry-on baggage X-ray scanner

(Source: JICA Study Team)

(3) Nepalgunj Airport

All the departing passengers' baggage are being inspected by X-ray machine at the entrance of the terminal. After the check-in carry-on baggage is passed through the X-ray inspection machine and passenger passes through a walk-through metal detector scanner and then police personnel perform body check.

Photo 3.5-7 Checked-in luggage X-ray scanner	Photo 3.5-8 Carry-on baggage X-ray scanner

(Source: JICA Study Team)

3.5.4 Evaluation based on the International Standard, ICAO

At TIA, security process that checked baggage was returned to the passenger after inspected at the PTB entrance was problem. New X-ray inspection system has been installed behind the check-in counter in line with the renovation of the international PTB and problem of security process is dissolved.
Regarding passenger inspection and carry-on baggage inspection at TIA, the X-ray inspection device were updated in 2019 and explosives inspection device has been installed.

3.5.5 Issues

At TIA, the international PTB is currently undergoing renovation work, and security equipment has been improved in line with the internal layout changes, so there is no problem.

Pokhara International Airport and Gautam Buddha International Airport are scheduled to open in the future, and it is necessary to install security equipment in accordance with international standards for international airports.

X-ray inspection equipment is installed at domestic airports in the Terai area and it is hoped that security equipment will be installed at mountain airports in the future.

3.6 Human Resource Development in Civil Aviation Agency of Nepal (CAAN)

3.6.1 Human Resource Development System of CAAN

CAAN constitutes the Human Resource Development Policy-2013/14 for the following purposes:

a) To examine in-house and abroad trainings regarding regulatory and service provider disciplines required for CAAN employees according to different service, group, subgroup and level categories in line with the objective of CAAN operation system establishment.
b) Nomination of suitable employees and ensure their participation in various appropriate studies, trainings, observation visits, conferences, or seminars in order to enhance their work efficiency and capacity.
c) To provide advice, as required, to concerned directorate and department for the formulation of training plan in a way that it can be of help to the employees in their career progression.
d) To enhance the effectiveness of service of CAAN by bringing about substantial reforms in the development of HR.
e) To record and manage different kinds of trainings, seminars or workshops in which CAAN employees take part in a unified way.
f) To develop the Civil Aviation Academy (CAA) to international standards by equipping necessary resources capable of conducting trainings relating to all disciplines required by CAAN as envisioned by the National Civil Aviation Policy 2063B.S.
g) To attract and retain the adequately trained manpower in CAAN, as one of the objectives of this policy.

3.6.2 Employee Recruitment Conditions for CAAN

To be an Air Traffic Controller or Air Traffic Control Engineer who is in charge of maintaining the equipment, one must have a bachelor's degree at a university or college, major in either Science, Physics, or Mathematics. In Table 3.6-1, the educational background required for the Air Traffic Control Engineer for CAAN is shown.

Table 3.6-1 Educational Background Required by the Air Traffic Control Engineer, who is In-charge of Maintaining Equipment

Category	Level	Required Academic Background
Air Taffic Controller	7th*[1]	Bachelor in Science and IT Communication/ Management or equivalent Engineering
Flight Information Service	7th	Bachelor in Science and IT Communication/ Management or equivalent Engineering
Electronics	7th	Bachelor in Electronics and Communication/Radio/ Telecommunication/Electrical and Electronics or equivalent Engineering
	5th	Diploma in Electronics/Electronics and Communication/ Telecommunication/Electrical or equivalent Engineering (3 years course) after S.L.C*[2]
Electrical	7th	Bachelor in Electrical/Electrical and Electronic/Power system or equivalent Engineering
	5th	Diploma in Electrical/Electrical and Electronic power system or equivalent Engineering- 3 years course after S.L.C
Mechanical	7th	Bachelor in Mechanical equivalent Engineering
	5th	Diploma in Mechanical or equivalent Engineering- 3 years course after S.L.C

(Source: CAAN)

*[1] : 7th is a university graduate

*[2] : S.L.C is School Leaving Certificate (High school graduation certificate)

3.6.3 Training of the First-time Staff in CAAN

CAAN recruits new staffs based on the estimated number of staffs who will reach retirement age in the year 2018/2019, and the training plan according to service and class of position is indicated in Recruitment Plan-2013/14.
According to the Training Program set in December 2013, training categories with implemention date, trainers and training duration are set as follows: Items 1 &2 are to be provided at CAA while the rest are to be provided at CAA plus ICAO and others.

1. Job Entry/Indoctrination Training (Basic ATS Course, Basic ARFFS Course)
2. Induction Training (Relating with organizational traditions, relevant rules, regulations, and act, air transportation, aviation security, aviation safety including safety management system.)
3. On-the-job Training (Administration; Financial Administration; ATS; ARFFS; CNS; AVSEC; ANS; Air Route; PBN etc.)
4. In Service Training (Management and Executive Management)
5. Basic Inspector Training (ANS Safety Oversight Audit/Inspection Training, Aerodrome Safety Audit/Inspection Training, Flight Operation Safety Audit/Inspection Training, AVSEC Inspector/ Auditor)
6. Inspector Certification Training (ANS Safety Oversight Audit/Inspection Training, Aerodrome Safety Audit/Inspection Training, Flight Operation Safety Audit/Inspection Training, AVSEC Inspector/ Auditor)
7. Air Navigation Certification Traning (ANS Safety Training, Aerodrome Safety Training, Flight Operation Safety Training, AVSEC, Airfield Lighting, Instructors)
8. Recurrent Training (ANS Safety Oversight Audit/Inspection/Service Provider Training, Aerodrome Safety Audit/Inspection/Service Provider Training, Flight Operation Safety Audit/Inspection/Service Provider Training, AVSEC Inspector and Service Provider)
9. Refresher Training (ANS Safety Oversight Audit/Inspection/Service Provider Training, Aerodrome Safety Audit/Inspection/Service Provider Training, Flight Operation Safety Audit/Inspection/Service Provider Training, AVSEC Inspector and Service Provider)
10. Electro-mechanical Equipment Installation/Maintenance Training (Airfield Lighting Installation and Maintenance, Electrical Power System, Generator, General Lighting and Building Wiring, Electrical Automation and Control, Heavy Equipment, Diesel Generator, ATS Operation and Maintenance, Runway Sweeping Machine Training, Baggage Handling, Elevator, Escalator, Air Conditioning System, Fire Vehicle Maintenance, Air Pressure , Hydraulic, Transmission, Pump Maintenance, ICAO ANNEX-14 Certification, Quality Management System Training, Runway Friction Testing Training)
11. ATC Procedural Control Training (Aerodrome, Approach and Area Control Operations)
12. Terminal Radar Control Training (Radar Approach Control Operations)
13. Enroute Radar Control Training (Radar Area Control Operations)
14. ANS Training (Radar, VOR/DME, NDB, Localizer, PAPI, Air Field Lighting System Photometric Calibration, Met Equipment, Maintenance/ Measuring Tools, Weighing Machine, etc.)
15. Communication, Navigation, Surveillance and Security Equipment Training (VCCS, AMHS, Microwave Link, AMHS Refresher, V-Sat, GNSS, Satellite Communication, Digital Voice Recording Course, Data Communication, HF/VHF Maintenance Course; DVOR/DME, ADS-B, GBAS and ILS/GBAS; Radar and RDPS System, Test & Measurement Equipment, MLAT & ADS-B, Fiber Optic, Radar/Surveillance – Mono Pulse, Secondary Surveillance Radar, Multi Sensor Surveillance, Data Processing System etc.)
16. ATS Message Handling Service Training (Automatic Message Handling System Operations)
17. Aeronautical Information Management Training (Basic AIS; Advance AIS; E-cartography; GIS)
18. Aerodrome Engineering (Pavement, Design; Pavement Inspection, Procurement Management, Obstacle, Construction Audit Training, Airport Planning, Airport Familiarization; Airport Management)
19. Rescue and Firefighting Training; Emergency Vehicle Driving Training; Fuel Fire Training; Breathing Apparatus; First Aid Training; Fire Prevention; Bulk Fuel Equipment Manegement; Crisis Management; Command & Control; Fire Vehicle/Emergency Vehicle Operation; Aerodrome Monitoring; Dangerous Goods Handling Training Course)
20. AVSEC Training (AVSEC Management Training; AVSEC Quality Control; AVSEC Instructor Certification; AVSEC Inspectors Course; Crisis Management Training; AVSEC Basic Training; Screeners Certification Course; AVSEC Recurrent Training; AVSEC Refresher Training; AVSEC Supervisor Training; Cargo Security Course; Certification Course for Inspector/Instructor/Auditors; Aviation Security Equipment Operation and Maintenance Training)
21. Revenue and Tax Training (General Accounting/Finance Training; Refresher Training;

	Aeronautical/Non-Aeronautical Revenue Management System; Advanced Accounting System; Automation and Software Training; Financial Management Training; Tax, Public Procurement Regulation, Bidding, E-bidding related Training)
22.	Airport Operations Training (Airport Management; Terminal Management; Customer Service; Public Relations; Crisis Management; Emergency Handling)
23.	Administration/Management Training (Recruitment, Procurement related Training; Store Management; Library/Law/Statistics etc.; Monitoring & Evaluation; Aviation Insurance Related; Airport Statistics; Airport Management; Airport Revenue and Charges training; Procedure of Regulation Making; Air Service Agreement/Air Transport related Training; SSP Training; USOAP Audit related Course; Corporate Law related Training; Air Transport Economics; Aviation Commercial Management; Assets Management and Insurance; Aeronautical/Non-aeronautical Charges; Data Management System; Aviation Statistics; General Administration Training)
24.	Instructor Training (ATS; AVSEC; Communication, Navigation, Surveillance; Aerodrome Engineering; ARFFS; Train-the-Trainer)
25.	Internal Audit Training (Aeronautical Revenue Generation & Billing System; Advanced Accounting System; Internal Auditing Tech. & System; Management Training (Finance, Corporate, HRD, Revenue; Regulation, Public Procurement Regulation, etc.)

Induction Training is for the first-time employees, providing general philosophy in aviation safety including organization traditions and culture, related rules, regulation and behavior, air transportation, aviation security and safety management system. This training is conducted for seven days at most.

Job entry/Indoctrination Training is for the first-time employees who are assigned as Air Traffic Controller and Fire Extinguishing Rescue Worker.

On-the-job Training is for the employees who are assigned to a new job. This is conducted and provided for 15 days at most.

In Service Training is for the employees who are selected from the employees with three years or more work experience. This is provided and conducted for 30 days at most.

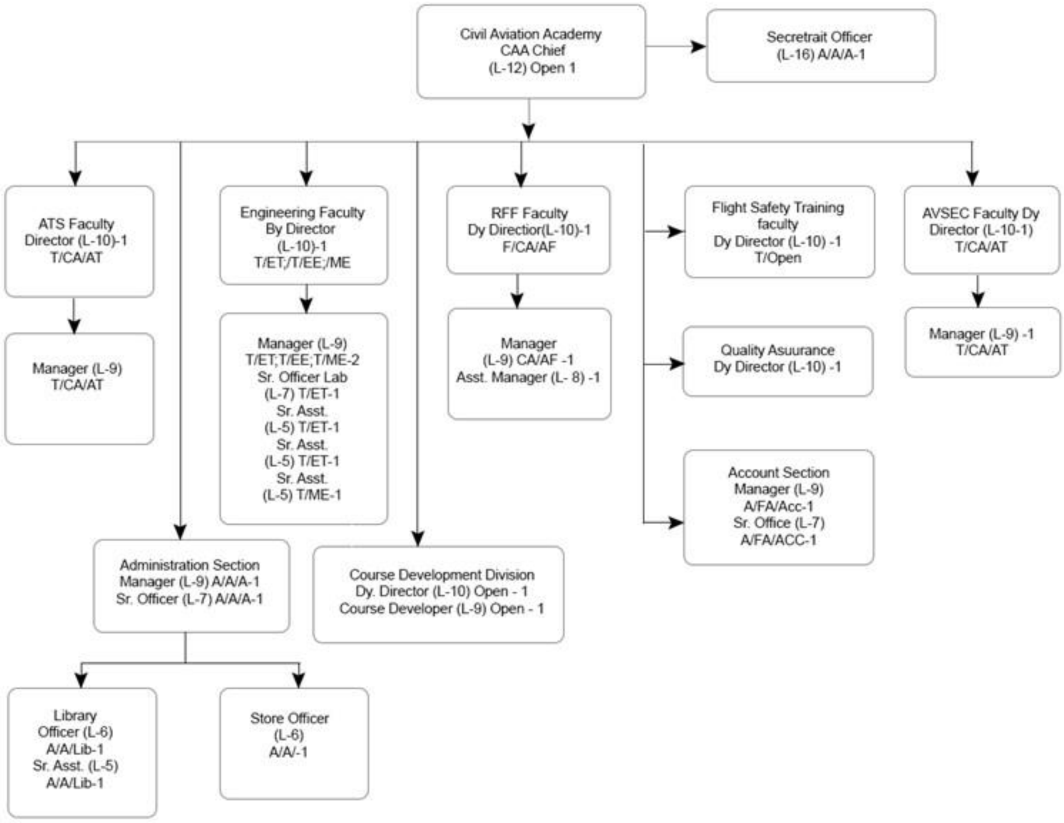
Earlier, a four-story facility (Former Training Center) was in place at TIA for the initial training and so on. However, the building collapsed five years ago due to the earthquake, which had impacted the training for the fresh staffs. At present, CAA (Civil Aviation Academy) that was established in the past through JICA project for the purpose of specialized training for air traffic controllers and technicians, is being used for the new staff training too. Since, CAA is small, it is necessary to coordinate the timing between the trainings. For this reason, CAAN is currently constructing a new training facility near CAA. The facility is expected to start its operation by 2022.

3.6.4 Features of the Civil Aviation Academy (CAA)

(1) Organization of the Civil Aviation Academy

The predecessor of CAA is the Civil Aviation Training Center that has been operated since 1976, providing training mainly for Air Traffic Controller of Nepal in compliance to ICAO standard. CAA's purpose is to provide high-quality trainings for the aviation sector professionals from in and out of Nepal.

Figure 3.6-1 shows the organization of the Civil Aviation Academy consisting of the Air Traffic Services Faculty (ATS), Engineering Faculty, Aerodrome Rescue and Fire Fighting Faculty, Aviation Security Faculty, Flight Safety Training Faculty (a total of five faculties), and Curriculum Development Division, Quality Assurance Division, Administration Section and Accounting Section.



(Source: CAAN)

Figure 3.6-1 Organization of the Civil Aviation Academy

(2) Facilities of the Civil Aviation Academy

Current training facilities of the Civil Aviation Academy consist of two classrooms, which accept 16 trainees, and two practice rooms. These two classrooms are full of training equipment all provided by Japan so there is no extra space for accepting new training equipment. In the last five years, the training equipment granted by JICA has been used for the training for Air Traffic Controller as well as Air Traffic Control Engineer. Belows are the currently installed training equipment.

- ✓ VOR/DME
- ✓ LLZ
- ✓ MSSR
- ✓ Air Trafficn Control Simulator

Photo 3.6-1 CAA Entrance

Photo 3.6-2 CAA Courtyard

Photo 3.6-3 Class Room (viewing rear)

Photo 3.6-4 Class Room (viewing forward)

Photo 3.6-5 SSR Simulator

Photo 3.6-6 LLZ Simulator

Photo 3.6-7 VOR/DME Simulator

Photo 3.6-8 Enroute Simulator

(Source: JICA Study Team)

(3) Training Results of the Civil Aviation Academy

Currently, the following trainings are provided in CAA:

- ✓ Five courses in ATS (Approach and Enroute, first-time staff, refresh)
- ✓ Nine courses in Aerodrome Rescue and Fire Fighting (Basic, Operation procedure, On-site, Monitoring, Driving vehicles)
- ✓ Three courses in Aviation Security (Passenger inspection, TIA Security in General, Basic)
- ✓ Three courses in Air Traffic Control Engineering (SMMS, LLZ, MSSR)
- ✓ Four courses in Admin / Account Section (Procurement, Administration, Refresh)
- ✓ Five courses in Flight Safety Training Division (SMS, Ramp Control, Tarmac Safety, Human Factor)

Actual training results in 2018 are as follows:

Table 3.6-2 Actual Number of CAAN Trainees in 2018

ATS Faculty	
Approach and Area (Enroute) Control Radar Surveillance Course	8
Approach and Area Control Course (AAC-003)	19
Civil Avia on Air Law and Opera on Procedures (CAALOP)	64
Civil Avia on Air Regula on For Dispatcher	2
MSDPS Course based on MSSR for ATC	4
Total	97
AVESC Faculty	
Field Based Avia on Security Course	40
Pre-Board Passenger Screening Training	23
TIA AVSEC Orienta on Programme	20
X-ray Examina on & Screening Procedure Course	16
Total	99
Flight Safety	
Airside and Ramp Safety Awareness Programme	39
Flight Operation Officer/Flight Dispatcher License Course	27
Ramp Operation and Safety	18
Safety Management and Human Factors Course (NOC)	14
Total	98
ARFF Faculty	
Advanced Aerodrome Rescue & Fire Fighting Course-006	30
Aerodrome Rescue & Fire Fight ng Course (ARFF008)	16
ARFF Field Based Course at Bhairahawa	22
Basic ARFF Refresher Course-009	16
Watch Tower Opera on Course (WTOC-002)	26
Total	110
Engineering Faculty	
Induction/Orientation Training Course for Engineering Personnel	16
Spare Parts Maintenance & Management System (SMMS) Basic Course	15
Total	31
Administration Department	
Induction/Orientation Training Course on "Administration and Management"	10
Curriculum Department	
Aerodrome Emergency Handling Course (119/207/RFF AEH)	10

(Source: CAAN)

CAA's training plan in 2019 is shown in the following table.

Table 3.6-3 CAA's Training Plan in 2019

S.N.	Program	Duration	Group	Participants	Remark
	A. ATS Faculty				
1	ATC Licensing, Aerodrome Control and AFIS Course (AAA-008)	29 weeks	1 group	16	
2	ATC Licensing, Aerodrome Control and AFIS Course (AAA-009)	29 weeks	1 group	16	
3	Approach and Area Control Radar Surveillance Course	11 weeks	2 groups	16	
4	AFIS Refresher Course	1 week	1 group	9	
5	ATS Refresher Course	1 week	2 groups	18	
6	ADC Refresher Course	1 week	1 group	10	
	B. Aerodrome Rescue and Fire Fighting Faculty				
1	ARFF Refresher Course-010	3 weeks	1 group	16	
2	Basic ARFF Training Course-011	14weeks	1 group	16	
3	Basic ARFF Training Course-012	14weeks	1 group	16	
4	Breathing Apparatus Course-007	1week	1 group	16	
5	Watch Tower Operation Course-005	3days	1 group	12	
6	Basic First Aid Training	2 days	1 group	10	
7	ARFF Field Based Training	1 week	1 group	8	
8	ARFF Field Based Training	1 week	1 group	8	
9	ARFF Field Based Training	1 week	1 group	8	
10	ARFF Field Based Training	1 week	1 group	8	
11	Advanced ARFF Course-008	6 weeks	1 group	16	
12	Watch Tower Operation Course-006	3days	1 group	12	
13	Watch Tower Operation Course-007	3days	1 group	12	
14	Basic ARFF Training Course-013	14weeks	1 group	16	
15	Breathing Apparatus Course-008	1week	1 group	16	
16	ARFF Field Based Training	1 week	1 group	8	
17	Advanced First Aid Training	2 days	1 group	10	
18	Advanced ARFF Course-008	6 weeks	1 group	16	
19	Emergency Fire Vehicle Driving / Operation Training	5 days	1 group	10	
	C. Aviation Security Faculty				
1	Pre-board Passenger Screening Training	75 hrs	6 groups	48	
2	TIA AVSEC Orientation Training	28 hrs	1 group	20	
3	AVSEC Field Based Training	26 hrs	6 groups	120	
4	AVSEC Post Evaluation	26 hrs	2 Airports		
5	AVSEC Screeners Certification		5 groups		
6	AVSEC Instructor Certification		1 group	16	
7	Basic AVSEC Officer Level Training		1 group	12-16	
	D. Engineering Faculty				
1	Basic SMMS Training Course	28 hrs	1 group	12	
2	Localizer Training Course	28 hrs	1 group	12	
3	Radar (MSSR) Training Course	5 weeks	1 group	12	
	E. Admin / Account Section				
1	Administrative Refresher Program	2 days	2 groups	16	
2	Public Procurement Management Course	7 days	1 group	16	
3	Insurance ToT	10 days	1 group	16	
4	Administrative and Office Management Course	7 days	1 group	16	
	F. Flight Safety Training Division				
1	Safety Management System (SMS) Course for CAAN	6 days	2 groups	12-16	
2	Ramp Operation and Safety Course for CAAN	4 days	1 group	12-16	
3	Human Factor for CAAN	5 days	1 group	12-16	
4	Airside and Ramp Operations Safety Field Based	4 days	2 groups	12-16	
5	Airside and Ramp Operation Safety Awareness Program Field Based	3 days	2 groups	12-16	

(Source: CAAN)

(4) Current Status in the Enhancement of the Civil Aviation Academy

During the 11th to 14th of December 2017, CAA on-site assessment audit program was performed by ICAO Expert Team in respect of the training manuals, materials, equipment and simulators that have been updated.
As a corrective action of the audit, CAA acknowledged the need to improve the abilities of training instructors and staffs.
CAA received the membership of ICAO TRAINAIR PLUS Program on 17 January 2019.
CAA completed the “Aerodrome Emergency Handling” (119/207/RFF AEH) as the Standardized Training Package (STP) on 28 December 2018, with the help of ICAO approved auditor for training course.
Considering this, CAA is believed to have a competency for setting up curriculum for Competency Based Training (CBT).

On the other hand, under CAA training plan, the building for ATS training is under construction and Singapore-made ATC simulator will be situated in the training building.
The Aerodrome Rescue and Fire Fighting Training Facility is also under construction. Therefore, it is believed that the constraints for the usage of the training rooms will be overcome.

3.6.5 Issues

(1) Challenges of the Training for the First-time Employees

Challenges of the training for the first-time employees based on interview survey are as follows:

a) As a human resource development plan, it is necessary to consider lifelong training plan to provide training according to the job to be stepped up, such as initial new recruite training, basic training in each field, specialized training, refresh training and management level training.
b) The curriculums for the first-time employees and introduction training are based on the those of Singapore Academy and other institutions as references, but making a good curriculum is difficult for CAAN. Therefore, CAAN requests Japan to support development of the curriculum for the administrative employees training, excluding Air Traffic Controllers and Fire Extinguishing Rescue Worker.

(2) Summary of Issues and Proposed Measures (Civil Aviation Academy)

The biggest issue was the shortage of training facility capacity, but this would be overcome by the construction of a new training building. It is known that upon completion, the training of Air Traffic Controllers would be started.
The second biggest issue is that there are no resident instructors. Instead of resident instructor, assigning a long-experienced staff who completed the training program in the past as an instructor would be feasible. However, the important point is the training materials. Regarding training materials, that should be made in accordance with the purpose as well as the set curriculum fully, any eligible instructor can provide the standardized level of trainings with short preparation time. Since CAAN and CAA received the membership of ICAO TRAINAIR PLUS program, it is believed that they have skills enough to prepare appropriate training materials. It is recommended to form a project team temporarily for modifying the materials or making new materials because improving skills for setting up new training materials is important.
During the survey, there is one request from trainees saying: “Because the SMMS training is useful for us staffs in aviation sector we would like to have many more chances to receive trainings. Please set up trainings instructed by the Japanese staffs.” This more or less shows the staff’s strong will to study aviation technologies due to the lack of training chances in Nepal.

3.7 Improvements to Safety Audit

3.7.1 Overview

With the aim of satisfying ICAO safety standards, CAAN has tied up a technical cooperation program with the Republic of France on 14 September 2017 as MOU. This MOU is aimed for promoting bilateral cooperation for the newly developed Nepal's civil aviation sector effective for four years.
CAAN has been receiving support from the European Union (EU) and ICAO for safety audits and confirmation of flight operation and airworthiness. Besides EU and ICAO, CAAN has started cooperation relationship with Boeing and FAA.

3.7.2 Organizations for Safety Audit (ANS Operation, Airport Operation, Operation by Aielines)

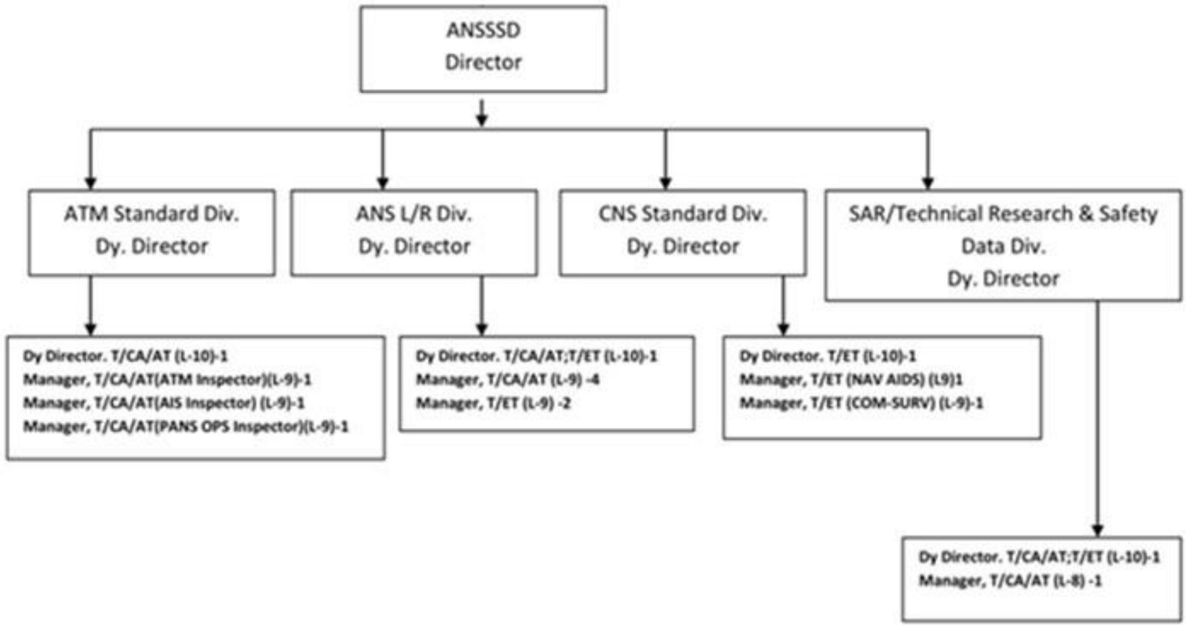
Currently, the organizations for Regulator and Service Provider are divided as departments in CAAN. The feature of regulator belongs to the Civil Aviation Safety Regulation Directorate and divided into departments depending on the field of business in the following:

- ✓ ANS Safety Standards Department: Air Traffic Control, Aviation Security
- ✓ Aerodrome Safety Standards Department: Airport Operation and Management
- ✓ Flight Safety Standards Department: Aircraft Inspection, Safety
- ✓ ICAO, International Affairs and Legal Department: ICAO Standards, In charge of ICAO Audit

3.7.3 Safety Audit of Air Traffic Control and Aviation Security Operation

(1) Safety Audit system

Figure 3.7-1 shows the organizational chart of the Aviation Security Operation Safety Standards Department (ANSSSD), which is responsible for overlooking safety of air traffic control operation. As of the December 2019 field survey, the capacity of ANSSSD was 21 staffs.



(Source: CAAN)

**Figure 3.7-1 Organization Chart of
Aviation Security Operation Safety Standards Department (ANSSSD)**

(2) Status of Safety Audit

The implementing status of Safety Audit for Air Traffic Control Service is shown in Table 3.7-1.

Table 3.7-1 Status of Safety Audit for Air Traffic Control Service

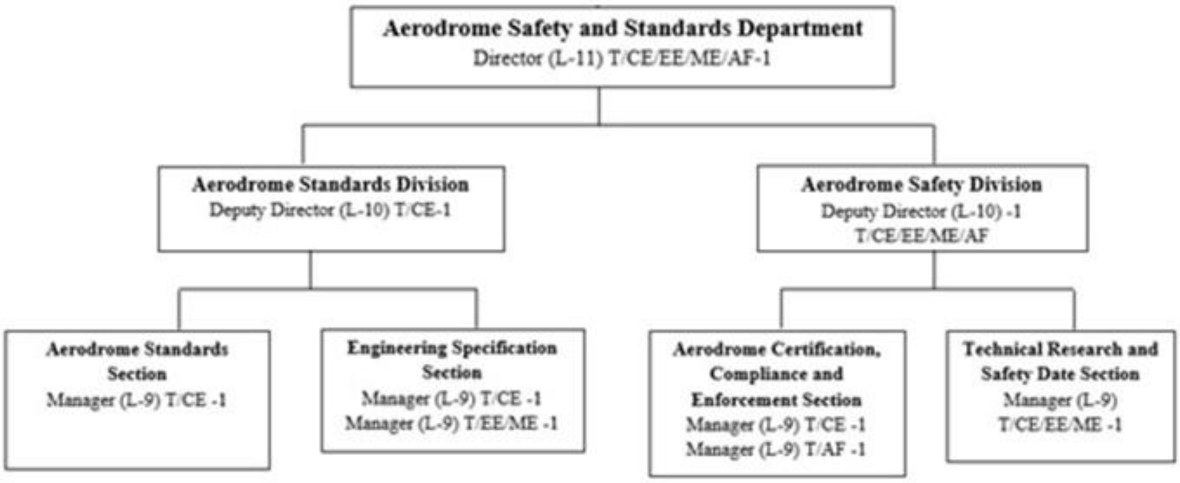
	2012	2013	2014	2015	2016	2017	2018	2019
AIMD						Aug.	Apr.	
ATMD						Aug.	Apr.	May
Bhairahawa	Aug.			Feb.		Feb.	Nov.	
Bharatpur				Feb.		Feb.		
Biratnagar		Jan.	Feb.	Jul.		Nov.		
CAA							Dec.	
Chandragadhi				Jul.			Mar.	
CND						Aug.		
Dhangadhi								Feb.
Dolpa							Oct.	
Janakpur		Mar.		Feb.				
Jomsom				Oct.				
Jumla					Sep.			
Kathmandu		Mar.		Jan.	Jun.		Dec.	
Lukla					May			
Nepalgunj	Dec.			Jan.			Oct.	Mar.
Pokhara		Sep.		Sep.				
Simara		Mar.			Feb.		Feb.	
Surkhet					Jan.			Mar.
TIACAO						Aug.	Sep. Dec.	
Tumlingtar							Dec.	Jan.

(Source: CAAN)

3.7.4 Safety Audit of Airport Operations

(1) Safety Audit System

The organization chart of the Aerodrome Safety and Standards Department (ASSD) responsible for safety audit of airport operations is shown in Figure 3.7-1. As of December 2019, there are nine staffs assigned.



(Source: CAAN)

Figure 3.7-2 Organization Chart of ASSD

The Aerodrome Inspector Handbook is made as a monitoring procedure and a checklist for monitoring aerodrome safety.

(2) Status of Safety Audit

The yearly safety audits and irregular safety audits are implemented at TIA, Biratnagar, and Nepalgunj airports that received Aerodrome Certificate in 2010, 2017, and 2019, respectively. Except for those these airports, implementing status of irregular safety audits is shown in Table 3.7-2.

Table 3.7-2 Status of Safety Audit for Airports with No Aerodrome Certificate

	2015	2016	2017	2018	2019
Gautam Buddha			Feb.	Apr.	
Bharatpur			Dec.		
Chandragadhi			Oct.		Apr.
Dhangadhi				Apr.	May
Janakpur			Mar., Dec.		
Jomsom				Nov.	
Jumla					May
Nepalgunj				Apr.	
Pokhara	Jan.		Sep.	Nov.	
Rara					May
Simara			Dec.		
Surkhet				Apr.	May

(Source: CAAN)

3.7.5 Technical Cooperation by the French Civil Aviation Directorate

Based on the MoU, France French Civil Aviation Authority (DGAC) supports the Civil Aviation Authority of Nepal (CAAN) in respect of technical information exchange aiming to set goals, with the help of two resided DGAC experts, in the field of Flight Operation Audit as well as Airworthiness Audit performed by CAAN. DGAC considers the CAAN support not only as partly an investment but also a chance to provide various types of trainings.

3.7.6 Technical Cooperation by International Civil Aviation Organization (ICAO)

ICAO has been proposing CAAN to be divided into service provider and regulator since 2009. As of April 2015, ICAO and Nepal signed the agreement on technical cooperation.
In the meantime, as of 29 November 2019, ICAO funded NPR 5.5 million with the aim of dividing CAAN into two separate entities.
In addition to funding, ICAO drafted a new law. The drafted new law has been forwarded to the ministerial meeting for approval in order to divide CAAN into service provider and regulator.

3.7.7 Issues

CAAN has a safety regulation department that sets standards, but dose not have a department that controls audit. In order to carry out safety management properly, ICAO has advocated to set a regulator which is an organization that audits the work situation from the aspect of safety management in addition to the agency that is said to be a provider of air traffic control.
Currently, MoCTCA and CAAN are newly installed as the Air Service Authority of Nepal (ASAN) and are considering the separation of responsibility between rule-making department and safety auditing department in the future.
As stated above, CAAN has challenges to clear safety standards provided by ICAO as soon as possible, and to establish the regulator function as new organization.

For this, CAAN is focusing on human resource capacity development through oversea training. Especially as for safety auditing, it is necessary to take related trainings, andit is being carried out in France and in Singapore. During this survey, there was request for Japan, for technical cooperation in the formulation of a manual for safety audits in the field of Civil Aviation.

3.8 Aviation Accident Investigation and Recurrence Prevention System

3.8.1 Overview

The Aviation Accident Investigation Commission is formed in the Ministry of Culture, Tourism, and Civil Aviation and the commission members are assigned by the order of the minister once an accident occurred. Accident investigation is conducted by the commission members. Among the ICAO member states, accident investigation is conducted normally by the team of a nation, where the accident occurred, a nation where the accident aircraft is registered, a nation where the airline involved in the accident belonged to, and an Accident Investigation Commission in the state where the accident aircraft is designed and manufactured. However, in many cases, the accident investigation is conducted by the nation itself where the accident occurred.
In the case of Nepal's accident investigation, the members of the Accident Investigation Commission are required to cooperate with the investigation commission members of the accident aircraft manufacturer in order to exchange information. This requires the commission members to acquire a certain level of knowledge and experience in the accident investigation field.

The accident investigation report is submitted to the Minister of Culture, Tourism, and Civil Aviation by the Accident Investigation Commission. From the recurrence prevention point of view, the Accident Investigation Commission would be required to submit a recommendation, which will be instructed to the airlines and related entities by the Minister. Thus, the Accident Investigation Commission members are formed by both aviation field members and other related members.

3.8.2 Organization of Accident Investigation Commission

According to the Aircraft Accident Investigation Procedure Manual of CAAN established in July 2011, the serious accident with fatalities is investigated by accident investigation commission members selected from the following ten entities under the consideration of the Ministry of Culture, Tourism, and Civil Aviation. The accident with no fatalities is investigated by a team formed by the Chief Investigator's discretion so that the members are varied.

1. Flight operations
2. Maintenance and aircraft records
3. Site survey
4. Cabin safety
5. Medical and human factors
6. Structures
7. Systems
8. Power plants
9. Flight recorders
10. Meteorology and Air Navigation Services

3.8.3 Investigation and Analysis by the Accident Investigation Committee

Currently, CAAN has 12 reports of aviation accident investigation that are published on the CAAN's website. The contents are summarized in Table 3.8-1 to Table 3.8-3.

Table 3.8-1 Summary of the Aeronautical Accident Investigation in Nepal (Part 1)

	1	2	3	4
Date of Accident	2019.4.14	2018.9.8	2018.5.16	2018.3.12
Registration	9N-AMH	9N-ALS	9N-AJU	S2AGU
Aircraft Type and Model	Let Kunovice (Czech) L410UVP-E20	Airbus (France) Heli AS350 B3e	Cessna (USA) Grand Caravan	Bombardier (Canada) DHC-8-402
Operator	Nepal Summit Air	Nepal Altitude Air	Nepal Makalu Air	Bangladesh US Bangla Air
Type of Flight	Charter	Charter	Charter	BS-211
Route/Airport	Lukla	Samagaon-KTM	Surkhet-Simikot	TIA
Accident Location	Helipad of the inner perimeter fence of the aerodrome	Steep cliff at an altitude of 6840 ft. in a dense forest.	At an altitude of 12800 at EKLABHUJ KHARKA, about 7.7 NM South East of Simikot Airport.	R/W 20 VOR Approach A about 442 meters southeast of the touchdown point of runway 20.
Condition and Situation	1. Excursed the runway during take-off roll from runway 24.	1. Deteriorating weather conditions	1. HF frequency was difficult to communicate to be affected by ionosphere disturbances. 2. Simikot Tower was unaware of the departure and the position of the ill-fated aircraft. 3. the aircraft could not maintain VMC.	1. VOR approach at TIA 2. No decision for return
Analysis	1. Operation by co-pilot. 2. Unreasonable acceleration and meandering without using the entire length of the runway.	1. PIC's decision to follow the same direct route back to VNKT in spite of the deteriorating weather conditions.	1. Continued inadvertent flights in bad weather (IMC). 2. flight for prolonged period in high altitude without oxygen supplement. 3. latent deficiencies in risk management and inadequacies in pilot training.	1. The PIC was under stress due to behavior of a colleague in the company and lack of sleep. 2. No practice for visual approach for runway 20 in the simulator. 3. A poor CRM between the crew.
Recommendations	To Summit Air 1. Training for rejected takeoff procedures in simulator. 2. Improve FDR function. To CAAN 1. Restriction of handing over of flight control by PIC to co-pilot. 2. Recordings of the pilot –ATC recording in all airports. 3. Study the possibilities of shifting the existing helipad at Lukla. 4. The interim recommendation issued by the commission should be followed accordingly.	To Altitude Air 1. Training and awareness programs for weather analysis. 2. Ensure safety culture in the company. 3. Ensure retention of required skilled and trained manpower. To CAAN 1. Ensure the availability of required skilled manpower to the company. 2. Strengthen the effective safety oversight.	To CAAN 1. training programs for single engine pilots. 2. Develop criteria for scenario-based training, use of flight simulators. 3. Training with IFR to pilot. 4. Review a definite qualifications and training requirements for instructors. 5. Evaluate the effectiveness of the essential management posts. 6. Existing problem on HF Frequency. Online weather camera to be rectified. 7. To deal with the post-accident trauma stress management. To Makalu Air 1. Adopt an Effective Engine Health Monitoring Program 2. Conduct scenario-based training for pilots. 3. Introduce continuous monitoring of the aircraft in flight. 4.Review SMS, hazard identification and risk management and mitigation. 5. Ensure that the provisions of FOR including Use of oxygen. To MoCTCA 1. Continuous monitoring of the implementation and compliance-status of remedial safety measures.	To CAAB 1. Physical and Psychological status should be assessed. 2. All airline pilots should undergo psychological evaluation as part of the training. To the Operator 1. Effective implementation of CRM. 2. Ensure the proper implementation of SOP. 3. To monitor and assess mental status of the crew. 4. Policy to de-roster any crew member found to be stressed. 5.timely reviewed and updated the relevant document. 6. Simulator training. 7. Reassess preflight briefing. 8. KTM Route clearance training. 9. Ensure Line Oriented Safety Audit. 10. Encourage Crews to be specific regarding their medical issues. 11. No Smoking in the flight. To CAAN 1. Strengthen the capacity of the ATCs. 2. The ATC to be more vigilant after the landing clearance in VMC.

(Source: JICA Study Team)

Table 3.8-2 Summary of the Aeronautical Accident Investigation in Nepal (Part 2)

	5	6	7	8
Date of Accident	2017.5.27	2016.2.24	2015.6.2	2015.3.4
Registration	9N-AKY	9N-AHH	9N-AJP	TC-JOC
Aircraft Type and Model	Let Kunovice (Czech) L410UVP-E20	Bombardier (Canada) DHC-6-400	Elticino-Tarmac (Switzerland) Heli AS350B3	Airbus (France) A330-303
Operator	Nepal Goma Air	Nepal Tara Air	Nepal Mountain Heli	Turkey Turkish Air
Type of Flight	Charter	Scheduled	Charter	TK-726
Route/Airport	TIA-Lukla	Pokhara-Jomson	Tembathang-TIA	TIA arrival
Accident Location	Sloppy terrain 130 feet short of the runway of Lukla airport.	Jomson Valley	On sloppy mountain terrain between Tembathang and Kathmandu.	Touch down towards the left edge of Runway 02
Condition and Situation	1. deteriorating weather 2. Aircraft was too close to the threshold of altitude. 3. After climb immediately, aircraft stalled.	1. Bad weather condition. 2. Flights deviating from the route. 3. Flight maintaining low altitude.	1. Bad weather condition. 2. Flight maintaining low altitude. 3. Hitting neutral wire of high tension line of NEA.	1. Approach Runway 02. 2. Below the minima. 3. Fog over the airport
Analysis	1. Critical terrain and rapidly deteriorating weather condition. 2. Pilot's loss of situational awareness 3. Improper pilot response to stall warning. 4. Voilation of SOP by the ATS and Pilot as well.	1. Loss of situational awareness. 2. Flight low altitude. 3. CFIT	1. Loss of situational awareness 2. Cumulative fatigue 3. Lack of obstacle maker at crash site	1. Decision of the flight crew to continue approach and landing below the minima. 2. Not to perform a missed approach.
Recommendations	To CAAN and the Operator 1. Launch Aviation Safety Campaign. 2. the pilots' proficiency also be taken into consideration while assigning flights to the crews and remedial action. To Goma Air 1. emphasizing on airport based training including the stall warning. 2. Review the Airline's Operation Manual and SOP. 3. Ensure compliance to the provisions of VFR flights. 4. Review the block time. 5. Effective implementation of SMS. To CAAN 1. Assign appropriate numbers of ATCs in AFIS Tower. 2. Initiate to upgrade their essential emergency medical facilities. 3. Rescue and Fire Service at Lukla. 4. SOP, proper CRM, CFIT. 5. Maintain essential MET EQ. 6. Extension of runway at Lukla. 7. Lighting system at Lukla for sudden and rapid lifting of fog. To MoCTCA 1. Monitoring for the effective	To Tara Air 1. An effective operational control of the aircraft should be maintained even outside main operation base. 2. Training new technology. 3. Ensure compliance to VFR flight. 4. Not to make an attempt in marginal weather condition. 5. Devise some mechanism for enroute weather. To CAAN 1. Safety oversight capability. 2. Develop procedures relating to navigation and communication. 3. Implement SMS 4. ELT registration 5. Using same visibility check point chart should be consistent. 6. Supervision for training. 7. Ccockpit image recorders. 8. Review the existing Flight Data Monitoring programs. To MoCTCA 1. Establish permanent Aircraft Accident Investigation Commission. 2. Resouce investigation. To DHM 1. Develop and facilitate to provide enroute weather.	To Mountain Heli 1. Develop a system on all the operation of the helicopter. 2. Operating outside the VHF range. 3. Install tracker device on all helicopters. 4. ensure the proper briefing to crews before flight. 5. Conduct Wire Strike Avoidance Training. 6. The passengers are positively identified and verified by any kind of IDs before boarding. To CAAN 1. Ensure helicopters are maintaining 500ft. AGL. 2. Flying hour limitation. 3. Introduce personality traits test. 4. Develop a requirement for wire strike avoidance training. 5. Issue awareness information to concerned operators and pilots. 6. Install marking in high tension wire as per ICAO Annex 14, Chapter 6.	To the Operator 1. Review the pilot qualification requirements to operate to TIA. 2.Ensure the Standard State Instrument Arrival procedures. 3. Ensure NAV data of FMS. 4. Act efficiently and effectively with understanding receiving NOTAM. 5. Establish a system of verifying the quality of charts. 6. Review RNP AR of TIA. 7. Review its crew composition requirements to flying TIA. 8. Ensure the crew safety procedures. To CAAN 1. Review crew qualification. 2. Ensure effective and efficient coordination between AIS and aerodrome authorities. 3. Ensure raw AIP. 4. Ensure providing vigilant and weather information. 5. Refresher training to ATC. 6. Report ATIS and Daily Facilities Status check list. 7. restore ATIS Communication. To MET 1. Ensure the SPECI representing deterioration in visibility. 2. Provide MET observation.

(Source: JICA Study Team)

Table 3.8-3 Summary of the Aeronautical Accident Investigation in Nepal (Part 3)

	9	10	11	12
Date of Accident	2014.8.3	2014.2.16	2013.5.16	2012.9.28
Registration	9N-AJI	9N-ABB	9N-ABO	9N-AHA
Aircraft Type and Model	Eliticino-Tarmc (Switzerland) Heli AS350B3	Bombardier (Canada) DHC-6-300	Bombardier (Canada) DHC-6-300	Dornie (Germany) Dornier 228-202
Operator	Nepal Fishtail Air	Nepal Nepal Air	Nepal Nepal Air	Nepal Sita Air
Type of Flight	Charter	Scheduled	Scheduled	Scheduled
Route/Airport	Panglang Helipad	TIA-Pokhara-Jumla	Jomson Airport	TIA depature
Accident Location	Last Resort helipad	The ridge of mountain between Pokhara and Jumla	Jomson airport Over runway06	420 m south-east of the threshold of Runway at TIA
Condition and Situation	1. clear Sky and Sunshine 2. impact with tail rotor blade on the ground	1. Refueling purpose at Pokhara. 2. Direct track was not possible due weather. 3. In course of avoiding weather pilots had to fly up and down and changing the heading.	1. Tail wind 8-12 kTs. 2. Touched down runway at a distance of approximately 776ft far from the threshold of runway 06.	1. Depature from runway 20 2. No strong wind 3. No bird strike
Analysis	1. Due to lack of procedure of the company in an unmanned Helipad. 2. Lack of situtional awareness of the resort manager.	1. Losing situational awareness while flying into instrument meteorological weather condition to the extent of Collision with terrain. 2. Inappropriate and insufficient crew coordination while changing course of action.	1. Change the runway to be used from 24 to runway 06 and landed with the prevailing tail wind of 08-12 KTS. 2. Lack of CRM	1. The flight crew did not maintain the airspeed above the stall speed and there was insufficient height available to recover when the aircraft departed controlled flight.
Recommendations	To CAAN 1. Check flight before first solo PIC flight. 2. Clearance should be amended. 3. Prepare a regulatory document related with the operation of helicopter at remote and unmanned areas or helipad. To Fishtail Air 1. SOP in single pilot operation. 2. Comprehensive safety briefing by PIC or operator. 3. Helicopter safety briefing leaflets. 4. Necessary safety precautions while approaching helicopter 5. The PIC should be briefed properly by the operations regarding safety precautions.	To MoCTCA 1. Establish an independent and effective aircraft accident investigation mechanism. To DHM 1. develop a mechanism to obtain the weather data not only of the airport stations but also from other parts of the country. To CAAN 1. violation of SOP, proper application of CRM, CFIT. 2. Appropriate Terrain Awareness Warning System. 3. Analysis of en-route weather. 4. Install onboard aircraft equipment for real time tracking in flight. To Nepal Air 1. Strengthen the training requirements on Crew. 2. Consequential safety risk especially in process of recruitment. 3. Enhance the flight dispatcher's capability. 4. Policy for the prevention of CFIT. 5. Effective implementation of SMS.	To MoCTCA 1. Establish Independent and effective aircraft accident investigation mechanism. 2, Promote safety culture. To CAAN 1. Violation of SOP, proper application of CRM, CFIT 2. Consider on the runway length and slope, Runway layout, runway condition, Runway marking, regulated weight, approach, trends of wind. 3. take risk mitigation mechanism 4. Training including STOL airfields and aircrafts operating limitations. 5. Stop tail-wind landing 5 kTs. To Napal Air 1. CRM training 2. Investigate and mitigate the risk. 3. Develop and maintain the procedures in STOL operation. 4. Update SOP ad guideline. 5. Develop SMS expert	To the Operator and CAAN 1. Ensure that their respective weighing machines. 2. Ensure all the hand bags and checked baggage, especially when carried to and from STOL airports. 3. Ensures all Dornier 228 aircraft are checked to confirm their engines. To CAAN 1. Training requirements in relation to engine malfunctions. 2. Review the training requirements for airline personnel responsible. 3. Review the suitability of the average weights 4. Checks of aircraft loadsheets. 5.Ensure that passengers are given safety briefings before departure. 6. Ensure controllers in the Airport Fire Watch Tower see all TIA areas. 7. Ensure Fire Service vehicles access To Sita Air 1. Review the policy that prevents pilots from landing. 2. safety briefings before departure. To TIA 1. Bird control program.

(Source: JICA Study Team)

Looking at those 12 accident cases, VFR flight accident around mountain airports or along flight routes have been occurred frequently. Among almost half of all cases are collision with the mountain on their flight route during bad weather.

When an accident is occurred, under the initiative of the Minister, accident investigation committee is established with the members designated from MoCTCA and CAAN and the investigation is carried forward. Normally as an ICAO member country, accident investigation committee member include country in which accident occurred, country of aircraft registration, operating country and country in which aircraft is manufactured. The country where the accident occurred shall cooperate thoroughly for the investigation of the committee.

3.8.4 Accident Reocurrence Prevention System

The recommendations of the Accident Investigation Committee regarding the improvement of accidents in mountainous areas are summarized in the following. The improvement recommendations pointed out a wide range of views, including specific airport facility development proposals, human resource development, and organizational reforms. Among the recommendations for improvement measures, examples covering a wide range of areas are shown.

(1) Civil Aviation Authority of Nepal and Airline Operators

1) Hold regular Aviation Safety Campaign and launch Safety Reporting System while emphasizing a non-punitive environment and being brought into notice behavior related to safety of all aviation personnel including pilots, ATS personnel, and maintenance staffs.
2) Considering that increased stress and fatigue as results of present air traffic congestion in TIA affected pilots' ability, take necessary remedial action for the assignment of flights.

(2) Goma Air Pvt. Ltd.

1) Review and strengthen company training policy and training program of the flight crews emphasizing on airport-based training incorporating unforeseen situations including effective response to the stall warning in simulator training.

2) Review and confirm the Airline's Operation Manual and SOP incorporating stabilized point and committed point in the approach procedure of the Category C stall airfield. Refering to this, flight crews shall use clear guidance to decide to continue the flight or take a roundabout route.

3) Develop a mechanism to monitor and ensure compliance of provisions of VFR flights, SOP and other relevant safety directives by the flight crew.

4) Review the block time of each sector and provide enough ground time for each flight.

5) GOMA Air should enhance the flight dispatcher's capability to enable them to fulfill their responsibilities as per the provision of company SOP.

6) GOMA Air should consider and further strengthen the effective implementation of SMS process more importantly based on reporting system by crews.

7) In the view of available number of flights, it is necessary that GOMA Air should identify the requirement of crew size to meet the flight requirement. Therefor they should be trained to identify the hazard, changes in systems, operational environment, and consequential safety risks.

(3) CAAN; Civil Aviation Authority of Nepal

1) Rgardless of the air traffic volume, ensure that assigned numbers of ATS personnel are manned in each shift of ATS Unit (AFIS Tower).

2) Depending upon the volume of air traffic, define the minimum experience required for an ATS personnel in each shift.

3) In participation with the management of local hospital or health post close to busy airport like Lukla, CAAN should initiate upgrade their essential emergency medical facilities such as readiness of oxygen and ventilators.

4) Assign adequate manpower for the rescue and fire fighting service and strength their equipment at Lukla Airport.

5) Implement on the spot inspection including violation of SOP, proper CRM, CFIT, and ensure effective mechanism for improving evaluation.

6) Take immediate action to set up and maintain essential MET equipment at Lukla Tower including the display of the real-time surface wind information of the runway threshold.

7) Consider immediately to extend the runway to the southern direction to allow landing approach at Lukla Airport.

8) Recommende indroductionof visual aid system or aviation lights at Lukla Airport where fogs and clouds are often occurred drastically on the final approach of the airport.

(4) MoCTA; Ministry of Culture, Tourism and Civil Aviation

1) Implement continuous coordination and monitoring with CAAN for the effective implementation of the safety recommendations issued by investigation commissions.

2) Ensure enough resources of finance, personnel, and technical experts available so that the investigation of an aircraft accident can be performed effectively and timely.

3) An independent and permanent organization should be established for the aircraft accident and incident investigation purpose. This organization should also be given the responsibility of monitoring the implementation of the safety recommendations issued by the Accident Investigation Commissions in the past and also act as the research body for the safety enhancement in the aviation sector.

3.8.5 Issues

With the information from CAAN and the follow-up status for improvement measures by the accident investigation committee, following issues were revealed.

- ✓ Since CAAN has no equipment to analyze Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR), analysis is entrusted to either the nation where the aircraft is manufactured or to France in which technical cooperation is signed.
- ✓ CAAN has a view that staffs that have been trained for development of tools and methods for accident investigation are required as for the accident investigation method, they want to take some trainings in Japan.
- ✓ While accident investigation committee submits the recommendation to MoCTCA, CAAN, and airlines for recurrence prevention and improving the operation of aircrafts, there is no systematical follow-up in CAAN for the improvement action.
- ✓ While an accident investigation is conducted by CAAN, no incident investigation is done. Since it is needed large analysis in considering preventaion measures of accidents, both accident and incident are needed to be surveyed.

3.9 Issues

Issues extracted in this chapter and the study policy in this survey are summarized in Table 3.9-1. The results of the preliminary study are described in Chapters 4-6.

Table 3.9-1 Issues of aviation sector in Nepal and Study Policy in this survey

Item	Issue	Study Policy
Airport Capacity Enhancement in Kathmandu Metropolitan Area	✈ The maximum runway capacity at TIA is nearing its limit. ✈ Even after the completion of master plan, handling capacity of airport in Kathmandu area will be insufficient due to limited runway capacity. ✈ Ramechhap airport located 150km from Kathmandu about 4 hours by road cannot serve as an alternative airport for TIA. ✈ Although the Nijgadh second international airport is planned to have two runways and annual passengers of 67 million to serve as a complement airport of TIA, it takes time to show the effect since some specialized work such as 1.35 km tunnel and bridges are included in the construction work of fast track connecting to Kathmandu.	As a measure to enhance the airport capacity of Kathmandu metropolitan area, it looks difficult to handle the aviation demand only by developing Lamechhap Airport and Nijgadh second International airport as alternative. The construction of Banepa domestic airport seems to be effective solution. On the other hand, issues related to construction of Banepa domestic airports as described in 3.1.3, measures to improve the airport capacity in the Kathmandu metropolitan area including measures for Banepa domestic airport development is described in Chapter 4.
Enhancement of Domestic Air Transportation	✈ After the start of operation of Pokhara International Airport and Gautam Buddha International Airport, some passenger using TIA are expected to use those airports. This will increase the air traffic demand in Nepal rather than complementing TIA. ✈ Airports in Terai region are being developed according to the airport master plan created by each airport, and it is expected that domestic operator will be using bigger aircrafts with the increase in domestic demand. ✈ Airports under construction by CAAN are in the mountain region with runway length of 700m or less. Due to this, if regular flights come to those airports, aircraft which can be operated will be STOL aircraft.	When working on the capacity enhancement of Kathmandu area, the situation listed on the left will be reflected.
Improvement of Mountain Airport Safety (Issues for airport facilities)	✈ Many of the present mountain airport have runway length of 700m or less, which is not enough for the STOL aircraft's takeoff and landing. ✈ Additionally, the distance from end of the runway to end of the runway strip can hardly be secured at some airports.	At mountain airports, it is difficult to extend the runway due to topographical condition, but consideration for extending runway as much as possible are described in Chapter 5.
Air Navigation Facility Issues (Communication)	a) VHF communication Dead Zone ✈ Between Nepalganj-Simikot, Pokhara-Jomsom, Kathmanu-Lukla, there are dead zones for VHF communication, where air-to-ground communication cannot be performed. This led to pilot without information on surrounding aircraft and weather data to ensure safety during flight and while landing. ✈ Two sites for installation of RCAG have been selected in the preparatory survey of grant aid project "Main Airport Aviation Safety Equipment development plan". Although it was not adopted in	In order to improve VHF communication at mountain airports and their surrounding airspace, consideration for installing RCAGs at locations that can cover major airports is discussed in Chapter 5.

Item	Issue	Study Policy
	the end, the confirmation for the range of VHF communication for the elimination of current dead zone on the selected site was verified.	
Air Navigation Facility Issues (Communication)	b) Lack of communication line to mountain airports ✈ The information exchange between the mountain airport and base airport are performed by poor quality HF communication and telephone line. Since HF communication has lots of voice breakages, the necessary information is notified and acquired through telephone line. ✈ At mountain airports, AMHS lines are not available except for some airports. Therefor, flight information and weather information are reported only by voice, the amount of information is limited, accuracy and timeliness are lacking.	Currently, there is no communication line other than telephone lines for communication between airports. In Chapter 5, consideration for the introduction of digital HF including securing a backup communication line, and depending on situation, diversion of ground-to-air communication depending on the situation are discribed.
Air Navigation Facility Issues (Navigation)	✈ Since radio waves do not reach the mountainous areas, navigation assistance facilities such as VOR / DME cannot be used, and it is difficult to install similar ground navigation assistance facilities. ✈ Due to this, VFR aircraft uses GPS information as a reference. However, the GPS accuracy in Nepal is not guaranteed to be used at a level for aircraft navigation. Therefor, it is necessary to verify the GPS accuracy and introduce a position accuracy supplementing system. ✈ In mountainous areas, it is necessary to be able to fly while ensuring a safe distance between aircrafts and between aircraft and topography.	GPS information has an error, and further accuracy is required for flight operations. Therefore, the introduction of SBAS, which is a system to reinforce GPS accuracy, will be discussed in Chapter 5.
Air Navigation Facility Issues (Surveillance)	✈ The enroute surveillance radar currently in operation does not cover the northern mountainous areas. ✈ Regarding the installation of ADS-B under the guidance of ICAO, most of the aircraft operating in the mountainous airport are not equipped with ADS-B related systems, Therefor, it is difficult to use ADS-B for aircraft surveillance in the northern mountainous areas at present. ✈ There are steep mountains around the mountain airport, and the visibility range is often limited. ✈ The introduction of the conventional monitoring system is not considered realistic because there are problems in acquiring a place to install airport radars, transporting equipment and materials for installation work, and labors.	Consideration for the introduction of surveillance system that also has a WAM function, such as MLAT in Japan, to mountain airport is necessary. It is discussed in Chapter 5.
Air Navigation Facility Issues (Weather)	✈ Shortage of Human Resources: DHM has assigned staff at TIA to observe weather and provide weather information. But due to limited personnel, air traffic controller is acting for the weather observation at the mountain airport. The number of airports which are sent professional staff for weather observation from DHM is limited, and it is under the situation that wether obsercation can not be conducted based on the specialized viewpoint. ✈ Lack of Metrological Equipment: Wind direction / velocity, temperature, and hygrometer are installed at mountain airports, but other observation devices and devices to grasp changes in weather conditions are not installed. Since changes of weather situation, accidents and flight cancellation have	At present, DHM is introducing meteorological observation systems at 88 locations nationwide. The system is planned to be installed at some airports, but it will be necessary to install these systems at mountain airports in the future and automatically acquire weather data around the airport For the airport where the weather condition changes drastically, a small doppler radar or wind shear sensor installation needs to be considered to detect changes in weather condition and inform

Item	Issue	Study Policy
	occurred due to deterioration of weather conditions along the flight route and changes in weather conditions around the destination airport. ✈ Lack of Weather Forecasting Technology: Due to the lack of observational data from the meteorological instruments around mountain airports, it is difficult for DHM to construct a forecasting model. Above all, at mountain airports, it is very difficult to predict the weather condition due to the unique topographical characteristics around each airport. Building a unique weather prediction model requires a large amount of data collection and a research period for model building.	pilot about the condition to improve safety. It is further discussed in Chapter 5.
Improvement of Air Navigation System	✈ Regarding the maintenance of aviation security systems, it is necessary to consider facilities and functions that not only improve safety but also improve efficiency of air traffic control and increase the capacity of TIA.	Consideration will be made for introducing an aviation security system that will contribute to the expansion of TIA capacity. Especially for TIA where ILS cannot be installed, consider GBAS with flexible landing system. Additionally, it is important to examine compatibility and effectiveness of new flight procedures using those ground facilities.
Improvement of Air Navigation System (Expansion of Radar Coverage to Western Nepal)	✈ Most of central Nepal is within the radar coverage area, but the mountainous area and western Nepal (Tarai Plain) falls under blind areas. ✈ There are distinct routes for international flights and domestic flights in this area, the problem is that some areas along those routes are not within the radar coverage area. ✈ Regarding the monitoring of high-altitude air routes in the same area, there are currently four ADS-B stations installed, and it is considered that there is no problem because all aircraft flying the air routes are equipped with ADS-B. However, due to mixed operation of aircrafts with ADS-B and smaller aircrafts without it, it causes the surveillance ineffective in the range of low-altitude air routes and around airports.	To solve this problem, it is necessary to obligate all aircraft operating over this region to install ADS-B, so that even low-altitude around the airport in western part can be monitored. However, there is an issue of cost allocation, other means also need to be considered.
Improvement of Air Navigation System (Development of Information Network)	✈ Currently, the Civil Aviation Authority of Nepal does not have a network that centrally manages information necessary for air traffic control such as flight plan information, weather information, and aircraft position information. For this reason, the ACC (Area Control Centre) and the controllers at each airport cannot share the necessary information, and the controllers cannot provide the necessary information to pilots and airlines ✈ Obtaining meteorological information during the flight is an important issue, but it is also a big issue in obtaining appropriate meteorological information before flight, and it is necessary to take some measures to reduce error in assumed judgements of pilots.	It is necessary to consider how to connect each airport in Nepal and obtain weather information at the destination airports easily.
Improvement of Air Navigation System (Visibility from ATC	✈ The ATC tower at TIA lacks visual coverages of domestic apron. If the controller lacks visibility, it will be difficult to guide when traffic is crowded,	Since the improvement of efficiency could help in enhancement of TIA capacity, it

Item	Issue	Study Policy
Tower at TIA)	which will affect smooth arrivals and departures. In addition, it is important for the controller to confirm the position of the aircraft, which leads to not only improvement in efficiency but also improvement in safety.	is important to consider measures for these issues.
Improving Airport Security	✈ The improvement of security equipment is in progress at TIA and major domestic airports but not yet at mountain airports. ✈ Although TIA security devices are being updated, it is desirable to install more advanced devices in the future.	In the medium to long term, it is desirable to improve security equipment at mountain airports and upgrade security equipment at international airports.
Capacity Development of Human Resources of CAAN	✈ Although initial trainings were conducted at 4-storey training facility at TIA, which collapsed because of the 2015 earthquake, the CAA (Civil Aviation Academy) set through JICA project is in use, but it is too small. A new training facility is under construction, which will be started operation by 2022. ✈ The curriculum for the first-time employees is based on that of Singapore Academy and other institutions as references. CAAN requests Japan to support the curriculum development for the administrative employees training, excluding Air Traffic Controllers and Fire Extinguishing Rescue Worker	It is necessary to identify the background education of those being hired as CAAN staff and consider implementing consistent education starting from hiring to management and to retirement.
Features of Civil Aviation Academy	✈ There is a shortage of resident instructors. ✈ Training materials which follow the purpose and curriculum fully lead less preparation work of resident instructors, and also it will be possible that any eligible instructor can provide the standardized level of trainings. Since CAAN and CAA received the membership of ICAO TRAINAIR PLUS program, it is believed that they can prepare appropriate training materials. Forming a project team for training materials temporarily would be recommended because skills for setting up new training materials and modifying them can be improved by concentrated hands-on jobs. ✈ Due to less opportunity to learn aviation technology, CAAN staff has a request to get more opportunities to attend training and seminars. The need for SMMS training is particularly high.	Consideration for the investigation of the CAA training items and see whether proper training is provided for each occupation. Also, confirm the implementation status of the training in which Japan is providing technical cooperation. Regarding the lack of training, it is necessary to consider the possibility of implementing under the JICA scheme and make a proposal.
Improvement of Safety Supervision Function	✈ Within CAAN's organization, there is a safety regulation department that sets standards, but no department or agency to control or oversees auditing those works. In order to implement properly safety management, the ICAO has proposed the establishment of a regulator, which is an organization that audits the business situation from the aspect of safety management, in addition to the agency that is said to be a provider of air traffic control. ✈ Currently, MoCTCA and CAAN are newly installed as the Air Service Authority of Nepal (ASAN), and are considering the separation of responsibility between rule-making department and safety auditing department in the future. ✈ CAAN has challenges to clear safety standards provided by ICAO as soon as possible and to establish the function of regulator as a new entity.	Although CAAN is considering the organizational restructuring of regulators and providers, it will be needed to investigate the status of the establishment of the new organization and whether it can carry out its work smoothly. Depending on the situation, consideration for the need of technical cooperation will be seen.

Item	Issue	Study Policy
Aviation Accident Investigation/Recurrence Prevention Measures	✈ Since there is no analysis device for FDR (Flight Data Recorder) or CVR (Cockpit Voice Recorder), the analysis is either outsourced to the aircraft manufacturing country or consider technical cooperation of France. ✈ There is need for the human capacity who receive training for the development of tools related to accident investigation, regarding accident investigation methods, there are some needs of training in Japan. ✈ There is no systematical follow-up from MoCTCA, CAAN or airlines, on the recommendation for accident recurrence prevention system as a part of the results in an accident investigation. ✈ While an accident investigation has been conducted, no incident investigation has been done. In the future, both accident and incident investigation are to be surveyed in order to manage setting recurrence prevention measures.	Analysis of the past accident investigation reports and confirmation regarding the implementation status of accident investigation techniques, management, and recurrence prevention follow-up is carried out. It is also necessary to consider technical cooperation regarding accident investigation.

(Source: JICA Study Team)

3.10 Consistency in National Development Plans and Measures

The national development plan of Nepal shows issues and implementation policies for each sector. Regarding the aviation sector, they intend to improve the safety, reliability, and convenience of aviation services in Nepal, thereby stimulating the demand using aviation services domestically and internationally and leading to economic growth in Nepal. In addition, it is also serving as important social connections securing traffic routes to remote areas where land traffic is unavailable.

(1) Improvement of Aviation Services

In the recent year, increasing airport capacity to meet the rapidly increasing air demand and improving customer service at airports and with airlines are recognized as challenges.

1) Enhancement of Airport Capacity

The on-time completion of ongoing Gautam Buddha International Airport project and Pokhara New international Airport project is urgent task and one of the important goals.
In addition, the expansion of TIA and the construction of the Nijgardh Second International Airport are in progress to meet the air traffic demand in Kathmandu, but the expansion of the current TIA airport is not sufficient, and the huge capital investment and securing access road are required for the Nijigardh Second International Airport. Therefor, consideration for the construction of domestic airport within Kathmandu area was also made.

2) Improvement of customer service at airport and with airlines

Just like the airport construction projects, it is considered to utilize PPP scheme for the operation of local airport. It is also mentioned to operate rocal airports which are important for both society and tourism for 365 days and improving accessibility through providing the aviation service between regional airports.

(2) Safety of Aviation Services

In Nepal, there are constant number of aircraft accidents, and one of the goals is to eliminate them. Regarding the improvement of aviation safety, efforts are being implemented by introducing the latest CNS (communication, navigation, surveillance) related equipment and facilities. At the same time, efforts to improve aviation safety monitoring system satisfied with international standard are considerd. In addition, they aim to reduce future accidents through applying lessons learned from accidents obtained by investigations in systematic, effective, scientific, continuous and neutral methods.
Regarding security, the main goal is to improve the security check system at an international standard.

(3) Improve Reliability of Aviation Services

Implementing a scheduled flight operation is mentioned in the national development plan. There is no clear reference in the national development plan regarding the cause analysis and effects the scheduled operation. However, the congestion at TIA of the domestic hub causes delayed flight operation.
Further aviation demand is expected by implementing measures to expand airport capacity to meet aviation demand, mitigating congestion at major airports and improve customer service, and improving aviation service safety for on-time operation.
Furthermore, under the Civil Aviation Act of Nepal, it is expected that the CAAN will be divided into operators and regulators to improve the operational efficiency and the professionalism of staff, and this will lead to improvement of operational efficiency and high professionalism. In addition, the Government of Nepal will develop a strategy for national air transport agreements, thereby signing aviation agreements with new countries, or through diplomatic routes to facilitate entry into international markets not served by Nepalese airlines. Thanks to this, it aims to improve Nepal's

economy by increasing number of tourist and profitability of Nepalese airline.
In addition to these sector-wide growth strategies, in national development plan, the Remote Area Air Transport Fund will be effectively used to secure important air routes to improve access to remote area which can not be expected profit.
Based on these policies of government of Nepal, following chapters contains improvement of air services, follow-on project such as Gautam Buddha International Airport, Pokhara New International Airport and Nijgardh Second International Airport which is under planning phase. Also, verification will be done for the construction possibility of Banepa domestic airport which has been examined by CAAN.
As per the history of Japan's support until now, analysis will be made on the aviation safety and room for improvement of security check systems, then Japan's future support plans will be considered.

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Chapter 4 Preliminary Study for the Capacity Enhancement of Airport in Kathmandu Metropolitan Area

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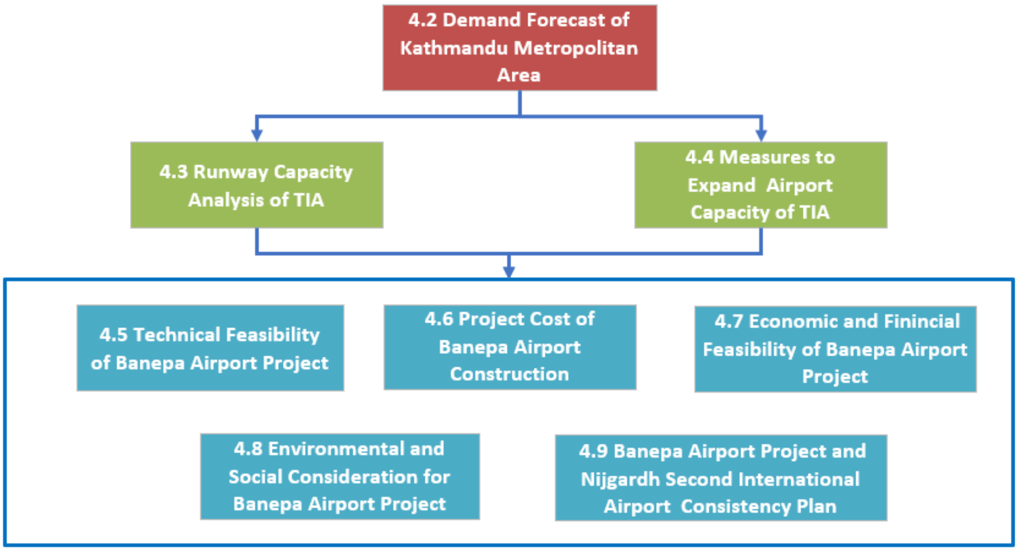
4 PRELIMINARY STUDY FOR THE CAPACITY ENHANCEMENT OF AIRPORT IN KATHMANDU METROPOLITAN AREA

4.1 Overview

In this chapter the measures to towards enhancement of airport capacity of Kathmandu Metropolitan Area will be examined as per the flow shown in Figure 4.1-1, to the issues that are described in chapter 3.



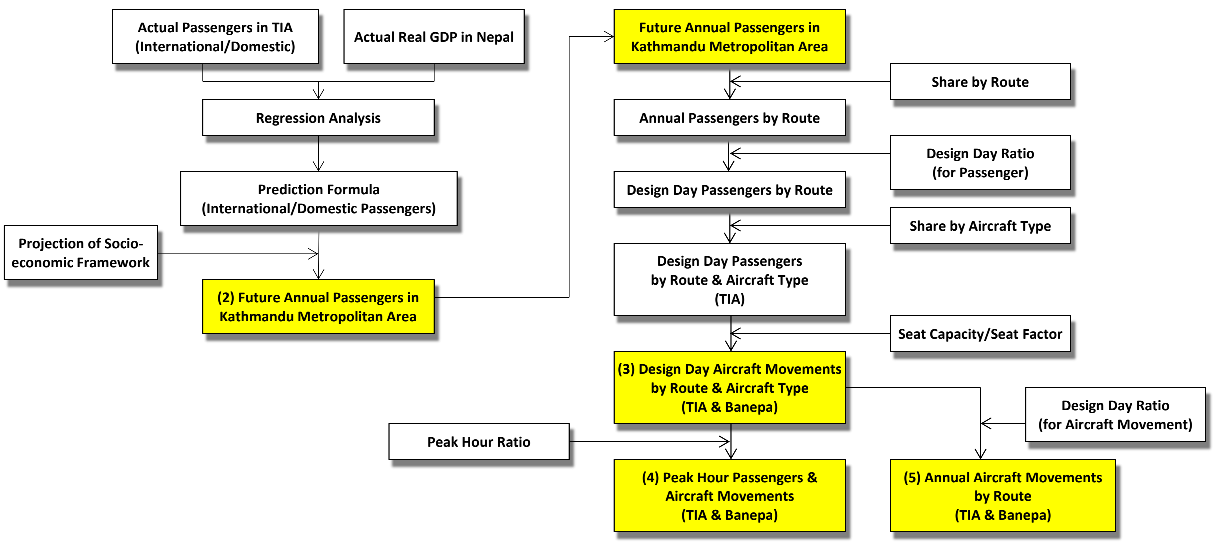
(Source: JICA Study Team)

Figure 4.1-1 Flow on the Measures to Enhance Airport Capacity in Kathmandu Metropolitan Area

4.2 Air Demand Forecast in Kathmandu Metropolitan Area

4.2.1 Overview

In the air traffic demand forecast, the annual passengers (international and domestic) in TIA is estimated in the begining, and based on this, aircraft movements and peak demand are estimated. Figure 4.2-1 shows the study flow of air traffic demand forecast.



(Source: JICA Study Team)

Figure 4.2-1 Study Flow of Air Traffic Demand Forecast

4.2.2 Air Passenger Demand Forecast

(1) Regression Analysis and Prediction Formula

Regarding the model for estimating air passenger demand, ICAO states in the "Manual on Air Traffic Forecasting, third edition 2006" as follows:

－ Regression analysis is by far the most popular method of forecasting civil aviation demand.

In this study, the construction of the prediction formula is based on regression analysis.
The formula in the regression model is based on a linear model, the explanatory variable in the regression model is real GDP, and the dependent variable is the number of TIA passengers. The result of regression analysis is as shown in Table 4.2-1.

Table 4.2-1 Prediction Formula for Air Passenger Demand Estimation

	Model for International Passengers	Model for Domestic Passengers
Analysis Period	2005-2018	2005-2018
Coefficient of Determination	0.974	0.763
t-Value of Variable	21.3	6.2
Prediction Formula	Y ＝ 7.876 × X － 2,543 Y: Annual International passenger (000) X: Real GDP（Billion Real NPR）	Y ＝ 3.949 × X － 1.096 Y: Annual Domestic passenger (000) X: Real GDP（Billion Real NPR）

(Source: JICA Study Team)

(2) Projection of Socio-economic Framework

Regarding the future GDP, the IMF (International Moneytary Fund) publishes forecasts up to 2024, and estimates an annual growth rate of 5.0% in 2024 (Table 4.2-2).

Table 4.2-2 Forecast for Annual Growth Rate of GDP by IMF

	2019	2020	2021	2022	2023	2024
GDP Growth rate	7.1%	6.3%	5.8%	5.3%	5.0%	5.0%

(Source: IMF, World Economic Outlook Database, October 2019)

Considering the growth rate of GDP in major Asian countries over 30 years (Table 4.2-3), it is assumed that future GDP growth will decrease by 1% in 10 years as shown in Table 4.2-4.

Table 4.2-3 Trend of GDP Growth in Major Asian Countries

	1980-1990	1990-2000	2000-2010	2010-2020	Decrease in 30 years	Average Decrease per 10 years
Japan	4.5%	1.3%	0.6%	1.0%	3.6%	1.2%
Korea	9.9%	6.9%	4.7%	2.8%	7.1%	2.4%
China	9.3%	10.4%	10.5%	7.1%	2.1%	0.7%
Taiwan	8.2%	6.7%	4.2%	2.4%	5.8%	1.9%
Thailand	7.9%	4.5%	4.6%	3.2%	4.7%	1.6%
Singapore	7.7%	7.1%	5.8%	3.4%	4.4%	1.5%
Average						1.5%

(Source: IMF, World Economic Outlook Database, October 2019)

Table 4.2-4 Future GDP Growth Rate

	2025-30	2030-35	2035-40	2040-45	2045-50
GDP Growth rate	5.0%	4.5%	4.0%	3.5%	3.0%

(Source: JICA Study Team)

(3) Annual Air Passenger Demand

The annual passenger demand is estimated from the prediction formula and future GDP as shown in Table 4.2-5 and Figure 4.2-2.

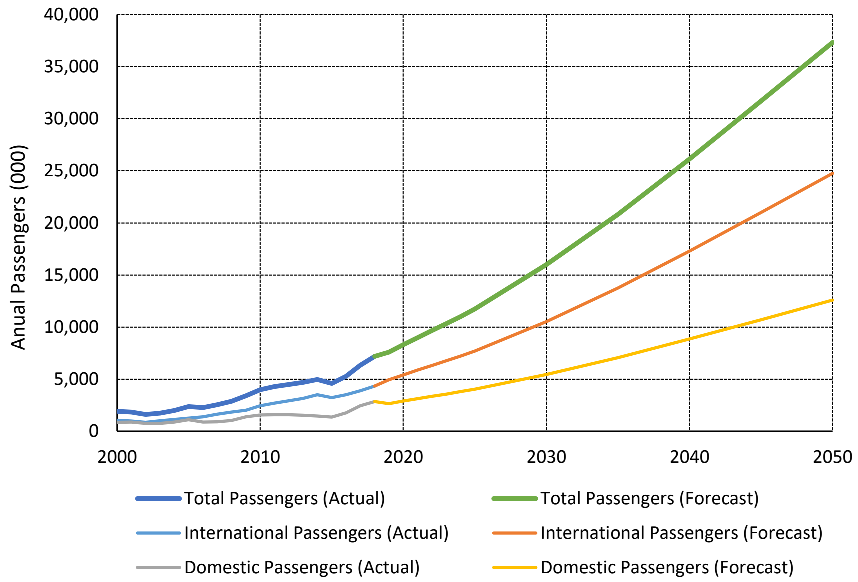
Regarding the annual passenger forecast, CAAN has published the demand shown in Chapter 2, 2.3.2 (5) in 2012. Comparing the demand in final year (that is 2035) in CAAN forecast with the result of this survey, the forecast of this survey is almost the same to CAAN optimistic forecast as shown in Table 4.2-6.

Because CAAN forecasts use a time-series model based on data up to 2011, they do not reflect demand growth in recent years, nor do reflect economic growth. On the other hand, since the forecast of this study is based on the correlation model between passenger demand and economic scale, the forecast reflects the recent increase in demand. Therefore, it is considered appropriate to be close to optimistic forecast which is higher demand among CAAN forecasts.

Table 4.2-5 Annual Air Passenger Forecast

	International Passenger		Domestic Passenger	
	Passenger (1000 person)	Annual Growth Rate	Passenger (1000 person)	Annual Growth Rate
2018 (actual)	4,342		2,848	
2030	10,531	7.7%	5,459	5.6%
2040	17,281	5.1%	8,844	4.9%
2050	24,747	3.7%	12,587	3.6%

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 4.2-2 Air Passenger Demand Forecast

Table 4.2-6 Comparison of Passenger Demand with CAAN Forecast

		CAAN Forecast			JICA Study
		Optimistic Forecast	Probable Forecast	Pessimistic Forecast	
2035	International	13,768	10,198	8,746	13,752
	Domestic	7,736	5,730	4,914	7,074

(Source: JICA Study Team)

4.2.3 Aircraft Movement Forecast

The aircraft movement is basically estimated based on the daily aircraft movement by route and aircraft type, and the daily aircraft movement is calculated based on the annual passengers by route and aircraft type. Therefore, it is necessary various factors such as "route share" to allocate passengers to each route, "share of aircraft type" to allocate passengers to each aircraft type, "seat capacity and seat occupancy rate" to convert from passenger numbers to aircraft movements and "design day ratio" to convert from annual passenger number to daily passenger numbers.

(1) Annual Air Passengers by Route

1) International

The share of international routes is categorized into Northeast Asia, Southeast Asia, Southwest Asia and the Middle East. The share of routes is based on the seat capacity by route in TIA's 2019/2020 winter schedule.

Table 4.2-7 Share for International Route

Route	Northeast Asia	Southeast Asia	Southwest Asia	Middle East
Share	20%	15%	20%	45%

Note: Northeast Asia: Japan, China、Korea
Southeast Asia: Thailand, Malaysia, Singapore
Southwest: India, Bangladesh, Bhutan
Middle East: Qatar, UAE, Turkey
(Source: Prepared by JICA Study Team based on TIA Schedule from CAAN)

Table 4.2-8 shows the annual international passengers by route.

Table 4.2-8 Annual International Passengers by Route

	Percentage	2030	2040	2050
Northeast Asia	20%	2,106	3,456	4,949
Southeast Asia	15%	1,580	2,592	3,712
Southwest Asia	20%	2,106	3,456	4,949
Middle East	45%	4,739	7,776	11,136
Total	100%	10,531	17,281	24,747

Note: Unit in 1000 person/year
(source: JICA Study Team)

2) Domestic

The share of domestic route is set as shown in Table 4.2-9 bassed on the current share by route of TIA in 2018.

Table 4.2-9 Share for Domestic Route

Route	Percentage	Route	Percentage
Pokhara	19.7%	Biratnagar	17.4%
Nepalgunj	13.8%	Bhairahawa	12.2%
Simara	7.5%	Bharatpur	7.4%
Chandragadhi	7.4%	Dhangadhi	5.8%
Lukla	4.0%	Janakpur	2.6%
Tumlingtar	1.0%	Surkhet	0.5%
Phaplu	0.3%	Bhojpur	0.2%
Rukum Salle	0.1%	Taplejung	0.1%

(source: JICA Study Team)

Table 4.2-10 shows the annual domestic passengers by route.

Table 4.2-10 Annual Domestic Passengers by Route

	Percentage	2030	2040	2050
Pokhara	19.7%	1,078	1,746	2,484
Biratnagar	17.4%	950	1,540	2,191
Nepalgunj	13.8%	754	1,222	1,739
Bhairahawa	12.2%	668	1,082	1,540
Simara	7.5%	408	661	941
Bharatpur	7.4%	405	655	933
Chandragadhi	7.4%	403	652	929
Dhangadhi	5.8%	314	509	725
Lukla	4.0%	221	358	509
Janakpur	2.6%	140	226	322
Tumlingtar	1.0%	55	89	126
Surkhet	0.5%	27	44	63
Phaplu	0.3%	19	30	43
Bhojpur	0.2%	10	15	22
Rukum Salle	0.1%	4	7	10
Taplejung	0.1%	4	7	10

Note: Unit in 1000 person/year
(source: JICA Study Team)

(2) Design Day Air Passengers by Route

The design day passengers is estimated by multiplying the annual passenger by the design day ratio, and the design day ratio is set based on the definition of "average day of peak month". The design day ratio is set based on the trend of the design day ratio obtained from the results of the past three years (see Table 4.2-11 and Table 4.2-12).

Table 4.2-11 Design Day Ratio (International)

	2016	2017	2018	Average Value
Peak Month	11-12	10-11	10-11	
Design day Ratio	1/319	1/310	1/314	1/310

(source: JICA Study Team)

Table 4.2-12 Design Day Ratio (Domestic)

	2016	2017	2018	Average Value
Peak Month	10-11	10-11	10-11	
Design day Ratio	1/265	1/277	1/286	1/290

Note: value based on 2018 result
(source: JICA Study Team)

The design day passengers by route are estimated as shown in Table 4.2-13 and Table 4.2-14 for international and domestic, respectively.
Peak passenger numbers by route are obtained for international and domestic flights as shown in Table 4.2-13 and Table 4.2-14.

Table 4.2-13 Design Day Passengers by Route (International)

	2030	2040	2050
Northeast Asia	6,790	11,150	15,960
Southeast Asia	5,100	8,360	11,970
Southwest Asia	6,790	11,150	15,960
Middle East	15,290	25,080	35,920
Total	33,970	55,740	79,810

Note: Unit in persons/day
(source: JICA Study Team)

Table 4.2-14 Design Day Passengers by Route (Domestic)

	2030	2040	2050
Pokhara	3,720	6,020	8,570
Biratnagar	3,280	5,310	7,560
Nepalgunj	2,600	4,210	6,000
Bhairahawa	2,300	3,730	5,310
Simara	1,410	2,280	3,240
Bharatpur	1,390	2,260	3,220
Chandragadhi	1,390	2,250	3,200
Dhangadhi	1,080	1,760	2,500
Lukla	760	1,230	1,760
Janakpur	480	780	1,110
Tumlingtar	190	310	440
Surkhet	90	150	220
Phaplu	60	100	150
Bhojpur	30	50	80
Rukum Salle	20	20	40
Taplejung	10	20	30
Total	18,810	30,480	43,430

Note: Unit in persons/day
(source: JICA Study Team)

(3) Design Day Air Passengers by Route and Aircraft Type

1) International

In order to estimate the aircraft movement by aircraft type, the international passengers by route is allocated by aircraft type. The aircraft type is categorized as shown in Table 4.2-15. The share for passenger allocation by aircraft type is shown in Table 4.2-17 in consideration of the current share (see Table 4.2-16) and upsizing of aircraft in future.

Table 4.2-15 Categorization of Aircraft Type (International)

Aircraft Classification	Seat number	Aircraft Type
Large Jet	300-350 seats	A330, B777
Medium Jet	Around 250 seats	B787, B767
Smaller Jet	Around 150 seats	A320, B737
Propeller	Around 70 seats	ATR72

(Source: JICA Study Team)

Table 4.2-16 Current Situation of Aircraft Share

	Large Jet	Medium Jet	Smaller Jet	Propeller
Northeast Asia	60%	—	40%	—
Southeast Asia	30%	—	70%	—
Southwest Asia	—	—	95%	5%
Middle East	60%	—	40%	—

(Source: JICA Study Team)

Table 4.2-17 Future Share of Aircraft Type

		Large Jet	Medium Jet	Smaller Jet	Propeller
2025-35	Northeast Asia	70%	—	30%	—
	Southeast Asia	50%	—	50%	—
	Southwest Asia	—	50%	45%	5%
	Middle East	70%	—	30%	—
2040-50	Northeast Asia	80%	—	20%	—
	Southeast Asia	60%	—	40%	—
	Southwest Asia	—	60%	40%	—
	Middle East	80%	—	20%	—

(Source: JICA Study Team)

2) Domestic Flights

In order to estimate the aircraft movement by aircraft type, the domestic passengers by route is allocated by aircraft type. The aircraft type is categorized as shown in Table 4.2-18, four domestic hub airports (Pokhara, Biratnagar, Nepalgunj and Bhairahawa) are expected introduction of jet aircraft from 2030 as shown in Table 4.2-19.

Table 4.2-18 Categorization of Aircraft Type (Domestic)

Aircraft Type	No. of Seat	Target Model
Jet	150 seats	A319, B737
ATR72-Class	75 seats	ATR72, DHC8-400
ATR42-Class	40 seats	ATR42
STOL	19 seats	DHC6, Do228

(Source: JICA Study Team)

Table 4.2-19 Assumption of Introduction of Jet Aircraft (Domestic)

Year of Introduction	Assumption of introduction ratio
FY2030	Replacing ½ part of ATR72 by Jet
FY2040	Replacing 2/3 part of ATR72 by Jet
FY2050	Replacing ATR72 by Jet

(Source: JICA Study Team)

(4) Design Day Aircraft Movements by Route and Aircraft Type

The aircraft movement is estimated by dividing the passenger numbers calculated in "(3) Design Day Air Passengers by Route and Aircraft Type" by the passengers per flight (multiply seat capacity by seat occupancy rate). The seat capacity and seat occupancy rate are shown in Table 4.2-20. The design day international aircraft movements is shown in Table 4.2-21, and the design day domestic aircraft movements is shown in Table 4.2-22.

Table 4.2-20 Seat Capacity and Seat Occupancy Rate

		Large Jet	Medium Jet	Small Jet	Propeller
International	Seat number	330	260	150	70
	Seat occupancy	85%			
		Jet	**ATR72**	**ATR42**	**STOL**
Domestic	Seat number	150	75	40	19
	Seat occupancy	90%			

Note: Seat capacity is set as the average of the major aircraft that correspond to each category.
(Source: JICA Study Team)

Table 4.2-21 Design Day International Aircraft Movements

		Large Jet	Medium Jet	Small Jet	Propeller	Total
2030	Northeast Asia	17	0	16	0	33
	Southeast Asia	9	0	20	0	29
	Southwest Asia	0	15	24	6	45
	Middle East	38	0	36	0	74
	Total	64	15	96	6	181
		Large Jet	**Medium Jet**	**Small Jet**	**Propeller**	**Total**
2040	Northeast Asia	32	0	17	0	49
	Southeast Asia	18	0	26	0	44
	Southwest Asia	0	30	35	0	65
	Middle East	72	0	39	0	111
	Total	122	30	117	0	269
		Large Jet	**Medium Jet**	**Small Jet**	**Propeller**	**Total**
2050	Northeast Asia	46	0	25	0	71
	Southeast Asia	26	0	38	0	64
	Southwest Asia	0	43	50	0	93
	Middle East	102	0	56	0	158
	Total	174	43	169	0	386

(Source: JICA Study Team)

Table 4.2-22 Design Day Domestic Aircraft Movements

		Jet	ATR72	ATR42	STOL	Total
2030	Pokhara	12	25	10	0	47
	Biratnagar	12	22	5	0	39
	Nepalgunj	10	17	4	0	31
	Bhairahawa	9	15	3	0	27
	Simara	0	0	39	0	39
	Bharatpur	0	0	39	0	39
	Chandragadhi	0	20	2	0	22
	Dhangadhi	0	15	2	0	17
	Lukla	0	0	0	44	44
	Janakpur	0	7	0	0	7
	Tumlingtar	0	0	5	0	5
	Surkhet	0	0	3	0	3
	Phaplu	0	0	0	4	4
	Bhojpur	0	0	0	2	2
	Rukum Salle	0	0	0	1	1
	Taplejung	0	0	0	1	1
	Total	43	121	112	52	328
		Jet	ATR72	ATR42	STOL	Total
2040	Pokhara	27	27	17	0	71
	Biratnagar	26	24	7	0	57
	Nepalgunj	20	19	6	0	45
	Bhairahawa	18	17	5	0	40
	Simara	0	0	63	0	63
	Bharatpur	0	0	63	0	63
	Chandragadhi	0	32	3	0	35
	Dhangadhi	0	25	2	0	27
	Lukla	0	0	0	72	72
	Janakpur	0	12	0	0	12
	Tumlingtar	0	0	9	0	9
	Surkhet	0	0	4	0	4
	Phaplu	0	0	0	6	6
	Bhojpur	0	0	0	3	3
	Rukum Salle	0	0	0	1	1
	Taplejung	0	0	0	1	1
	Total	91	156	179	83	509
		Jet	ATR72	ATR42	STOL	Total
2050	Pokhara	57	0	24	0	81
	Biratnagar	53	0	11	0	64
	Nepalgunj	42	0	8	0	50
	Bhairahawa	37	0	7	0	44
	Simara	0	0	90	0	90
	Bharatpur	0	0	89	0	89
	Chandragadhi	0	45	4	0	49
	Dhangadhi	0	35	3	0	38
	Lukla	0	0	0	103	103
	Janakpur	0	16	0	0	16
	Tumlingtar	0	0	12	0	12
	Surkhet	0	0	6	0	6
	Phaplu	0	0	0	9	9
	Bhojpur	0	0	0	5	5
	Rukum Salle	0	0	0	2	2
	Taplejung	0	0	0	2	2
	Total	189	96	254	121	660

(Source: JICA Study Team)

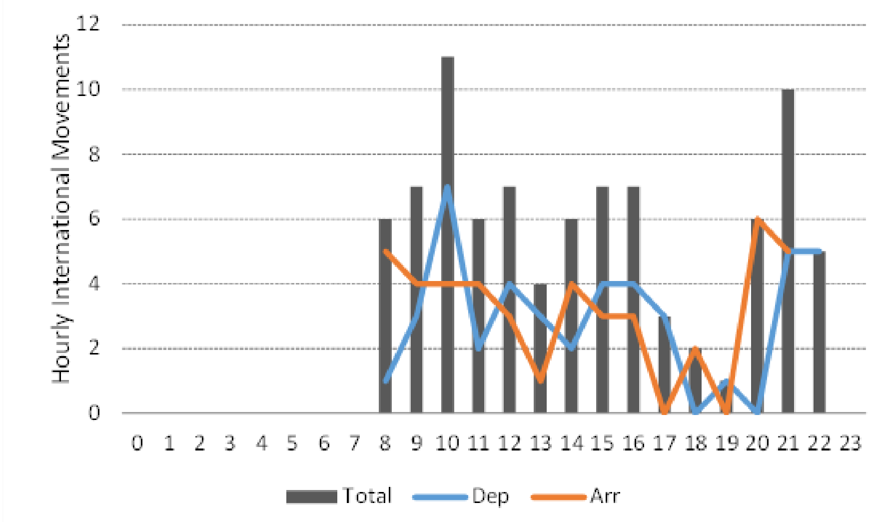
4.2.4 Peak Hour Demand Forecast

(1) Peak Characteristics Analysis

The peak hour passengers and aircraft movements are estimated by multiplying the design day passengers and aircraft movements by peak hour ratio.
The peak hour ratio is set by the ratio of the movements during peak hour to the daily movements, based on the schedule of departure and arrival of aircraft at TIA (the flight log of October 26, 2019).

1) International

The peak of the internatonal flight is between 10 and 11 am and between 9 and 10 pm, and the peak time zone is considered to be 5 hours from 8 to 12 o'clock. The peak hour ratio is set to 0.080 based on the average number of flights over these 5 hours and the number of daily flights (Figure 4.2-3).

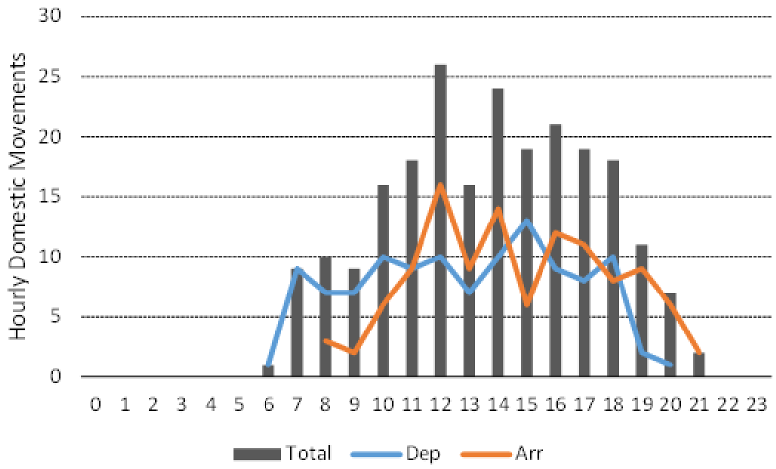


(Source: JICA Study Team)

Figure 4.2-3 Time Fluctuation of International Flight

2) Domestic

The peak of the domestic flight is between 12 am and 1 pm, and there are also many flights in the afternoon. The peak time zone is considered to be 5 hours from 12 am to 4 pm , and the peak hour ratio is set to 0.093 based on the average number of flights over these 5 hours and the number of daily flights (Figure 4.2-4).

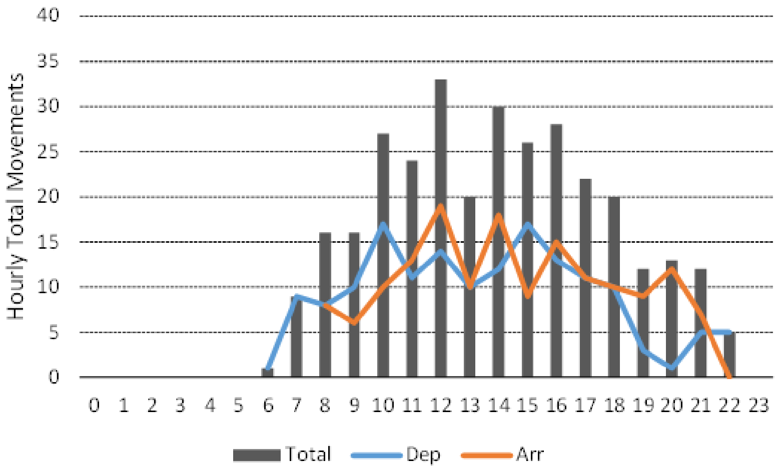


(Source: JICA Study Team)

Figure 4.2-4 Time Fluctuation of Domestic Flight

3) International plus Domestic

The peak of the International plus domestic flight is between 12 am and 1 pm, and there are also many flights before and after the peak time. The peak time zone is considered to be 7 hours from 10 am to 4 pm, and the peak hour ratio is set to 0.086 based on the average number of flights over these 7 hours and the number of daily flights (Figure 4.2-5).



(Source: JICA Study Team)

Figure 4.2-5 Time Fluctuation of International plus Domestic Flight

(2) Peak Hour Passenger

From the result of design day passengers and peak hour ratio, peak hour passengers are estimated as shown in Table 4.2-23 and Table 4.2-24.

Table 4.2-23 Peak Hour International Passengers

	2030	**2040**	**2050**
Design Day Passengers (person/Day)	33,970	55,740	79,810
Peak hour ratio	0.080	0.080	0.080
Peak Hour Passengers (person/hour)	2,720	4,460	6,380

(Source: JICA Study Team)

Table 4.2-24 Daily Peak Hour Domestic Passengers

	2030	2040	2050
Design Day Passengers (person/Day)	18,810	30,480	43,430
Peak hour ratio	0.093	0.093	0.093
Peak Hour Passengers (person/hour)	1,750	2,830	4,040

(Source: JICA Study Team)

(3) Peak Hour Aircraft Movements

From the result of design day aircraft movements and peak hour ratio, peak hour aircraft movements are estimated as shown in Table 4.2-25, Table 4.2-26, and Table 4.2-27.

Table 4.2-25 Peak Hour Aircraft Movements (International)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	181	269	386
Peak hour ratio	0.080	0.080	0.080
Peak Hour Aircraft Movements (times/hr)	14	22	31

(Source: JICA Study Team)

Table 4.2-26 Peak Hour Aircraft Movements (Domestic)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	328	509	660
Peak hour ratio	0.093	0.093	0.093
Peak Hour Aircraft Movement (times/hr)	31	47	61

(Source: JICA Study Team)

Table 4.2-27 Peak Hour Aircraft Movements (International plus Domestic)

	2030	2040	2050
Peak Day Aircraft Movement (times/day)	509	778	1,046
Peak hour ratio	0.086	0.086	0.086
Peak Hour Aircraft Movement (times/hr)	44	67	90

(Source: JICA Study Team)

4.2.5 Annual Aircraft Movement Forecast

(1) Seasonal Variation Analysis

Annual aircraft movement is estimated by following formula.

Annual aircraft movements = Design day aircraft movements / Design day ratio for movement

The design day ratio for movement is set as the ratio of the design day aircraft movement to the annual movement. Table 4.2-28 and Table 4.2-29 shows design day ratio for movement.

Table 4.2-28 Design Day Ratio for Movement (International)

	2016	2017	2018	Design Value
Peak Month	11	10	10	
Design day ratio	1/298	1/327	1/329	1/320

Note: design values are based on average of three years 2016-18

(Source: JICA Study Team)

Table 4.2-29 Design Day Ratio for Movement (Domestic)

	2016	2017	2018	Design Value
Peak Month	10	10	10	
Design day ratio	1/206	1/254	1/258	1/260

Note: design values are based on 2018 results

(Source: JICA Study Team)

(2) Annual Aircraft Movement

The annual aircraft movement is estimated by dividing the design day aircraft movement by the design day ratio. Table 4.2-30, Table 4.2-31, and Table 4.2-32 show the estimated annual aircraft movements.

Table 4.2-30 Annual Aircraft Movements (international)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	181	269	386
Design day ratio	1/320	1/320	1/320
Annual Aircraft Movement (times/year)	57,900	86,100	123,500

(Source: JICA Study Team)

Table 4.2-31 Annual Aircraft Movements (Domestic)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	328	509	660
Design day ratio	1/260	1/260	1/260
Annual Aircraft Movement (times/year)	85,300	132,300	171,600

(Source: JICA Study Team)

Table 4.2-32 Annual Aircraft Movements (International plus Domestic)

	2030	2040	2050
Annual Aircraft Movement (times/year)	143,200	218,400	295,100

(Source: JICA Study Team)

4.2.6 Air Traffic Demand Forecast in Banepa New Airport

(1) Aircraft Types and Routes Relocated to Banepa Airport

The purpose of Banepa Airport is to contribute to the expansion of TIA's runway capacity by accepting the relocation of operations of ATR42 and smaller aircraft operating in TIA. Therefore, the routes to be relocate to Banepa Airport are the routes currently operating ATR42 and smaller aircraft at TIA. The routes and airctaft to be relocate to Banepa Airport are shown in Table 4.2-33.

Table 4.2-33 Aircraft Type and Routes to be Relocate to Banepa Airport

	Runway:1,200 m		Runway: 800 m
	ATR42	STOL	STOL
Pokhara	△		
Biratnagar	△		
Nepalgunj	△		
Bhairahawa	△		
Simara	○		
Bharatpur	○		
Chandragadhi	△		
Dhangadhi	△		
Lukla		○	○
Tumlingtar	○		
Surkhet	○		
Phaplu		○	○
Bhojpur		○	○
Rukum Salle		○	○
Taplejung		○	○

Notes: ATR72 is the main aircraft on the routes marked with △, but this routes also include flights operated by small airlines with small aircraft, and these flights are subject to relocation to Banepa Airport.
(Source: JICA Study Team)

(2) Air Traffic Demand in Banepa Airport

The demand in Banepa Airport is the number of passengers and aircraft movements allocated to the subject routes and aircraft type.

Table 4.2-34 Annual Passengers by Route

	Runway: 1,200 m			Runway: 800 m		
	2030	2040	2050	2030	2040	2050
Pokhara	108	175	248	—	—	—
Biratnagar	48	77	110	—	—	—
Nepalgunj	38	61	87	—	—	—
Bhairahawa	33	54	77	—	—	—
Simara	408	661	941	—	—	—
Bharatpur	405	655	933	—	—	—
Chandragadhi	20	33	46	—	—	—
Dhangadhi	16	25	36	—	—	—
Lukla	221	358	509	221	358	509
Tumlingtar	55	89	126	—	—	—
Surkhet	27	44	63	—	—	—
Phaplu	19	30	43	19	30	43
Bhojpur	10	15	22	10	15	22
Rukum Salle	4	7	10	4	7	10
Taplejung	4	7	10	4	7	10
Total	1,416	2,291	3,261	258	417	594

Note: Unit, 1000 person/day
(Source: JICA Study Team)

Table 4.2-35 Design Day Aircraft Movements by Route

	Runway:1,200 m			Runway: 900 m		
	2030	2040	2050	2030	2040	2050
Pokhara	10	17	24	—	—	—
Biratnagar	5	7	11	—	—	—
Nepalgunj	4	6	8	—	—	—
Bhairahawa	3	5	7	—	—	—
Simara	39	63	90	—	—	—
Bharatpur	39	63	89	—	—	—
Chandragadhi	2	3	4	—	—	—
Dhangadhi	2	2	3	—	—	—
Lukla	44	72	103	44	72	103
Tumlingtar	5	9	12	—	—	—
Surkhet	3	4	6	—	—	—
Phaplu	4	6	9	4	6	9
Bhojpur	2	3	5	2	3	5
Rukum Salle	1	1	2	1	1	2
Taplejung	1	1	2	1	1	2
Total	164	262	375	52	83	121

Note: Unit, movement/day
(Source: JICA Study Team)

4.3 Analysis of Runway Capacity at TIA

The TIA's runway capacity is the most important factor in considering the future airport development policy in Kathmandu Metropolitan Area, and it is necessary to understand the current situation prior to the study.

(1) Site Survey for Runway Occupancy Time

The runway occupancy time is an important data for the study on runway capacity of TIA, however, there is no useful data available for the study. Therefore, the site survey to obtain the data for runway occupancy time by aircraft type was conducted at the tower of fire station located close to the runway. The survey method is as described below:

Table 4.3-1 Survey Method

・Record passage times at major points along aircraft movement (Figure 4.3-1)	(Landing Aircraft) ① Passing landing runway threshold ② Passing hold line at exit taxiway (Take-off Aircraft) ① Passing hold line at entry taxiway ② Aligning runway center line ③ Start of take-off ④ Passing take-off runway threshold
・Survey time	2 days, 7:00-12:00 (with the purpose of taking morning peak data based on the schedule of take-off /landing aircraft, Figure 4.3-2)
・Survey location	Observation tower at fire station

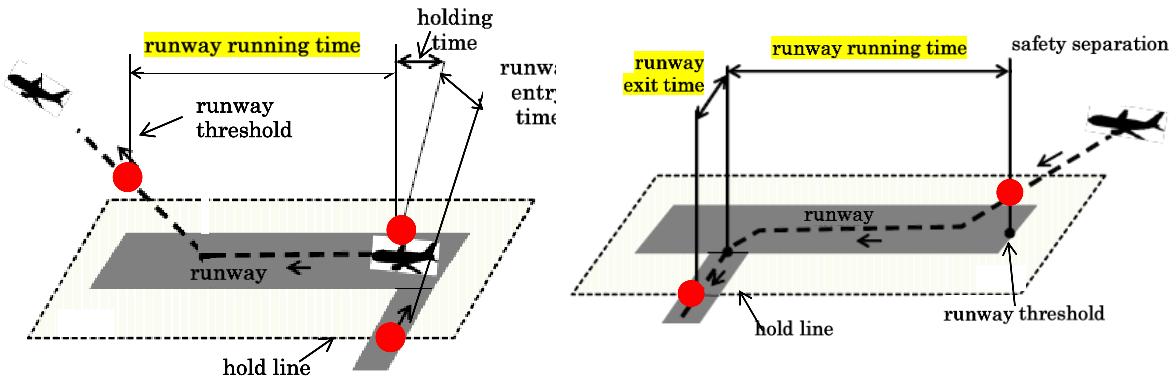
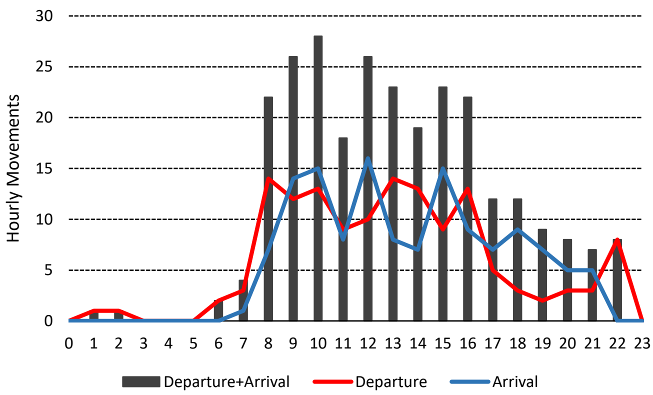


Figure 4.3-1 Checkpoints for Measurement of Passage Time



(Source: Flight Status, 1-7 November 2019)

Figure 4.3-2 Time Fluctuation of the Number of Take-off and Landing

(2) Result of Runway Occupancy Time Survey

Table 4.3-2 shows the result of the runway occupancy time by aircraft type. The runway occupancy time shown here is calculated under the condition that the parallel taxiway is fully constructed (the takeoff aircraft can enter the runway using the taxiway at the end of runway).

Table 4.3-2 Runway Occupancy Time by Aircraft Type

		STOL	ATR42/J41	ATR72	Jet
During Landing	Pass runway threshold- Exit hold line	1:15	1:15	1:19	1:21
During Take-off	Pass hold line- Align runway center line	0:15	0:20	0:20	0:30
	Waiting clear for take-off	0:18	0:16	0:13	0:14
	Start of take-off- Pass threshold	0:43	0:45	0:49	0:52
	Total	1:16	1:21	1:22	1:36
Safety Interval	Landing→Take-off	0:25	0:48	0:59	1:27
	Take-off →Landing	1:09	1:51	2:05	2:09
	Take-off →Take-off	0:44	0:19	0:41	0:48
	Landing→Landing	2:01	2:36	2:07	2:34
(Runway Occupancy Time by operational pattern) — include 2 movements of take-off or landing					
	Landing→Take-off	2:56	3:24	3:40	4:24
	Take-off →Landing	3:40	4:27	4:46	5:06
	Take-off →Takeoff	3:16	3:01	3:25	4:00
	Landing→Landing	4:31	5:06	4:45	5:16
(Occurrence rate by operational pattern)					
	Landing→Take-off	33%	35%	33%	13%
	Take-off →Landing	22%	29%	22%	46%
	Take-off →Take-off	14%	21%	22%	21%
	Landing→Landing	31%	15%	22%	21%
(Runway Occupancy Time) — include 2 movements of take-off or landing		3.37	3.52	4.05	4.49

(Source: JICA Study Team)

(3) Analysis of Runway Capacity of TIA

The runway capacity is estimated as the number of hourly movements based on the runway occupancy time. The runway occupancy time is calculated by a weighted average based on the share of the number of flights by aircraft type. The number of flights by aircraft is based on the flight log on October 26, 2019.

The runway capacity is estimated to be 28 times/hour (see Table 4.3-3). Compared to the runway capacity studied at Fukuoka Airport and Naha Airport in Japan, that is, 32 to 33 times/hour, the runway capacity at TIA of 28 times/hour is low even if parallel taxiway is completed. This is since the TIA secures a long safety separation between consecutive landing aircraft in the reason of following situations.

- ➢ Due to the topography around the airport, TIA sets the route for missed approach and departure that turn from north to south of the airport and pass directly above the arrival route. Therefore, in order to secure an enough safe separation between the landing aircraft and preceding landing aircraft, the minimum separation is set to 10 miles and the number of aircraft flying in the Kathmandu Valley is limited to one.
- ➢ At TIA, aircraft with different approach speeds such as jet aircraft, turboprop aircraft (ATR72, ATR42, etc.) and STOL aircraft arrive using on the same route. The air traffic controller is required to line up the arrival aircraft ensuring a required safety separation on this arrival route, and these tasks become difficult. Therefore, the minimum safety separation is set at 10 miles so that the space between aircraft can be safety secured.

Table 4.3-3 Estimation for Runway Capacity of TIA

(Smaller aircraft not allocated at Banepa)

Aircraft type	Number of operations				Occupancy time	Processing capacity
	Domestic Flight	International Flight	Total	Share		
STOL	14	―	14	8%	3:37	60min/4:14 ＝28 times/hr
ATR42/J41	37	―	37	22%	3:52	
ATR72	67	1	68	39%	4:05	
Jet	―	54	54	31%	4:49	
Total/Average	118	55	173		4:14	

In the case that a small aircrafts are relocated to Banepa Airport for the purpose of expanding the airport capacity in Kathmandu Metropolitan Area, runway capacity of TIA is slightly low at 27 times/hour (Table 4.3-4), because jet aircraft with long occupancy time remain in TIA.

According to the interview with TIA's ATC staff, the runway capacity under the IMC *(Instrument Meteorological Condition, weather condition other than VMC (Visual Meteorological Condition), which visibility is less than 5 km and cloud altitude is less than 300 m)* is 23-24 times/hour.

Table 4.3-4 Estimation for Runway Capacity of TIA (after Relocate Flight to Banepa)

Aircraft type	Number of operations				Occupancy time	Processing capacity
	Domestic Flight	International Flight	Total	Share		
ATR72	67	1	68	56%	4:05	60min/4:24 ＝27 times/hr
Jet	―	54	54	44%	4:49	
Total/Average	67	55	122		4:24	

(Source: JICA Study Team)

4.4 Policy for Expansion of Airport Capacity of Kathmandu Metropolitan Area

(1) Relationship between TIA Capacity and Future Demand

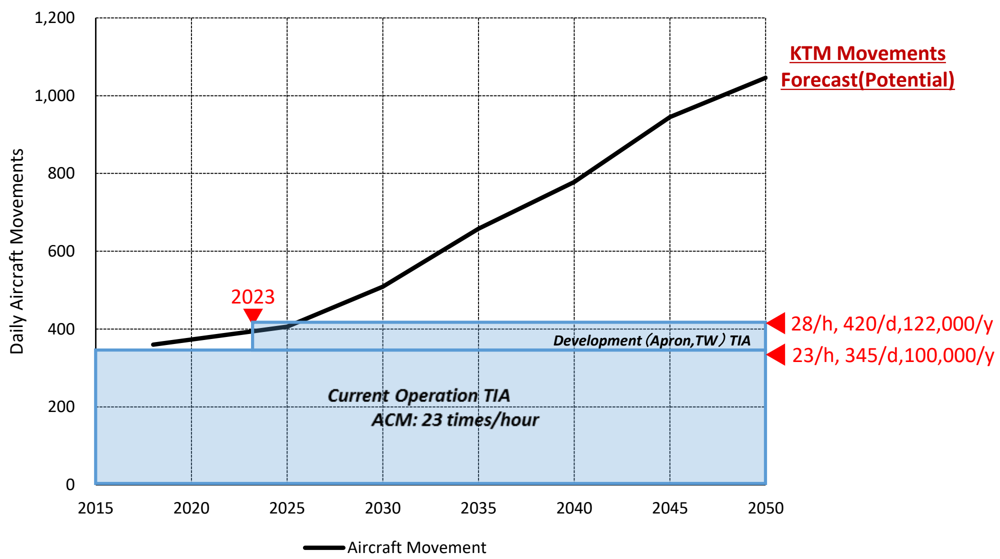
Design day aircraft movements in TIA is estimated as in Table 4.4-1.

Table 4.4-1 Design Day Aircraft Movements in TIA

	2018 (Actual)	2025	2030	2035	2040	2045	2050
International	109	133	181	236	269	329	386
Domestic	251	273	328	422	509	616	660
Total	360	406	509	658	778	945	1,046

Note: Unit, Movement/day
(Source: JICA Study Team)

The capacity of TIA is currently expected to be 23-24 times/hour and estimated to be 28 times/hour after completion of parallel taxiway. Regarding the daily capacity of TIA, in the case of assumption of consecutive peak duration of 15 hours, current capacity will be 345-360 times/day, and 420 times/day after completion of parallel taxiway. As shown in Figure 4.4-1, it is expected that the daily aircraft movements will reach the airport capacity in around 2025.

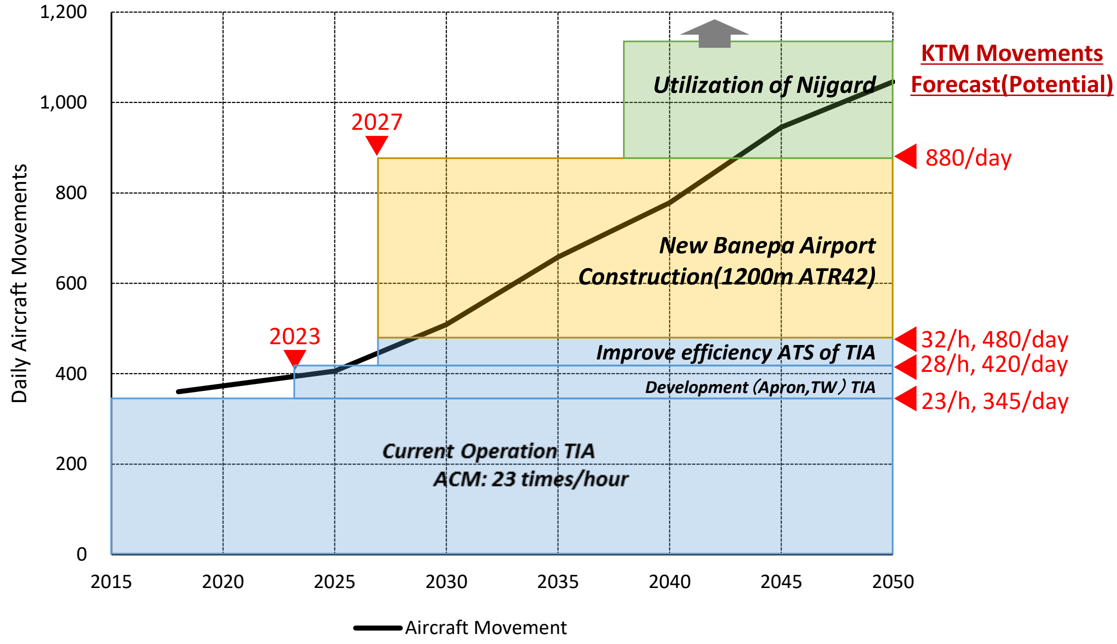


(Source: JICA Study Team)

Figure 4.4-1 Relationship between Aircraft Movements and Airport Capacity of TIA

(2) Outline of Policy for Expansion of Airport Capacity

As mentioned above, since it is expected that the aircraft movements of TIA will reach the airport capacity in the future, it is necessary to urgently take measures to expand the airport capacity in Kathmandu Metropolitan Area. Figure 4.4-2 shows the relationship between aircraft movement in TIA and the expansion of airport capacity, and the policies for expansion of capacity are detailed below.



(Source: JICA Study Team)

Figure 4.4-2 Relationship between Capacity expansion Policy and Demand

1) Development of Parallel Taxiway at TIA

At the time of completion of parallel taxiway currently under construction, the runway capacity of TIA is estimated to be 28 times/hour (420 times/day) besed on the results of the runway occupancy time survey conducted in this study.
However, since it is expected that the aircraft movements will exceed the runway capacity after 2025, it is necessary to take measure for expansion of airport capacity.

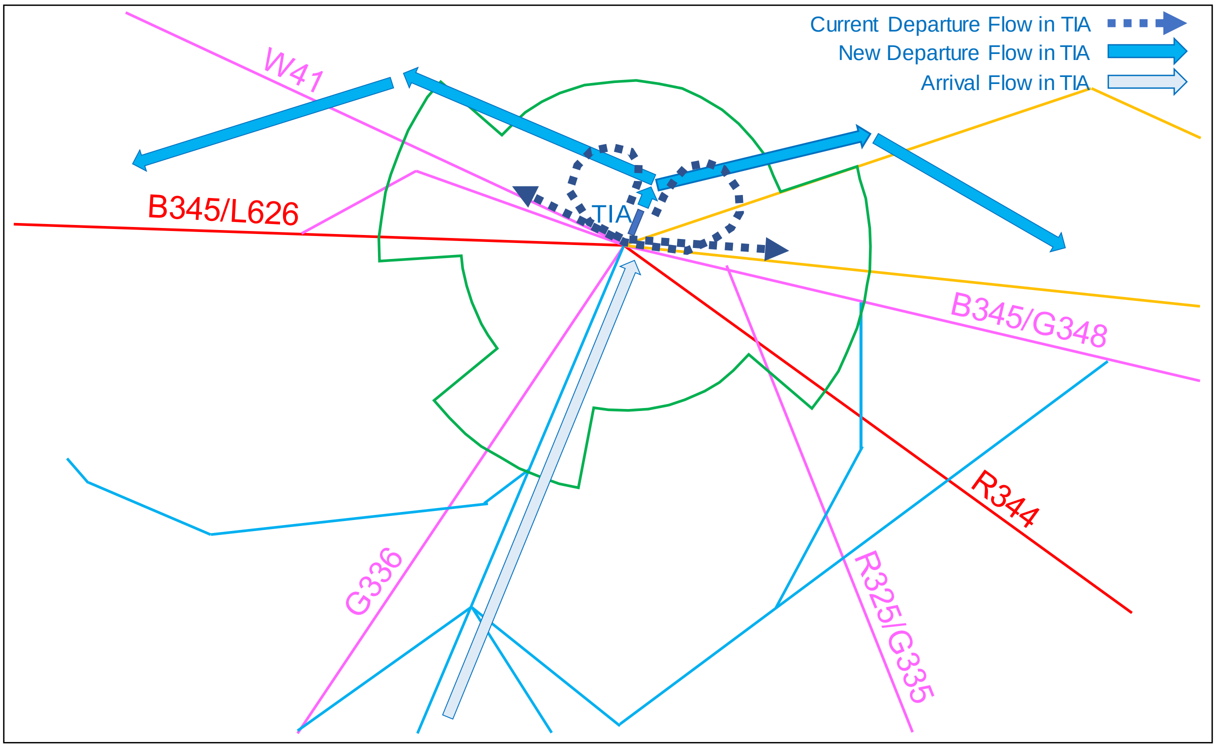
2) Development of Banepa New Airport

In order to expand the airport capacity in Kathmandu Metropolitan Area, CAAN has conducted a survey on new airport development, and Banepa is listed as a candidate site. Banepa Airport is planed as an airport to accept smaller aircraft including ATR42. This will increase the capacity of TIA by reducing the movements of small aircraft and providing the slot to larger aircraft.
Another issue with the current TIA is the mixture of high-speed jet aircraft and low-speed propeller aircraft. In such a situation, it is difficult for air traffic controller to properly guide and line up approaching aircrafts, therefore, TIA secures long separation between landing aircrafts. This limits TIA's capacity, causing early capacity limitations.
It is considered that Banepa Airport will reduce the operation of small aircraft in TIA and will contribute to efficient control and capacity expansion.

3) Improvement of ATM of TIA

The improvement of the ATM operation at TIA is carried out in two major steps. The first step is to design a new flight procedure and revise the procedures for control operation. The second step is to shorten the minimum control interval for landing aircraft in TIA by developing Banepa Airport.

As for the first step, regarding the design of a new flight procedures for the current go-around path and departure method, it includes checking the possibility for the development of new flight departure path by northwest or northeast as an alternative route for current turning from the north side to the south side. This will eliminate the interference between go-around flights or landing and departure flights, which subsequently shorten the control interval of landing aircrafts. As a result, it is considered that the efficiency of the current control operation can be improved, and handling capacity can be increased by several times per hour through the implementation of new control operation method.



(Source: JICA Study Team)

Figure 4.4-3 Conceptual Representation of New Departure and Landing Procedure

For the second step, the development of the Banepa Airport will allow aircraft with different approach speeds to be sorted to out, thereby shortening the separation time between the aircraft and increasing the TIA's runway capacity. Although detail is describeddiscussed below, regarding the flow of departure/arrival at Banepa Airport and departure from TIA, since, the aircraft operating are different in two airports, smaller propeller type aircraft at Banepa and bigger jet aircraft in TIA, the range of altitude in which they fly are different. So, it is considered that interference in the traffic flow will not be there.

Specifically, using the data obtained in the runway occupancy time survey for analyzing runway capacity, when the runway capacity is calculated under the condition that the interval between the landing aircraft and its preceding aircraft is reduced to 1min (previously 2:00-2:30 min), the runway capacity can be around 32 times/hr.

However, such introduction of new flight procedures and separating aircraft types in two airports can bring possible short control interval, it is necessary to train the controllers to understand the new operation methods. Considering the training period for formulating a new air traffic control systems and monitoring operation in the newly established airspace around the Kathmandu valley, improvement of air traffic control efficiency will take at least about 4 years.

4) Development of Second International Airport at Nijgadh

The development plan for the new Nijgard international airport at a distance of 60 km in the southwest of Kathmandu is underway. By the opening of the new airport, the airport capacity in Kathmandu Metropolitan Area will greatly increase. It is possible to expand the capacity of TIA by transferring some of the internatonal flights of small jets operated in TIA to Nijgard Airport and providing these available slots to large jets.

On the other hand, completion of Fast Track (Kathmandu-Terai Expressway) is a major issue in order for the Nijgardh Second International Airport to contribute to the enhancement of airport capacity of Kathmandu area and it will be taking time to achive this.

(3) Evaluation of Policy for Expansion of Airport Capacity in Kathmandu Metropolitan Area

The policy for expanding airport capacity in Kathmandu Metropolitan Area is described as above step by step.

As shown in Figure 4.4-2, the effect of capacity expansion by the development of Banepa Airport is great. Regarding the development of Nijgard Airport, it is expected that the development of one runway will increase the capacity of 400 to 500 movements/day.

4.5 Technical Feasibility of Construction of Banepa Airport Project

4.5.1 Examine Suitability of Airport Features and Scale

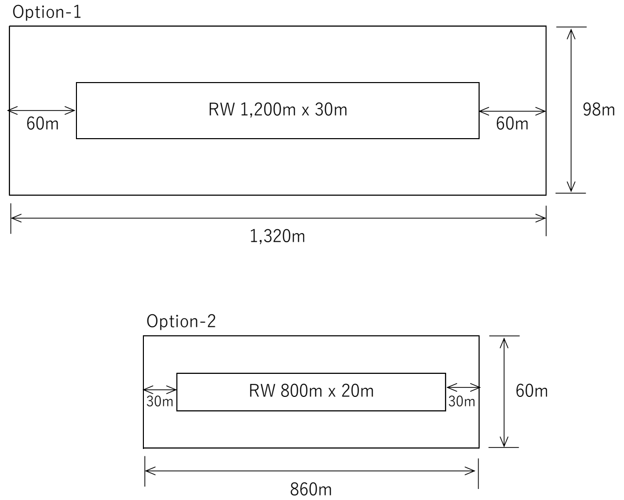
(1) Overview of FS carried out by CAAN

CAAN conducted a Detailed Feasibility Study (hereafter referred to as Detailed FS) on Banepa airport in 2018. This Detailed FS consists of study of site conditions including the soil investigation with which two cases of Option-1 (runway length of 1200m) and Option-2 (runway length of 800m) is being decided and compared.
Table 4.5-1 shows the facility sizes of those two cases.

Table 4.5-1 Detail FS on the airport facility scale of the cases

	Option-1	Option-2
Airport Area	34.84 ha	24.15 ha
Target Aircraft	ATR-42/ Jetstream-41	DHC-6 TwinOtter
Airport Code	2C	1B
Runway Specification	1200m x 30m	800m x 20m
Apron Area	31,540m^2	21,170m^2
Apron Capacity	16 for DHC-6 & 5 for ATR-42	20 for DHC-6

Figure 4.5-1 shows runway and runway strip for option-1 and option-2.



(Source: JICA Study Team)

Figure 4.5-1 Layout Plan for Option-1 & Option-2

(2) Outline of Project

Out of the airport facility development scale planned in the Detailed FS, the runway length will be designed based on the targeted aircraft to be operated. Takeoff and landing distance of ATR-42 and DHC-6 which are the targeted aircraft are shown in Table 4.5-2 and Table 4.5-3.

Table 4.5-2 ATR42-320 Performance Requirement

Items	Distance
Takeoff Distance (Maximum Takeoff Weight, Altitude 0m, Standard Atmospheric Temperature)	1,041m
Takeoff Distance (300NM, Altitude 0m, Standard Atmospheric Temperature)	1,026m
Takeoff Distance (300NM Navigation takeoff weight, Altitude 3000ft, Standard Atmospheric Temperature+10ºC)	1,222m
Landing Distance (Maximum Landing Weight, Altitude 0m)	1,222m

(Source: Technical Specification)

Table 4.5-3 DHC-6 Performance Requirement

Items	Distance
Takeoff Distance (Altitude up to 15.2m)	366m
Landing Distance (From Altitude 15.2m)	320m

STOL operation using full wheel brakes and engine reverse thrust
Altitude 0m MSL, No wind, Dry concrete runway conditions.
(Source: Technical Specification)

The runway length for option-1 and option-2 are enough for the standard conditions. However, it is necessary to consider the correction for the altitude, temperature, and route distance while determining the runway length. Those data and the correction of the runway slope will be needed.
The specification for runway strip and RESA by ICAO is as shown in the Table 4.5-4. In the Detailed FS, Airport reference code for option-1 was 2C and the airport reference code for option-2 was 1B. In ICAO, since the airport code is determined by the runway length, for runway length less than 800m airport code 1 is used, if runway length is more than 800m and less than 1200m code 2 is used and if it is more than 1200m code 3 is used. Therefor it is preferable to be adopted code 3C for Option-1 and 2B for Option-2.

Table 4.5-4 Specification for Runway strip and RESA

Airport Code	1	2	3
Runway Strip Width (Distance from runway centerline to longitudinal boundary of runway strip)	30m	40m	75m
Length of Runway Strip	Runway Length + Both side 30m	Runway Length + Both side 60m	Runway Length + Both side 60m
RESA Length	30m Preferred length	30m Preferred length	90m

(Source: JICA Study Team)

As related to the airport land, installation of parallel taxiway and the number of apron spot were considered. Table 4.5-5 shows annual passengers and Table 4.5-6 shows design day aircraft movements when Banepa Airport is completed.

Table 4.5-5 Annual Passengers of Banepa domestic airport

	Runway Length: 1,200 m			Runway: 800 m		
	2030	2040	2050	2030	2040	2050
Total	1,416	2,291	3,261	258	417	594

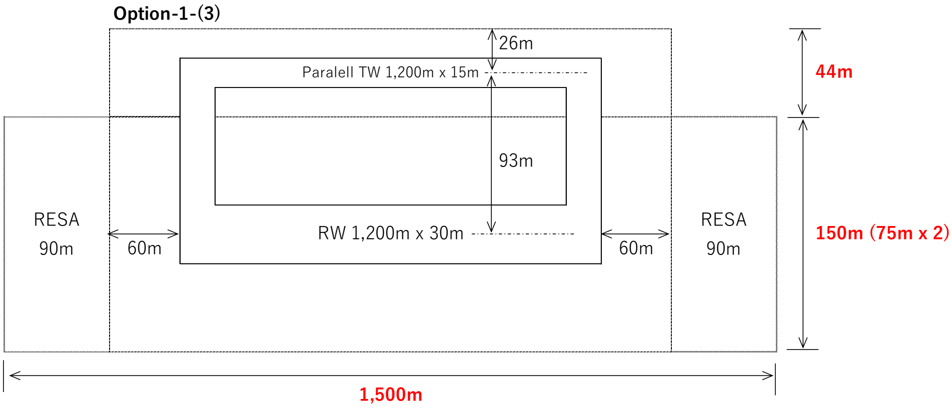
Note: Unit, 1,000 person/day
(Source: JICA Study Team)

Table 4.5-6 Design Day Aircraft Movements of Banepa domestic airport

	Runway Length: 1,200 m			Runway Length: 800 m		
	2030	2040	2050	2030	2040	2050
Total	164	262	375	52	83	121

Note: Unit, movement/day
(Source: JICA Study Team)

In case of 1,200m runway length of Banepa airport, design day aircraft movments will be 164 as of 2030. Since design day ratio is 1/320, annual aircraft movements will be 52,480. The ICAO Airport Planning Manual states that parallel taxiways may be constructed if the total number of annual operations reaches 50,000 within 5 years. Since the number of aircraft movements exceeds 50,000, it is desirable to install parallel taxiways at the Banepa domestic airport.
Figure 4.5-2 shows the layout plan of the basic facilities when a parallel taxiway is installed.



(Source: JICA Study Team)

Figure 4.5-2 Basic Facility Layout Plan of Banepa Airport in ase of Parallel Taxiway Installation

As a result of calculating the required number of apron spots based on the number of daily arrivals and departures in Table 4.5 6, the number of apron spots set in the Detailed FS (DHC-6 16 spots, ATR-42 5 spots) are satisfied with the required number.

4.5.2 Study of Measures for Technical Issues in Construction Work

(1) Study on Planning of Earthwork

The Detailed FS shows the soil volume of Option-1 and Option-2 as shown in the Table 4.5-7.

Table 4.5-7 Earthwork Volume Calculation Result (Detailed FS)

	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m）	5,394,000	108,000	RW slope 1.0%
Option-2（RW800m）	699,000	457,000	RW slope 0.25%

(Source: CAAN Detailed FS)

In order to prove the validity of the Detailed FS, the soil volume was calculated again under the same condition as for the planned height and layout of facilities. Since the Detailed FS did not mention about the slope of embankment, considering the general cases adopted at Japanese airport, slope of 1:2.0 is used for soil volume calculation. The result of the calculation is shown in the Table 4.5-8.

Table 4.5-8 Earthwork Volume calculation Result (Embankment slope used is 1:2)

	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m）	5,705,258	784,757	RW slope 1.0%
Option-2（RW800m）	709,707	2,618,383	RW slope 0.25%

(Source: JICA Study Team)

Table 4.5-9 shows examples of embankment slopes at mountain airport in Japan. Generally 1:2.0 to 1:3.0 is used for embankment slope.

Table 4.5-9 Cases of Airport Embankment Slope

Airport	Embankment Height (m)	Embankment Slope (From the 1st Row to Top Row)	Number of Steps	Soil type
Kagoshima	26	1:2	3	
Kushiro	42	1:1.8-1:2-1:2.3	5	
Aomori	25	1:3	4	
Okayama	25	1:2	4	Sandstone(5m): Decomposed Granite soil (0.5)
Takamatsu	60	1:2-1:1.8	11	Rock and good quality Decomposed Granite soil
Hiroshima	120	1:2	24	

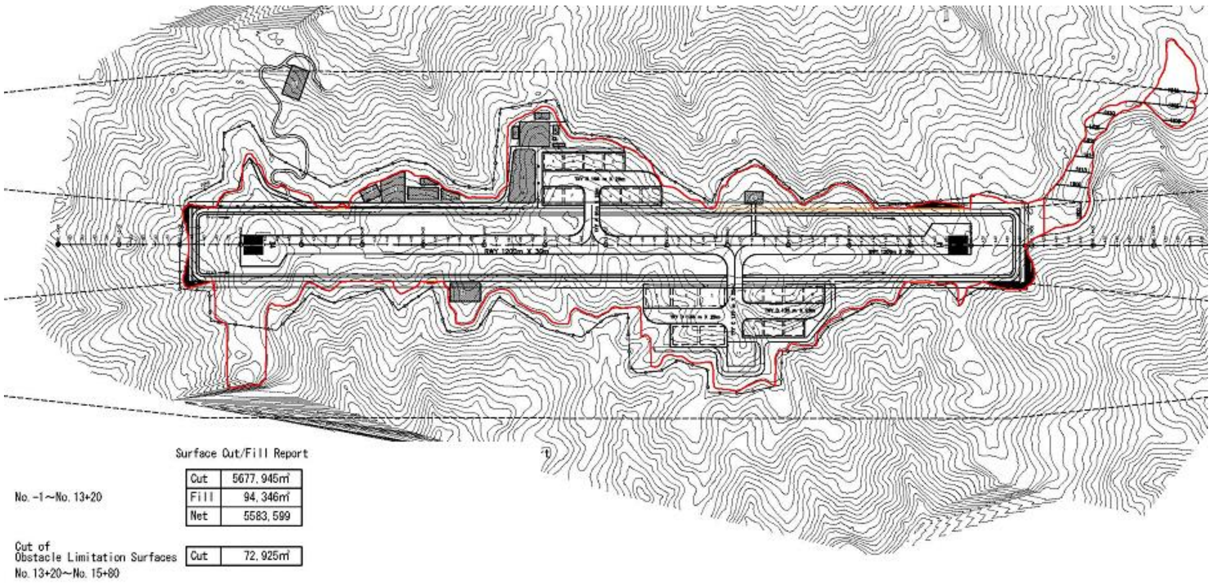
(Source: JICA Study Team)

When the embankment slope is adopted as 1:2, since the slope of existing mountain is so steep that the embankment slope cannot be attached to the existing slope of mountain, and the length of the embankment slope becomes longer. Due to this, the filling volume becomes very large especially in Option-2 which has a higher planned hight.
Therefor, in order to reduce the embankment volume, the soil volume calculated under the condition that 1:0.3 is adopted for the embankment slope with reinforced earth method to strengthen the slope is shown in Table 4.5-10. With this case it’s found that the volume of soil is same as Detailed FS, which measns the soil volume calculation of the Detailed FS is considerd reasonable.

Table 4.5-10 Earthwork Volume Calculation Result (Embankment Slope used is 1:0.3)

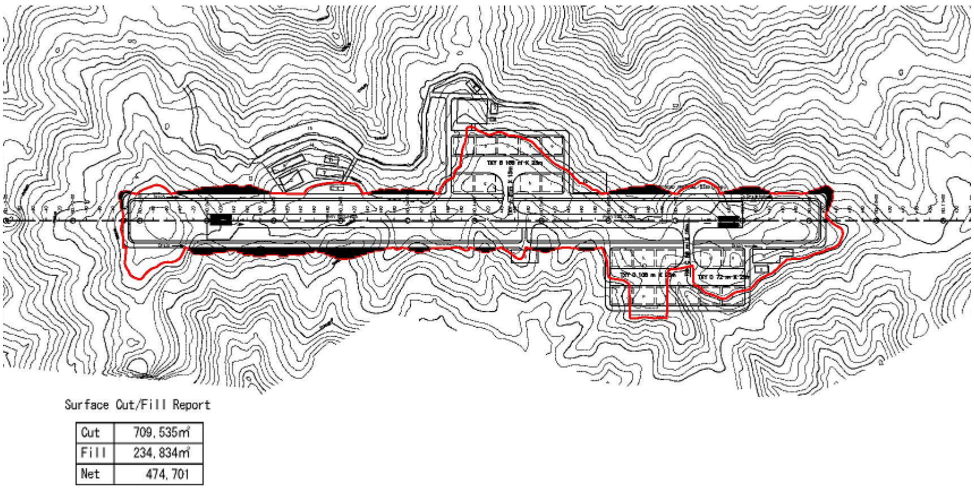
	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m）	5,677,945	94,346	RW slope 1.0%
Option-2（RW800m）	709,535	234,834	RW slope 0.25%

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 4.5-3 Banepa Airport Layout (RW1,200m Airport Code 2C)



(Source: JICA Study Team)

Figure 4.5-4 Banepa Airport Layout (RW800m Airport Code 1B)

In this earthwork plan, the embankment slope was set to 1:0.3 assuming slope reinforcement. An example of slope reinforcement in Japan is shown in Table 4.5-11. In this study, the slope is set to 1: 0.3, but it is necessary to consider a slope reinforcement method considering the soil condition at design stage.

Table 4.5-11 Example of Slope Reinforcement

Airport	Maximum Embankment Hight	Slope	Slope Reinforcement Method	Note
Oki	60m	1:1.5	Soil Cement	
Nanki- Shirahama	55m	1.1.5	Soil Cement, Geogrid	
Tajima	70m	1:1	Soil Cement + Rock fixed Steel Frame	Steps for each 10m direct hight

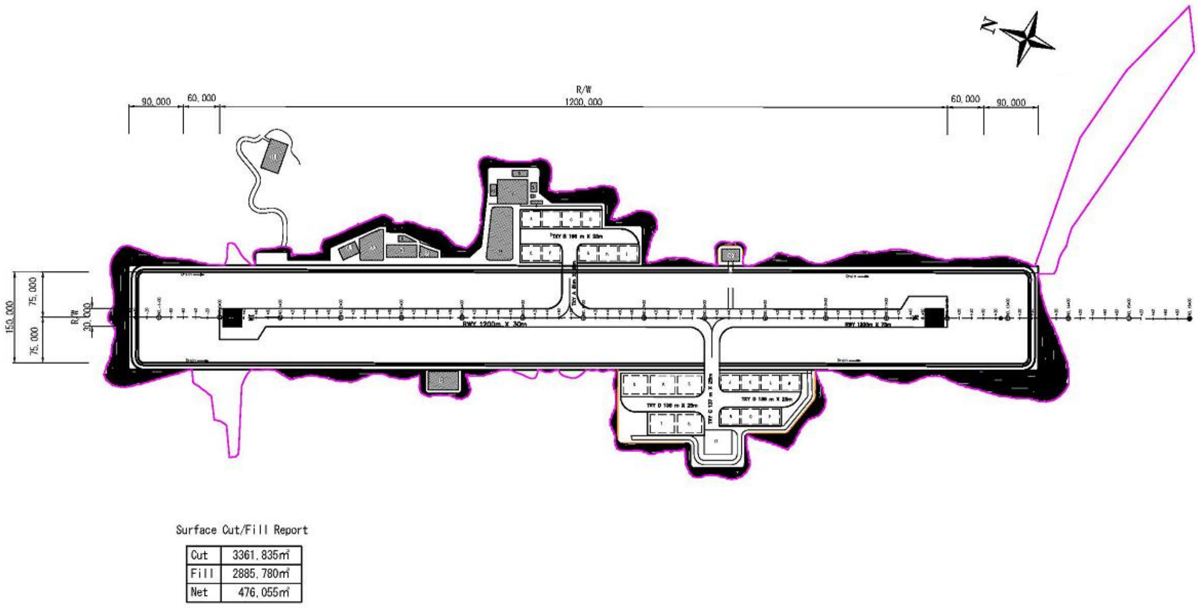
(Source: JICA Study Team)

The Detailed FS plan is that the cut volume is considerably larger than the fill volume and it was planned to use the excess cut volume for the site preparation work at TIA. Practically since soil transportation causes traffic congestion and environmental/noise problems, it is desirable to balance the soil volume in the airport site as much as possible and not to take the soil out of the site.
Therefore, it was examined under the condition that the cut volume and the fill volume are balanced so that the soil would not be carried out outside the airport site, and that facilities for airport code 3C were installed with Option-1. Table 4.5-12 shows the calculated soil volume. The runway longitudinal slope and cross slope were set as level. In the case of code 3C, the fill volume increases since the runway strip width spreads from 49m to 75m on one side, and the area of RESA also increase.

Table 4.5-12 Earthwork Volume Calculation Result (Main research/ Balanced soil volume, Airport Code 3C)

	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m） Airport Code 3C	3,361,835	2,885,780	EL=1813m, RW slope Level

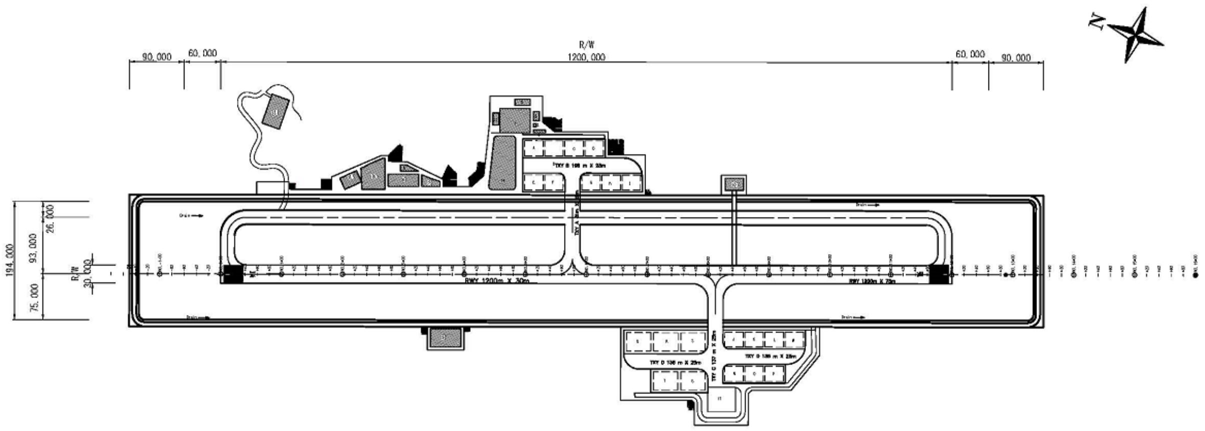
(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 4.5-5 Banepa Airport Layout (Optoin-1/ Balanced Soil Volume, Airport Code 3C)

As described in 4.5.1, Banepa Airport needs to be installed parallel taxiway in order to handle the demand. The necessary land range for parallel taxiway is shown in Figure 4.5-6. In that case, it is necessary to construct additional 44m wide area. The calculated soil volume is shown in Table 4.5-13.



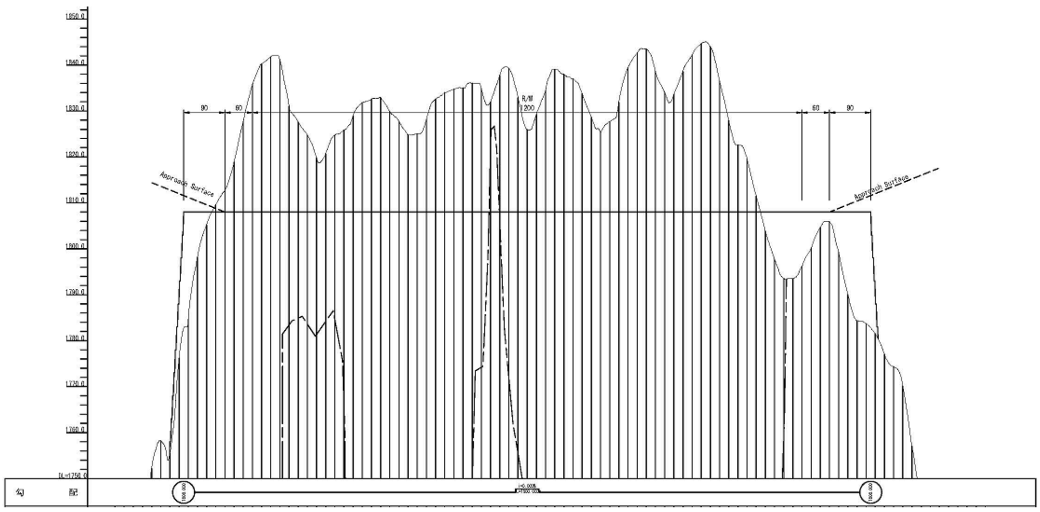
(Source: JICA Study Team)

Figure 4.5-6 Banepa Airport Layout (Option-1/ Balanced Soil Volume, with Parallel Taxiway)

Table 4.5-13 Earthwork Volume Calculation Result (Main Research/ with Parallel Taxiway)

	Cut (m^3)	Fill (m^3)	Note
Option-1（RW1,200m） Airport Code 3C Parallel Taxiway	4,198,851	3,877,949	EL=1808m, RW slope Level

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 4.5-7 Banepa Airport Longitudinal Plan (Option-1/ Balanced Soil volume, with Parallel Taxiway)

(2) Drainage (Regulating pond) Plan

It is found that 70% of the airport construction area is forest around the top of mountain and it is expected that the amount of outflow to the surrounding stream/river will increase when the airport is constructed. For that case, in order to avoid flooding in the surrounding area, it is suitable to construct regulating pound in the airport site and adjust the amount of outflow.
Figure 4.5-8 shows the example of regulating pond at Tajima Airport in Japan. The chachment area is set not tobe changed as much as possible before and after the development.

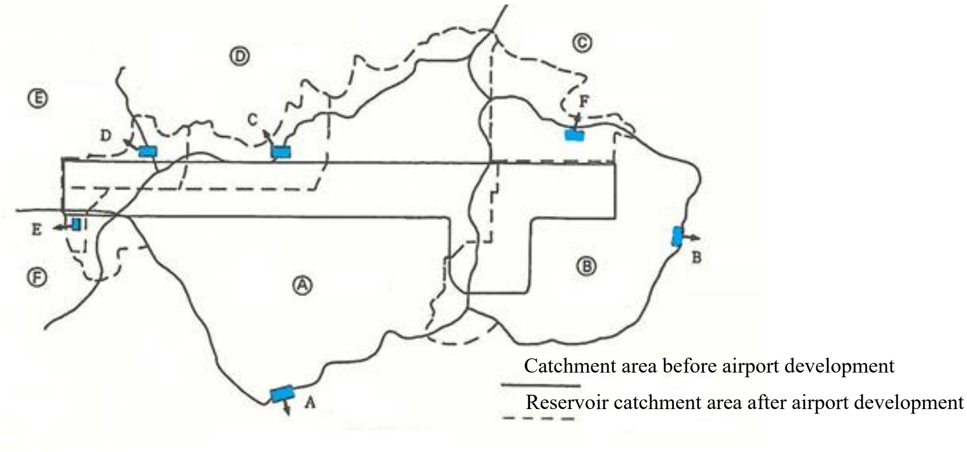


Figure 4.5-8 Location Map of Regulationg Ponds in Tajima Airport

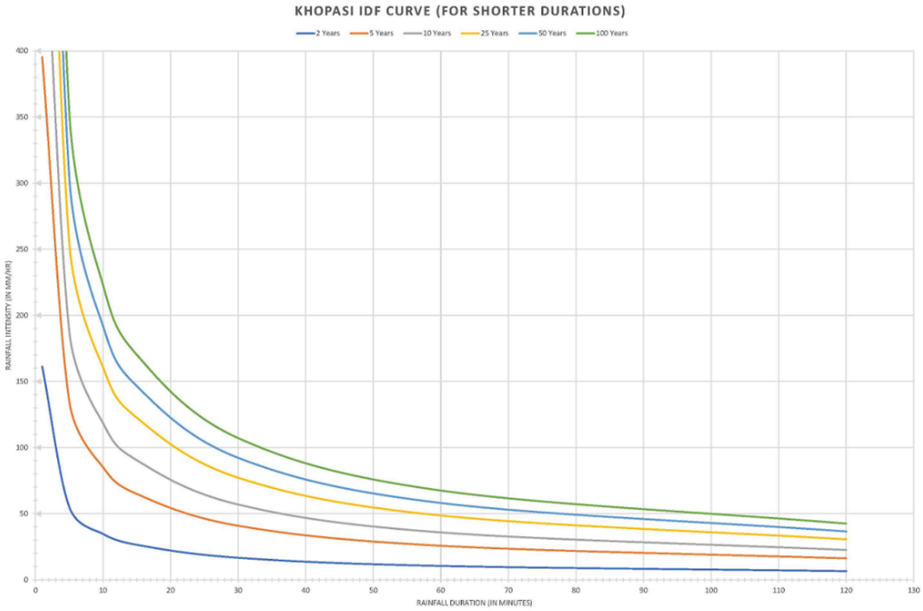
Table 4.5-14 shows the rainfall amount at Khopasi observatory from 2011 to 2016.
The month with the highest monthly rainfall is July followed by August, September and June. On the other hand, the average rainfall in December and January is low.
The average annual rainfall is 1,076.47mm, of which 80.87mm (74.6%) is concentrated during the monsoon season. (June to September)

Table 4.5-14 Annual & Monthly Rainfall Record at Khopasi (2011-2016)

Month	Precipitation (mm)						
	2011	2012	2013	2014	2015	2016	Average
January	0.00	8.20	9.40	1.40	3.60	2.20	4.13
February	47.80	31.80	34.40	17.00	26.40	4.20	26.93
March	9.40	1.40	8.20	26.00	87.40	9.20	23.60
April	67.30	81.60	63.20	15.60	65.00	4.20	49.48
May	188.20	37.40	109.60	124.80	46.20	136.20	107.07
June	293.00	43.60	180.00	98.60	28.40	238.00	146.93
July	225.00	283.60	263.20	211.40	349.40	278.60	268.53
August	245.40	175.00	202.20	261.10	283.50	115.80	213.83
September	257.20	51.40	112.00	205.20	324.30	91.40	173.58
October	35.40	8.60	142.40	93.40	37.20	0.00	52.83
November	22.80	0.00	0.00	0.00	16.00	0.00	6.47
December	0.00	0.00	0.00	18.40	0.00	0.00	3.07
Total	1,391.50	722.60	1124.60	1072.90	1267.40	879.80	1,076.47

Source: Climatological and Meteorological Records of Nepal, 2011-2016
Location of Metrological Station: Khopasi (Index No. 1049)

In the Detailed FS, they obtained 23 years (1990-2016) observation data of Khopasi station for drainage planning and set rainfall intensity formula.



(Source: CAAN Detailed FS)

Figure 4.5-9 Rainfall Intensity Formula at 7 Banepa Airport

It is necessary to examine the detailed installation location of regulating pond and its capacity using the rainfall intensity formula in the future study.

(3) Study on Access Road Plan

Current access from the existing road to around the top of the mountain is a mountain trail. Since this trail is unpaved and steep, only 4WD vehicles can pass through. If the airport construction begins it is necessary to develop access road to the terminal facility on the top of the mountain.
As for the access road, it is reasonable that the design specification shall be design speed 30-40km/hr in mountain area, 2 lane, and maximum slope of 10 %, which are also adopted at Sinduli highway. As for the cost, it is set considering the current trend of construction cost per 1 kilometer of road along the mountainous terrian in Nepal, which is around 130-230 million yen.

(4) Study on Construction Methodology and Schedule

Tajama Airport in Japan could be taken as an example for Banepa Airport construction as it is also located on the top of mountain and has a length of 1200m. Table 4.5-15 shows the main work quantity and construction schedule for Tajima airport.

Table 4.5-15 Construction Schedule of Tajima Airport in Japan

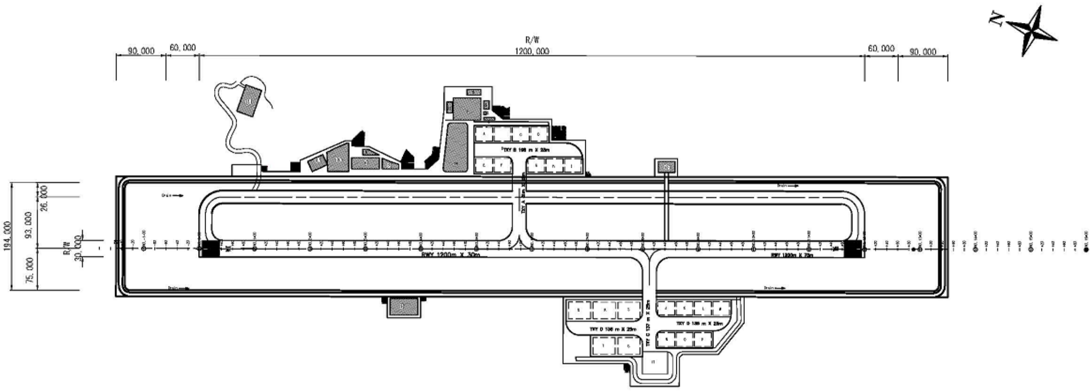
Work Item	Quantity	1990	1991	1992	1993	1994
Project Schedule		★Work Start				★ Operation
Earth Work						
Debris removal work	107,000 m^3					
Cut and fill work	7.6 million m^3					
Surface finishing work	300,000 m^2					
Slope Protection Work						
Sodding Work	115,000 m^2					
Retaining Wall Work						
Drainage Work	Drainage 4,700m					
Pavement Work	47,600m^2					

(Source: JICA Study Team)

While the construction period for Banepa Airport depends on especially the procurement status of construction equipment (large and heavy equipment) for earthwork, the construction period is expected to be about four years, same as Tajima Airport.

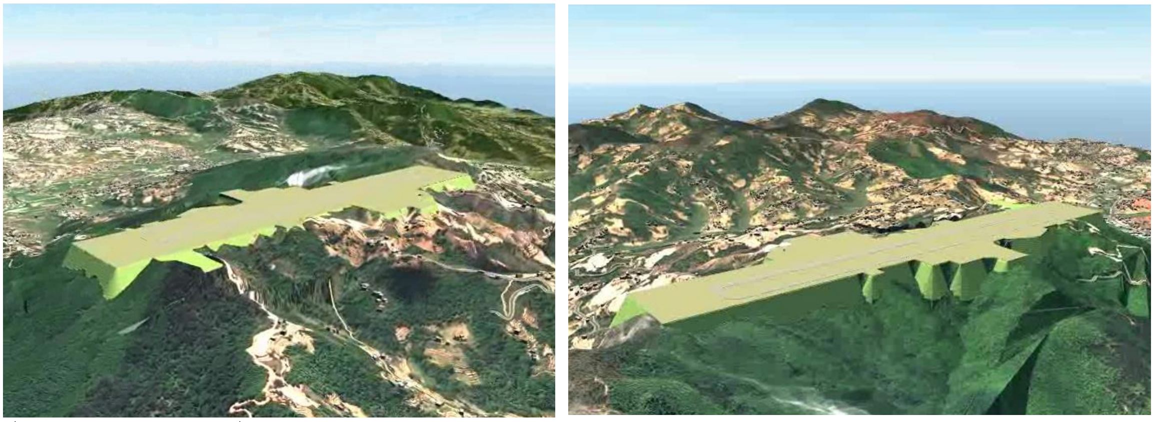
4.5.3 Adopting the Best Development Plan

As shown in Table 4.3-3, STOL aircraft accounts for 8% and ATR42 for 22% of aircrafts useing TIA. Considering the expansion of the runway capacity of TIA, the runway length of Banepa airport should be 1,200m which ATR42 can be operated.
In addition, it is expected that annual aircraft movements shall be 52,480 when the operation of Banepa Airport starts, and it is desirable to construct parallel taxiways.
Figure 4.5-10 shows the best layout plan of Banepa airport development based on the above conditions, and Figure 4.5-11 shows a bird's-eye view.



（Source：JICA Study Team）

Figure 4.5-10 Banepa Airport Bset Layout Plan（RW1,200m, with Parallel Taxiway）



（Source：JICA Study Team）

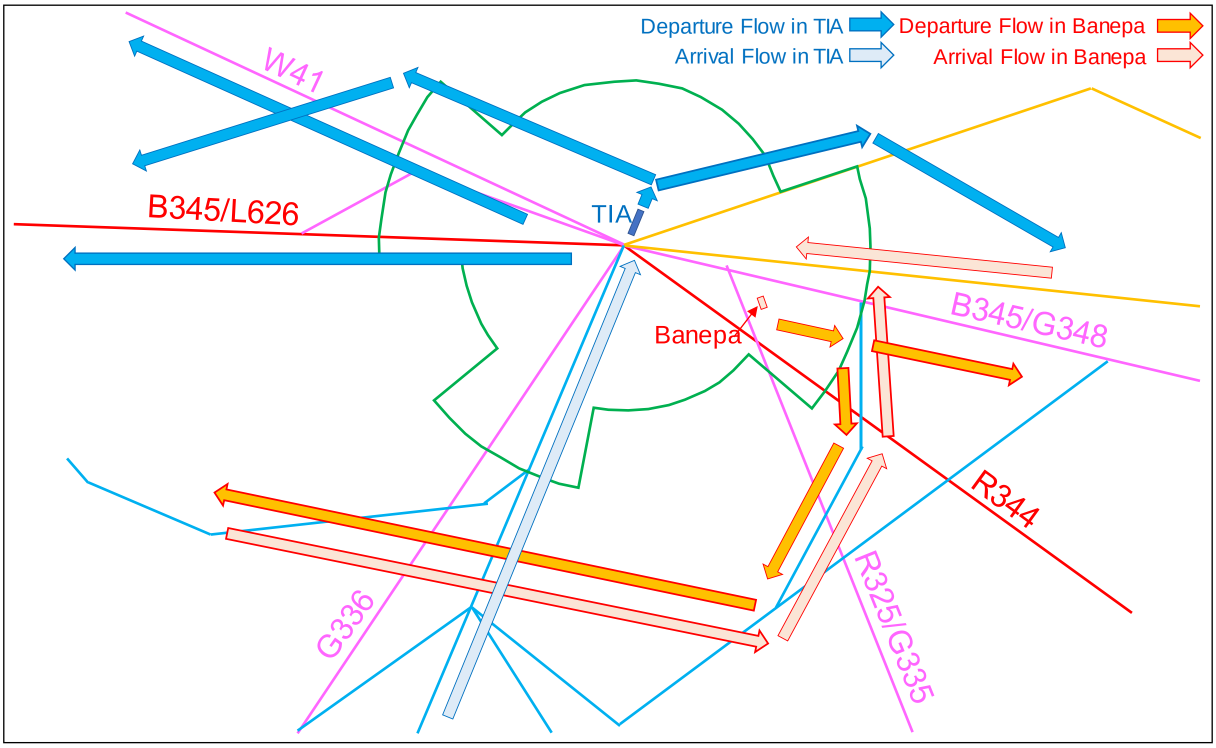
Figure 4.5-11 Bird's-eye View of Banepa Airport Best Layout Plan （RW1,200m, with Parallel Taxiway）

In this study, a preliminary study was conducted based on the Detailed FS studied by CAAN, but it is necessary to study the following issues while developing Banepa Airport.

- Study of runway longitudinal and cross sectionplan to reduce the earthwork volume
- Re-study of embankment slope and selection of soil reinforcement method
- Study of proper apron and landside position, and apron spot layout
- Study of access method and access road position from the foot
- Study of utility facility layout

4.5.4 Study on the Airspace around TIA and Banepa Airport (Departure/Arrival Routes)

Considering the construction of Banepa Airport, since it is located in the terminal area of TIA, it is necessary to take into account airspace setting and departure/arrival routes for both airports.
First, assuming that the current terminal area does not change, it is necessary to divide the eastern low altitude zone of TIA around Banepa Airport into the airspace for Banepa Airport.
If the airspace for both TIA and Banepa Airport are operated separately due to the reorganizing of airspace, the assumed departure/ arrival routes at each airport are as shown in Figure 4.5-12. Since Banepa airport is basically allocated for smaller aircraft and small turboprop aircrafts, it is assumed that the altitude zone for the operation will be low. In addition, as the location of Banepa airport is towards the east side of TIA, the departure/arrival aircraft from/to Banepa Airport can be operated without disturbing the traffic flow of aircraft operating from TIA, by using east side airspace for incoming and outgoing flights.



(Source：JICA Study Team)

Figure 4.5-12 Possible Departure/Arrival Routes at TIA and Banepa Airport

4.6 Project Cost of Banepa Airport Construction Project

4.6.1 Setting of Construction Quantity and Unit Cost

Necessary project materials are described in the Detailed FS as shown in Table 4.6-1.

Table 4.6-1 Necessary Material Quantity

No	Construction Material	Quantity	Unit
1	Fine aggregate (sand)	1,800	m^3
2	Coarse aggregate (aggregate)	71,500	m^3
3	Cement	30,500	Bag
4	Stone	3,500	m^3
5	Crushed stone	27,500	m
6	Rebar	10	MT
7	Asphalt	4,200	MT
8	PVC pipe	200	Rm
9	Wood	5	m

(Source: CAAN Detailed FS)

As for the procurement of the materials, sand, aggregates, steel bars and so on can be brought from the local sites and approved borrow pit. For cement, asphalt, and PVC pipes, it is available from local market. The unit cost of construction materialsis set by reviewing the existing cost estimation in the Detail FS by CAAN. The Table 4.6-2 shows the quantity and unit cost for the main construction work in the Detail FS.

Table 4.6-2 Construction Unit Rate

Construction	Units	Rate (NPR)
Earthwork		
Excavation and Filling (Sand)	m^3	131
Excavation and Filling (Soft Rocks)	m^3	284
Excavation and Filling (Hard Rocks)	m^3	1,187
Embankment shaping	m^3	175
Transportation (Distance 25km)	m^3	593
Pavement work		
Lower subgrade	m^3	3,607
Upper subgrade	m^3	3,016
Surface asphalt	m^3	16,179

(Source: CAAN Detailed FS)

4.6.2 Estimation of Project Cost

Table 4.6-3 shows the approximate construction cost for option-1 (Runway length of 1200m) at Banepa Airport site. The cost becomes higher than that is estimated in Detailed FS due to modification in runway strip specification according to ICAO, balancing of earthwork volume and cost for theregulating cost.

Table 4.6-3 Estimated Construction Cost of Banepa Airport (option-1)

S. NO	Work Item	Option-1（'000 NRs）	Remarks
A	General	75,561	
B	Earth Work	5,621,076	Cut Volume 4,000,000m^3 10% soil, 80% soft rock and 10% hard rock Fill Volume 3,600,000m^3
C	Pavement Work	619,489	Asphalt Pavement 105,000m^2
D	Drainage Work	843,000	
E	Boundary Fence Work	91,177	
F	Miscellaneous Work	23,855	
G	Road and Parking Work	1,200,000	
H	Building and Utility Work	3,046,185	
I	CNS/ATM	1,695,000	
	Total of Construction Cost	13,215,343	
	Contingency（10%）	1,321,534	
	VAT（13%）	1,717,995	
	Total of Construction Cost	16,254,872	
	Consultant Cost	528,614	
	Contingency（10%）	52,861	
	VAT（13%）	68,720	
	Total of Consultant Cost	650,195	
	PIU (Management Cost)	550,000	
	Total of Construction and Consultant Cost	17,455,067	

	Total of Construction and Consultant Cost (Japanese Yen)	16,756,864	1NRs=0.96JPY

(Source: JICA Study Team)

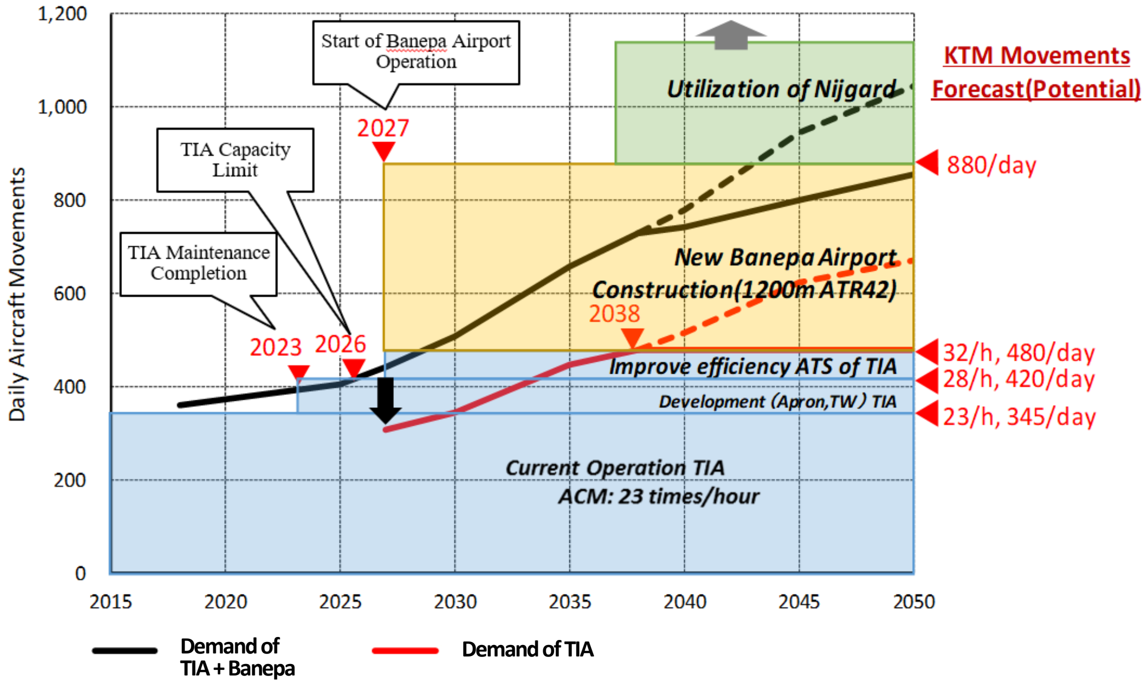
4.7 Financial and Economic Viability

4.7.1 General

(1) Project Scenario

The project development scenario of Banepa Airport is set as follows. Figure 4.7-1 shows the relationship between air traffic demand and capacity of airport facilities in Kathmandu area. As for the capacity of airport facility, since the bottleneck are brought by peak hour aircraft movements and runway capacity, design day aircraft movements is used for this study.

i. Aviation demand in Kathmandu metropolitan area is growing steadily
ii. In 2023, expansion work of apron, parallel taxiway, and international passenger terminal building will be completed.
iii. As shown in Figure 4.7-1, as for the future aviation demand in Kathmandu metropolitan area, the capacity of facilities of TIA will reach the limit due to runway capacity in 2026 (construction of second runway is impossible due to difficulty in land acquisition).
iv. By starting the operation of Banepa Airport in 2027 and aloocating domestic flights withSTOL aircraft and ATR42 to Banepa airport, mixture of STOL aircrafts and jet/propeller aircrafts, which prevent from runway capacity of TIA improving, will be mitigated. In addition, by improving the ATS of TIA, air control system will be optimized and runway capacity will also increase. In other words, carring out those two projects, one is development project of Banepa airport and the other is improvement of the ATS of TIA, will bring large effect. Figure 4.7-1 shows expectedproject effect forthe airport facility capacity.
v. Banepa Domestic Airport has capacity to handle the aviation demand until 2050. On the other hand, TIA will reach its runway capacity limit in 2038.
vi. After 2038, it will be necessary to share the operation with Nijgardh International Airport and handle the total aviation demand in Nepal.



(Source: JICA Study Team)

Figure 4.7-1 Relationship between capacity increment and demand for arrival and departure

Table 4.7-1 Outcome Forecast

Project	Specification	Expected outcome
Construction of Banepa Domestic Airport	Operate STOL and ATR42 class Aircraft in Banepa airport R/W1200m, For ATR42	ACM 400/day
Improving ATS at TIA	Flight Procedure Design (Missed approach, Flight interval, etc.,), Improve runway handling capacity	ACM 4/h,60/day, 18,000/year

(Source: JICA Study Team)

(2) Setting of With Project Case and Without Project Case

In the economic and financial analysis, cost and benefits are compared between the cases where the project is implemented (With Project Case) and the cases where the project is not implemented (Without Project Case).
In addition, as a sensitive analysis, a study was conducted to verify the benefits only from Banepa Airport without considering the investment and benefit from/to TIA.

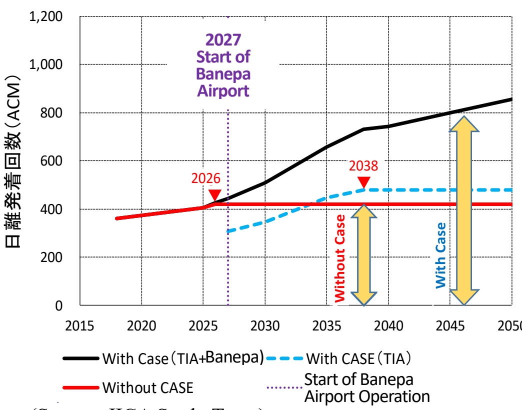
Table 4.7-2 With Project Case and Without Project Case

Case	Scenario Case A: （TIA＋Banepa）	Scenario Case B: （only Banepa）
With Project Case	✈ Implementation of Banepa domestic airport project (For ATR42 and STOL aircraft). ✈ By above measure, it will prolong the capacity of airport facility by creating TIA's slots. ✈ Furthermore, improvement of ATS operation method (Shortening of clearance interval between aircrafts) will highly increase the Capacity of TIA. ✈ Banepa Airport will have a capacity to handle the aviation demand until 2050 and as for TIA the limit of runway handling capacity will be in 2038.	✈ Implementation of Banepa domestic airport project (For ATR42 and STOL aircraft). ✈ Banepa Airport will have a capacity to handle aviation demand until 2050.
Without Project Case	✈ Without Banepa domestic airport project ✈ Due to lack of handling capacity with current TIA's airport facility, the aviation demand will reach its limit.	✈ Without Banepa domestic airport project

(Source: JICA Study Team)

(3) Setting Aviation Demand

In the With Project case, the assumption is such that, in actual, capacity of TIA airport facility will exceed in 2026 but by starting the operation of Banepa Airport in 2027 and improving the ATS of TIA, TIA can handle future demand until 2038.
Whereas, as for Without Project case, the airport facility of TIA will level off after 2026. Figure 4.7-1 shows design day aircraft movements for both cases.



(Source: JICA Study Team)

Figure 4.7-1 Aviation Demand Scenario

(4) Basic Conditions

The basic conditions are as shown in Table 4.7-3.

Table 4.7-3 Basic Conditions

Features	Conditions
Base Price	Cost benefits were measured at FY2020 rate. Reference banknote is Nepalese Rupee (NPR)
Year of Starting Operation	Set as 2027 (Approximately 2 years for design and procurement and 4 years for construction)
Analysis Period	The period is set from 2027 to 2054, 30 years after the start of operation.
Social Discount Rate (SDR)	Social Discount Rate is set as 10%
Conversion Factor	Conversion factor from Financial Cost to Economic cost is 1% refered to airport project by ADB.

(Source: JICA Study Team)

4.7.2 Economic Analysis（EIRR）

(1) Aviation Demand used for Economic Analysis

For aviation demand used for Economic Analysis, air passenger demand for both With Project case and Without Project case is shown in Table 4.7-4 and the one for Case B; only Banepa is shown in Table 4.7-5

Table 4.7-4 Classification of Air Passenger Demand（Case A：TIA＋Banepa）

	2027	2028	2029	2030	2035	2040	2045	2050	2055
Passenger (with-case) (In 1000 person)									
Domestic Flight (Nepalese)	1,939	2,059	2,179	2,300	2,948	3,660	3,660	3,660	3,660
Domestic Flight (Foreigner)	2,619	2,799	2,979	3,159	4,126	5,184	5,184	5,184	5,184
International Flight (Nepalese)	2,183	2,333	2,483	2,633	3,438	4,320	4,320	4,320	4,320
International Flight (Foreigner)	6,548	6,998	7,448	7,898	10,314	12,961	12,961	12,961	12,961
Passenger (without-case) (In 1000 person)									
Domestic Flight (Nepalese)	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832
Domestic Flight (Foreigner)	2,460	2,460	2,460	2,460	2,460	2,460	2,460	2,460	2,460
International Flight (Nepalese)	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
International Flight (Foreigner)	6,151	6,151	6,151	6,151	6,151	6,151	6,151	6,151	6,151
Passenger (with-without) (In 1000 person)									
Domestic Flight (Nepalese)	107	228	348	468	1,117	1,828	1,828	1,828	1,828
Domestic Flight (Foreigner)	159	339	519	699	1,665	2,724	2,724	2,724	2,724
International Flight (Nepalese)	132	282	432	583	1,388	2,270	2,270	2,270	2,270
International Flight (Foreigner)	397	847	1,297	1,748	4,163	6,810	6,810	6,810	6,810

(Source: JICA Study Team)

Table 4.7-5 Breakdown of Air Passenger Demand (Case B: Only Banepa)

	2027	2028	2029	2030	2035	2040	2045	2050	2055
Passenger (defference between with-case and without-case) (In 1000 person)									
Domestic Flight (Nepalese)	473	504	535	566	733	916	1,110	1,304	1,304
Domestic Flight (Foreigner)	709	756	803	850	1,099	1,375	1,665	1,957	1,957

(Source: JICA Study Team)

(2) Economic Cost

1) Project Cost

Project cost in economic analysis includes construction costs, consultant fee, physical contingency costs and PIU (Administrative cost), and inflation contingency costs, interest rates during construction and taxes are not included. In calculating the economic cost, the local currency cost of the construction cost is assumed to be 53% (proportion of foreign currency: general civil engineering 30%, construction 70%, utility 85%). The standard conversion factor of 0.9 is used for the local currency cost.

Table 4.7-6 Project Cost in Economic Analysis for Banepa Airport Development (Case A and B)

Item	Total		2021	2022	2023	2024	2025	2026
	Million JPY	Million NPR	Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)			
Eligible Portion								
Construction Cost	12,014	12,515	0	0	2,503	5,006	3,755	1,252
Physical Contingency	1,201	1,252	0	0	250	501	375	125
Consultant Fee	481	501	100	100	75	100	75	50
Physical Contingency	48	50	10	10	8	10	8	5
Non-Eligible Portion								
PIU(Admin.Cost)	500	521	4	4	103	204	153	52
Grand Total	14,244	14,838	114	114	2,939	5,821	4,366	1,484

(Source: JICA Study Team)

2) TIA Development Cost

Regarding the TIA development cost, it is decided not to include the project costs that are currently being planned, but toadd up the cost of facility maintenance, which includes construction of new PTB and expansion of apron, required up to the handling capacity limit in 2038.

Table 4.7-7 Project Cost in Economic Analysis of TIA Maintenance (Case A)

Item	Total		Phase-1					Phase-2				
			2021	2022	2023	2024	2025	2030	2031	2032	2033	2034
	Million JPY	Million NPR	Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)			Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)		
Eligible Portion												
Construction Cost	70,526	73,464	0	0	15,300	20,400	15,300	0	0	6,739	8,986	6,739
Physical Contingency	7,053	7,346	0	0	1,530	2,040	1,530	0	0	674	899	674
Consultant Fee	2,116	2,204	306	153	306	459	306	135	67	135	202	135
Physical Contingency	212	220	31	15	31	46	31	13	7	13	20	13
Non-Eligible Portion												
PIU(Admin.Cost)	2,906	3,027	12	6	624	834	624	5	3	275	368	275
Grand Total	82,811	86,262	349	174	17,791	23,779	17,791	154	77	7,836	10,474	7,836

(Source: JICA Study Team)

3) Maintenance Cost

Table 4.7-8 summarizes the actual operation and maintenance cost of airports in Nepal in the past.

Table 4.7-8 Administrative Expenses of Airports in Nepal (2017-2018)

Airports	Annual Cost (NRs) 2018-2019	Annual Cost (NRs) 2017-2018	Annual Passengers
Gautam Buddha Airport	48,279,105	44,809,028	About 370,000 (2018)
Nepalgunj Airport	59,111,632	54,224,587	About 400,000 (2018)
Pokhara Airport	46,021,489	42,698,134	About 600,000 (2018)
Biratnagar Airport	75,149,951	56,794,677	About 540,000 (2018)
Average	57,140,544 (57 million Rs.)	49,631,607 (50 million Rs.)	

(Source: JICA Study Team)

Based on the above results, operation and maintenance cost in economic analysis are set as shown in Table 4.7-9.

Table 4.7-9 Operation and Maintenance Costs in Economic Analysis

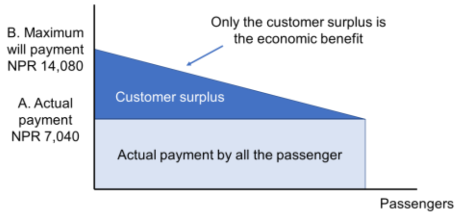
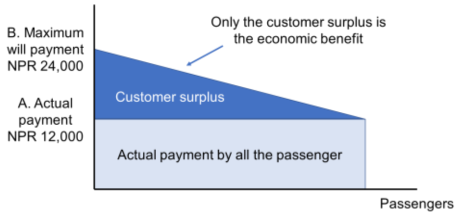
Items	FY2027-2036 (Million NPR Annually)	FY2037-2046 (Million NPR Annually)	FY2047-2055 (Million NPR Annually)	Analysis Method
Airport Operation Cost	108	162	216	Based on previous record of other airports, initial value is set at 60 Million NPR/500,000 passenger annually. Considering the annual passenger demand, economic price are converted using 0.9 of standard conversion value. ・2027-2036: double ・2037-2046: 3 times ・After 2047: 4 times
Maintenance Cost	138	275	413	Set by construction cost ratio ・2027-2036: 1.0% ・2037-2046: 2.0% ・After 2047: 3.0%

(Source: JICA Study Team)

(3) Mesuring of Economic Benefit

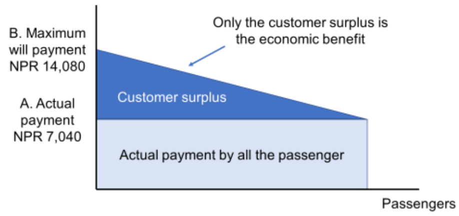
Setting for the economic benefits are summarized as in Table 4.7-10 and Table 4.7-11.

Table 4.7-10 Economic Benefit Calculation Method (Case A: TIA+Banepa)

Domestic / International	**Origin**	**Benefit Calculation Methods**	
Domestic Passenger	Nepalese	Consumer Surplus	It is desirable to calculate the benefits of domestic passengers using consumer surplus by reducing generalized costs, but as for Nepalese passengers, since the time value of users is extremely low, this method does not provide benefits. Therefore, for Nepalese passengers using  domestic flights, the benefit was calculated by the consumer surplus method. Here, the difference between the economic benefit of the passenger (willing to pay) and the economic cost will be added up as an economic benefit, the domestic one-way airfare is set at NPR 7,040 and the maximum economic benefit is set at twice the airfare.
	Foreigner		Not considered
International Passenger	Foreigner	Added Value of stay consumption	Value-added portion of the amount spent locally by the foreigner during their stay is taken as economic benefit. 1added value per person: 44 USD x 12.4 day x 113.9（Exchange Rate）x 18.3 % ≒ 11,000 NPR  ✈ Average one day expenditure per visitor: 44 USD（Nepal Tourism Statistics 2018） ✈ Average stay period: 12.4 day（Nepal Tourism Statistics 2018） ✈ Value-added rate: 18.3% Applied In 2018, as per the tourism white paper of Japan, the tourism consumption (final demand) in japan from Japanese and foreign tourists was estimated at 27.1 trillion Yen and value-added rate of 47.9% was calculated based on 12.9 trillion Yen of value-added in Japan. In Japan, due to the high labor cost, the ratio of labor cost against the sales account is large, and it seems that this causes high value-added rate. Thereforwe refered to 31.3% (FY2015-2016, Third Tourism Satellite Account of India, Gross Value Added (Rs. 9,442 billion) for the tourism industry divided by Gross Value of Output (Rs. 30,159 billion) for the tourism industry) in India, where it seems they have similar economic structure and labor cost, . From this 31.3%, 13% of the consumption tax rate in Nepal was subtracted and 18.3% was adopted.
	Nepalese	Consumer Surplus	Same as domestic flights, for Nepalese passengers using international flights, the benefit were calculated using the consumer surplus method. Here, the difference between the economic benefit of the passenger (willing to pay) and the economic cost will be recorded as an economic benefit, the domestic one-way airfare is set at NPR 12,000 (Nepal Airline routes) and the maximum economic benefit is set at twice the airfare.

(Source: JICA Study Team)

Table 4.7-11 Economic Benefit Calculation Method (Case B: only Banepa)

<table>
<tr><th>Domestic / International</th><th>Origin</th><th colspan="2">Benefit Calculation Methods</th></tr>
<tr><td rowspan="2">Domestic Passenger</td><td>Nepalese</td><td>Consumer Surplus</td><td>It is desirable to calculate the benefits of domestic passengers using consumer surplus by reducing generalized costs, but as for Nepalese passengers, since the time value of users is extremely low, this method does not provide benefits. Therefore, for Nepalese passengers using domestic flights,


the benefit was calculated by the consumer surplus method.
Here, the difference between the economic benefit of the passenger (willing to pay) and the economic cost will be added up as an economic benefit, the domestic one-way airfare is set at NPR 7,040 and the maximum economic benefit is set at twice the airfare.</td></tr>
<tr><td>Foreigner</td><td>Value Added</td><td>Value-added portion of the amount spent locally by the foreigner during their stay is taken as economic benefit.
1 added value per person: 44 USD x 9.4 days x 113.9（Exchange Rate）x 18.3 % ≒ 8,600 NPR
✈ Average one day expenditure per visitor: 44 USD（Nepal Tourism Statistics 2018）
✈ Average duration of stay: 9.4 day (12.4 days minus 3 days as expected before and after staying in Kathmandu)
✈ Value added rate:18.3% Applied</td></tr>
</table>

(Source: JICA Study Team)

(4) Outcome of Economic Analysis

The summary of the result of economic analysis of this project are as shown in Table 4.7-13 and Table 4.7-14.
In both cases, the benefit of the value-added amount of stay consumption of foreigners can be expected in both cases, and the EIRR value is 20.7% in case A (TIA + Banepa) and 22.5% in case B (only Banepa). This confirms the relevance of the project.

Table 4.7-12 Summary Result of Economic Analysis

Items	Calculation Result	
	Case A（TIA+Banepa）	Case B（Only Banepa）
Economic Internal Rate of Return（EIRR）	20.7%	22.5%
Economic Net Present Value（ENPV）	113,484 million NPR	23,396 million NPR
Benefit Cost Ratio（BCR）	4.97	4.54

(Source: JICA Study Team)

Table 4.7-13 Result of economic analysis (Case A: TIA+Banepa)

		Total	NPV	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				Design		Construction				O & M													
Traffic forecast (with - without)																							
【Domestic Flight】 Nepal residents	1000 person	消費者余剰								107	228	348	468	598	727	857	987	1,117	1,253	1,389	1,525	1,623	1,721
【Domestic Flight】 Visitor	1000 person	考慮しない								159	339	519	699	892	1,086	1,279	1,472	1,665	1,787	1,908	2,271	2,271	2,271
【International Flight】 Nepal residents	1000 person	消費者余剰								132	282	432	583	744	905	1,066	1,227	1,388	1,489	1,590	1,893	1,893	1,893
【International Flight】 Visitor	1000 person	付加価値額								397	847	1,297	1,748	2,231	2,714	3,197	3,680	4,163	4,466	4,769	5,678	5,678	5,678
Project cost	**million NPR**	**53,926**	**21,470**	**118**	**118**	**2,982**	**5,885**	**4,429**	**1,526**	**246**	**246**	**246**	**399**	**322**	**8,082**	**10,720**	**8,082**	**246**	**246**	**437**	**437**	**437**	**437**
Investment cost	million NPR	41,435	22,329	118	118	2,982	5,885	4,429	1,526				154	77	7,836	10,474	7,836						
O & M cost	million NPR	12,491	3,120							246	246	246	246	246	246	246	246	246	246	437	437	437	437
National economic benefit	**million NPR**	**1,160,543**	**267,525**							**3,353**	**7,154**	**10,956**	**14,757**	**18,838**	**22,919**	**27,001**	**31,082**	**35,163**	**37,915**	**40,668**	**47,965**	**48,311**	**48,657**
【Domestic Flight】 Nepal residents	million NPR	172,257	35,064							378	801	1,224	1,647	2,104	2,561	3,017	3,474	3,931	4,410	4,888	5,367	5,712	6,057
【Domestic Flight】 Visitor	million NPR	406	75							0	1	2	3	4	5	6	7	8	9	10	11	12	13
【International Flight】 Nepal residents	million NPR	263,435	61,969							794	1,694	2,595	3,495	4,461	5,428	6,394	7,360	8,327	8,933	9,539	11,357	11,357	11,357
【International Flight】 Visitor	million NPR	724,445	170,416							2,182	4,659	7,135	9,611	12,269	14,926	17,583	20,241	22,898	24,564	26,231	31,230	31,230	31,230
Sensitivity analysis																							
Cost +10%	million NPR	59,319	23,592	130	130	3,280	6,474	4,872	1,678	270	270	270	439	355	8,890	11,792	8,890	270	270	481	481	481	481
Benefit -10%	million NPR	1,044,488	149,501	0	0	0	0	0	0	3,018	6,439	9,860	13,281	16,954	20,627	24,300	27,974	31,647	34,124	36,601	43,168	43,480	43,791
Balance																							
Base case	million NPR	1,106,616	144,664	-118	-118	-2,982	-5,885	-4,429	-1,526	3,108	6,909	10,710	14,357	18,515	14,837	16,281	23,000	34,917	37,670	40,230	47,527	47,873	48,219
Case 1: Cost +10%	million NPR	1,101,224	142,520	-130	-130	-3,280	-6,474	-4,872	-1,678	3,083	6,884	10,685	14,317	18,483	14,029	15,209	22,192	34,893	37,645	40,187	47,484	47,830	48,176
Case 2: Benefit -10%	million NPR	990,562	128,053	-118	-118	-2,982	-5,885	-4,429	-1,526	2,772	6,193	9,614	12,882	16,632	12,545	13,581	19,892	31,401	33,878	36,164	42,731	43,042	43,354
Case 3: Cost +10%, Benefit -10%	million NPR	985,169	125,909	-130	-130	-3,280	-6,474	-4,872	-1,678	2,748	6,169	9,590	12,842	16,599	11,737	12,509	19,083	31,377	33,854	36,120	42,687	42,999	43,310

				5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	
		Total		2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2054	2055
				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
				O & M															
Traffic forecast (with - without)																			
【Domestic Flight】 Nepal residents	1000 person	消費者余剰		1,818	1,914	2,011	2,108	2,205	2,302	2,399	2,496	2,594	2,691	2,691	2,691	2,691	2,691	2,691	2,691
【Domestic Flight】 Visitor	1000 person	一般化費用		2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271
【International Flight】 Nepal residents	1000 person	考慮しない		1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893	1,893
【International Flight】 Visitor	1000 person	付加価値額		5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678
Project cost	**million NPR**			**437**	**437**	**437**	**437**	**437**	**437**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**
Investment cost	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M cost	million NPR			437	437	437	437	437	437	629	629	629	629	629	629	629	629	629	629
National economic benefit	**million NPR**			**48,998**	**49,340**	**49,682**	**50,024**	**50,365**	**50,709**	**51,052**	**51,395**	**51,738**	**52,081**	**52,082**	**52,083**	**52,084**	**52,085**	**52,086**	**52,087**
【Domestic Flight】 Nepal residents	million NPR			6,398	6,738	7,079	7,420	7,761	8,103	8,445	8,787	9,129	9,471	9,471	9,471	9,471	9,471	9,471	9,471
【Domestic Flight】 Visitor	million NPR			14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
【International Flight】 Nepal residents	million NPR			11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357	11,357
【International Flight】 Visitor	million NPR			31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230	31,230
Sensitivity analysis																			
Cost +10%	million NPR			481	481	481	481	481	481	692	692	692	692	692	692	692	692	692	692
Benefit -10%	million NPR			44,099	44,406	44,714	45,021	45,329	45,638	45,947	46,255	46,564	46,873	46,874	46,875	46,876	46,877	46,878	46,878
Balance																			
Base case	million NPR			48,561	48,903	49,245	49,586	49,928	50,271	50,423	50,766	51,109	51,452	51,453	51,454	51,455	51,456	51,457	51,458
Case 1: Cost +10%	million NPR			48,517	48,859	49,201	49,543	49,884	50,227	50,360	50,703	51,046	51,389	51,390	51,391	51,392	51,393	51,394	51,395
Case 2: Benefit -10%	million NPR			43,661	43,969	44,276	44,584	44,892	45,200	45,318	45,626	45,935	46,244	46,245	46,246	46,247	46,248	46,249	46,249
Case 3: Cost +10%, Benefit -10%	million NPR			43,618	43,925	44,233	44,540	44,848	45,157	45,255	45,563	45,872	46,181	46,182	46,183	46,184	46,185	46,186	46,187

Discount Rate	10%
EIRR	40.2%
B/C	12.46
EIRR (Case 1)	38.4%
EIRR (Case 2)	38.2%
EIRR (Case 3)	36.4%

(Source: JICA Study Team)

Table 4.7-14 Results of Economic Analysis (Case B: only Banepa)

		Total	NPV	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				Design		Construction				O & M													
Traffic forecast (with - without)																							
【Domestic Flight】 Nepal residents	1000 person	消費者余剰								473	504	535	566	600	633	666	700	733	770	806	843	880	916
【Domestic Flight】 Visitor	1000 person	考慮しない								709	756	803	850	900	949	999	1,049	1,099	1,154	1,209	1,264	1,320	1,375
Project cost	**million NPR**	**27,329**	**12,861**	**114**	**114**	**2,939**	**5,821**	**4,366**	**1,484**	**246**	**246**	**246**	**246**	**246**	**246**	**246**	**246**	**246**	**246**	**437**	**437**	**437**	**437**
Investment cost	million NPR	14,838	10,923	114	114	2,939	5,821	4,366	1,484														
O & M cost	million NPR	12,491	3,120							246	246	246	246	246	246	246	246	246	246	437	437	437	437
National economic benefit	**million NPR**	**227,497**	**57,773**							**3,919**	**4,178**	**4,437**	**4,695**	**4,971**	**5,247**	**5,523**	**5,799**	**6,075**	**6,379**	**6,684**	**6,988**	**7,293**	**7,597**
【Domestic Flight】 Nepal residents	million NPR	50,495	12,824							870	928	985	1,042	1,103	1,165	1,226	1,287	1,348	1,416	1,483	1,551	1,619	1,686
【Domestic Flight】 Visitor	million NPR	177,002	44,949							3,049	3,250	3,452	3,653	3,868	4,083	4,297	4,512	4,727	4,963	5,200	5,437	5,674	5,911
Sensitivity analysis																							
Cost +10%	million NPR	30,062	14,122	126	126	3,233	6,403	4,802	1,632	270	270	270	270	270	270	270	270	270	270	481	481	481	481
Benefit -10%	million NPR	204,747	32,285	0	0	0	0	0	0	3,527	3,760	3,993	4,226	4,474	4,723	4,971	5,219	5,467	5,741	6,015	6,289	6,563	6,837
Balance																							
Base case	million NPR	200,168	23,034	-114	-114	-2,939	-5,821	-4,366	-1,484	3,673	3,932	4,191	4,450	4,726	5,002	5,277	5,553	5,829	6,134	6,246	6,551	6,855	7,160
Case 1: Cost +10%	million NPR	197,435	21,750	-126	-126	-3,233	-6,403	-4,802	-1,632	3,649	3,908	4,166	4,425	4,701	4,977	5,253	5,529	5,805	6,109	6,203	6,507	6,811	7,116
Case 2: Benefit -10%	million NPR	177,418	19,447	-114	-114	-2,939	-5,821	-4,366	-1,484	3,281	3,514	3,747	3,980	4,229	4,477	4,725	4,973	5,222	5,496	5,578	5,852	6,126	6,400
Case 3: Cost +10%, Benefit -10%	million NPR	174,685	18,163	-126	-126	-3,233	-6,403	-4,802	-1,632	3,257	3,490	3,723	3,956	4,204	4,452	4,701	4,949	5,197	5,471	5,534	5,808	6,082	6,356

		Total		2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2054	2055
				5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	
				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
				O & M															
Traffic forecast (with - without)																			
【Domestic Flight】 Nepal residents	1000 person	消費者余剰		955	994	1,033	1,071	1,110	1,149	1,188	1,227	1,266	1,304	1,304	1,304	1,304	1,304	1,304	1,304
【Domestic Flight】 Visitor	1000 person	一般化費用		1,433	1,491	1,549	1,607	1,665	1,723	1,782	1,840	1,898	1,957	1,957	1,957	1,957	1,957	1,957	1,957
【International Flight】 Nepal residents	1000 person	考慮しない		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
【International Flight】 Visitor	1000 person	付加価値額		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project cost	**million NPR**			**437**	**437**	**437**	**437**	**437**	**437**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**	**629**
Investment cost	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M cost	million NPR			437	437	437	437	437	437	629	629	629	629	629	629	629	629	629	629
National economic benefit	**million NPR**			**7,918**	**8,239**	**8,560**	**8,881**	**9,202**	**9,524**	**9,847**	**10,169**	**10,491**	**10,813**	**10,813**	**10,813**	**10,813**	**10,813**	**10,813**	**10,813**
【Domestic Flight】 Nepal residents	million NPR			1,757	1,829	1,900	1,971	2,042	2,114	2,185	2,257	2,329	2,400	2,400	2,400	2,400	2,400	2,400	2,400
【Domestic Flight】 Visitor	million NPR			6,161	6,410	6,660	6,910	7,160	7,410	7,661	7,912	8,163	8,413	8,413	8,413	8,413	8,413	8,413	8,413
【International Flight】 Nepal residents	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
【International Flight】 Visitor	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sensitivity analysis																			
Cost +10%	million NPR			481	481	481	481	481	481	692	692	692	692	692	692	692	692	692	692
Benefit -10%	million NPR			7,126	7,415	7,704	7,993	8,282	8,572	8,862	9,152	9,442	9,732	9,732	9,732	9,732	9,732	9,732	9,732
Balance																			
Base case	million NPR			7,481	7,802	8,123	8,444	8,765	9,087	9,218	9,540	9,862	10,184	10,184	10,184	10,184	10,184	10,184	10,184
Case 1: Cost +10%	million NPR			7,437	7,758	8,079	8,400	8,721	9,043	9,155	9,477	9,799	10,122	10,122	10,122	10,122	10,122	10,122	10,122
Case 2: Benefit -10%	million NPR			6,689	6,978	7,267	7,555	7,844	8,134	8,233	8,523	8,813	9,103	9,103	9,103	9,103	9,103	9,103	9,103
Case 3: Cost +10%, Benefit -10%	million NPR			6,645	6,934	7,223	7,512	7,801	8,091	8,170	8,460	8,750	9,040	9,040	9,040	9,040	9,040	9,040	9,040

Discount Rate	10%
EIRR	22.5%
B/C	4.49

EIRR (Case 1)	21.0%
EIRR (Case 2)	20.9%
EIRR (Case 3)	19.5%

(Source: JICA Study Team)

(5) Result of Sensitivity Analysis

Table 4.7-15 shows the result of sensitivity analysis on the Economic Internal Rate of Return (EIRR). For sensitivity analysis, three cases were considered: 1) Case where the cost was +10%; 2) Case where the benefit was -10%; 3) Case where the cost is 10% and the benefit was -10%.

Table 4.7-15 Result of Sensitivity Analysis in Economic Analysis

Item	Calculation Result	
	Case A (TIA+Banepa)	Case B (Only Banepa)
Case 1: Cost +10%	19.6%	21.0%
Case 2: Benefit -10%	19.5%	20.9%
Case 3: Cost +10%, Benefit -10%	18.5%	19.5%

(Source: JICA Study Team)

4.7.3 Financial Analysis（FIRR）

In the financial analysis of this project, the cost and revenue for the case where Banepa Airport is developed (with Project Case) and the case where it is not implemented (Without Project Case) are created. The difference (Incremental Case) is calculated from that and Financial Internal Rate of Return (FIRR) is calculated based on differential cash flow, thereby evaluating the project financially.

(1) Aviation Demand used for Financial Analysis

Aviation demand (Annual passengers and aircraft movements) used for the financial analysis is as shown in Table 4.7-16 and Table 4.7-17.

Table 4.7-16 Aviation Demand for Financial Analysis (Case A: TIA + Banepa)

Item			2027	2028	2029	2030	2035	2040	2045	2050	2055
Annual Passenger	Domestic	Nepalese	107	228	348	468	1,117	1,721	2,205	2,691	2,691
		Foreigner	159	339	519	699	1,665	2,271	2,271	2,271	2,271
	International	Nepalese	132	282	432	583	1,388	1,893	1,893	1,893	1,893
		Foreigner	397	847	1,297	1,748	4,163	5,678	5,678	5,678	5,678
Arrival/ Departure	Domestic	Jet	0	14	29	43	55	88	98	173	173
		ATR72	8	-6	-21	-35	0	-5	10	-68	-68
		ATR42	4	12	20	28	60	89	110	149	149
		STOL	2	5	9	12	27	40	52	71	71
	International	L-Jet	4	8	11	15	35	56	56	56	56
		M-Jet	0	1	2	3	8	13	13	13	13
		S-Jet	5	10	16	21	50	45	45	45	45
		Propeller	1	1	2	2	3	-4	-4	-4	-4

(Source: JICA Study Team)

Table 4.7-17 Aviation Demand for Financial Analysis (Case B: Only Banepa)

Item			2027	2028	2029	2030	2035	2040	2045	2050	2055
Annual Passenger	Domestic	Nepalese	473	566	600	633	733	916	1,110	1,304	1,304
		Foreigner	709	850	900	949	1,099	1,375	1,665	1,957	1,957
Arrival/ Departure	Domestic	ATR42	93	112	118	125	144	179	217	254	254
		STOL	44	52	0	0	67	83	103	121	121

(Source: JICA Study Team)

(2) Expenditure Calculation

1) Project Cost

The Project cost in financial analysis includes construction cost, consulting fees, physical contingency, PIU (administrative cost) and taxes, and it does not include inflation contingency costs and interest rate during construction.

Table 4.7-18 Project Cost of Banepa Airport Development Project (Case A and B)

Item	Total		2021	2022	2023	2024	2025	2026
	Million JPY	Million NPR	Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)			
Eligible Portion								
Construction Cost	12,687	13,216	0	0	2,643	5,286	3,965	1,322
Physical Contingency	1,269	1,322	0	0	264	529	396	132
Consultant Fee	507	529	106	106	79	106	79	53
Physical Contingency	51	53	11	11	8	11	8	5
Non-Eligible Portion								
PIU(Admin.Cost)	528	550	4	4	109	216	162	55
Add 13% VAT	1,715	1,787	14	14	354	701	526	179
Grand Total	16,757	17,455	134	134	3,457	6,848	5,136	1,746

(Source: JICA Study Team)

Table 4.7-19 Project Cost of TIA Development Project (Case A)

Item	Total		Phase-1					Phase-2				
			2021	2022	2023	2024	2025	2030	2031	2032	2033	2034
	Million JPY	Million NPR	Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)			Design (Million NPR)	Tender (Million NPR)	Construction (Million NPR)		
Eligible Portion												
Construction Cost	76,798	79,998			16,830	22,440	16,830	0	0	7,169	9,559	7,169
Physical Contingency	7,680	8,000			1,683	2,244	1,683	0	0	717	956	717
Consultant Fee	2,304	2,400	337	168	337	505	337	143	72	143	215	143
Physical Contingency	230	240	34	17	34	50	34	14	7	14	22	14
Non-Eligible Portion												
PIU(Admin.Cost)	3,366	3,506	13	7	687	918	687	0	0	358	478	358
Add 13% VAT	10,283	10,712	44	22	2,232	2,983	2,232	19	9	951	1,271	951
Grand Total	100,661	104,856	427	214	21,802	29,140	21,802	176	88	9,353	12,500	9,353

(Source: JICA Study Team)

2) Operation and Maintenance Cost

The operation and maintenance cost for financial analysis is shown in Table 4.7-20.

Table 4.7-20 Operation and Maintenance Cost in Financial Analysis

Items	FY2027-2036 (Million NPR Annually)	FY2037-2046 (Million NPR Annually)	FY2047-2055 (Million NPR Annually)	Analysis Method
Airport Operation Cost	120	180	240	Based on previous result of other airports, initial value is set at 60 Million NPR/500,000 passenger annually. Annual passenger demand scale is considered. ・2027-2036: double ・2037-2046: 3 times ・After 2047: 4 times
Maintenance Cost	145	291	436	Set by construction cost ratio ・2027-2036: 1.0% ・2037-2046: 2.0% ・After 2047: 3.0%

(Source: JICA Study Team)

(3) Revenue Calculation

For aviation revenue to be used in financial analysis are as follows:

1) Aviation Revenue

As for aviation revenue, Nepal has “Airport Service Charge Regulation” which is shown in Table

4.7-21.

Table 4.7-21 Airport Service Charge Regulation in Nepal

TIA Domestic Flight Landing+C3:M33 Charges			
Less than 10Tons	Per Ton	NPR	55
10-25Tons	Upto 10Tons	NPR	550
	After that Per Ton	NPR	110
25-50Tons	Upto 25 Tons	NPR	2,200
	After that Per Ton	NPR	165
More than 50 Tons	Upto 50Tons	NPR	6,325
	After that Per Ton	NPR	220

Parking Charges for Domestic Flight			
Less than 40Tons	Per Ton	NPR	37.5
40-100Tons	Upto 40Tons	NPR	1,500.0
	After that Per Ton	NPR	54.0
More than 100Tons	Upto 100Tons	NPR	4,740.0
	After that Per Ton	NPR	75.0

Not Charged for 3hrs or less, after that every 6hrs.

International Flight Landing Charges			
Less than 10Tons	Per ton	USD	1.25
10-25Tons	Upto 10Tons	USD	12.25
	After that Per Ton	USD	2.50
25-50Tons	Upto 25Tons	USD	49.00
	After that Per Ton	USD	3.75
50-75Tons	Upto 25Tons	USD	140.50
	After that Per Ton	USD	6.00
75-100Tons	Upto 25Tons	USD	293.25
	After that Per Ton	USD	7.35
More than 100Tons	Upto 50Tons	USD	475.00
	After that Per Ton	USD	8.55

Parking Charges for International Flight			
Less tan 50Ton	Per Ton	USD	1.00
50-100Ton	Upto 50Tons	USD	49.00
	After that Per Ton	USD	1.05
More than 100Ton	Upto 100Tons	USD	122.25
	After that Per Ton	USD	1.95

Not Charged for 3hrs or less, after that every 6hrs.

Navigation Charge for Domestic Flight		
Less than 25Tons	USD	45.90
25-50Tons	USD	76.50
50-75Tons	USD	152.75
More than 25Tons	USD	305.50

Passenger Service Charges for Domestic Flight		
Domestic Destination	NPR	200

Aii Nationals

(Others)		
Tourism Service Fee	NPR	565

Aii Nationals

Passenger Service Charges for International Flight)		
SAARC countries	NPR	700
Other countries	NPR	1,000

Aii Nationals

(Source: CAAN)

2) Actual Aeronautical Revenue and Non-Aeronautical Revenue

Actual Aeronautical Revenue and Non-Aeronautical Revenue at TIA is summarized as in Table 4.7-22.

Table 4.7-22 Examples of Revenue at TIA

Item		2015/2016	2016/2017	2017/2018	2018/2019	Average
		(thousand NPR)				
Aeronautical Revenue	Landing Charge	711,200	733,307	774,841	1,037,760	814,277
	Parking Charge	140,193	121,280	155,988	224,802	160,566
	Passenger Charge	1,666,149	1,987,831	2,218,208	2,289,034	2,040,306
	Navigation Charge	369,699	453,730	488,718	509,800	455,487
	Others	86,612	93,185	98,861	111,847	97,626
	Total（A）	2,973,853	3,389,333	3,736,616	4,173,243	3,568,261
	A÷C	72%	71%	67%	74%	71%
Non-Aeronautical Revenue	Terminal Rent	149,409	173,752	246,705	211,170	195,259
	Land Rent	26,819	23,200	69,039	51,991	42,762
	Bank Interest	184,691	315,234	435,218	113,907	262,263
	Flight Catering	41,081	59,080	60,158	61,630	55,487
	Ground Handling	553,022	494,054	558,866	609,775	553,929
	Others	226,854	290,006	493,205	430,616	360,170
	Total（B）	1,181,876	1,355,326	1,863,191	1,479,089	1,469,871
	B÷C	28%	29%	33%	26%	29%
	B÷A	40%	40%	50%	35%	41%
Total（C）		4,155,729	4,744,659	5,599,807	5,652,332	5,038,132

(Source: created by JICA Study Team based on CAAN Data)

3) Tariff Calculation

Based on "Airport Service Charge Regulation" of Nepal and examples of revenue at TIA, the following conditions are adopted as shown in Table 4.7-23 which are to be used in financial analysis.

Table 4.7-23 Unit Rate to be used in Financial Analysis

Items			Units Cost (NPR)	Remarks
Landing Charge	Domestic Flight	Jet	14,357	
		ATR72	2,237	
		ATR42	1,413	
		STOL	373	
	International Flight	L-Jet	217,386	
		M-Jet	193,189	
		S-Jet	41,444	
		Propeller	5760	
Passenger Service Charge	Domestic Flight	100%	200	Current Price
	International Flight (SAARC)	20% of Passenger	1400	Set at double plrice of current price as with the construction of new PTB
	International Flight (Others)	80% of Passenger	2000	
Parking Charge		20% of Landing Charge		Average for past 4years
Navigation Charge		57% of Landing Charge		Average for past 4years
Non-Aeronautical Revenue		50% of Landing Charge		Considering the improvement of new PTB, set from 41% (average for past 4years)

(Source: JICA Study Team)

(4) Results of Financial Analysis

The summary of results of financial analysis are shown in Table 4.7-25 and Table 4.7-26.
In Case B: only Banepa Airport, income is only from domestic service charges and FIRR was negative. For Case A: TIA and Banepa Airport, it is possible to handle the demand for larger aircraft, such as international flights, by allocating ATR42 and STOL aircraft to Banepa Airport. This brings higher effect, and lead to the EIRR value of 10.2%.

Table 4.7-24 Summary Result of Financial Analysis

Items	Calculation Result	
	Case A (TIA+Banepa)	Case B (Only Banepa)
Financial Internal Rate of Return（FIRR）	10.2%	-5.5%
Financial Net Present Value（FNPV）	2,057 million NPR	-11,968 million NPR
Benefit Cost Ratio（BCR）	1.01	0.20

(Source: JICA Study Team)

Table 4.7-25 Financial Analysis Results (Case A: TIA + Banpa)

		Total	NPV	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				Design		Construction				O & M													
Project cost	**million NPR**	**62,892**	**25,283**	**134**	**134**	**3,503**	**6,916**	**5,204**	**1,791**	**265**	**265**	**265**	**501**	**383**	**9,677**	**12,864**	**9,677**	**265**	**265**	**471**	**471**	**471**	**471**
Investment cost	million NPR	49,446	26,564	134	134	3,503	6,916	5,204	1,791				235	118	9,412	12,589	9,412						
O & M cost	million NPR	13,446	3,363							265	265	265	265	265	265	265	265	265	265	471	471	471	471
Revenue	million NPR	**309,946**	**44,672**	**0**	**0**	**0**	**0**	**0**	**0**	**935**	**1,937**	**2,980**	**4,019**	**5,112**	**6,203**	**7,297**	**8,389**	**9,484**	**10,344**	**11,006**	**12,788**	**13,008**	**13,270**
Pasenger Service Charge	million NPR	92,705	13,445	0	0	0	0	0	0	275	587	900	1,212	1,547	1,882	2,217	2,552	2,887	3,103	3,318	3,938	3,948	3,958
Landing Charge	million NPR	65,472	9,277	0	0	0	0	0	0	176	395	615	832	1,049	1,264	1,481	1,697	1,915	2,096	2,278	2,462	2,644	2,825
Navigation Charge	million NPR	52,842	7,663	0	0	0	0	0	0	157	335	513	691	882	1,073	1,264	1,455	1,646	1,769	1,891	2,245	2,250	2,256
Parking Charge	million NPR	18,541	2,689	0	0	0	0	0	0	55	117	180	242	309	376	443	510	577	621	684	788	790	792
Non-Aeroneutical	million NPR	80,386	11,598	0	0	0	0	0	0	272	502	773	1,042	1,325	1,608	1,892	2,175	2,459	2,656	2,853	3,301	3,371	3,440
Sensitivity analysis																							
Cost +10%	million NPR	69,182	27,784	148	148	3,853	7,607	5,724	1,970	292	292	292	551	421	10,645	14,139	10,645	292	292	518	518	518	518
Benefit -10%	million NPR	278,951	40,205	0	0	0	0	0	0	842	1,743	2,682	3,617	4,601	5,583	6,567	7,550	8,536	9,219	9,904	11,460	11,702	11,943
Balance																							
Base case	million NPR	247,054	19,414	-134	-134	-3,503	-6,916	-5,204	-1,791	670	1,672	2,714	3,518	4,729	-3,474	-5,557	-1,288	9,219	9,978	10,534	12,263	12,532	12,800
Case 1: Cost +10%	million NPR	240,764	16,888	-148	-148	-3,853	-7,607	-5,724	-1,970	643	1,645	2,688	3,468	4,691	-4,442	-6,842	-2,256	9,192	9,952	10,487	12,216	12,485	12,753
Case 2: Revenue -10%	million NPR	216,059	14,946	-134	-134	-3,503	-6,916	-5,204	-1,791	576	1,478	2,417	3,116	4,218	-4,094	-6,287	-2,127	8,270	8,954	9,433	10,989	11,232	11,473
Case 3: Cost +10%, Revenue -10%	million NPR	209,770	12,421	-148	-148	-3,853	-7,607	-5,724	-1,970	550	1,451	2,390	3,066	4,180	-5,062	-7,572	-3,095	8,244	8,927	9,386	10,942	11,185	11,426

		Total	NPV	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	
				2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2054	2055
				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
				O & M															
Project cost	**million NPR**			471	471	471	471	471	471	676	676	676	676	676	676	676	676	676	676
Investment cost	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M cost	million NPR			471	471	471	471	471	471	676	676	676	676	676	676	676	676	676	676
Revenue	million NPR			13,302	13,333	13,363	13,393	13,424	13,481	13,539	13,596	13,653	13,709	13,709	13,709	13,709	13,709	13,709	13,709
Pasenger Service Charge	million NPR			3,967	3,977	3,987	3,996	4,006	4,016	4,025	4,035	4,045	4,055	4,055	4,055	4,055	4,055	4,055	4,055
Landing Charge	million NPR			2,831	2,837	2,842	2,847	2,853	2,878	2,904	2,929	2,954	2,978	2,978	2,978	2,978	2,978	2,978	2,978
Navigation Charge	million NPR			2,261	2,267	2,272	2,278	2,283	2,289	2,294	2,300	2,306	2,311	2,311	2,311	2,311	2,311	2,311	2,311
Parking Charge	million NPR			793	795	797	799	801	803	805	807	809	811	811	811	811	811	811	811
Non-Aeroneutical	million NPR			3,449	3,457	3,464	3,472	3,480	3,495	3,510	3,525	3,540	3,554	3,554	3,554	3,554	3,554	3,554	3,554
Sensitivity analysis																			
Cost +10%	million NPR			518	518	518	518	518	518	744	744	744	744	744	744	744	744	744	744
Benefit -10%	million NPR			11,971	12,000	12,026	12,053	12,081	12,133	12,185	12,236	12,288	12,338	12,338	12,338	12,338	12,338	12,338	12,338
Balance																			
Base case	million NPR			12,831	12,862	12,892	12,922	12,953	13,010	12,863	12,920	12,977	13,033	13,033	13,033	13,033	13,033	13,033	13,033
Case 1: Cost +10%	million NPR			12,784	12,815	12,845	12,875	12,906	12,963	12,796	12,852	12,909	12,965	12,965	12,965	12,965	12,965	12,965	12,965
Case 2: Benefit -10%	million NPR			11,501	11,529	11,556	11,583	11,611	11,662	11,509	11,560	11,612	11,662	11,662	11,662	11,662	11,662	11,662	11,662
Case 3: Cost +10%, Benefit -10%	million NPR			11,454	11,482	11,509	11,536	11,564	11,615	11,441	11,493	11,544	11,594	11,594	11,594	11,594	11,594	11,594	11,594

Discount Rate	10%
EIRR	16.8%
B/C	1.77

FIRR (Case 1)	15.5%
FIRR (Case 2)	15.4%
FIRR (Case 3)	14.2%

(Source: JICA Study Team)

Table 4.7-26 Financial analysis results (Case B: Only Banpa)

		Total	NPV	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				Design		Construction				O & M													
Project cost	**million NPR**	**30,901**	**14,939**	**134**	**134**	**3,457**	**6,848**	**5,136**	**1,746**	**265**	**265**	**265**	**265**	**265**	**265**	**265**	**265**	**265**	**265**	**471**	**471**	**471**	**471**
Investment cost	million NPR	17,455	12,850	134	134	3,457	6,848	5,136	1,746														
O & M cost	million NPR	13,446	3,363							265	265	265	265	265	265	265	265	265	265	471	471	471	471
Revenue	million NPR	**17,879**	**2,822**	**0**	**0**	**0**	**0**	**0**	**0**	**323**	**325**	**347**	**371**	**389**	**411**	**432**	**453**	**478**	**500**	**523**	**547**	**571**	**599**
Pasenger Service Charge	million NPR	6,861	1,082	0	0	0	0	0	0	118	126	134	142	150	158	167	175	183	192	202	211	220	229
Landing Charge	million NPR	1,090	170	0	0	0	0	0	0	20	18	20	24	23	24	25	26	30	30	31	32	34	38
Navigation Charge	million NPR	3,911	617	0	0	0	0	0	0	67	72	76	81	85	90	95	100	104	110	115	120	125	131
Parking Charge	million NPR	1,372	216	0	0	0	0	0	0	24	25	27	28	30	32	33	35	37	38	40	42	44	46
Non-Aeroneutical	million NPR	4,645	737	0	0	0	0	0	0	94	84	90	96	101	106	112	117	124	130	136	142	148	155
Sensitivity analysis																							
Cost +10%	million NPR	33,991	16,406	148	148	3,803	7,533	5,649	1,920	292	292	292	292	292	292	292	292	292	292	518	518	518	518
Benefit -10%	million NPR	16,091	2,540	0	0	0	0	0	0	291	293	312	334	350	369	389	408	430	450	471	492	514	539
Balance																							
Base case	million NPR	-13,023	-12,093	-134	-134	-3,457	-6,848	-5,136	-1,746	58	60	81	105	124	145	166	188	213	235	53	76	101	128
Case 1: Cost +10%	million NPR	-16,113	-13,584	-148	-148	-3,803	-7,533	-5,649	-1,920	31	33	55	79	97	119	140	161	186	208	6	29	54	81
Case 2: Revenue -10%	million NPR	-14,810	-12,375	-134	-134	-3,457	-6,848	-5,136	-1,746	26	27	47	68	85	104	123	142	165	185	0	21	44	68
Case 3: Cost +10%, Revenue -10%	million NPR	-17,900	-13,866	-148	-148	-3,803	-7,533	-5,649	-1,920	-1	1	20	42	58	78	97	116	139	158	-47	-26	-4	21

		Total	NPV	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	
				2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2054	2055
				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
				O & M															
Project cost	**million NPR**			471	471	471	471	471	471	676	676	676	676	676	676	676	676	676	676
Investment cost	million NPR			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M cost	million NPR			471	471	471	471	471	471	676	676	676	676	676	676	676	676	676	676
Revenue	million NPR			621	646	671	695	725	746	773	798	822	852	852	852	852	852	852	852
Pasenger Service Charge	million NPR			239	248	258	268	278	287	297	307	316	326	326	326	326	326	326	326
Landing Charge	million NPR			37	39	40	41	46	44	47	48	49	54	54	54	54	54	54	54
Navigation Charge	million NPR			136	142	147	153	158	164	169	175	180	186	186	186	186	186	186	186
Parking Charge	million NPR			48	50	52	54	56	57	59	61	63	65	65	65	65	65	65	65
Non-Aeroneutical	million NPR			161	168	174	180	188	193	200	207	213	221	221	221	221	221	221	221
Sensitivity analysis																			
Cost +10%	million NPR			518	518	518	518	518	518	744	744	744	744	744	744	744	744	744	744
Benefit -10%	million NPR			558	582	604	626	653	671	696	718	740	767	767	767	767	767	767	767
Balance																			
Base case	million NPR			150	176	200	225	254	275	97	121	146	176	176	176	176	176	176	176
Case 1: Cost +10%	million NPR			103	129	153	177	207	228	29	54	78	108	108	108	108	108	108	108
Case 2: Benefit -10%	million NPR			88	111	133	155	182	200	20	42	64	91	91	91	91	91	91	91
Case 3: Cost +10%, Benefit -10%	million NPR			41	64	86	108	135	153	-48	-26	-4	23	23	23	23	23	23	23

Discount Rate	10%
EIRR	-6.2%
B/C	0.19

FIRR (Case 1)	-8.7%
FIRR (Case 2)	-9.0%
FIRR (Case 3)	-13.4%

(Source: JICA Study Team)

(5) Result of Sensitivity Analysis

Table 4.7-27 shows the results of sensitivity analysis of the Financial Internal Rate of Return (FIRR). The three cases considered while carrying out sensitivity analysis, 1) Case where cost is +10%; 2) Case where the benefit was -10%; and 3) Case where cost is +10% and benefit is -10%.

Table 4.7-27 Result of Sensitivity Analysis in Financial Analysis

Items	Calculation Result	
	Case A (TIA+Banepa)	Case B (Only Banepa)
Case 1: Cost +10%	9.3%	-7.6%
Case 2: Benefit -10%	9.3%	-7.9%
Case 3: Cost +10%, Benefit -10%	8.5%	-10.8%

(Source: JICA Study Team)

4.8 Survey on Social and Environment

4.8.1 Related organizations, laws and standards

(1) Ministry of Forest and Environment (MoFE)

The Ministry of Forest and Environment (MoFE) is in charge of environmental policies and regulations. The Environment Protection Rules (1997) stipulates that MoFE for EIA, ministry or agency related to the project for IEE (for aviation projects MoCTCA) shall be the approver.
The overview of organization structure of MoFE is as shown in Figure 4.8-1.

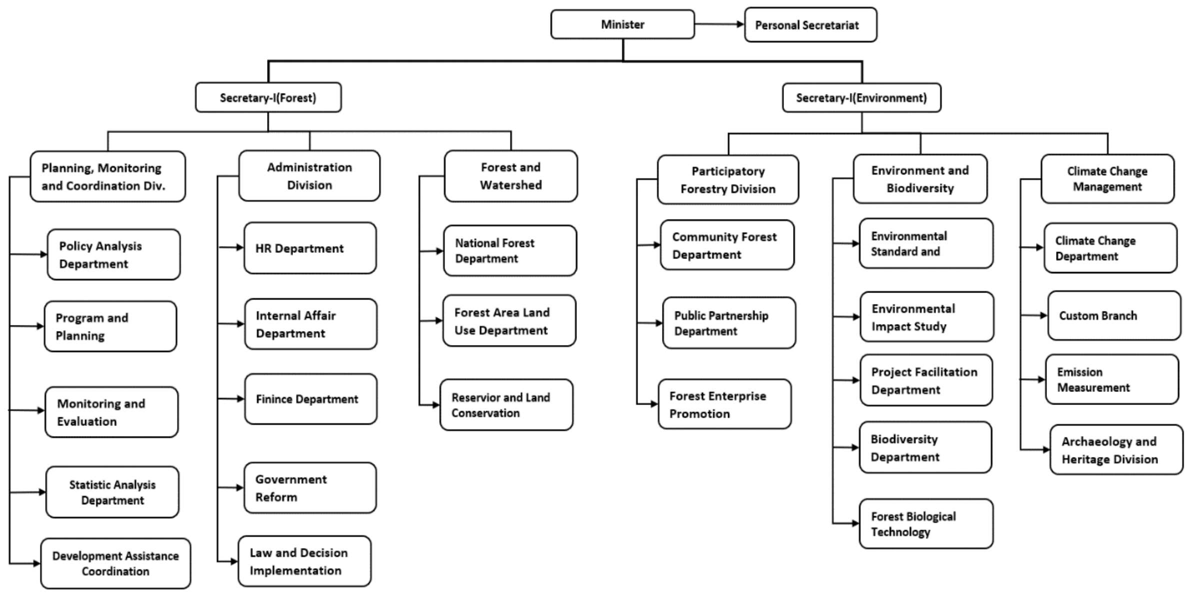


Figure 4.8-1 Organizational Chart of MoFE

4.8.2 Environmental and Social Consideration

(1) Related Laws and Regulation

Table 4.8-1 shows the environmental protection laws and regulations in Nepal

Table 4.8-1 Environmental Protection Laws

		No	title
A	Constitution and National Development Policies	1	The Interim Constitution of Nepal, 2063 BS (2007 AD)
		2	Three Years Interim Plan, 2011-2013
		3	Civil Aviation Policy, 2006
		4	Napal Tourism Policy, 1995
B	Act, Regulations and Rule	1	Environmental Protection Act (EPA) ,1997
		2	Environment Protection Rules (EPR), 1997
		3	Forest Act, 1993
		4	Forest Rules, 1995
		5	Soil Conservation and Watershed Conservation Act, 1982
		6	Land Acquisition Act, 1977
		7	The Labor Act, 1992
		8	Child Labor Prohibition and Regulation Act, 2001
		9	Nepal Civil Aviation Act 1958, and Civil Aviation Regulations, 1996
		10	Nepal Tourism Act, 1978
		11	Nepal Tourism Board Act, 1996
		12	Water Resources Act, 1992
		13	Water Resources Regulations, 1993
C	Guidelines, Work Procedure and Program	1	National Environmental Impact Assessment Guideline, 1993
		2	Work Procedure for Providing the Forest land for Other Uses. 2007
		3	National Adaptation Program of Action (NAPA), 2010

(Source: JICA Study Team)

(2) Environmental Impact Assessment (EIA) in Nepal

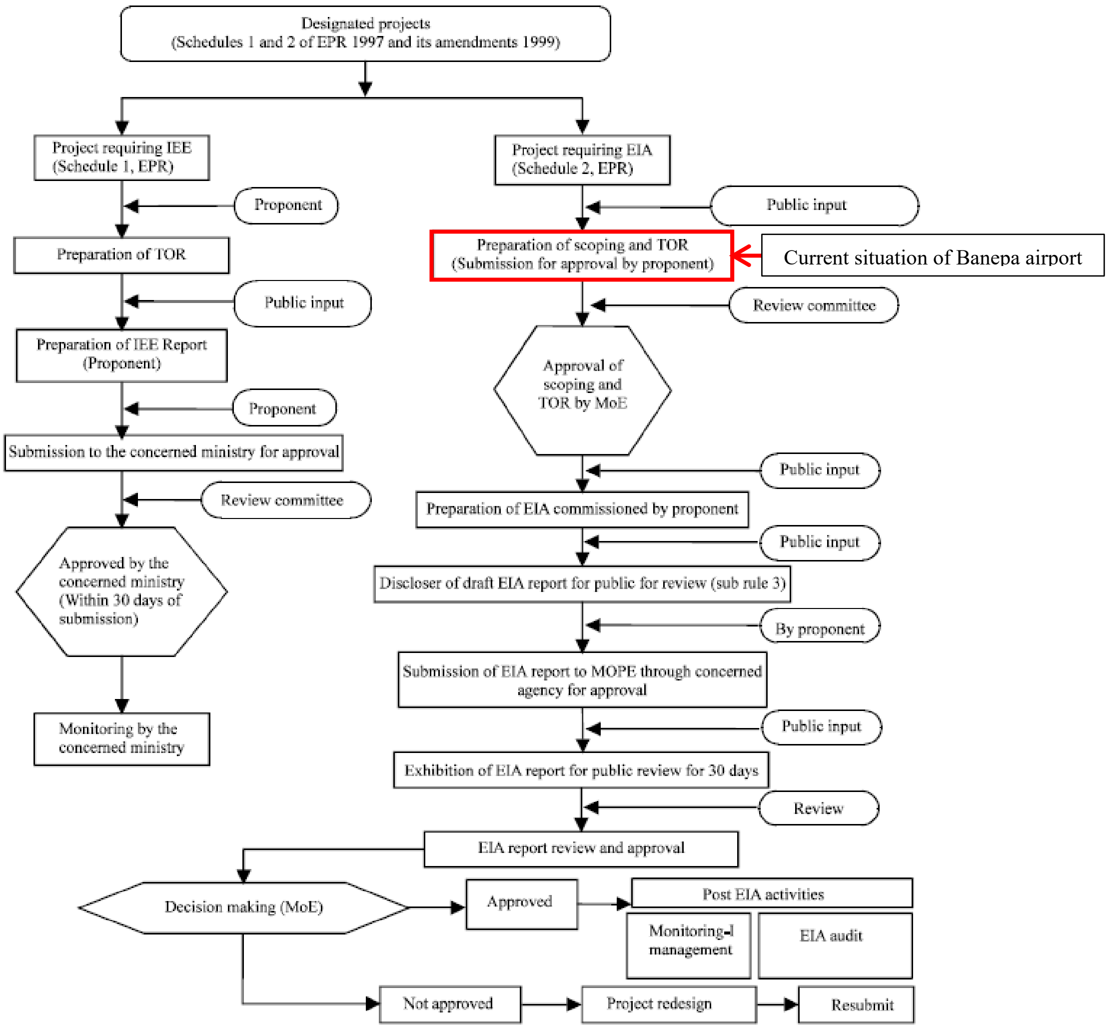
In Nepal, before the implementation of projects, it is required to either carry out Initial Environmental Examination (IEE) or EIA based on the project type. When the Environmental Protection Act (EPA(1997)) was formulated in 1996, and Environment Protection Rule (EPR(1997)) was formulated in 1997, the legal framework for Environmental Impact Assessment was created.
EPA (1997) and EPR (1997) stipulate the EIA approval process, projects which are required IEE or EIA preparation. The implementation criteria for the airport opening project are shown in Table 4.8-2.

Table 4.8-2 Implementation Criterai for Conducting EIA/IEE about Airport Project

Criteria	Criteria for conducting a survey	
	Project	Schedule
Initial Environmental Examination（IEE）	Existing Airport Expansion	Schedule-1.F.2
Environmental Impact Assessment（EIA）	New Airport Development	Schedule-2.F.2

(Source: JICA Study Team)

Since Banepa domestic airport is new airport, implementation of EIA is required.
In EPR (1997), IEE is required when the project cost is between 10 million and 100 million NPR, and EIA is required when the project cost exceeds 100 million NPR. Banepa domestic airport project also requires EIA under this regulation.
An overview of the EE and EIA approval process is shown in (Source: Nepal Government)
Figure 4.8-2.
Initial Environmental Survey (IEE) applies to small project with relatively small environmental impacts as described in EPR (1997) attachment 1. In the IEE, TOR of survey is formulated, the impact on the environment is investigated and analyzed according to the TOR, and then takes mitigation measures. The IEE report is submitted to the relevant authorities for approval.
On the other hand, EIA is applied to large-scale projects that have a relatively large impact on the environment as described in EPR (1997) attachment 2.
In the EIA, preparation of a scoping document (documents narrowing down the scope of consideration) is required before the determination of TOR.
Once both documents have been approved by the Ministry of Forests and Environment, which is the responsible agency, a detailed study will be conducted on the impact on the environment and measures to reduce it, and an environmental management plan will be prepared. In the implementation of EIA, it is obligatory to hold a public hearing at the site where the project will affect. The EIA is then submitted to the Ministry of Forests and Environments for approval.
While a scoping document and TOR in IEE will be submitted to related authorities for approval, those in EIA should be submitted to MoFE.



(Source: Nepal Government)

Figure 4.8-2 Flow of IEE/EIA in Nepal

CAAN is proceeding with the EIA procedure for Banepa domestic airport, and in 2018, the TOR and scoping document were prepared and submitted to the Ministry of Forests and Environment, which is the responsible agency, for approval.

(3) Environmental Impact Assessment as per JICA Guideline

The categories of the "Japan International Cooperation Agency Environmental and Social Considerations Guidelines" (hereinafter "JICA Guidelines") are as follows.

Applicable Guideline ： JICA Guidelines (April 2010)
JICA Category classification: A
Classification basis: As it corresponds to the "airport sector", which is a sector that has a high impact in the JICA Guidelines, it is necessary to consider the following items when implementing the project.

- Countermeasure for pollution during construction: Air, water quality (muddy water treatment), waste, soil, noise and vibration
- Countermeasures during operation: Investigation of the aircraft noise effect and implementation of necessary measures
- Natural environment: Conduct EIA, confirm impacts, and implement countermeasures

・Social environment: Employment measures for affected local residents, and implementation of appropriate procedures for land acquisition

4.9 Consistency between Banepa Airport Project and Nijgadh second International Airport

The viability of Nijgadh Airport to serve as an alternative international airport of TIAdepends on the completion of Fast Track. While it seems that earthwork are being started, construction work on structures such as bridges and tunnels has not started yet, and it is expected that it will take at least 10 years to complete.
Hence, it is assumed that it is not function as an alternative airport for TIA whose handling capacity will exceed its limit by 2023.

Chapter 5 Preliminary Study of Measures Related to Improving Safety of Mountainous Airport

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5 PRELIMINARY STUDY OF MEASURES RELATED TO IMPROVING SAFETY OF MOUNTAINOUS AIRPORT

5.1 Improvement of airport facilities

5.1.1 Facility improvement for enhancing safety

(1) Consideration of Airport for Facility Improvement

The current runway length at the mountain airports are not up to specification for the operation of STOL aircraft (DHC-6), that are currently operating on those runways.
The ICAO standard states that the runway gradient must be less than 1%, but some of the airport have longitudinal gradient of 1% or more. In addition, there are some airport whose runway strip width does not meet the ICAO standard, which instruct that the distance from the runway centerline to long shide of landing area shall be 30m or more. The interview with pilot stated that the longer runway would be safer for the operation.
Although it is desirable to extend the runways at all six airports based on the above situation, it was judged that it would be effective to start improvement from airports with a large number of passengers annually. Therefore, Lukla, Simikot and Jomsom airport are prioritized for the requirement of improvement of facilities,

Table 5.1-1 Facility of Mountain Airport and Interview Results

Airport	Simikot	Rara	Jumla	Dolpa	Jomsom	Lukla
Annual Passenger	54,261	19,360	14,163	19,352	46,401	124,929
Annual Takeoff and Landing	13,960	2,360	1,588	1,556	3,209	31,636
Runway	650 x 20m	650 x 20m	675 x 20m	560 x 20m	815 x 20m	527 x 20m
Slope	Max 6.5%	Max 6.5%	Plain	Max 8%	Riverbed	Max 11.7%
Runway Strip Width (distance from runway center line to long side of landing zone)	25m	20m	30m	20m	40m	15m
Apron Spot	Small 3 spots + 3 spots under construction	Small 2 spots	Small 3 spots	Small 3 spots	Small 4 spots	Small 4 spots
Pilot	Runway Extension	Runway Extension, Overrun Prevention	Runway Extension	Runway Slope Improvement, Overrun Prevention	Runway Extension	Runway Extension, Overrun Prevention, Apron Extension
Aviation Director, Joint Director	Large Tourism Demand	Large Tourism Demand	–	–	Large Tourism Demand	Large Tourism Demand
Number of accidents	7	1	3	3	2	8
Accident casualties	7	–	18	3	18	32

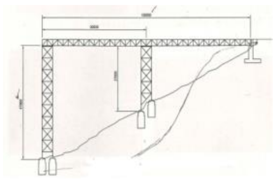
(Source: CAAN)

In addition, Lukla airport lacks the number of apron spots during the busy season, but since the airport is on a slope of 11.7% around the runway, the location where the apron can be constructed is limited, and the land around the airport is limited. It is difficult to expand the apron because there is no free space.

(2) Study on Facility Improvement Plan

During the study three airport are prioritized for the requirement of improvement of facilities, those airports are Lukla, Jomsom, and Simikot. The possibility of runway extension was examined, and the results are summarized in Table 5.1-2.

Table 5.1-2 Summary of Runway Extension of Mountain Airport

	Lukla Airport	Jomsom Airport	Simikot Airport
Current Runway Dimension & Orientation	530m x 20m 06/24	815m x 20m 06/24	650m x 20m 10/28
RWY Extension Direction & Extension Length	RWY06 side 100m and 30m wide	RWY06 side 100m and 80m Wide	Both RWY10 and RWY28 side 100m each and 80m Wide
Method of Extension	Steel Structure 	Embankment	Embankment (RWY28 side) Cutting (RWY10)
Estimated cost	4 BillionNPR or More	230 MillionNPR	600 MillionNPR
Transportation of construction materials	There are no roads, needs to be transported by helicopter with capacity to lift 3 tons(total weight of steel is 2,500 tons).The transportation can be made in 850 trips, if five trips per day, it takes 166 days to complete (but considering provision of efficiency 230 to 250 days is needed). The timely maintenance after every 50 hrs and 100 hrs are required, thus, another spare helicopter is may be needed for spare part transportation.	The road is connected from Pokhara to Jomsom, and materials and equipment can be transported by vehicle. Embankment materials can be procured locally.	Roads are connected from the Chinese side, and materials and equipment can be transported from China. Embankment materials can be procured locally.
Challenges	In addition to runway length other issues existing are shortage of apron spots and insufficient width of runway strip, but its difficult to expand current facilities	Land acquisition required for runway extension	Land acquisition required for runway extension
Evaluation of runway extension	Aprons and Landing area are difficult to expand, and it is desirable to build a new airport in another location	It is desirable to extend the runway	It is desirable to extend the runway

(Source: JICA Study Team)

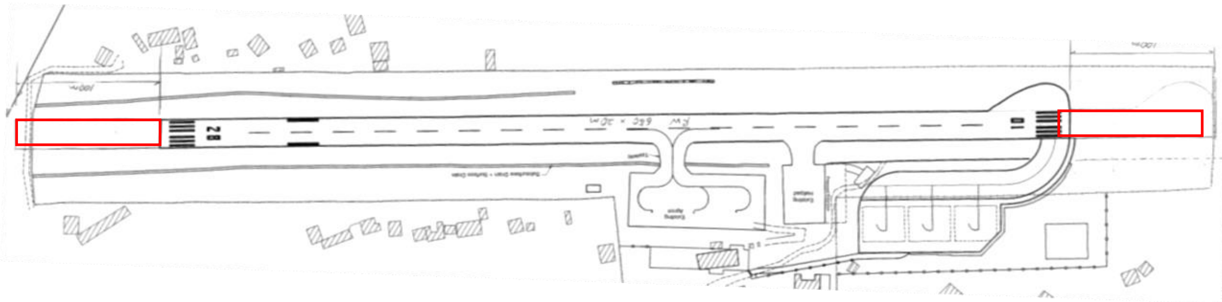
Lukla Airport has a steep topography at the side of runway extension allowing construction provision of landing strip width of about 30m. In addition, there are many issues during transportation of materials, moreover, it will cost 4 BillionNPR to extend the runway 100m. Since it is not a fundamental solution for improving facilities as there is difficulty in expanding current airport facilities such as apron due to limited land, it is desiable to construct new airport around the neaby ridge.
Since the extension of the runway at Jomsom and Simicot Airports is thought to increase safety, the effects of the extension will be discussed in the next section.

5.1.2 Examining benefits and cost of improvement plans

(1) Cost of Extension Projects

For Simikot Airport currently the runway length is 650m and the runway strip width is around 30m on either side of runway centerline. The runway can be extended for about 100m on both RWY10&28 side of runway.

Since there is stream in the direction of RWY28 side it is necessary to introduce culvert such as box culvert. Also, since some area of runway extension falls outside the current airport boundy, it is also necessary to acquire the necessary area of land.



(Source: JICA Study Team)

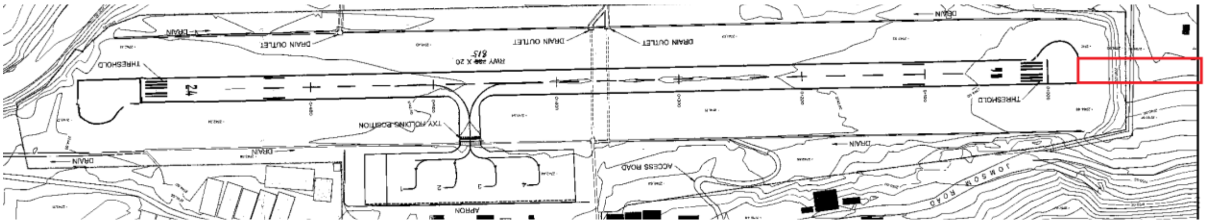
Figure 5.1-1 Runway Extension Plan of Simikot

Table 5.1-3 Cost Estimation for Runway Extension of Simikot Airport

S.No	Features of Airport Facilities/ Utilities	Dimension/Area	Unit	Unit Rate (NRs)	Preliminary Cost Estimated (NRs)	Remarks
A	General Items				15,000,000	
B	Earthworks	90,000	m^3	3,835	345,133,980	Cut Volume 90,000m^3 20% soil, 70% soft rock and 10% hard rock Fill Volume 90,000m^3
C	Pavement Structure Works	4,000	m^2	14,721	58,885,020	RW 200m延長
D	Drainage Works				30,000,000	
E	Chainlink Fence Works				15,000,000	
F	Miscellaneous Works				15,000,000	
G	Roads and Parking				7,500,000	
	Total A to G				486,519,000	
	Add 10% for Physical Contingency				48,651,900	
	Add 13% VAT				63,247,470	
	GRAND TOTAL WITH VAT				598,418,370	

(Source: JICA Study Team)

As for the Jomsom Airport, there is a river very close to RWY24 side, making it difficult to extend. For extension in RWY06 side, there is space for the extension, which is currently assumed for around 100m possibility. However, since the extension area is outside the boundry of airport, it is necessary to acquire the land.



(Source: JICA Study Team

Figure 5.1-2 Runway Extension Plan of Jomsom

Table 5.1-4 Cost Estimation for Runway Extension of Jomsom Airport

S.No	Features of Airport Facilities/ Utilities	Dimension/Area	Unit	Unit Rate (NRs)	Preliminary Cost Estimated (NRs)	Remarks
A	General Items				15,000,000	
B	Earthworks	90,000	m^3	965	86,888,160	Cut Volume 90,000m^3 90% soil, 10% soft rock Fill Volume 90,000m^3
C	Pavement Structure Works	2,000	m^2	7,361	14,721,255	RW 100m延長
D	Drainage Works				30,000,000	
E	Chainlink Fence Works				15,000,000	
F	Miscellaneous Works				15,000,000	
G	Roads and Parking				7,500,000	
	Total A to G				184,109,415	
	Add 10% for Physical Contingency				18,410,942	
	Add 13% VAT				23,934,224	
	GRAND TOTAL WITH VAT				226,454,580	

(Source: JICA Study Team)

(2) Effects and Economics

The extension of runway will not only improve the operation safety but also contribute to the service with ATR42-600 STOL aircraft which will be introduced on domestic flight in future, requiring runway length of 1000m for the operation. An economic effect is also expected when a 40-seater aircraft is in service at a mountain airport where 19 seaters currently operete.

5.2 Aviation Safety Systems

5.2.1 Challenges for Safety Improvement of Mountain Airports

(1) Interview Results with Related Stakeholders

One of the important issues in the aviation safety in Nepal is to reduce accidents for the mountain flights. Almost, all mountain flight accident occurs on the route to the destination airport or while returning. The interview with air traffic controllers (ATCO) and air traffic safety electronics personnel (ATSEP), Pilots and flight managers were carried out to identify the cause of accident during mountain flights. The results are summarized in Table 5.2-1.

For the purpose of examining the solution to the future issues the interview results are classified into communication, navigation, surveillance, weather and so on.

Table 5.2-1 Summary of Interview Result

Stakeholder	Issues	Classification
ATCO / ATSEP	✈ Nepal has VHF dead zone for air-to-ground voice communication ✈ Entrance or existence of dead zones are named like Virgin Pass, Simikot pass, Jomsom Pass and PP(Phaplu) pass. ✈ There is distance of 50NM from TIA to Lukla Airport and faces sound interruption for about 6 minutes from Lamajura pass to Gumba.	Communication (Air-to-Ground)
	✈ HF was used previously, for air-to-ground communication but due to weak sound quality it has been not in use for about 10-15 years	
	✈ For ground-to-ground voice communication, both hotline and mobile phones were used to communicate with nearby airport control units	Communication (Ground-to-Ground)
	✈ Although 18 airports are connected with AFTN, it can share basic flight plan information but information necessary for operation such as weather at another airport cannot be obtained fast.	
	✈ VFR aircraft flying in mountainous area cannot be monitored	Surveillance
	✈ Some airport is susceptible to the wind due to its topography and aircraft operation	Weather
Pilot Flight manager	✈ There are several dead zones for VHF air-to-ground voice communication	Communication (Air-to-Ground)
	✈ Communication with the controller is required for obtaining weather information of the flight route during flight especially wind information	
	✈ In the mountainous area it is not possible to use ground-based navigation support facilities (VOR/DME), so refer GPS information	Navigation
	✈ Need for the controller to monitor flight positions	Surveillance
	✈ The flight manager obtains the position information of their aircraft using an on-board position tracking system (V2 tracker, Foster Co-pilot) ✈ The update frequency of the aircraft position information is every two minutes	
	✈ Mountain airport have its high traffic during August-October	ATM
	✈ Some airport lacks sufficient metrological observation equipment	Weather
	✈ On the route to Lukla airport weather information near Lamujura is required to ensure safety	
	✈ Before the flight to mountain airport weather information and weather forecast information on the flight path are required	
Accident Investigation Report	✈ Ensure ground-to-air communication in VHF dead areas	Communication
	✈ Strengthening of safety monitoring systems in mountain areas	Surveillance
	✈ Utilization of surveillance system of operators (airline)	
	✈ Canceling of operation at Jomsom Airport under condition of 5knots or more tailwind	Weather
	✈ Provision of weather information on the flight path	
	✈ Display of ground surface wind information and installation of necessary weather observation equipment	
	✈ Notification regarding the updrift from the valley on the western side of Lukla airport	

(Source: JICA Study Team)

(2) Sorting out Issues at Mountain Airports

Based on the interview with the stakeholders, the issues and safety concerns assumed by those issues are summarized as in Table 5.2-2.

Table 5.2-2 Summary of Issues and Safety Concerns

Field	Issues	Safety concerns
Communication (Air-to-Ground)	✈ There is dead zone area of VHF between Nepalgunj and Simikot, Pokhara and Jomsom and Kathmandu and Lukla for ground-to-air communication. ✧ Geographical restriction exists for communication from airports ot control centers. ✈ HF is not used for the ground-to air communication due to its poor quality and inaudibility.	✈ In the area where VHF dead zone exist information such as presence of other aircraft flying around, weather information on route and destination airport cannot be obtained although they are essential to ensure the flight safety. ✈ It is difficult for the pilot to make decision ensuring safety without important information.
Communication (Ground-to-Ground)	✈ For communication between airports, HF is not used due to its poor-quality sound which is almost inaudible. ✈ AMHS is used for the information sharing between airports and also airport and control station but mostly AFTN is used. ✈ Most of the ground-to-ground communication are performed by hotline and mobile phones	✈ Most of the information such as aircraft departure and arrival report and weather information, which are necessary for confirmation and ensuring safety of flights is communicated by voice. ✈ In a voice call, time is taken during the transmission and there could be accuracy impaired information and errors.
Navigation	✈ No ground navigation facilities available ✈ Landing assistance facilities are not available ✈ As the navigation information, GPS information are used as secondary tools, but many aircraft do not have GPS receiver that can provide accurate position information	✈ When it , it becomes difficult to fly visually due to sudden weather worsenings, airplanes is not able to obtain its position. ✈ It is difficult to fly by visually confirming the safe route to follow. ✈ When the destination airport is not visible due to bad weather, only option is to return or to alternative airport, and it causes decrease in service rate.
Surveillance	✈ It is impossible to monitor flight position because aircraft flies out of radar range. ✈ ADS-B cannot determine the position information of aircraft as most of small aircraft used for mountain flight do not have DS-B. ✈ Location tracking equipment on small aircraft and helicopter is only connected to mobile networks. ✧ Since there are a lot of places on mountain area where mobile base station is not installed and radio wave is obstructed due to topography, flight position information cannot be obtained.	✈ Controller cannot accurately determine the location of the aircraft and ensure safe clearance between aircrafts. ✈ Although the pilot inquires the traffic information it is difficult to provide information for safe operation. ✧ During VFR flight it is possible for pilot to confirm safety visually, but if required the pilot inquires of the controllers information.
Weather	✈ Lack of weather information or weather forcast along flight route due to lack of weather observation devices. ✧ Wide-area weather radar under construction ✧ Although there is plans to equip weather radar for local weather observation, date is not fixed.	✈ Due to inability to forecast weather in advance the pilot may take flight under bad conditions. ✈ It is not possible to secure safety by allowing flights or adjusting flight timing.
Weather	✈ Weather information around airport cannot be obtained ✧ Insufficient weather observation equipment ✈ No metrological technician at mountain airports ✈ Due to complicated weather change in mountain area, forecast model has not been developed.	✈ Due to inability to forecast weather in advance the pilot may take flight under bad conditions. ✈ Inability to provide necessary weather information to pilots.

(Source: JICA Study Team)

5.2.2 Improvement of aviation safety system at mountain airport

In this section the improvement of safety system of mountain airports and how to improve the aviation safety system for flights to those mountain airports will be addressed. Matters that should be taken into account for examining the improvement will be also discussed.

(1) Communication

For the measures to improve ground-to-air communication in the mountainous airport, introduction of digital HF can improve both ground-to-air and ground-to-ground communications. On the other hand, due to high cost and implementation process for the airline, and also preparation needed for CAAN, it is expected to take some time.

Table 5.2-3 Countermeasures and consideration for communication

Measures	Details	Considerations
Introduction of RCAG	✈ VHF transceiver station to be set up near Nepal Telecom base station in Chitresthan (Lukla), Maithapla and Bharta Lagna (Simikot/Rara/Jomsom)	✈ Confirmation on timely maintenance possibility ✈ Examine communication coverage before installing ✈ Need of solar panel as back-up power supply
Introduction of Digital HF	✈ Introduction of digital HF at major mountain airports (those airports with large number of passengers and lack AMHS)	✈ Preliminary investigation and assignment of multiple frequencies are required because it depends on ionospheric condition. ✧ Switch to communicable channel according to the state of ionosphere ✈ For use in ground-to-air communication, on-board device is necessary to be mount. ✧ Installation of onboard equipment is expensive and require new certification procedure for airlines.

(Source: JICA Study Team)

(2) Ground-to-ground Communication (Data Communication)

The measures to improve data communication at mountain airports are as shown in Table 5.2-4. Since large-capacity date communication is required for introduction of AMHS, it is desirable to implement VSAT in parallel.

Table 5.2-4 Countermeasures and Considerations for Data Communication

Measures	Details	Consideration
Introduction of VSAT	✈ Except for Lukla Airport, which have VSAT installed already and Jomsom Airport, which has an optical fiber network in city, high-speed data communication will be possible at mountain airports. ✈ Ensure redundancy of ground-to-ground communication ✈ By introducing VSAT, it will become possible to introduce AMHS	✈ Require installation of ground antennas ✈ Require to pay usage fee for the networks ✈ Increased in cost will be a burden for airline or passenger while using the network
Introduction of AMHS	✈ Reliable communication will be possible through use of data communication avoiding use of telephone or mobile phones. ✈ In cooperation with weather system, weather information can be automatically notified.	✈ Prerequisite is the introduction of network infrastructures such as installation of VSAT

(Source: JICA Study Team)

(3) Navigation

The measures to improve data communication at mountain airports are as shown in Table 5.2-5. As for the navigation, GPS related measures are necessary for improving the safety of mountain flights for the airline, thus, CAAN is expected to put in place a mandatory regulation for the airline company in the future.

Table 5.2-5 Countermeasures and considerations for Navigation

Measures	Details	Consideration
Technical Assistance of Flight design procedure for mountain airports (Cloud Break)	✈ Instrumental Flight for mountain airport is realized by setting Flight procedure. ✈ It is possible to achieve both improvement of safety and improvement of service rate.	✈ There are no international standards so CAAN must design it own ✈ Ground installation of equipment such as LOC is required ✈ Requires training of pilots and controllers.
Recommendation GPS onboard with RAIM function	✈ Providing technical support to establish operation rules using GPS ✈ In order to operate using GPS, GPS onboard is recommended before making it mandatory.	✈ Airlines need to equip aircraft with compatible equipment. ✈ CAAN needs to change domestic regulations for flights. ✈ CAAN needs to disclose flight route information to fly with GPS (currently routes are set by airlines by themselves)

(Source: JICA Study Team)

(4) Surveillance

Measures for the improvements of surveillance at mountain airports are as shown in Table 5.2-6. It is recommended that the currently installed tracking device (V2 Tracker) for notifying aircraft position information is compatible with satellite communication. In this study, the recommendation is regarded as a prerequisite to ensure to obtain the aircraft position during flight in mountainious area. In practice, it would be desirable for CAAN to understand its necessity and recommend it as aregulator with the cooperation of airlines. Eventually, CAAN makes it mandatory.

Table 5.2-6 Countermeasures and Considerations for Air Surveillance

Measures	Details	Consideration
Recommendation using Satellite Network for tracking device	✈ V2 Tracker mounted on aircrafts for mountain flights (fixed wing/rotor wing) can obtain reliable position information ✧ Currently connection with mobile phone networks only ✈ Help in quicker search and rescue operations by obtaining its position ✈ If ground network is established thereby CAAN and airline share information, CAAN can provide control services referring to the position information	✈ Charges for satellite data usage will incur for airline ✈ Need changes in the regulations so that CAAN can recommend satellite communication for the onboard tracking device
Installation of MLAT to mountain airports	✈ Position information of aircraft can be obtained through signal of Mode A/C mounted on aircraft. ✈ In case of A-MLAT (made in Japan), it is possible to obtain aircraft position around airport ✈ With the use of position information by the controllers, obstacles and traffic information can be shared with pilots, thereby ensuring flight safety.	✈ Topographic condition may limit the range for the surveillance ✈ Depending on location of antenna, regular maintenance may be difficult to carry out.

(Source: JICA Study Team)

(5) Weather Observation

Measures for the improvement of weather observation and forecasting at mountain airports are as shown in Table 5.2-7.

Table 5.2-7 Countermeasures and Consideration for Weather observation

Measures	Details	Considerations
Installation of wind shear detector	✈ Needs to be installed at the end of runway in Lukla, Jomsom, Simikot and Rara Airports where the wind is strong and common.	✈ Current equipment has mechanism to uplink to aircraft by data link ✈ Since small mountain aircraft do not support those data links it is necessary to consider monitoring by controllers and notifying by voice communication.
Introduction of ITV	✈ Real time weather condition can be grasped for places where aircraft is difficult to fly without visibility.	✈ It may be difficult for the installation and maintenance of ITV around mountain airports.

(Source: JICA Study Team)

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Chapter 6 Aviation Safety Systems and Airport Security Preliminary examination of business for improvement

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6 PRELIMINARY STUDY OF PROJECTS RELATED TO AVIATION SAFETY SYSTEM AND AIRPORT SECURITY SYSTEM

6.1 ATC Operational Issues

6.1.1 Interview Results with related Stakeholders

Regarding the current air traffic control operation in Nepal, interviews with relevant stakeholders were conducted on the issues related to air traffic control in Nepal as a whole except for mountain airport. The following points are the issues related to current ATC operation in Nepal. The summary of interview is as shown in the Table 6.1-1. In order to examine solutions to the issues, the interview points are also classified under major fields.

Table 6.1-1 Summary of interview for Air Traffic Control operation in Nepal

Stakeholders	Place	Issues	Classification
ATCO/ ATSEP	TIA	✈ The domestic apron side cannot be seen	Surveillance
		✈ Lack of enough apron bay for aircraft makes it difficult for the effective implementation of ground control.	ATM
		✈ Difficulty in setting minimum interval between arriving aircraft below current 10NM considering on landing miss approach and departure procedures.	
		✈ Due to various constraints, it is difficult to increase the handling capacity of the airport and airspace resulting in frequent holding of arrival flights in air	
	Overall	➢ In western part of Terian region low altitude zones fall under blind zone and cannot be monitored by radar.	Surveillance
		✈ Many of the smaller aircraft taking-off and landing at Nepalgunj Airport cannot be monitored as they fly in low altitude.	
		✈ There are many aircraft without ADS-B, therefore most of them cannot be monitored.	
		✈ Due to lack of weather forecast data, pre-weather information cannot be provided and ATS, which is based on weather forecast, cannot be performed.	Weather
Pilot Flight Manager	TIA	✈ Crowded aircraft at the airport	ATM
		✈ Arrival aircraft holding in air is frequent	
		✈ Most of the delay are due to ATS and delay in morning flight causes remaining flight to delay	
Accident Investigation Report	TIA	✈ Eliminate congestion at airport	ATM
		✈ Repair ATIS systems	
		✈ Provide weather information including low visibility certainly	Weather
		✈ Record weather information at each airport without fail	

(Source: JICA Study Team)

(1) Sorting out issues related to Air Traffic Control Operation

Based on the interviews with the related stakeholder issues are gathered and resulting safety measures or operational efficiencies issues are summarized as in Table 6.1-2.

Table 6.1-2 Various Issues and Safety/Operational issues in Nepal

Field	Issues	Safety/Operational Problem
Surveillance (Airport)	✈ At the domestic apron at TIA, the movement of aircraft and GSE cannot be monitored	✈ Air traffic controller cannot accurately determine accurately the position of aircraft or GSE, so cannot provide safety clearance between aircraft and GSE. ✈ It is necessary to move aircraft efficientyly due to limited space of apron at TIA. However, it is impossible to monitor monitor accurate position and movement. Therefor, the operation efficiency is reduced.
Surveillance (Enroute)	✈ Low altitude aircraft in western Terrai region cannot be monitored. ✈ Since all aircrafts operating at Nepalgunj, which is hub airport in western Terrai region, flight low altitude, it is difficult to assure flight position.	✈ Air traffic controllers cannot accurately determine the position of aircraft, so they cannot keep safety clearance between aircrafts. ✈ Even if pilot want to confirm traffic information in the surrounding area, it cannot be provided necessary information for safety operation. ✈ On the domestic routes in western Nepal, IFR aircraft such as ATR72 faces difficulties in maintaining safety clearance between smaller aircrafts.
Weather	✈ Due to insufficient metrological observation equipment for high altitude, weather information on enroute cannot be obtained. ✈ It is difficult to develop aviation weather forcast model due to lack of weather data for weather forecast because of difficulties of obtaining weather data on enroute. Therefore, aviation weather forecast data cannot be provided. ✈ The airline cannot formulate operation plans several hours ahead as it considers weather conditions. ✈ Pre-adjustment between the air traffic control center and airlines is not possible considering changes in weather conditions. ✧ Wide-area weather radar is under construction ✧ Although there is a plan to develop weather radar for local weather observation, actual schedule is not fixed.	✈ Due to inability to predict weather conditions in advance, many flights have to fly under severe weather conditions. ✈ It is not possible to decide the pros and cons of flight or ensure safety by adjusting departure timing. ✈ It is not possible to provide necessary weather information to pilots. ✈ Airlines are taking individual response to obtain high altitude weather forecast data. ✧ The necessary information for safety operation of aircraft is obtained at the airlines' own expense. ✧ The level of operational safety varies with each airline company based on their effort towards obtaining safety information.
Controller	✈ The capacity of TIA and surrounding airspace is not maximized, congestion is normal. ✈ Since TIA is the only international airport with lot of domestic flight also operating, it causes traffic congestion. Therefore, both international and domestic flights are delay. ✈ Due to congestion at the airport and surrounding airspace, the workload of air traffic controllers is very high.	✈ Due to high workload on air traffic controller, it may impair their ability to make correct decision and concentrate due to psychological pressure and fatigues on the safe operation. ✈ TIA will not be able to fulfill its original airport handling capacity and number of passengers and cargo will slow down thereby opportunity loss will increase. ✧ It is likely to cause significant impact on revenue from tourism

(Source: JICA Study Team)

6.2 Improvement of Aviation Safety System throughout Nepal

In this section, measures that are required to be implemented for the improvement of safety and operational efficiency of aircraft in Nepal as whole will be discussed. In addition, consideration on the matters while implementing improvement measures will be also addressed.

(1) Airport Surface Monitoring at TIA

Measures to improve the airport surface monitoring are as summarized in Table 6.2-1. Since TIA is currently implementing an expansion plan, it is necessary to implement measures of airport surface monitoring gradually.

Table 6.2-1 Countermeasures and Consideration for Flight Scene Monitoring at TIA

Measures	Details	Consideration
Introduction of MLAT at TIA	✈ In line with TIA's gradual development scenario, MLAT needs to introduce to improve monitoring ability. ✧ Phase 1 : Infront of domestic terminal ✧ Phase 2 : Whole airport	✈ Although TIA has a M/P showing its final form, it is necessary to develop a plan to optimize the operation according to its phase development and status. ✈ If the facilities' arrangement in the airport change depending on the development plan, it is necessary to change the location of antenna or increase the number of antennas accordingly. ✈ MLAT will be introduced to provide efficient airfield operation in view of introducing airport guidance system such as A-SAGCS in future

(Source: JICA Study Team)

(2) Aircraft Surveillance

For the elimination of blind area in low altitude zone in western Nepal, CAAN has been implementing ADS-B installation plan, but it needs to be discussed with the related parties regarding the installation of ADS-B receiving station on-board. Also related regulation and clarification on kind of system to be used needs to be discussed.

Table 6.2-2 Countermeasures and Consideration of Aircraft Surveillance

Measures	Details	Consideration
Introduction of air route surveillance radar	✈ Introducing enroute surveillance radar in Nepalgunj airport. ✈ By installing radar, it will be possible to acquire the position data of aircraft flying on domestic routes in the low altitude zone in western Nepal.	✈ In consideration with the CAAN's plan to install ADS-B, expectation of the time preriod for installing ADS-B by airlines and the necessity of radar installation should be agreed with CAAN.

(Source: JICA Study Team)

(3) Operation of ATC in TIA

Measures to improve the operation efficiency of air traffic control operation in TIA are as shown in Table 6.2-3. There are two main approaches considered towards improvement. One is to improve airport operations and the other is to improve air traffic control operation in TIA terminal area and on enroute around TIA.

Table 6.2-3 Countermeasures and Consideration on Operation of ATC in TIA

Measures	Details	Consideration
Introduction of Airport CDM (A-CDM) to TIA	✈ The necessary information will be shared in real time between all stakeholders in the airport (air traffic controllers, flight managers, airport operators, ground handling, weather etc.). ✈ Due to quick information sharing among all stakeholders, each stakeholder can obtain necessary information for operational decision making easily and it will improve operational efficiency. ✈ It will eliminate delays.	✈ For the introduction of A-CDM, it is necessary to provide education to air traffic control agencies (including the TIA operation department) and airlines through technical assistance. ✈ For technical assistance, it is necessary to establish operational procedures in Nepal, while installing demonstration equipment at TIA, by conducting simulated operations and drafting operation manuals.
Shortening of separation minima within TIA terminal control area	✈ Revising the departure and missed approach procedures at TIA, so that they do not interfere with the arrival aircrafts. ✈ If there is no interference with the arriving aircraft, the separation minima of the arrival aircrafts in the terminal area can be reduced to less than 10 NM.	✈ It is necessary to design flight procedures with a view to review the air traffic control operation procedures in the terminal area ✈ When shortening separation minima and radar separation minuma, it is necessary to train air traffic controllers. Therefore, it is required to set training and study period by technical assistance.

(Source: JICA Study Team)

6.3 Improvement of Airport Security at TIA

As mentioned in previous sections, a new X-ray inspection equipment is installed behind the check-in counters in 2019 in line with the present on-going renovation and layout change of international passenger terminal building at TIA. As a result, the baggage checked thereafter is not handled by the passenger increasing security.
However, this equipment does not have function for inspecting explosives, so it is desirable to introduce next-generation equipment that can perform explosive inspection too for in-line checked baggage in future.

(Source: Rapiscan Home Page)

Figure 6.3-1 In-line checked baggage inspection equipment
(Next-generation explosive inspection equipment)

For passenger inspection and carry-on baggage inspection, X-ray inspection equipment are updated in 2019, together with explosive inspection equipment, thereby strengthening security.

		
Photo 6.3-1 X-ray equipment for checked-in baggage behind check -in counter	**Photo 6.3-2 Explosive inspection device installed in security area after immigration**	**Photo 6.3-3 X-ray inspection device in security area after immigration (installed in 2019)**

(Source: JICA Study Team)

6.4 Improvement of Airport Security at Other Airports

For Pokhara international airport and Gautam Buddha international airport, the terminal building is under construction. Since those airports are international airport it is desirable to provide security facility in accordance with international standards.

For the mountain airports, most of the airport has no x-ray inspection device for luggage, staff perform manual inspection. In future when propeller aircraft such as ATR42-600s Aircraft comes into operation, it is desirable to install X-ray inspection equipment in line with maintenance of passenger terminal buildings.

		
Photo 6.4-1 Inspection of baggages at Jomsom	**Photo 6.4-2 Rara airport passenger terminal**	**Photo 6.4-3 Simikot airport check-in counter**

(Source: JICA Study Team)

Chapter 7 Examining Future JICA Assistance in Aviation Sector in Nepal

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7 EXAMINING FUTURE JICA ASSISTANCE IN AVIATION SECTOR IN NEPAL

7.1 Overview

The chapter 3 of this report stated various issues in relation to Nepal aviation sector and measures for those issues were examined in Chapters 4-6. In this chapter, roadmaps towards addressing those issues were created based on the short-term, medium-term and long-term resolving methods. Subsequently, short-term measures were examined and the projects that could be assisted by JICA were sorted out. The flow of the study is a shown in Figure 7.1-1.

(Source JICA Study Team)

Figure 7.1-1 Study Flow for Future JICA Field of Support

7.2 Analysis of Issues and Measures

Regarding the issues and measures of the Nepal aviation sector discussed in Chapters 3 to 6, the urgency / significance of the issues (magnitude of impact) and its consistency with Nepal's aviation policy are evaluated in Table 7.2-1 to Table 7.2-16. In addition, regarding the urgency / significance of the issues, it will be examined the extent of seriousness of the issues to the aviation safety / capacity. The evaluation of the measures is made by focusing on the extent to which it contributes to the improvement of aviation safety / capacity.

Table 7.2-1 Evaluation of Capacity Enhancement of Airport in Kathmandu Metropolitan Area

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ The runway capacity at the peak time of TIA is approaching the limit.
✈ Since insufficient runway capacity even after the completion of TIA master plan development, the development of TIA is not the only solution for capacity enhancement of airport in Kathmandu metropolitan area.
✈ Ramechhap airport is located 150 km away from Kathmandu and the access time from Kathmandu will not be shortened from 4 hours in case of access road improved. It is difficult for Ramechhap airport to serve as an alternative airport of TIA.
✈ Nijgadh Second International Airport is an international airport with two runways and an annual passenger movoment of 67 million. This airport will have function as an alternativeariport of TIA. However, the construction of a fast truck, which is an access road from Kathmandu to the airport, is not progressing well. Because the fast track includes a 1.35 km tunnel and bridge, it is not completed soon and it still takes time.</td><td>✈ Development of parallel taxiway, international passenger terminal building and apron in TIA
✈ Banepa domestic airport development
✈ Development of Nijgadh Second International Airport and Fast truck
✈ New flight procedure design
✈ Shortening separation minima of arrival aircraft
✈ Change in air traffic control procedures due to change in flight procedure and reduce separation minima</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
TIA may continue to carry out an important role as a major airport in the Kathmandu metropolitan area. Therefore, early implementation of TIA development projects is essential. On the other hand, even if this development is implemented, it is not possible to make the most of the expanded airport operation capacity and runway operation capacity unless the current airspace operation capacity is improved. The construction of New Banepa Airport is an effective measure as solution. By moving the operation of ATR42 and STOL aircrafts to Banepa Airport, it will become not only an empty slot at TIA, but also separation minima for arrival aircraft will be shortened. At result, air traffic control capacity is improved by achiving efficient operation (additional technical assistance is required).

【Consistency with Aviation Sector Policy in Nepal】
The expansion of airport operation capacity in the Kathmandu metropolitan area is an important factor for the continuous economic growth of Nepal.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-2 Evaluation of Development Status of Major Domestic Airport

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ After starting operation of Pokhara International Airport and Gautam Buddha International Airport, it is expected that some passengers currently using TIA will use those airports. It is thought to have the effect of stimulating the demand for air travel to Nepal, not to have the role of alternative airport of TIA.
✈ Airports in the Terai region are being developed according to the airport master plan prepared for each airport, and it is expected that domestic flight aircraft will grow in size as domestic demand increases.
✈ In the mountainous airports under construction by CAAN, the runway length is 700 m or less. Even if a regular flight is in service, it is a STOL aircrafts.</td><td>✈ CAAN is in the process of developing Pokhara International Airport and Gautam Buddha International Airport.
✈ CAAN also is in the process of developing airports in the Terai region.</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
Due to the wide variety of develop airports and facilities, it is necessary to prioritize development.

【Consistency with Aviation Sector Policy in Nepal】
The development of domestic airports is also important in national development plan.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-3 Evaluation of Issues Related to Aviation Safety Facility (Communication)

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">a) VHF communication Dead Zone
✈ Between Nepalganj-Simikot, Pokhara-Jomsom, and Kathmanu-Lukla, there is dead zone for VHF communication, where air-to-ground communication cannot be performed. This led to pilot without information on surrounding aircraft and weather data to ensure safety during flight and while landing.
✈ Two sites for installation of RCAG have been selected in the preparatory survey of grant aid project “Main Airport Aviation Safety Equipment development plan”. Although, implementation was not carried out, the confirmation for the range of VHF communication for the elimination of current dead zone was verified.</td><td>✈ Introduction of RCAG to Chitrestan, Maithapla and Bharta Lagna
✈ Introduction of digital HF for air-to-ground communication at major mountain airports (6 locations)</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
It is most important for pilots to obtain flight information and weather information from ATCO during the flight for its safety. RCAG needs to be installed for this reason.

【Consistency with Aviation Sector Policy in Nepal】
Although it is recognized that RCAG can improve safety in mountainous areas, CAAN point out that it is difficult to maintain and manage RCAGs installed in mountainous areas. In addition, when using digital HF for air-to-ground communication, it is necessary to install a transmission and receiver devices on board at the expense of airline company, so it is necessary to check the cost-effectiveness among stakeholders and there should be agreement.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-4 Evaluation of Issues Related to Aviation Safety Facility (Ground-to-Ground Communication)

Task	Measure
a) Lack of communication line to mountain airports ✈ The information exchange between the mountain airports and hub airports is performed by poor quality HF communication and telephone line. HF communication has lot of voice breakages, so the necessary information is notified and acquired through telephone. ✈ At mountain airports, except for some airports, AMHS lines are not available. For this reason, flight information and weather information are reported only by voice, the amount of information is limited, accuracy and timeliness are lacking.	✈ Introduction of VSAT ✈ Introduction of AMHS ✈ Introduction of digital HF **Evaluation** 【Urgency and Importance of the Task】 It is great importance that the pilot is able to get various information on flight and weather from air traffic controllers. The air traffic controllers in each airport need to obtain this information. At present, necessary information is exchanged through telephone lines, it leads to insufficient information, so AMHS is necessary to improve the safety operation. It is important to introduce AMHS, even if RCAG is difficult so that pilot can get flight information from airports. By replacing HF that is not used with digital HF, the redundancy of ground-to-ground communication can be secured. 【Consistency with Aviation Sector Policy in Nepal】 It is considered important towards establishment of information exchange network

(Source JICA Study Team)

Table 7.2-5 Evaluation of Issues Related to Aviation Safety Facility (Navigation)

Task	Measure
✈ Since radio waves do not reach the mountainous areas, navigation aid facilities such as VOR / DME cannot be used, and it is difficult to install similar ground-based navigation aid facilities. ✈ VFR aircrafts use GPS information as a reference. However, the GPS accuracy in Nepal is not guaranteed, to be used at a level for aircraft navigation. So, it is necessary to verify the GPS accuracy and introduce a position accuracy augmentation system. ✈ In mountainous areas, it is necessary to be able to fly while ensuring a safe distance between aircraft and topography and among aircrafts. ✈ When sudden severe weather occurs, it is difficult to proceed VFR flight, and VFR flight pilots cannot obtain accurate aircraft position by itself.	✈ Recommendation of GPS equipped with RAIM functions ✈ Design of new flight procedure (Cloud Break) for mountain airports **Evaluation** 【Urgency and Importance of the Task】 GPS is used instead of VOR/DME by the current STOL aircraft, so it is important to improve GPS accuracy and reliability. As counter measures, utilization of either RAIM or SBAS can be made, however both measures require effort in the installation of on-board systems which may cause difficulty. 【Consistency with Aviation Sector Policy in Nepal】 It is difficult to take measures such as making mandatory installation as the installation of on-board system requirement is under control of airline and no request has been made by CAAN.

(Source JICA Study Team)

Table 7.2-6 Evaluation of Issues Related to Aviation Safety Facility (Surveillance)

<table>
<tr><th rowspan="1">Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ At present, the enroute surveillance radar in operation does not cover the northern mountainous areas.
✈ Regarding the installation of ADS-B under guidance of ICAO, most of the aircraft operating in the mountainous airport are not equipped with ADS-B related systems, So, at present it is difficult to use ADS-B for aircraft surveillance in the northern mountainous areas.
✈ There are steep mountains around the mountain airport, and the visibility range is often limited.
✈ The introduction of the conventional surveillance system is not considered realistic because there are problems in acquiring a place to install airport surveillance radars, transporting equipment and materials for installation work, and labors.</td><td>✈ It is recommended to use satellite communication for the tracking device mounted on aircraft
✈ Introduction of MLAT at mountain airports</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
As it is important for air traffic controllers to confirm the position of aircraft, there is difficulty in monitoring mountain flight since the surveillance radar cannot extend its coverage in mountainous area, for that it is necessary to adopt system that does not rely on ground facilities such as from satellites. Although there are satellite-based ADS-B under development, due to cost issues, its use may be difficult in Nepal. On the other hand, use of tracking device mounted on an aircraft can be considered but it requires on-board equipment incorporation for satellite communication and also have to weigh the cost for satellite communication.

【Consistency with Aviation Sector Policy in Nepal】
Airlines request strongly that CAAN provide aircraft position data to pilots. However, it is difficult to take measures such as making mandatory installation as the installation of on-board system requirement is under control of airline and no request has been made by CAAN.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-7 Evaluation of Issues Related to Aviation Safety Facility (Weather)

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ <u>Shortage of Human Resources:</u> DHM has assigned staff at TIA to observe weather and provide weather information. But due to limited personnel, air traffic controller provides weather data, which in turn lack the observation of meteorology from specialized point of view.
✈ <u>Lack of Metrological Equipment:</u> At the mountain airports, wind direction / velocity, temperature, and hygrometer are installed, but other observation devices, such as device to grasp changes in weather conditions are not installed. Therefore, the change in weather around destination airport and on enroute is difficult, it causes accidents or cancellation of flights.
✈ <u>Lack of Weather Forecasting Technology:</u> Due to the lack of observational data from the meteorological instruments around mountain airports, it is difficult for DHM to develop a forecasting model. Especially, at mountain airports, it is very difficult to predict the weather due to the unique topographical characteristics around each airport.
✈ Developing unique weather prediction model requires large amount of data collection and research period for model building.</td><td>✈ Introduction of X-band Radar
✈ Introduction of ITV
✈ Introduction of wind shear detector</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
X-band radar, ITV and wind shear detector are necessary to be installed to obtain data regarding weather and to make accurate weather forecast as it is required for the ensuring safety operation of aircraft. However, there are challenges for the installation of X-band radar, ITV including maintenance issues in the mountainous area.

【Consistency with Aviation Sector Policy in Nepal】
The airline needs information of the weather forecast on the flight route for safety, and strongly demands requirement of X-radar and ITV. However, CAAN has not mentioned any request.
For Lukla airport, there is demand for the installation of wind shear detection device by CAAN.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-8 Evaluation of Issues Related to Aviation Safety Facility (Airport)

Task	Measure
✈ Regarding the maintenance of air navigation systems, it is necessary to consider facilities and functions that not only improve safety but also improve efficiency of air traffic control and increase the capacity of TIA.	✈ Introduction of airport CDM (A-CDM) at TIA
	Evaluation
	【Urgency and Importance of the Task】 As recommended by ICAO, A-CDM can improve the airport operation efficiency by coordinating ATC, airline, airport operators, meteorology and military. Even in Japan it is in the stage of introducing it. In Nepal, there is urgent need of improving operational efficiency of TIA. Technical cooperation in the beginning that provides understanding of the operational concept is recommended. 【Consistency with Aviation Sector Policy in Nepal】 CAAN is requesting technical cooperation from Japan, since ICAO recommends its introduction at major airports.

(Source JICA Study Team)

Table 7.2-9 Evaluation of Issues Related to Aviation Safety Facility (Expansion of Radar Coverage in Western Nepal)

Task	Measure
✈ Most of central Nepal is within the radar coverage area, but the mountainous area and western Nepal (Tarai Plain) falls under blind areas. ✈ Although there are major routes for international flights and domestic flights in this area, the problem is that some areas are not within the radar coverage area. ✈ Regarding the monitoring of high-altitude enroute in the same area, there are currently four ADS-B stations installed, and it is considered that there is no problem because all aircrafts flying on enroute are equipped with ADS-B. However, due to mixed operation of ADS-B equipped aircraft and smaller low altitude aircraft with no ADS-B installed, it causes the surveillance ineffective.	✈ Introduction of enroute surveillance radar at Nepalgunj airport ✈ Introduction of MLAT to Nepalgunj, Bhairawa, Biratnagar airport
	Evaluation
	【Urgency and Importance of the Task】 Aircraft flying at high altitude can be monitored by air traffic controllers as they are already under surveillance radar and ADS-B coverage. However, most aircrafts flying at low altitudes in western Nepal, or STOL aircrafts using Nepalgunj Airport do not equip ADS-B, and air traffic controllers cannot verify the location information. Therefore, considering the safety of aircraft operation, installation of radar or MLAT is important. 【Consistency with Aviation Sector Policy in Nepal】 CAAN is carrying out ADS-B implementation for high-altitude aircraft surveillance, which can enhance surveillance and safety of low altitude aircraft operation. However, no specific request for installation of radars had been made.

(Source JICA Study Team)

Table 7.2-10 Evaluation of Issues Related to Aviation Safety Facility (Development of Information Network)

Task	Measure
✈ Currently, the Civil Aviation Authority of Nepal does not have a network that centrally manages information necessary for air traffic control such as flight plan, weather and aircraft position. For this reason, the ACC (Area Control Center) and air traffic controllers at each airport cannot share necessary information. Air traffic controllers cannot provide the necessary information to pilots and airlines. ✈ Obtaining meteorological information during flight is an important issue. However, obtaining appropriate meteorological information before flight is the big issue. It is necessary to take measures to reduce decision making errors by pilots.	✈ Connecting all domestic airport to establish an information exchange network **Evaluation** 【Urgency and Importance of the Task】 The air traffic controller and pilot require flight information and weather data in accurate and quick manner. Currently there are only few airports that are connected by high speed digital network and most of airports are shared information through voice communication. It is important to develop a high-speed information network in order to improve the efficiency of air traffic control, improve the safety of flight operations, and quickly share various information. 【Consistency with Aviation Sector Policy in Nepal】 It is recognized that the development of an information network is necessary, but due to the budget perspective, only hub airports are connected. On the other hand, the development of information network is prerequisite for implementing ATFM requested by CAAN.

(Source JICA Study Team)

Table 7.2-11 Evaluation of Issues Related to Aviation Safety Facility (Visibility from ATC at TIA)

Task	Measure
✈ The ATC tower at TIA lacks line of site at domestic apron. If air traffic controller lacks visibility, it will be difficult to guide when traffic is crowded, which will affect smooth arrivals and departures. It is important for air traffic controller to be able to confirm the position of the aircraft, which not only leads to improvement in efficiency but also improvement in safety.	✈ Construction new ATC tower at TIA ✈ Introduction of MLAT at TIA **Evaluation** 【Urgency and Importance of the Task】 Currently, domestic apron cannot be seen from the ATC tower. The fact that air traffic controller cannot confirm the position of aircrafts at the airport, construction of new ATC tower with the height that allows the entire airport can be viewed is required. At the same time, to renew old management and facility building that has system necessary for air traffic services is necessary. Furthermore, there is requirement to install airport surface surveillance system such as MLAT in order to monitor movement of aircrafts and vehicles in the airport and improve efficiency of airport operation. 【Consistency with Aviation Sector Policy in Nepal】 CAAN has requested the construction of a new ATC tower. Regarding the construction of ATC tower, sufficient coordination of design requirements, implementation timing and scale is required with the CAAN in consideration with the expansion project of TIA which is implemented by ADB and CAAN's fund.

(Source JICA Study Team)

Table 7.2-12 Evaluation of Airport Security

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ By promoting the introduction of advanced security inspection equipment for security checks at international airports, the burden on passengers related inspections will be reduced, and inspections will be smoothed and stricter.
✈ Inspection accuracy will be increased by using security inspection equipment for security check at mountain airports.</td><td>✈ Introducing security inspection equipment at mountain airports
✈ Introduction of advanced security inspection equipment at international airports.</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
CAAN is proceeding with the installation of security inspection equipment along with the facility development at the airport.

【Consistency with Aviation Sector Policy in Nepal】
Installation of security inspection equipment is proceeding according to the development policy of CAAN.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-13 Evaluation of Development of Human Resources

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ The curriculum for the first-time employees is based on the curriculum of Singapore Academy and other institutions as references, but making a good curriculum is difficult for CAAN. Therefore, CAAN requests Japan to support the curriculum development for the administrative employees training, excluding air traffic controllers and fire fighting rescue staff.</td><td>✈ Dispatch training advisors
✈ If new equipment is introduced from Japan, training on newly introduced equipment will be possible.
✈ Technical cooperation in relation to training is provided from Japan</td></tr>
<tr><th>Evaluarion</th></tr>
<tr><td>【Urgency and Importance of the Task】
At CAAN, the Civil Aviation Academy (CAA) was established for human resource development required for aviation administration in Nepal and at the same time provide education for capacity building. Since CAA lack some curriculums, staffs are sent abroad to acquire latest skills. It is necessary to establish a department to study human resource development, such as personnel allocation in CAAN, and future personnel planning.

【Consistency with Aviation Sector Policy in Nepal】
CAAN requests Japan's cooperation in formulating a training curriculum to train administrative staff other than air traffic controller and fire fighting rescue staff.</td></tr>
</table>

(Source JICA Study Team)

Table 7.2-14 Evaluation of Features of Civil Aviation Academy

Task	Measure	Evaluation
✈ There is a shortage of resident instructors. ✈ If training materials which is made in accordance with the purpose as well as to fully set curriculum, so any eligible instructor can provide the standardized level of trainings. It is important that they can prepare appropriate training materials by themselves, therefore, CAAN and CAA received the membership of ICAO TRAINAIR PLUS program. CAAN and CAA have already done necessary training process, so it seems that CAAN and CAA understand the guidance of training materials development. ✈ Due to less opportunity to learn aviation technology, CAAN staff has a request that, if there are more opportunity to attend training and seminars, particularly the need for SMMS training is high.	✈ Temporarily set up formulation of training material project team to upgrade and create new training materials. ✈ Implementation of educational technical cooperation in CNS/ATM field by JICA ✈ Implementation of third country training => Accept trainees from countries that have insufficient training facilities or training programs among the countries that are members of SAARC (South Asian Association for Regional Cooperation)	【Urgency and Importance of the Task】 Considering the work situation of CAAN and future system and operation improvement, it is necessary to implement some training items. Since, CAAN has shortage of personnel who can act as instructor, it is necessary to involve external technical cooperation for instructors in each specialized field. 【Consistency with Aviation Sector Policy in Nepal】 CAAN has requested to increase the opportunity for staff to undergo training and seminars

(Source JICA Study Team)

Table 7.2-15 Evaluation of Improvement of Safety Supervision System

Task	Measure	Evaluation
✈ Within CAAN's organization, there is a safety regulation department that sets standards, but no department or agency to control or oversee audit works. In order to properly implement safety management, ICAO has proposed the establishment of a regulator, which is established the agengy that is called to be a provider of air traffic services individually and an organization that audits the business situation from the aspect of safety management. ✈ Currently, MoCTCA and CAAN are newly installed as the Air Service Authority of Nepal (ASAN) and are considering the separation of responsibility between rule-making department and safety auditing department in the future. ✈ CAAN has challenges to clear safety standards provided by ICAO as soon as possible and to establish the function of regulator as a new entity.	✈ Separate provider function individually from CAAN ✈ Guidance for the safety auditing procedure and method for regulators ✈ Implement training and education program for safety auditing ✈ Conduct safety audit training. Share implementation status of Japan in safety audit conducted by regulator. ✈ Education in following fields, SMS (Safety Management System) Hazard and Threat Safety audit Recurrence prevention Change management	【Urgency and Importance of the Task】 After restructuring the provider and the regulator, any technical cooperation and support are needed to establish the regulator. 【Consistency with Aviation Sector Policy in Nepal】 Restructuring of CAAN into provider and regulator is an important policy of CAAN. However, CAAN has not made any particular request to Japan.

(Source JICA Study Team)

Table 7.2-16 Evaluation of Aviation Accident Investigation and Recurrence Prevention System

<table>
<tr><th>Task</th><th>Measure</th></tr>
<tr><td rowspan="3">✈ Since there is no analysis device for FDR (Flight Data Recorder) or CVR (Cockpit Voice Recorder), the analysis is either outsourced to the aircraft manufacturing country or technical cooperation of France.
✈ There is need for the capable person who receive training for the development of tools related to accident investigation and the methodology of accident investigation. Therefore, CAAN requests to undergo training in Japan in accident investigation methods.
✈ Accident investigation committee provides the recommendation for accident recurrence prevention system as a part of the results in an accident investigation to MoCTCA, CAAN, airlines etc. However, the committee have not proceeded systematical follow-up to stakeholders.
✈ While an accident investigation is conducted, no incident investigation scheme is set. In the future, both accident and incident are to be surveyed in order to manage setting recurrence prevention measures.</td><td>✈ Education for investigation committee member
✈ Formulate process from investigation report creation to publication
✈ Setting accident investigation equipment
✈ Recommendation and management of implementation status by investigation committee to prevent accident recurrence
✈ Guidance for improvement process to prevent recurrence of accident
✈ Conduct accident investigation trainning
✈ Learn about accident investigation method and analysis techniques
✈ Lists for education items are as follows;
Initial accident investigation
Site exploration and management
Accident investigation equipment
Analyzing
Reporting</td></tr>
<tr><th>Evaluation</th></tr>
<tr><td>【Urgency and Importance of the Task】
In this field, technical cooperation from Japan is necessary for accident analysis and recurrence prevention measures. It is necessary to carry out immediate accident investigations, study recurrence prevention measures as per investigation results and ensure implementation of improvement measures for aircraft operations.

【Consistency with Aviation Sector Policy in Nepal】
Learn the techniques related to aviation accident investigation and implement accident investigation that does not rely on foreign cooperation.</td></tr>
</table>

(Source JICA Study Team)

7.3 Measures for the Issues in the Aviation Sector of Nepal (Short-Term, Medium-Term, Long-Term)

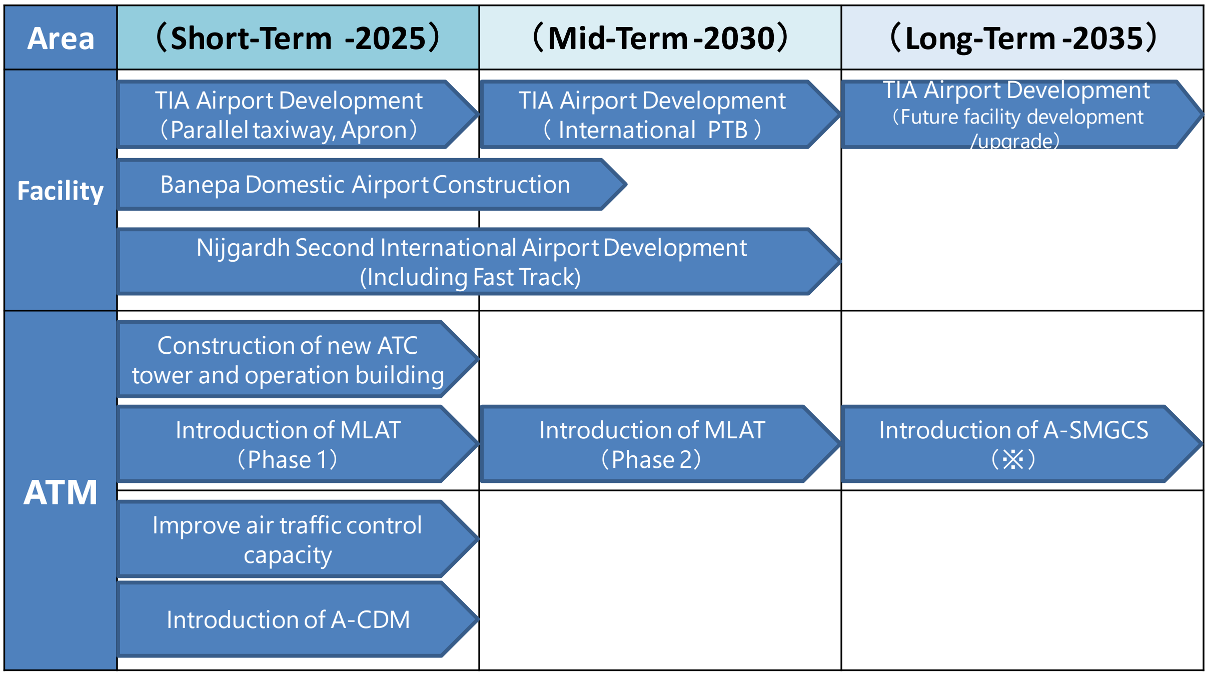
7.3.1 Overview

Based on the preliminary study results of Chapter 4,5 and 6, the roadmap of projects that are necessary for the Nepal's aviation sector is summarized in the following sections.

7.3.2 Measures for the Issues in Avaition Sector of Nepal (Short-Term, Medium-Term, Long-Term)

(1) Measure of Capacity Enhancement of Airport in Kathmandu Metropolitan Area

Improving the airport facility capacity for future demand in the Kathmandu Metropolitan Area is an urgent issue. TIA is planning to develop facilities over the medium to long term, but this alone cannot secure enough capacity to handle future demand. From the results of the study in Chapter 4, it may be possible to share the demand with the new Nijgadh second international airport in the future, but short-term measures are necessary, and the construction of the Banepa domestic airport will be necessary to increase the airport capacity in Kathmandu metropolitan area. And it can be judged that this is a highly effective measure by constructing Banepa Domestic Airport for ATR42 and STOL aircraft and additionally improving the capacity of air traffic control operation in TIA.



※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source JICA Study Team)

Figure 7.3-1 Roadmap for Capacity Enhancement of Airport in Kathmandu Metropolitan Area

(2) Roadmap for Improvement of Mountain Airport Safety/Aviation Safety System

As for the measures to improve the mountain airport safety/air navigation system, various improvement measures are as shown in Figure 7.3-2.

Area	（Short-Term -2025）	（Mid-Term -2030）	（Long-Term -2035）
Facility	Simkot and Jomson Runway Extension	Lukla new airport development	
Com	Introduction of RCAG Introduction of VSAT at major airport Introduction of AMHS at major airport	Development Air Navigation NW (IP)	Development Air Navogation NW (Intl') Development Digital Voice Com.
Nav	Introduction of Cloud Break Education on GNSS RAIM Recommendation	Expansion of RNP (RNP 1, RNP APCH, RNP-AR) Introduction of RNP2 GBAS Introduction Make RAIM Mandatory	Introduction of Adv. RNP SBAS Introduction
Sur	Introduction of Enroute Surveillance Radar ADS-B recommendation	Education on Satellite based ADS-B Making ADS-B Mandatory Introduction of MLAT at mountain Airport	Introduction of Satellite base ADS-B
ATM	Improve ATC operational efficiency Education on ATFM Satellite com. recommendation (small aircraft)	Introduction of ATFM (domestic) Making Satellite com. Mandatory (small aircraft)	Introduction of ATFM (International)
Weather	Install Wind Shear detector Introduction of X-Band radar Develop Aviation Weather Forecast model	Introduction of Doppler radar High-altitude Weather Information sharing with A/L Develop Mountain A/P Weather Forecast model	Mountain Weather Information sharing with A/L

(Source JICA Study Team)

Figure 7.3-2 Roadmap for Mountain Airport Safety/Avigation Safety System

7.4 Examining Future Cooperation of Japan in Aviation Sector

7.4.1 Overview

In this section, the priority criteria are set for the short-term measures from the improvement plans for the Nepal aviation sector, as in Section 7.3. The measures will be examined from the seven viewpoints and the three-levels of evaluation criteria as shown in Table 7.4-1.

Based on the results of this survey, the issues in the aviation sector in Nepal is divided into three categories: A) Capacity enhancement of Kathmandu Metropolitan area; B) Measures to improve the safety of mountain airports; and C) improvement in aviation safety and airport security.

The evaluation described below does not indicate the priority of future cooperation projects. In addition, the proposal of construction of Banepa Airport is preliminarily considered based on the request from CAAN. Therefore, it is not implying any commitment of the Government of Japan or JICA as future assistance.

Table 7.4-1 Evaluation Cretria For Short-Term Measures

	Items	Evaluation Criteria	Categories		
			A	B	C
①	Urgency/Signifi -cance of the task	Based on how important the issues are addressed by CAAN in its urgency and in maintaining safe and efficient operation of aircraft.	Very High	High	Average
②	Coherence with aviation policy	Coherence of issues with contents of the 15th National Development Plan of Nepal.	Coherent	Almost Coherent	Less Coherent
③	CAAN's requirement	Check whether the measures considered matchs with CAAN's need and policies.	Very High	High	Average
④	Technical difficulty and sustainability	Check the capability of CAAN in implementation and maintenance of the technology. Whether CAAN can realize state-of-the-art technology and/or operations which are set to future goal by ICAO and achieve minimum level of techonology or operation in maintaining safe operation of aircraft.	Very High	High	Average
⑤	Cost	Appropriatness of the the total project cost obtained. Cost born by the party and maintenance cost by CAAN appropriate	Cost-effective	Medium cost-effective	Less cost-effective

(Source JICA Study Team)

7.4.2 Requirements of CAAN

Regarding the requirement of CAAN, on March 22, 2020, The Director General of CAAN Mr. Rajan Pokhrel, submitted a document regarding the request for the JICA's cooperation. The contents are as shown in the Table 7.4-2 with the remark to the requests from the study teams.

Table 7.4-2 Remarks on the CAAN's Request

Item	Assistance Request	Remark from Survey Team
ATFM/ ACDM	【Assistance Request Content】 ✈ Implementation of ATFM and A-CDM in Nepal 【Reason】 1 : ATFM and A-CDM are included in ICAO-APAC seamless ATM plan 2 : ATFM is necessary component for the implementation of following: ① Integrated collaborative airspace management ② Air traffic flow management ③ Strategic Air traffic capacity management 3 : A-CDM is necessary to achieve efficient airprot operation through collaborative decision making 4 : Japan is pioneer in implementing ATFM/A-CDM in APAC region and has presented how to realize future operation in	✈ As for the support scheme, it is necessary to consider how to provide it, and at same time, it needs to proceed technical cooperation for the education of ATFM and A-CDM operational concept in the early stages. ✈ Japan is the third country in the world to introduce ATFM operation and systems, and Japan has accepted study tour from many Asian countries ✈ In Japan, A-CDM has been introduced at Haneda and Narita

	many working papers at ICAO meeting 【Condition】 ✈ For the implementation of ATFM and A-CDM, it is necessary to receive aircraft position data and flight plan information in real time.	airports. ✈ Although ATFM and A-CDM expect to expand the airport and airspace capacity, and improve the operational efficiency of ATC, it is difficult to provide quantitative indicators to measure the achievement.
GBAS for Tribhuvan International Airport	【Assistance Request Content】 ✈ Introduction of GBAS to TIA 【Reason】 1: Necessity to make a precision approach from both sides of the runway to improve flight rate. 2: Necessity to provide professional assistance from Japanese research institute (ENRI) for conduting ionosphere for GBAS introduction 3: Through the collaborative research between ENRI and Nepalese university, obtain Know-How of GBAS from Japan, which can be utilized in the introduction to airports other than TIA	✈ Long-term technical cooperation is required for obtaining data and acquisition as ionosphere ✈ During the introduction of GBAS, it is necessary to develop formula for the delay caused due to ionosphere, based on obtained data. ✈ Introduction of GBAS and prior counter measures of ionosphere are issues for ICAO to implement GNSS in Asia-Passific region. ✈ Introduction of GBAS in Nepal, it is required Japan's technical cooperation which is suitable technology for introduction into Asia-Pacific region.
New ATC Control Tower and Operations Building at Kathmandu	【Assistance Request Content】 ✈ Construction of new ATC tower at TIA ✈ Construction new operation building 【Reason】 1 : Visibility problem from exsiting ATC tower as airport expands 2：Due to lack of space at VFR room at ATC tower, the work space for air traffic controllers is limited by new systems intrioduction 3：Present tower is almost 30 years old since its construction 4 : Operation building lacks planning about building facilities, making it difficult for efficient operation	✈ Need to collaborate with ADB-supported airport expansion projects ✈ The construction of new ATC tower will not provide directly capacity enhancement of TIA, but it is highly important to implement form ensuring visibility and the future plans for the introduction of air navigation systems.
Cooperation & Training Programs in Aviation Skills Development	【Assistance Request Content】 ✈ Provide training program on new technologies for CAAN ✈ Contens of program include ATFM/A-CDM, GBAS, AMAN, DMAN etc. 【Reason】 ✈ Previous training program, which is proceed by past grant aid scheme, enhanced human resource development of CAAN. ✈ Due to evolving techonologies and techniques, it is important to seek training and education from Japan which can increase CAAN's capacity.	✈ There are various trainings in which Japan can initiate technical cooperation on technologies for the abilities that CAAN lacks.

(Source JICA Study Team)

7.4.3 Measures to Enhance Airport Capacity in Kathmandu Metropolitan Area

In regard to the measures to enhance the airport capacity in Kathmandu metropolitan area Table 7.4-3 shows candidates for Japan's future cooperation program in aviation sector.

Table 7.4-3 Candidates for Japan's Future Cooperation Program in Nepal Aviation sector (1)

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Criteria		Remarks
Facility	①	Banepa domestic airport development	Increase operation capacity of TIA	✈ Develop new Banepa domestic airport with 1,200m runway. ✈ Regarding ODA loan, it is necessary to verify CAAN's stance for browing as external debt is high.	Urgency/ Significance of the Task	A	Measures need to be taken for the runway capacity of TIA as it's approaching the limit.
					Coherence with Aviation Sector Policy	A	Important factor for the economic growth of Nepal.
					CAAN's Requirement	B	Due to financial issue, the conction of Banepa Airport does not have high priority.
					Technical Difficulty	B	Possibility of airspace separation with TIA; Possibility of construction of soil with soft rock; Requirement for high embankment on steep slope
					Cost	B	Economic and Finincial analysis Result.
					Comprehensive Evaluation	A	Is most effective means to enhance the airport capacity of Kathmandu metropolitan area
ATM	②	Construction of new ATC tower and introduction of MLAT at TIA (Aircraft position monitoring on airport surface)	Track the movement of aircraft and GSE around domestic terminal	✈ In consideration to airport master plan, the new ATC tower needs to be constructed at the height entire airport can be seen. ✈ Along with the the above, a management building and facility management building needed to be built. ✈ Necessary to carry out phase development in line with expansion of TIA →Phase1 : Around domestic terminal → Phase2 : entire airport	Urgency/ Significance of the Task	A	It is necessary to ensure safety of ground control operation, since domestic apron cannot be seen from ATC tower.
					Coherence with Aviation Sector Policy	A	It is important to monitor of airport surface movement and increase operational efficiency for solving airport congestion.
					CAAN's Requirement	A	Since current ATC tower is obsolete and monitoring airport ground movement from ATC tower is important, CAAN requires to construct new ATC tower
					Technical Difficulty	A	Since TIA is undergoing development work at present, it is necessary to take into account the location of ATC tower and formulate MLAT phased development plan.
					Cost	B	Possibility that cost may increase due to phase development.
					Comprehensive Evaluation	A	CAAN requests for new ATC tower. Japanese MLAT has technological advantage. It is necessary to install MLAT in new ATC tower.
ATM	③	Improvement of airport capacity of TIA (ATS Improvement)	Increase aircraft movement in TIA	✈ 3 years of technical cooperation ✈ Reduce radar separation minima by improvement of radar control technique ✈ Design flight procedure to shorten separation minima ✈ Increase airport capacity by shortening the separation minima	Urgency/ Significance of the Task	A	Improvement is required for the normal delay in arrival/departure flight at TIA.
					Coherence with Aviation Sector Policy	A	It is necessary to expand the airport capacity to meet the increasing air traffic demand.
					CAAN's Requirement	A	There is necessity to improve air traffic control capability of the TIA, so CAAN reruires Japan's technical cooperation.
					Technical Difficulty	B	Many countries, including Japan, have introduced PBN. Proper planning is required for simultaneous proceeding of flight procedures design and air traffic control operational changes.
					Cost	A	Cost-effective

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Criteria		Remarks
					Comprehensive Evaluation	A	CAAN requires to improve air traffic control capacity.
	④	Introduce airport CDM (A-CDM) at TIA (Considering some systems introduction support)	By sharing of necessary information between stakeholders will lead to smooth airport operation and reduce delay of flight	✈ Regarding A-CDM, technical assistance is provided to air traffic control agencies (including TIA operation departments) and airlines. ✈ Support in formulation of operation manuals, considering that the operation will start in actual ✈ Introduce an evaluation system and conduct trial operation so that effect of operation can be sensed.	Urgency/ Significance of the Task	A	Since the TIA is constantly busy and there are delays in arrivals/departure flights, it is important to ensure smooth operation of the airport.
					Coherence with Aviation Sector Policy	A	It is necessary to take measures to be in place for the collaboration with ICAO and countries in Asia-Pacific region. So, Nepal should consider introduction on A-CDM as it has been introduced in major airports in other countries.
					CAAN's Requirement	A	As recommended by ICAO for introduction of A-CDM, CAAN also considers it.
					Technical Difficulty	B	Since it is a new air traffic control operational procedure, technical cooperation from the other countries, which have already introduced it, is required.
					Cost	A	Cost-effective
					Comprehensive Evaluation	A	It is better to provide education by technical experts and introduce software tools.

(Source JICA Study Team)

7.4.4 Measure to Improve Safety at Mountain Airporrt

Regarding the measures to improve the safety of mountain airports, Table 7.4-4 and Table 7.4-5 shows proposal for Japan’s cooperation in aviation sector.

Table 7.4-4 Proposal for Japan’s Future Cooperation in Nepal Aviation sector (2-1)

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points	Remarks	
Facility	⑤	Runway extension	Improvement safety during takeoff/landing of aircraft	✈ Priority order is as follows; 1) Lukla, 2) Simikot and 3) Jomson. ✈ Lukla: RWY extension is difficult (less cost-effective). Alternative plan is construction new airport. ✈ Simikot: RWY extension 200 m possible (850 m) ✈ Jomsom: RWY extension 100 m possible (915 m)	Urgency/ Significance of the Task	A	Accidents often occure at mountain airports, so safety improvement measurement is required.
					Coherence with Aviation Sector Policy	B	Proceeding with the development of airport with more users and complete development in future.
					CAAN’s Requirement	B	Prioritizing the development of international airports and major domestic airports.
					Technical Difficulty	C	Transportation of materials and equipment is difficult due to lack of road access.
					Cost	B	Medium cost- effective
					Comprehensive Evaluation	B	Difficulty to verify quantitative effect on the improvement of safety and operational efficiency. Moreover, construction is also difficult.
Communication	⑥	Introduction of RCAG (At 3 location)	Ground-to-air communication will be possible (eliminating blind spot)	✈ Install near Nepal Telecom's communication base stations (3 locations, on the mountain) near Lukla, Simikot/ Rara and Jomson Airport. ※ Necessity to confirm the capability of continuous maintenance ※ It is necessary to check whether it can satisfy the coverage requirement for operation ※ Installation of solar panels as a back-up source is required	Urgency/ Significance of the Task	A	Since aircraft flying in mountainous areas cannot communicate with the air traffic controller, it is essential that pilots are able to obtain information to ensure operational safety.
					Coherence with Aviation Sector Policy	A	Aircraft accidents continue to occur in Nepal, and it is important to implement measures to prevent accidents.
					CAAN’s Requirement	B	Although the necessity for introduction is understood, it is difficult from the point of view of maintainance.
					Technical Difficulty	B	RCAG is an existing technology, but it is difficult to install equipments in mountainous areas.
					Cost	B	Medium cost-effective
					Comprehensive Evaluation	A	Necessary for ensuring safety. It is necessary to confirm whether maintenance can be constantly implemented.
	⑦	Introduction of digital HF (6 major airport)	Redundancy can be ensured for ground-to-ground communication between mountain airports and	✈ Installation at six airports. Priority for airport with large number of passenger and does not have AMHS ※ Preliminary	Urgency/ Significance of the Task	B	Information sharing between airports by ground-to-ground communication is very important, it is desirable to ensure redundancy.
					Coherence with Aviation Sector Policy	B	Ensuring the redundancy of communication lines is an important issue in order to improve safety of air traffic control operations.

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
			hub airports.	surveys and multiple frequencies required, depending on ionospheric conditions ※ When used in surface-to-air communication, it is necessary to mount a corresponding on-board device.	CAAN's Requirement	B	Previously analog HF has been in use, but it is not used now due to its poor quality. So, it is necessary to confirm recognition of CAAN for using digital HF.
					Technical Difficulty	B	At the time of introduction, it is necessary to confirm the state of radio wave propagation and the usable frequencies.
					Cost	A	Cost-effective
					Comprehensive Evaluation	B	Although it is necessary for the safety improvement, it is required to introduce the equipment and confirm the necessity of it to CAAN.
	⑧	Introduction of VSAT (5 airports other than Lukla)	Redundancy in communication between mountain airports, ACC and hub airports	✈ AMHS is available by introducing VSAT to major mountain airports. ✈ Possible to Exchange information more reliably than digital HF. ※ Construction of ground equipment such as antennas is required ※ In order to use a satellite communication line, it is necessary to pay a usage fee constantly.	Urgency/ Significance of the Task	A	It is an essential communication network for information sharing by data communication between airports through AMHS.
					Coherence with Aviation Sector Policy	A	It is not just for safe operation of aircraft but also necessary as a communication network for securing scheduled operations that will improve the reliability of aviation services.
					CAAN's Requirement	B	VSAT has already been introduced at some airports but it is doubted about its cost effectiveness.
					Technical Difficulty	A	The existing communication satellite network can be used, however can be used only by installing a ground antenna facility and contracting with a communication provider.
					Cost	A	Cost-efective
					Comprehensive Evaluation	A	It is necessary equipment for the introduction of AMHS at mountain airports.
	⑨	Introduction of AMHS (5 airports other than Lukla)	Accelerate speed of information sharing and exchange by data communication between airports	✈ Reliable information sharing platform by shifting from telephone and mobile phone communication to data base communication ✈ Huge amount of data exchange possible ✈ Redundancy of ground-to-ground communication can be ensured ✈ Automatic notice of weather information by linking with	Urgency/ Significance of the Task	A	Information sharing through large amounts of data exchange between airports is essential for improving operational safety and efficiency.
					Coherence with Aviation Sector Policy	A	It is important for Nepal to ensure the safety and on-time operation of aircraft which can be realized as a result of information sharing.
					CAAN's Requirement	A	AMHS is necessary for providing flight and weather information to the air traffic controller.
					Technical Difficulty	A	Connecting TIA's server using VSAT connection or existing data communication line.
					Cost	B	Medium cost-effective
					Comprehensive Evaluation	A	Necessary for providing flight and weather information to the air traffic controller.

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
				weather systems ※ Moutainous airports except for Lukra and Jomsom are connected by microwave network, VSAT and optic fiber must be introduced			

(Source JICA Study Team)

Table 7.4-5 Proposal for Japan's Future Cooperation in Nepal Aviation sector (2-2)

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
Navigation	⑩	Recommendation of GPS equipped with RAIM function	Aircraft flying to mountain airports can be accurately located and Flight safety will be improved	✈ Provide technical cooperation to establish operation rules for using GPS ✈ The aircraft position can be accurately tracked. It is support to prevent collision with obstacles even if the visibility deteriorates. ※ Airlines need to equip aircraft with compatible equipment. ※ CAAN needs to change domestic regulations for recommending installation of GPS with RAIM function. ※ It is necessary for the CAAN to create flight route information for the flight using GPS	Urgency/ Significance of the Task	B	It is necessary to verify the necessity of its operation in future.
					Coherence with Aviation Sector Policy	B	While it is important to improve safety and reliability in flight operations, it will cause burden to airlines. It is necessary to determine cost effectiveness.
					CAAN's Requirement	C	It is difficult to take measures such as mandatory installation of GPS equipped with RAIM. There is no special request by CAAN.
					Technical Difficulty	A	Only work with compatible on-board equipment.
					Cost	B	On-board equipment maintenance costs are borne by the airline.
					Comprehensive Evaluation	C	RAIM needs to be equipped with on-board equipment as well as SBAS, and it is difficult to introduce equipment to all aircrafts.
	⑪	Design support for flight procedure for mountain airports (Cloud Break)	Improvement of safety and rate of service	✈ In current technical support, flight procedure design for regional airport provide as well. ※Due to lack of international standards, CAAN	Urgency/ Significance of the Task	A	Improving flight safety in mountainous areas is important, moreover, improving the service rate of mountain flights is highly demanded by tourists.
					Coherence with Aviation Sector Policy	A	In Nepal, it is important subject to improve the safety of mountain flights, which aircraft accidents are frequent and improving convenience for passengers is essential.

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
				is required to formulate the flight procedure for mountain airports by ownself.	CAAN's Requirement	A	There is a proposal from CAAN to the current technical cooperation regarding it. A trial version will be created by the end of 2020. It is created by Buddha Airways independently and is planning a cooperation with other airlines.
					Technical Difficulty	C	It is not defined by international standards and must be designed independently.
					Cost	B	Installation costs for systems that supports navigation
					Comprehensive Evaluation	B	Effective countermeasures for mountain airports where it is difficult to install ground navigation aiding facilities.
Surveillance	⑫	Satellite communication recommended for tracking device	Airline companies will be able to accurately track the aircraft position information of all flights to mountain airports	✈ Currently, V2 Tracker, which is equipped on many mountain flight aircrafts (fixed wings and rotary wings), provide location information. (Currently only location Information is provided by using mobile phone NW.) ✈ It will be useful tool during the search and rescue time since the location of aircraft will be provided continuously. ✈ Airline and air traffic service provider can share aircraft position information in the future ※ Airline must pay satellite communication data usage fee	Urgency/ Significance of the Task	A	It is important to improve the safety of mountain flights by sharing the position information obtained from the aircraft and use it for aircraft surveillance.
					Coherence with Aviation Sector Policy	B	The position information obtained from the aircraft is useful for improving the safety of mountain flights, but the airlines need to bear the network cost, so it is necessary to verify the cost effectiveness.
					CAAN's Requirement	B	There are strong needs from airlines and CAAN requests to use as information, but there is a cost burden in using data. It is also necessary to establish network for sharing information.
					Technical Difficulty	B	The tracking device is installed on almost STOL aircrafts and helicopters. However, since satellite communication is not used, only mobile networks are used, it is necessary to install an antenna for satellite communication to each aircraft.
					Cost	B	Onboard equipment maintenance costs
					Comprehensive Evaluation	B	On-board equipment, satellite network and information sharing network with air traffic control systems are required.
	⑬	Introduction of MLAT (6 mountain airports)	ATC will be able to track aircraft position around mountain airports	✈ Aircraft position information is tracked by Mode A / C signals are equipped on aircraft of mountain flight ✈ In the case of A-MLAT in Japan, it can also function as a	Urgency/ Significance of the Task	A	Tracking aircraft position information in mountainous areas is necessary to reduce aircraft accidents in Nepal.
					Coherence with Aviation Sector Policy	A	It is important for Nepal to take measures to reduce frequent aircraft accidents.
					CAAN's Requirement	C	There is no special request.
					Technical Difficulty	C	In order to get the aircraft position information around the mountain airport, it is required to install many

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
				WAM, so that it can acquire the position information of aircraft around the airport. ✈ During low visibility flight, the position information of the aircraft can be tracked and information on surrounding obstacles and traffic can be provided from the air traffic survice provider. ※ Limited monitoring range due to topography conditions ※ Regular maintenance will be difficult depending on the installation location			receiving stations around airports. Since, the station will be located in mountainous area, installation and maintenance will be difficult.
					Cost	C	Since installation are in the mountainous area, the cost is higher than the usual installation in the airport.
					Comprehensive Evaluation	C	For surveillance in mountainous areas, it is better to use satellite-based monitoring technology rather than ground surveillance equipment.
Weather	⑭	Introduction of wind shear detector	The system will be able to detect dangerous sudden changes in airflow and notice it to landing aircraft.	✈ Introduced to four airports, Lukla, Jomsom, Simikot and Rara where have strong winds blow often and install near the end of the runway.	Urgency/ Significance of the Task	A	Understanding turbulence occurrence around mountain airports is necessary to improve the safety of aircraft operation in Nepal.
					Coherence with Aviation Sector Policy	A	It is important towards contribution for the reduction of aircraft accidents in Nepal.
					CAAN's Requirement	A	Some mountain airports, such as Lukla airport, are affected by wind shear.
					Technical Difficulty	B	Investigation are needed to ensure that turbulence around mountain airports can be measured.
					Cost	A	The product is much cheaper than usual wind shear detection system
					Comprehensive Evaluation	A	The installation of wind shear detectors has been requested by CAAN, airlines and pilots.
	⑮	Introduction of ITV (around 6 major airports)	Be able to grasp the current situation of places where weather conditions rapidly change around mountain airports.	✈ In case of low visibility, it is able to get weather conditions in real time around severe locations for flight. ※ It is difficult to install and maintain ITV around mountain airports	Urgency/ Significance of the Task	A	Real-time understanding of changes in weather conditions at mountain airports is important for ensuring the safety of aircraft operations.
					Coherence with Aviation Sector Policy	A	In Nepal, efforts contributing in improvement of the safety of aircraft operations are important.
					CAAN's Requirement	A	As well as airlines and pilots, it is important for air traffic controller to understand the weather conditions around the airports.
					Technical Difficulty	B	Existing technology.

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
					Cost	C	If the installation location is a mountainous area or a private land near the airport, initial installation costs and running costs are required.
					Comprehensive Evaluation	B	Although the visibility of the weather conditions around the airport will be improved by installing the ITV, it will be difficult to select the installation site and carry out the installation work.

(Source JICA Study Team)

7.4.5 Measures to improve Aviation Safety and Airport Security

The Table 7.4-6 shows the various possibility for Japan's future coorperation towards improvement of aviation safety and airport security.

Table 7.4-6 Proposal for Japan's Future Cooperation in Nepal Aviation sector (3)

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
ATM	⑯	Assistance for introducing GBAS	Increase Service rates without introducing expensive equipment like ILS	✈ GNSS education with two years of technical Assistance. ✈ Education on GBAS theory, operation method and system configuration ✈ Training for airlines through stakeholder meetings.	Urgency/ Significance of the Task	A	It will contribute to the improvement of the service rate, but it will take some time before the operation starts.
					Coherence with Aviation Sector Policy	A	Since aircraft can land in bad weather and service rate is improved, it contributes to improve operation at major airports and convenience to passengers.
					CAAN's Requirement	A	It is requested to realize curved approach procedures at low visibility by introduction of GBAS.
					Technical Difficulty	A	GBAS has a problem of delay due to ionosphere, so Japanese technical cooperation is necessary.
					Cost	B	Initial introduction /installation cost
					Comprehensive Evaluation	A	Although it will be a long-term project for 5 to 7 years until the start of operation, CAAN request to deploy it, and the benefits to the airlines, which have aircraft equipped necessary equipment for GBAS, is enourmous.
Surveillance	⑰	Introduction of enroute surveillance radar (MSSR)	Blind areas in the low altitude zone in western Nepal can be eliminated	✈ It is possible to acquire the position information of aircrafts flying the domestic ATS route in low altitude zone in western Nepal. ✈ The installation location of the enroute radar is assumed at Nepalgunj Airport. ※ It is necessary to consider the ADS-B installation plan under CAAN. ※ To consider using each target data, which is provided by new enroute radar, exsiting enroute	Urgency/ Significance of the Task	A	It is necessary to eliminate the current blind areas, and it is essential for improving the safety of aircraft operations.
					Coherence with Aviation Sector Policy	A	Measures that contribute in improving the safety of aircraft operations are important for Nepal.
					CAAN's Requirement	C	Aircrafts flying at high altitude have been already monitored by the existing enroute surveillance radar and ADS-B, and the aircraft position information can be confirmed, so there is no particular request.
					Technical Difficulty	B	Existing technology. New radar needs to be connected to TIA's current MSDPS.
					Cost	B	Radar equipment and installation costs
					Comprehensive Evaluation	B	In case of consideration for the safety of aircraft operation, it is necessary to install

Area	No	Short term (~5yrs)	Expected outcome	Detail/Issues of Measures	Evaluation Points		Remarks
				radar, ADS-B and MLAT, as input data for MSDPS.			enroute radar and/or MLAT.
Weather	⑱	Introduction of weather radar (X-band radar)	Perform high-precision weather observations around airports and enroute to improve the accuracy of weather forecast	✈ Technical cooperation for enroute weather forecasts model development. ✈ Assuming gradual installation, in the first stage, it will be installed around TIA, hub airports, and some points where weather condition changes drastically on the routes of small aircraft. ※Need to consider on the coordination between DHM and CAAN. ※ Necessary to discuss with DHM jointly with CAAN regarding type of weather data which is required to airlines. ✈ For technical cooperation, DHM will be the main counterpart, but it is considered that the training will also be attended by air traffic controllers.	Urgency/ Significance of the Task	A	It is recognized that there is a problem in ensuring safety of aircraft operations, as there is no information on the current status and forecasts for enroute weather information.
					Coherence with Aviation Sector Policy	A	Most aircraft accidents in Nepal occur while on enroute flight, it is important to improve flight safety by understanding the weather conditions.
					CAAN's Requirement	A	Not only DHM, but also CAAN and airline companies request to improve the accuracy of aviation weather information and weather forecasts.
					Technical Difficulty	B	It is an existing system. It is necessary to consider a phased development plan that takes into account the contents of the necessary meteorological data, the installation location of the radar and the result obtained by introduction.
					Cost	A	Currently, it is assumed to install three units around the Kathmandu basin. Initial equipment and installation work
					Comprehensive Evaluation	A	Improving the accuracy of aviation weather information is essential for improving the safety of aircraft operations. However, it is not easy to install X-band radar in mountainous areas and maintain it. Therefore, it is necessary to thoroughly examine the installation location, including phased development.
ATM	⑲	Introduction of ATFM (Considering some system introduction support)	Reduces delays on domestic small aircraft flights and maximizes the capacity of airports and airspace	✈ Technical cooperation of ATFM for air navigation service provider (including TIA operation department) and airline companies. ✈ Support for development of operation manual so that assuming actual operation start. ✈ Introduce an evaluation system and conduct trial operation so that actual operation can be sensed. ※ It is necessary to build a network that can enable information exchange and sharing between airports and ACC in future.	Urgency/ Significance of the Task	B	It should be solved that constant congestion in TIA and delays in departures/arrivals at domestic airports, but it is taken priority over the measures to improve the safety of aircraft operations.
					Coherence with Aviation Sector Policy	A	It is important to improve flight efficiency by reducing congestion at major airports and passenger convenience accordingly.
					CAAN's Requirement	A	There is a request from CAAN to solve TIA congestion, be smoothly traffic flow in domestic flight and achieve ICAO's future plan.
					Technical Difficulty	A	ATFM system is developed in Japan as well, but it is necessary to carefully investigate whether it matches the aviation situation in Nepal. Training will be conducted in advance by technical cooperation and the operational concept and requirements in Nepal will be examined.
					Cost	A	Cost-effective
					Comprehensive Evaluation	B	It is necessary to verify whether a certain effect can be obtained. In the beginning, it is recommended to proceed technical cooperation.

(Source JICA Study Team)

7.4.6 Organizing Evaluation Result

The Table 7.4-7, summarizes the evaluation results of proposal of Japan's future cooperation in aviation sector of Nepal as stipulated from Table 7.4-2 to Table 7.4-5. As for the comprehensive evaluation rating with A, it is rated and decided based on 5 of the criteria, the CAAN's requirement, Technical difficulty, viewpoint of Japanese technology, cost and prospect of the cooperation, which will decide Japan's future cooperation with Nepal's aviation sector. Section 7.5 describes specific measures. Criteria in comprehensive evaluation as "A" is as follows;

- Any evaluation items do not include "C".
- Urgency/ Significance of the Task must be evaluated as "A".
- Above two items must be satisfied, and the result of evaluation will be decided integrally.

Table 7.4-7 Evaluation Results of Proposals of Japan's Future Cooperation in Aviation Sector

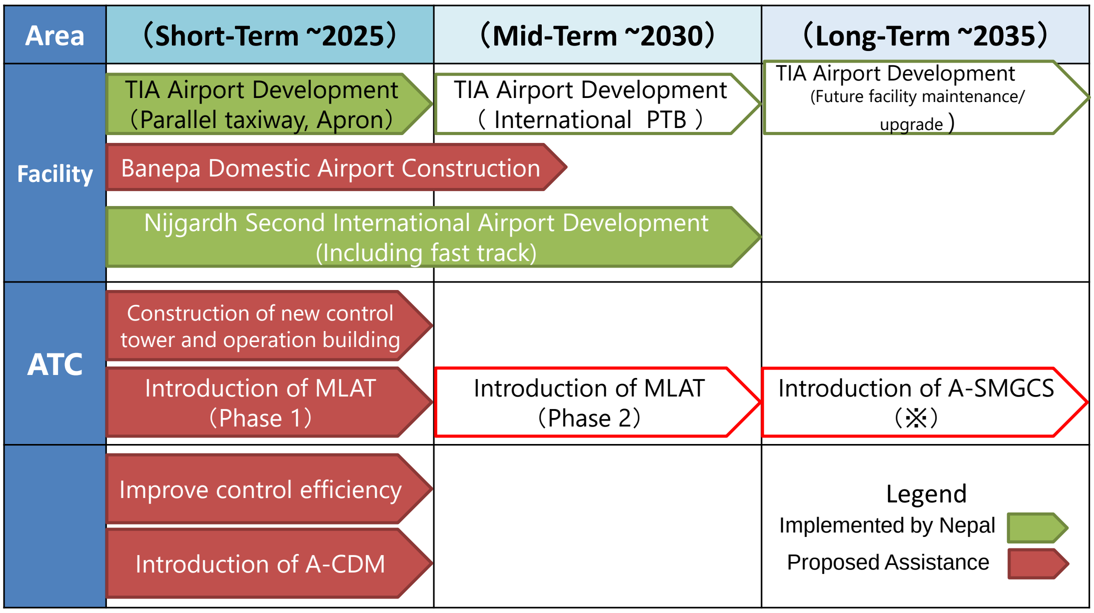
Area	No	Short term (~5yrs)	Evaluation Points					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
Facility	①	Banepa domestic airport development	A	A	B	B	B	A
ATM	②	Construction of new control tower and MLAT at TIA (Aircraft Position monitoring)	A	A	A	A	B	A
	③	Improvement of airport capacity of TIA (ATS Improvement)	A	A	A	B	A	A
	④	Introduce airport CDM (A-CDM) at TIA (Considering some system introduction support)	A	A	A	B	A	A
Facility	⑤	Runway Extension	A	B	B	C	B	B
Communication	⑥	Introduction of RCAG (3 location)	A	A	B	B	B	A
	⑦	Introduction of Digital HF (6 Major Airports)	B	B	B	B	A	B
	⑧	Introduction of VSAT (5 airports, Lukla installed)	A	A	B	A	A	A
	⑨	Introduction of AMHS (5 airports, Lukla Installed)	A	A	A	A	B	A
Navigation	⑩	Recommendation of GPS equipped with RAIM function	B	B	C	A	B	C
	⑪	Design support for flight procedure (Cloud Break) for mountain airports	A	A	A	B	B	B
Surveillance	⑫	Satellite communication recommended for tracking device	A	B	B	B	B	B
	⑬	Introduction of MLAT (6 mountain airports)	A	A	C	C	C	C
Weather	⑭	Introduction of wind shear detector	A	A	A	B	A	A
	⑮	Introduction of ITV (around 6 major airports)	A	A	A	B	C	B
ATM	⑯	Assistance for introducing GBAS	B	A	A	A	C	A
Surveillance	⑰	Introduction of air route monitoring radar (MSSR)	A	A	C	B	B	B
Weather	⑱	Introduction of weather radar (X-band radar)	A	A	A	B	A	A
ATM	⑲	Introduction of ATFM (Considering some system introduction support)	B	A	A	A	A	B

(Source JICA Study Team)

7.5 Proposals for Japan's Future Cooperation in Nepal Aviation Sector

7.5.1 Overview

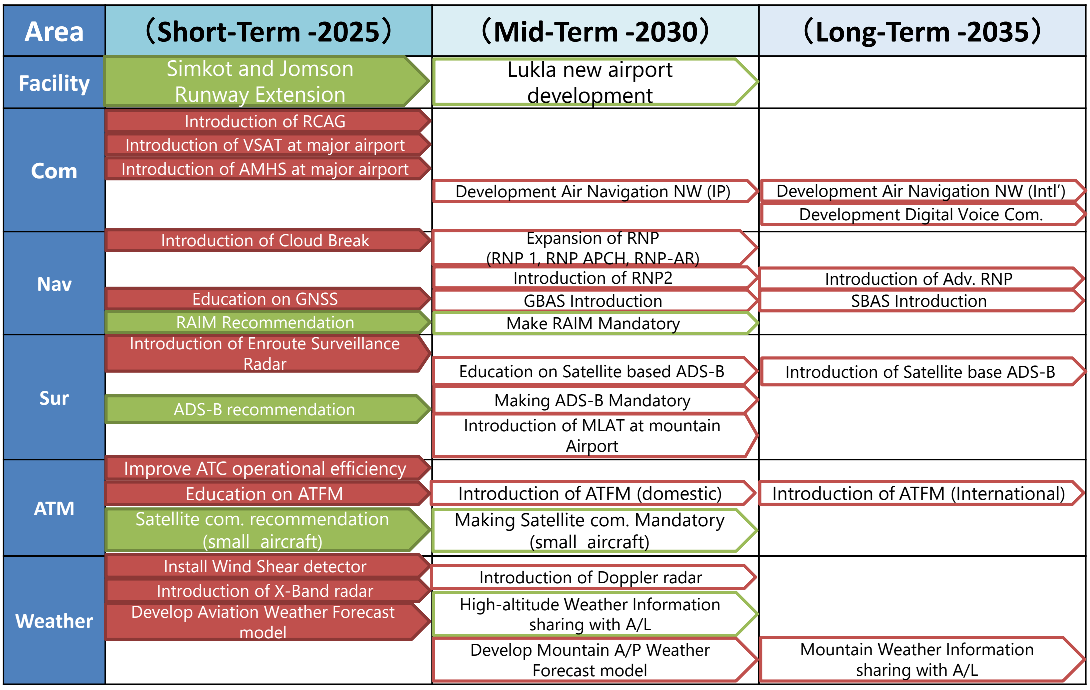
As discussed in section 7.3, the content for necessary short-term measures to address the issues of Nepal aviation sector by Japan's future cooperation are proposed as follow. Consultation with the Japanese side will be required for making them into actual cooperation projects. Among the short-term measures in the roadmap as shown in Figure 7.5-1 and Figure 7.5-2, the measures highlighted with red color are the proposing cooperation found in this survey.



※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source JICA Study Team)

Figure 7.5-1 Roadmap for Capacity Enhancement of Kathmandu Metropolitan Area



(Source JICA Study Team)

Figure 7.5-2 Roadmap for Safety improvement of Mountain Airport/ Aviation Safety Systems

The Table 7.5-1 shows the outline of the proposed measures. For the details about the airport capacity enhancement in the Kathmandu metropolitan area, the improvement of the safety of the mountain airport, and the improvement of the aviation security system will be discussed in the following sections.

Table 7.5-1 Proposals for Japan's Future Cooperation Nepal Aviation Sector

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
Facility	①	Banepa domestic airport development	Increase operation capacity of TIA	✈ Develop new Banepa domestic airport with runway of 1,200m. ✈ Regarding ODA loan, it is necessary to verify CAAN's stance for browing as external debt is high. ✈ Implementing together with ②, ③, and ④ is effective in improving the capacity of TIA.	Loan
ATM	②	Construction of new ATC tower and introduction of MLAT at TIA (Aircraft position monitoring on airport surface)	Track the movement of aircraft and GSE around domestic terminal	✈ In consideration to airport master plan, the new ATC tower needs to be constructed at the height entire airport can be seen. ✈ Along with the the above, a management building and facility management building needs to be built. ✈ Necessary to carry out phase development in line with expansion of TIA →Phase1：Around domestic terminal →Phase2：entire airport	Grant Aid
	③	Improvement of airport capacity of TIA (ATS Improvement)	Increase aircraft movement in TIA	✈ 3 years of technical cooperation ✈ Reduce radar separation minima by improvement of radar control technique ✈ Design flight procedure to shorten separation minima ✈ Increase airport capacity by shortening the separation minima	Technical Cooperation
	④	Introduce airport CDM (A-CDM) at TIA (Considering some systems introduction support)	By sharing of necessary information between stakeholders will lead to smooth airport operation and reduce delay of flight	✈ Regarding A-CDM, technical assistance is provided to air traffic service provider (including TIA operation departments) and airlines. ✈ Support in development of operation manuals, considering that the operation will start in actual ✈ Introduce an evaluation system and conduct trial operation so that effect of operation can be sensed.	Technical Cooperation
Communication	⑥	Introduction of RCAG (3 locations)	Ground-to-air communication will be possible (eliminating blind spot)	✈ Install near Nepal Telecom's communication base stations (3 locations, on the mountain) near Lukla, Simikot/ Rara and Jomson Airport ※ Necessity to confirm the capability of continuous maintenance ※ It is necessary to check whether it can satisfy the coverage requirement for operation ※ Installation of solar panels as a back-up source is required	Grant Aid
	⑧	Introduction of VSAT (5 airports other than Lukla)	Redundancy in communication between mountain airports, ACC and hub airports	✈ AMHS is available by introducing VSAT to major mountain airports. ✈ Possible to Exchange information more reliably than digital HF. ※Construction of ground equipment such as antennas is required ※In order to use a satellite communication line, it is necessary to pay a usage fee constantly.	Grant Aid
	⑨	Introduction of AMHS (5 airports other than Lukla)	Accelerate information sharing and exchange by data communication between airports	✈ Reliable information sharing platform by shifting from telephone and mobile phone communication to data base communication ✈ Huge amount of data exchange possible ✈ Redundancy of ground-to-ground communication can be ensured ✈ Automatic notice of weather information by linking with weather systems	Grant Aid

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
				※Moutainous airports except for Lukra and Jomsom are connected by microwave network, VSAT and optic fiber must be introduced	
Navigation	⑯	Assistance for introducing GBAS	Increase Service rates without introducing expensive equipment like ILS	✈ GNSS education with two years of technical Assistance ✈ Education on GBAS theory, operation method and system configuration ✈ Training for airlines through stakeholder meetings.	Technical Cooperation
Weather	⑭	Introduction of wind shear detector	The system will be able to detect dangerous sudden changes in airflow and notice it to landing aircraft.	✈ Introduced to four airports, Lukla, Jomsom, Simikot and Rara where have strong winds blow often and install near the end of the runway. ✈ Initially, it is installed at Lukla Airport only. ✈ For technical cooperation, CAAN will be the main counterpart, but it is considered that DHM staff will also participate in the training.	Grant Aid Technical Cooperation
	⑱	Introduction of weather radar (X-band radar)	Perform high-precision weather observations around airports and enroute to improve the accuracy of weather forecast	✈ Technical cooperation for enroute weather forecasts model development. ✈ Assuming gradual installation, in the first stage, it will be installed around TIA, hub airports, and some points where weather condition changes drastically on the routes of small aircraft. ※Need to consider on the coordination between DHM and CAAN. ※Necessary to discuss with DHM jointly with CAAN regarding type of weather data which is required to airlines. ✈ For technical cooperation, DHM will be the main counterpart, but it is considered that the training will also be attended by air traffic controllers.	Grant Aid Technical Cooperation

(Source JICA Study Team)

7.5.2 Measures in Technical Cooperation

(1) Grand Aid Projects

In order to improve the safety and efficiency of air traffic control operations in TIA, a new ATC tower will be proposed in line with the ongoing TIA expansion project. In addition, a new administration building and facility management building has also been proposed in line with the the new ATC tower, to accommodate the installation and upgrading of new technology systems because exsiting administration building and facility management building is decrepit and lack of space due to still exsisting past equipment and it causes to be low efficiency of operation and maintenance work.

Table 7.5-2 Project Outline for Improvement of ATC in TIA

Subject	Improvement of Air Traffic Control Capacity in TIA
Implementation Period	4 years
Background of Project	TIA has expanded its airport facilities to meet increasing passenger demand until now. On the other hand, due to the expansion, the apron in front of the domestic terminal is no longer visible from the ATC tower, the safety and efficiency of air traffic control operation in airport are impaired. Furthermore, the ATC tower in TIA has been more than 30 years old since its construction. The building has become obsolete and the VFR room, the office rooms required for operation and the rooms where systems are installed are becoming small, which is also one of the causes of the decrease in operational efficiency.
Purpose	In this project, the safety and operational efficiency of control operation in TIA will be improved by construction of a new ATC tower and introducing airport surface surveillance system. Furthermore, by constructing a new administration building and facility management building will ensure the expandability of facilities which is necessary for future operation and system improvement.
Project Content	1：New ATC tower (②) In consideration to the TIA expansion plan currently being implemented, a new ATC tower will be constructed at a height that ensure the visibility for monitoring entire airport. 2：New construction of administration and facility building (②) At the same time, by constructing new administration currently being and facility management building, regarding some systems are currently operated will reach renewal time, it will be replaced, and it is necessary for preparing to start new operation by upgraded system. 3：Introduction of MLAT (②) Upon establishing new ATC tower, the entire airport will be visible, at the same time MLAT will be installed to monitor the position of aircraft and GSEs on airport surface in order to improve the operational efficiency of airport surface movement.
Project Partner	CAAN
Project Outcome	Quantitative effect ✈ It will be able to monitor the movement status of aircraft and vehicles on domestic aprons. (0% → 100%) ✈ It will be able to confirm the movement status of aircraft and vehicles on entire airport surface by surveillance system. (0% → 100%) Qualitative effect ✈ The operational safety and efficiency of flight scenes in TIA are improved. ✈ The introduction of next-generation air navigation systems in Nepal becomes easily.
Prerequisite/External condition	■Prerequisite ✈ For smooth transition of operation and system, the system to be installed in the new facility will be newly installed and the system to be transferred from the old facility will be minimized. ✈ Not only will visibility be increased by raising the control tower, but the system will also be introduced to ensure that the moving aircraft and GSEs can be grasped. ✈ The system introduced in the project will be soft-part and the basic know-how necessary for operation and maintenance will be provided in it, while at the same time working with technical professionals to increase the capacity of the Kathmandu metropolitan area is considered.

(Source JICA Study Team)

(2) Technical Cooperation

In order to enhance airport capacity in Kathmandu metropolitan area, a new flight procedure system will be designed for TIA and technical cooperation for the introduction of A-CDM will be implemented to improve the operational efficiency of the airport.

Table 7.5-3 Technical Cooperation to Enhance Airport Capacity in Kathmandu Metropolitan Area

Subject	Technical Cooperation Project to Enhance Airport Capacity in Kathmandu Metropolitan Area
Implementation Period	3 years
Background of Project	In Nepal, the limit of runway capacity of TIA located in the kathmandu metropolitan area is approaching as the air traffic demand increases. Although there is only one runway at present, it is difficult to develop a second runway within the current airport site, so consideration for the development of a new airport to meet air traffic demand in the metropolitan area has been carried out. On the other hand, in order to enhance the overall airport capacity in the future, it is essiential to improve not only in the tangible elements of airport facilities development but also in the intabgible elements of improving efficiency of air traffic control operation and introducing new technologies in TIA. Additionlly, improving services for aircraft using TIA and improving operational efficiency are important measures that lead to capacity enhancement. Under these circumstances, CAAN worry about improvement technologies for (1) the introduction of A-CDM at TIA, (2) improvement the air traffic control efficiency of TIA and (3) air navigation systems (CNS/ATM as such GBAS, MLAT, High Speed Data Network, etc.), and considers to request Japan's technical cooperation to realize those technologies.
Purpose	With this project, the air traffic control capability in the Kathmandu metropolitan area will be improved by introducing A-CDM, improving the air traffic control capability in TIA, and improving the technology related to next-generation air navigation systems.
Project Content	1: Introduction of A-CDM at TIA (④) In order to expand the capacity of TIA, it is necessary to improve efficiency of ATC and airport operations. introduction of A-CDM is considered as a precondition. 2: Promotion of airspace operational efficiency to improve air traffic control capacity at TIA (③) In order to expand the throughput and capacity in the Kathmandu metropolitan area, a new flight procedure will be designed with the aim of improving the air traffic control capacity of the TIA. 3: Improvement of air traffic control technology by introducing air navigation systems (⑯) The basic knowledge about the systems and required training and education for operation and maintenance when introducing GBAS, MLAT and high-speed data network,
Project Partner	CAAN (ATCO, ATSEP), DHM, Airline (operation manager)
Project Outcome	Quantitative effect ✈ The existing flight delay of 30 mins or more at TIA will be decreased. (100% → 70%: over 30 minutes delayed flights decrease 30%) ✈ Shorten the average separation minima for approach control. (10NM → 7NM) Qualitative effect ✈ By proper information exchange, air traffic control and airport operations will be smooth, the delay time at the time of departure will be shortened, and at the same time the congestion of TIA will be solved. ✈ By redesigning flight procedures at TIA, we will reduce separation minima for landing aircrafts and increase the number of aircraft movement in TIA. ✈ Acquire the knowledge about the basic air traffic control system and the technique for operation and maintenance, which are necessary for the introduction of new air navigation systems.
Prerequisite/External condition	■Prerequisite ✈ Regarding the introduction of A-CDM, it is introduced a system that allows trial operation, and it is developed required operational rules and set up necessary system parameters for utilizing the system. ✈ The system to consider for starting operation in A-CDM is premised on a system that streamlines departure and arrival at airports such as DMAN and AMAN. ✈ It proceeds to design new departure/arrival or miss-approach procedures and create an environment that can shorten separation minima in terminal approach area. ✈ For GBAS, the system necessary to study the effect of ionosphere will be established and research on the correction coefficient due to effect of the ionosphere needs to be conducted.

(Source JICA Study Team)

1) Introduction of A-CDM in TIA

In order to enhance the airport capacity of Kathmandu metropolitan area and improve the efficiency of air traffic control and airport operations, the activities for introduction of A-CDM are carried out such as stakeholders' meeting for CAAN, airport operator, airlines etc. that presupposes to introduce A-CDM.
The technical cooperation is necessary to develop the operational manuals and regulations and support for implementation of A-CDM.

Table 7.5-4 Technical Cooperation on A-CDM

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
ATM	In order to expand the capacity of TIA, it is necessary to improve efficiency of ATC and airport operations. introduction of A-CDM is considered as a precondition.	➢ Implementation of smooth air traffic control and airport operations through appropriate information exchange. ➢ Reducing delay at the time of departure by improving air traffic control efficiency. ➢ Solve TIA congestion	➢ A-CDM basic training ➢ Establishing A-CDM team (ANSP, Airline etc.) ➢ Prepration of A-CDM introduction plan ➢ Development A-CDM operation manual and regulation ➢ Having practical training of A-CDM ➢ Building capability to implement A-CDM training by CAAN	✈ Air traffic controller ✈ Flight information service 12MM	Air traffic controller Flight information officer Airlines Aviation meteorologist Administration manager	N/A

(Source JICA Study Team)

2) Streamlining Airspace Operation of TIA

For the purpose of enhancing the airport capacity in Kathmandu metropolitan area, specifically, improving air traffic control capacity of TIA, it is considered the effective utilization of airspace and provide technical support for designing new flight procedures to solve the issue.
In addition to the flight procedure design, it is supported the implementation of flight inspection and if necessary, flight approval can also be done from installation of new flight procedures and start operation of it. At the same time, in order to operate the new flight procedures efficiently and effectively, training for air traffic controllers using simulators, especially for the purpose of shortening the separation minima will be conducted. Furthermore, the study of the requirements for airspace to introduce ATFM in the future is needs to be carried.

Table 7.5-5 Technical Cooperation on Airspace Operation Efficiency at TIA

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
ATM	In order to expand the throughput and capacity in the Kathmandu metropolitan area, a new flight procedure will be designed with the aim of improving the air traffic control capacity of the TIA.	➢ Effective use of airspace in TIA ➢ Reduction of separation minima of arrival aircraft ➢ Increase in number of aircraft movement in TIA ➢ Improve safety of large aircraft landing ➢ Reduce workload of air traffic controllers	➢ Update PBN roadmap ➢ Study airspace management ➢ Study flight procedure design ➢ Examine flight procedures of TIA ➢ Design new flight procedure ➢ Proceed desk verification and flight inspection ➢ Issuance of PBN flight procedure ➢ Operation approval of aircraft equipment ➢ Implementation of air traffic controllers training ➢ Study ATFM	✈ Flight procedure design ✈ ATC operation ✈ ATC technique 16MM	Air traffic controller Airline operator Flight procedure designer	N/A

(Source JICA Study Team)

3) Improvement of Air Traffic Control Technology by Introducing Air Navigation Systems

As a measure to improve the air navigation systems, the following technical cooperation needs to be implemented in each area of CNS, so that the effects of introduced system will be maximized.

Table 7.5-6 Technical Cooperation on Aviation Security System

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
N	It should be proceeded that the effectiveness of GBAS introduction, airport surveys, ionospheric impact assessment, antana installation site assessment and the system designe of GBAS is based on those outcomes on the assumption that the introduction of GBAS can enhance GPS signal leading to precise landing.	➢ Improving service rate and safety in TIA after introducing GBAS. ➢ Shortening of separation minima for approaching flight at TIA after GBAS introduction. ➢ Promote introduction of GBAS and SBAS to improve the reliability of GPS navigation.	➢ Learning GNSS basic theory and introducion process ➢ Airport survey and obstacle survey for GBAS introduction ➢ Ionosphere analysis study ➢ Implementation of ionosphere analysis ➢ Cost-effectiveness study ➢ Certification ➢ Flight procedure design ➢ Development of GBAS introduction plan	✈ ATC technique ✈ WGS84 survey, 20MM	Implementation plan ATSEP Ailine operator	Ionosphere Invistigation equipment (JPY): 1 Million
S	It is lectured that operation principle of MLAT, maintenance management and ATC operation by utilizing MLAT on the assumption that the introduction of MLAT which can monitor the position of aircrafts on airport surface in TIA.	➢ Enhancement of throughput and capacity in TIA after the introduction ➢ Assist visibility of aircrafts for air traffic controllers in visualizing and lead to smooth air traffic control, and improving the safety ➢ Eliminate TIA congestion and increasing the number of aircraft movement	➢ Training of MLAT operation principle, operation processing and display method ➢ Development of MLAT installation plan at TIA ➢ Training. of MLAT demonstration ➢ Training of MLAT maintenance method ➢ Training on apron control ➢ MLAT operation manual development and operation training	✈ ATC technique 10MM	Implementation plan ATSEP ATCO	Assuming MLAT installation with grant aid
C	It intends to improve air traffic control operations by connecting TIA and other airports in Nepal through high-speed data network and promote to exchange operation and weather information.	➢ CAAN, major airports, mountain airports, and operators can share operation and weather information to improve efficiency and safety of air traffic control. ➢ Improve the service rate by providing information necessary for operation, including AMHS information before flight ➢ TIA safety improvement	➢ Formulation of introduction plan for High Speed Data Network ➢ Support for maintenance ➢ Network theory training and setting of operation, technology and performance requirements ➢ Technical cooperation until AMHS operation manual formulation and implementation Flight information management training for flight information officers ➢ Maintenance training	✈ ATC technique ✈ Flight Information 12MM	Implementation plan ATCO Flight Information Officer Airline Operator Aviation Meteorologist ATSEP	Flight information management tool (JPY): 1 Million

(Source JICA Study Team)

(3) Loan Projects

As a measure to enhance the airport capacity in the Kathmandu metropolitan area, it is proposed to implement the ODA loan project for the development of Banepa Domestic Airport as shown in Table 7.5-7.

Table 7.5-7 Project Outline for Banepa Domestic Airport Development

Subject	Banepa Domestic Airport Development Project
Implementation Period	7years and 3months (After Nepal government approval and start of investigation)
Background of Project	Nepal is a landlocked country in between India and China, airways is the important means of transportation and distribution as well as land transportation. The number of international passengers at TIA, the only international airport in Nepal, has increased from 2.02 million in 2009 to 4.34 million in 2018 and the number of domestic passengers has increased from 1.37 million in 2009 to 2.84 million in 2018. In order to meet the increasing demand, TIA is developing facilities such as runway extension and constructing a new apron. However, the shortage of runway capacity has become a major issue, especially with the increase in the number of aircraft movement of small domestic aircrafts. In order to improve the airport capacity of the Kathmandu metropolitan area, CAAN is implementing measures such as developing of the Nijgardh second International Airport, the development of Pokhara International Airport, Gautam Buddha International Airport and the utilization of Ramechhap Airport. Considering from point of the functionality and construction schedule, these measures seems to be not effective. Banepa domestic airport project is planned to be situated at Banepa in Kavrepalanchok district. Because domestic small aircraft flights in TIA will be shifted to Banepa airport for contributing enhancement of the airport capacity in Kathmandu metropolitan area. The planned site is on a ridge in a hilly area. Since it is necessary to carry out earthwork cutting and filling of 4 million cubic meter within the limited area, the difficulty in the construction will be high.
Purpose	As the runway capacity of TIA is at its peak due to the large number of domestic small aircraft in service, construction of Banepa Domestic Airport at Banepa near Kathmandu and shifting the domestic small aircraft operation to Banepa will lead to increase airport capacity of Kathmandu metropolitan area. In addition, this will improve the convenience of air transportation and will help to promote economic growth in Nepal.
Project Content	1：Airport facility development (following facilities are new) ① Civil works: Runway, taxiways, aprons, access roads, parking lots, perimeter roads ② Architectural work: passenger terminal building, ATC tower, administrative building, fire and rescue station, electricrification facility, water supply facility, sewage treatment facility ③ Aeronautical lighting systems: Runway lights, taxiway lights, apron lights ④ Vehicle: Airport chemical fire vehicles 2：Consulting services (detailed design, bid assistance, construction supervision, Environmental management and supervision)
Project Partner	CAAN
Project Outcome	Quantative Effect: ✈ The number of domestic passengers, domestic cargo volume, the number of aircraft movement of domestic flight and delay time at Tribhuvan International Airport Qualitative Effect: ✈ Improving convenience and safety of air transportation, improving tourist satisfaction and promoting regional economic growth

(Source JICA Study Team)

7.5.3 Measures to Improve Safety at Mountain Airports

(1) Grant Aid Projects

The implementation of projects shown in Table 7.5-8 is considered to be effective in promoting CAAN's ability to improve operation of mountain flights.

Table 7.5-8 Project Outline for Safety Improvement at Mountain Airport

Subject	Improvement of flight safety at mountain airports
Implementation Period	2 years
Background of Project	In Nepal, flights to the mountain airport face the problem with communication in mountainous area, therefore, pilots cannot obtain essential information for operational safety of flight. At the same time, air traffic controller could not provide essential information to pilots for operational safety of flight. Additionally, the air traffic controllers at mountain airport uses only voice communication, usually through telephone or mobile for information exchange to another airport or ACC, so that this leads to lack for rapid information sharing of flight plan and weather information.
Purpose	This project focuses on introducing air-to-ground communication system and ground-to-ground communication system, which will ensure communication between pilots and air traffic controllers in mountainous area. Moreover, information sharing between controllers will be facilitated smoothly to improve safety of mountain flights.
Project Content	1：Introduction of RCAG (⑥) The ground station for RCAG will be installed near Nepal Telecom's base stations which are established in Chitresthan, Maithapla and Bharta Lagna, it will be able to communicate between air traffic controllers and pilots as per the mountain flights of Lukla, Simikot, Rara, Dolpa, Jumla and Jomsom. 2：Introduction of VSAT (⑧) Satellite communication antennas will be installed at Simikot, Rara, Jomson, Jumla, and Dolpa airport and digital communication line will be secured between mountain airports, hub airports and ACC to share flight plan information and weather information at high speed. 3：Introduction of AMHS （⑨） AMHS network and terminals will be installed at Simikot, Rara, Jomson, Jumla and Dolpa airport to enable reliable transmission of arrival/departure information, flight plan information, and weather information at mountain airports.
Project Partner	CAAN
Project Outcome	Quantitative effect: The pilots will be able to communicate with the air traffic controllers on all flights to the six mountain airports. (0% → 100%) The arrival/departure information of all flights at the six-mountain airport can be sent/received through AMHS. (0% → 100%) Qualitative effect: ✈ The safety of mountain flight will be improved by being available constant communication between the mountainous flight pilots and the air traffic controllers. ✈ Similar accidents and incidents which occured at past time could be reduced.
Prerequisite/External condition	■Prerequisite ✈ The RCAG installation site is preferable location, where maintenance can be performed, by installing it near the communication station of Nepal Telecom. ✈ When installing RCAG, it is necessary to install solar panels and storage batteries to ensure a backup power source. ✈ AMHS introduction is required high-speed digital network and it must be introduced together with VSAT. ✈ Soft component for installed systems shall be conducted for CAAN's staff in order to enhance their skill to operate or manage the systems. This will lead to ensure their reliable maintence performance. ✈ Replacement parts are delivered together with the main unit that can cope with failures that may occur within about three years after the system installation. The future procurement method for the replacement parts is decided considering the customs of the Nepalese government.

(Source JICA Study Team)

7.5.4 Measures Improve Aviation Safety and Airport Security

(1) Grand Aid Projects

By implementing the project shown in Table 7.5-9 through Japan’s cooperation, DHM's meteorological observation and forecasting accuracy will be improved, resulting in the improvement of the safety of aircraft operation in Nepal, such as, the occurrence of sudden weather changes. This will reduce the number of accidents that have been happening.

Table 7.5-9 Project Outline for Improvement of Aviation Weather Information

Subject	Improve of Weather Forecast Capability
Implementation Period	2 years
Background of Project	In Nepal, meteorological radars have been introduced to observe and predict high-altitude weather related to aircraft operations. A project has been implemented to install meteorological radars for observing high-altitude meteorological conditions at three locations in Nepal. One has already been installed in western Nepal. On the other hand, the plan is still in progress and has not yet achieved the safety and efficiency improvements in aircraft operation. Further, there is a collision has occurred on a mountain during flight to the destination airport due to sudden change in the weather conditions in mountain areas, which is called by CFIT (Controlled Flight into Terrain), it is one of characteristics in aircraft accident in Nepal.
Purpose	In this project, introducing X-band radar and wind shear detector will be possible to grasp the current situation in the mountainous areas, where weather conditions change drastically in Nepal, and it will be possible to acquire necessary data for weather forecast. Furthermore, the safety of mountain flights is improved by detecting wind shear that occurs near the end of the runway before aircraft landing at mountain airports.
Project Content	1：Introduction of X-band Radar X-band radars will be installed at a total of three locations on the east, west and south sides of the Kathmandu basin. With the introduction of the X-band radar, technical cooperation will be provided to DHM based on the local meteorological observation data for the development of a highly accurate aviation weather forecast model. 2：Introduction of Wind Shear Detector Wind shear detectors will be installed at four airports, Lukla, Jomsom, Simikot and Rara. However, since it may be necessary to verify the effectiveness of the wind shear detector and establish a method for providing information to the pilot, it will be introduced firstly at Lukla Airport, which has the highest demand in this project, and prceed to establish operational procedures.
Project Partner	DHM, CAAN
Project Outcome	Quantative effect: ✈ Regarding aircrafts entering and leaving the airspace within the Kathmandu basin, air traffic controller will be able to notify the pilot in advance of changes in local weather conditions. (0% → 100%) ✈ Wind shear which occurs near the end of the runway will be detected early at Lukla airport and can be notified to pilots and controllers. (0% → 100%) Qualitative effect: ✈ The accuracy of aviation weather information will be improved and the safety of flight operations on air routes will be improved. ✈ By building a model for aviation weather forecast, the forecasting accuracy will be improved, pilots will be able to obtain weather forecast information before departure and will be able to fly safely depending on the weather conditions on the flight route, thereby, reducing the occurance of accidents.
Prerequisite/External condition	■Prerequisite ✈ In order to achieve much safer operation using aviation weather information, CAAN has to establish operational procedures how to use pre-flight and in-flight weather information together with airlines and be implement information sharing and notification thoroughly. ✈ Soft component for installed systems is conducted to train how to operate or manage the system. In addition, weather forecast model using X-band ladar is constructed taking into account the cooperation with technical cooperation programs. ✈ Replacement parts are deliverd together with the main unit that can cope with failures that may occur within about three years after the system instllation. The future procurement

	method for the replacement parts is decided considering the customs of the Nepalese government. ■External Condition ✈ It is necessary to organize weather information that will finally be available, along with the progress status of the ongoing World Bank project (introduction of C-band radar and automatic weather observation device). ✈ Based on the above, it is necessary to proceed with discussion on what kind of weather forecast model can be developed in consultation with DHM.

(Source JICA Study Team)

(2) Technical Cooperation

For implementing weather observation and accuracy of weather forecast, it is necessary to develop new forecast model which is based on acquired data by introduction of weather observation radar and wind shear detector. At result, it will be expected to improve operational safety of flight by supporting to develop weather forecast model by technical cooperation of Japanese experts.

Table 7.5-10 Project Outline for Improvement of Aviation Weather Information

Subject	Technical Cooperation Project to Improve Precise Weather Information
Implementation Period	3 years
Background of Project	In Nepal, the installation of aviation weather observation equipment is not enough, and the accuracy of aviation weather forecast is low, which is regarded as a major problem. In addition, due to the lack of accuracy of aviation weather forecast, it is not sufficient for airlines to consider operational plans using the weather forecasts prior to flight, the sudden change of weather conditions during flight on en-route impairs the flight safety and service. This situation is a common factor leading to frequent accidents. So, it is necessary to improve aviation weather observation and forcast accuracy in order to reduce aircraft accidents in Nepal. With the support of the World Bank, DHM is installing a high-altitude weather observation radar and a ground-based weather observation system, but it is necessary to install an X-band radar, which is necessary to catch local weather changes. Furthermore, it is necessary to develope a more accurate weather forcast model based on all these meteorological observation data.
Purpose	In this project, the introduction of wind shear detection equipment will improve the safety of landing at mountain airports. In addition, the flight safety on enroute can be improved by introducing a radar that can observe local weather conditions. At the same time, improved forecast accuracy can lead to confirm the risk due to changes in weather conditions prior to flight operation, and it is able to reduce the possibility of accidents by changing and/or coordinating of flight plan.
Project Content	<u>1：Establishment operational method with wind shear detector(⑭)</u> It is developed an operational method including notification method to the pilot when wind shear is detected using the wind shear detector. In addition, it is provided necessary education and training on the maintenance method of the newly introduced wind shear detector. <u>2：Developing weather forcast model (⑱)</u> By combining multiple data such as C-band radar and high-altitude meteorological wind data including the observation results by X-band radar, it will be developed a model that can predict the state of aviation weather that changes rapidly locally. Furthermore, education and training will be provided to air traffic controllers and flight managers regarding aircraft operation methods using the weather forcast data.
Project Partner	DHM, CAAN (ATCO and ATSEP) and Airline (operation manager)
Project Outcome	<u>Quantaive effect:</u> ✈ It will be possible to check the occurrence of wind shear at airports equipped with wind shear detector. (0% → 100%) ✈ It becomes possible to know in advance weather condition changes such as rainfall at the location, where the X-band radar is installed. (0% → 100%) <u>Qualitative effect:</u> ✈ Accidents due to sudden weather changes such as wind shear at mountain airports will be reduced. ✈ In Nepal, the accuracy of aviation weather forecast will be improved and the number of accidents due to changes in weather conditions on enroute will be reduced. ✈ By acquiring aviation weather forecast information prior to flight and establishing a habit of

	operating based on its information, the number of accidents in Nepal will decrease and the safety of aircraft operation will be improved.
Prerequisite/External condition	■Prerequisite ✈ The wind shear detector will be installed at Lukla Airport, its performance will be evaluated, at the same time, the operation method such as the notification method to the pilot will be examined. ✈ The introduction of X-band radar will be limited to the Kathmandu basin and it will be verified what kind of data can be acquired and what kind of forcast model can be developed. ✈ As the location where local weather forecast information is required, it will be considered to other candidate sites where are preferable location for introduction of X-band radar and considered future development plans.

(Source JICA Study Team)

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Chapter 8 Demand Forecast Considering the Impact of Covid-19 and Review of Airport Capacity Expansion Measures in Kathmandu Region

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8 DEMAND FORECAST CONSIDERING THE IMPACT OF COVID-19 AND REVIEW OF AIRPORT CAPACITY EXPANSION MEASURES IN KATHMANDU REGION

8.1 Demand Forecast Scenario

In 2020, the COVID-19 has spreaded all over the world, and strict measures to prevent the spread of infection has been implemented, such as restrictions on domestic and international movements, stricter confirmation of infectious diseases at the immigration, and quarantine measures for a certain period of time. As a result, aviation demand in 2020 droped significantly from 2019. Furthermore, it is expected that domestic and international movement will continue to be restricted after 2020, and it is expected that it will take several years to recover.

In this study, demand forecasts had been done based on the number of passengers and aircraft movements up to 2018, and based on the results of that, measures to solve issues in the aviation sector of this country had been considered. In addition, considering the long-term decline of aviation demand, the demand forecast up to 2050 had been reconsidered. Furthermore, based on the results of the demand forecast, the measures required for the aviation sector in Nationwide had been reviewed and modified for the implementation time and contents.

8.2 Review of Demand Forecast for Kathmandu Region Considering the impact of COVID-19

8.2.1 Air Passenger Demand Forecast Considering the impact of COVID-19

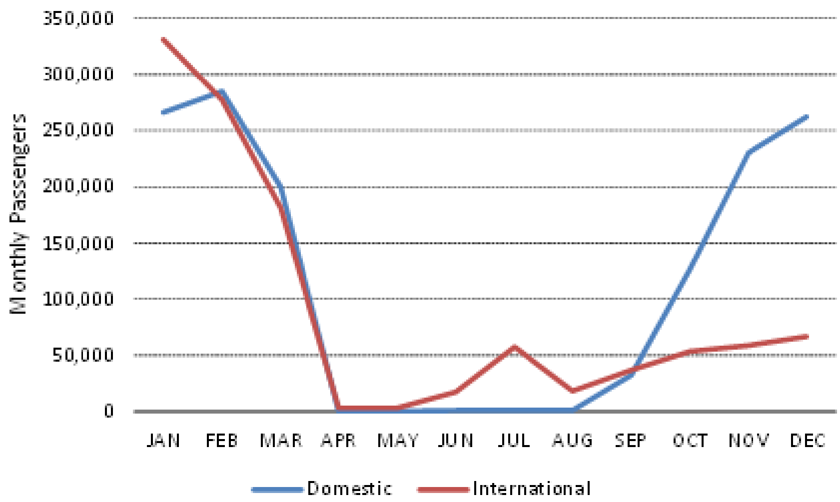
(1) Procedure for Air Passenger Demand Forecast Considering the impact of COVID-19

The demand analysis considering the impact of COVID-19 is conducted in the following three periods.

<u>2020</u>	A short-term future trend is assumed based on the monthly passenger number trend in 2020.
<u>2021-2025</u>	Regarding the short-term demand recovery scenario, IATA announced it in July 2020, stating that <u>"global demand is expected to recover to 2019 level around 2024."</u> Regarding TIA's short-term demand forecast up to 2025, a recovery period is assumed based on the IATA outlook and characteristics of route distance in Nepal.
<u>After 2030</u>	Demand is expected to recover to level before the COVID-19 epidemic by 2030, and demand will be reviewed based on regression analysis.

(2) Actual Trend of passengers in 2020

Figure 8.2-1 shows the monthly number of passengers in 2020, number when COVID-19 was spread. At the end of the year, domestic passengers recovered to the level at the beginning of the year, however, there is no recovery trend for international passengers.



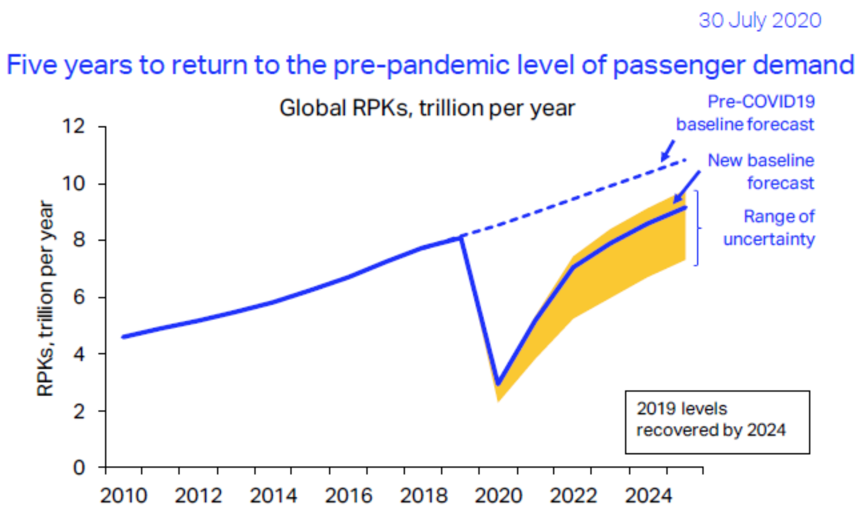
(Source: JICA Study Team)

Figure 8.2-1 Air Traffic Passengers in 2020 at TIA

(3) Demand Recovery in 2021-2025

As for the demand recovery scenario for international passengers, IATA has announced that "the global demand is expected to recover to 2019 level around 2024". (Source: IATA Economics' Chart of the Week, July 2020)

Figure 8.2-2 shows the outline of recovery scenario.



(Source: IATA Economics' Chart of the Week, July 2020)

Figure 8.2-2 IATA Demand Recovery Scenario

Based on the IATA scenario, the recovery scenario is assumed taking into account the characteristics of Nepal that the route distance is shorter than the world average.

Considering the trend in 2020, domestic passengers are still on the way of recovery in 2021, and it is expected that the recovery to 2019 level will be in 2022.

Table 8.2-1 shows the average route distance in the world and average distance of major route in TIA. The distance of TIA's international routes is shorter than the world average. From these situations, it is expected that demand will recover earlier than 2024 announced by IATA, and assume that international demand will recover to 2019 level in 2023 that is one year after 2022 when domestic demand will recover.

Table 8.2-1 Comparison of International Route Distance

	World Average	Average of Major Roure in TIA
International Route Distance	3,000 km	2,500 km

(Source: JICA Study Team)

(4) Regression Analysis and Prediction Formula

1) Establishment of Prediction Formula

Regarding the model for estimating air passenger demand, ICAO states in the "Manual on Air Traffic Forecasting, third edition 2006" as follows:

－ Regression analysis is by far the most popular method of forecasting civil aviation demand.

In this study, the construction of the prediction formula is based on regression analysis.

The formula in the regression model is based on a linear model, the explanatory variable in the regression model is real GDP considering the impact of COVID-19, and the dependent variable is the number of TIA passengers. The result of regression analysis is as shown in Table 8.2-2.

Table 8.2-2 Prediction Formula for Air Passenger Demand Estimation

	Model for International Passengers	Model for Domestic Passengers
Analysis Period	2005-2019	2005-2019
Coefficient of Determination	0.947	0.828
t-Value of Variable	15.3	7.9
Prediction Formula	$Y = 7.080 \times X - 2.051$ Y: Annual International passenger (000) X: Real GDP considering the impact of COVID-19（Billion Real NPR）	$Y = 4.478 \times X - 1.423$ Y: Annual Domestic passenger (000) X: Real GDP considering the impact of COVID-19（Billion Real NPR）

(Source: JICA Study Team)

2) Projection of Socio-economic Framework

Regarding the future GDP considering the impact of COVID-19, the IMF (International Moneytary Fund) publishes forecasts up to 2025, and estimates an annual growth rate of 5.0% in 2025 (Table 8.2-3).

Table 8.2-3 Forecast for Annual Growth Rate of GDP by IMF

	2019	2020	2021	2022	2023	2024	2025
GDP Growth rate	7.1%	0.0%	2.5%	6.0%	5.2%	5.0%	5.0%

(Source: IMF, World Economic Outlook Database, October 2020)

Considering the growth rate of GDP in major Asian countries over 30 years (Table 8.2-4), it is assumed that future GDP growth will decrease by 1% in 10 years as shown in Table 8.2-5.

Table 8.2-4 Trend of GDP Growth in Major Asian Countries

	1980-1990	1990-2000	2000-2010	2010-2020	Decrease in 30 years	Average Decrease per 10 years
Japan	4.5%	1.3%	0.6%	1.0%	3.6%	1.2%
Korea	9.9%	6.9%	4.7%	2.8%	7.1%	2.4%
China	9.3%	10.4%	10.5%	7.1%	2.1%	0.7%
Taiwan	8.2%	6.7%	4.2%	2.4%	5.8%	1.9%
Thailand	7.9%	4.5%	4.6%	3.2%	4.7%	1.6%
Singapore	7.7%	7.1%	5.8%	3.4%	4.4%	1.5%
Average						1.5%

(Source: IMF, World Economic Outlook Database, October 2019)

Table 8.2-5 Future GDP Growth Rate

	2025-30	2030-35	2035-40	2040-45	2045-50
GDP Growth rate	5.0%	4.5%	4.0%	3.5%	3.0%

(Source: JICA Study Team)

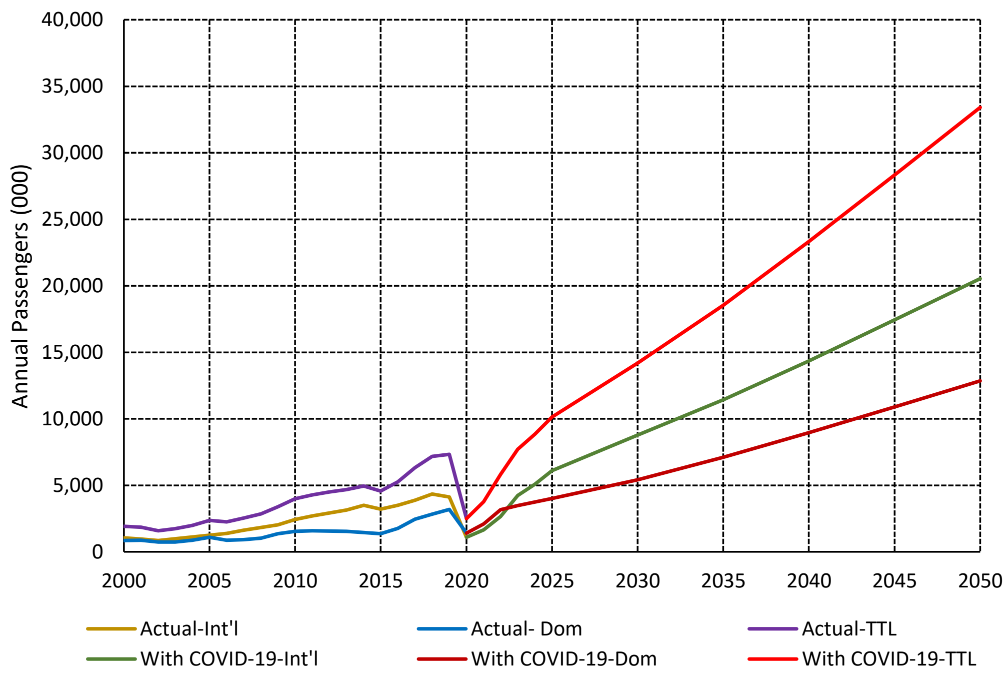
3) Annual Air Passenger Demand

The annual passenger demand is estimated from the prediction formula and future GDP as shown in Table 8.2-6 and Figure 8.2-3.

Table 8.2-6 Annual Air Passenger Forecast

	International Passenger		Domestic Passenger	
	Passenger (1000 person)	Annual Growth Rate	Passenger (1000 person)	Annual Growth Rate
2019 (Actual)	4,139		3,188	
2020 (Actual)	1,105	-73%	1,406	-56%
2021	1,658	50%	2,109	50%
2022	2,652	60%	3,164	50%
2023	4,243	60%	3,480	10%
2024	5,092	20%	3,758	8%
2025	6,110	20%	4,028	7%
2030	8,774	7.5%	5,424	6.2%
2040	14,360	5.0%	8,958	5.1%
2050	20,541	3.6%	12,867	3.7%

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 8.2-3 Air Passenger Demand Forecast

(5) Comparison of Demand Forecast in Chapter 4 and Demand Review in Chapter 8

The impact of COVID-19 on aviation demand is confirmed by comparing the years reaching the same demand scale based on the results of Chapter 8 and Chapter 4. The results are shown in Table 8.2-7 and Figure 8.2-4, and confirmed as follows for international and domestic, respectively.

(International) Due to the impact of COVID-19, the demand growth is expected to be delay by 3 to 5 years.

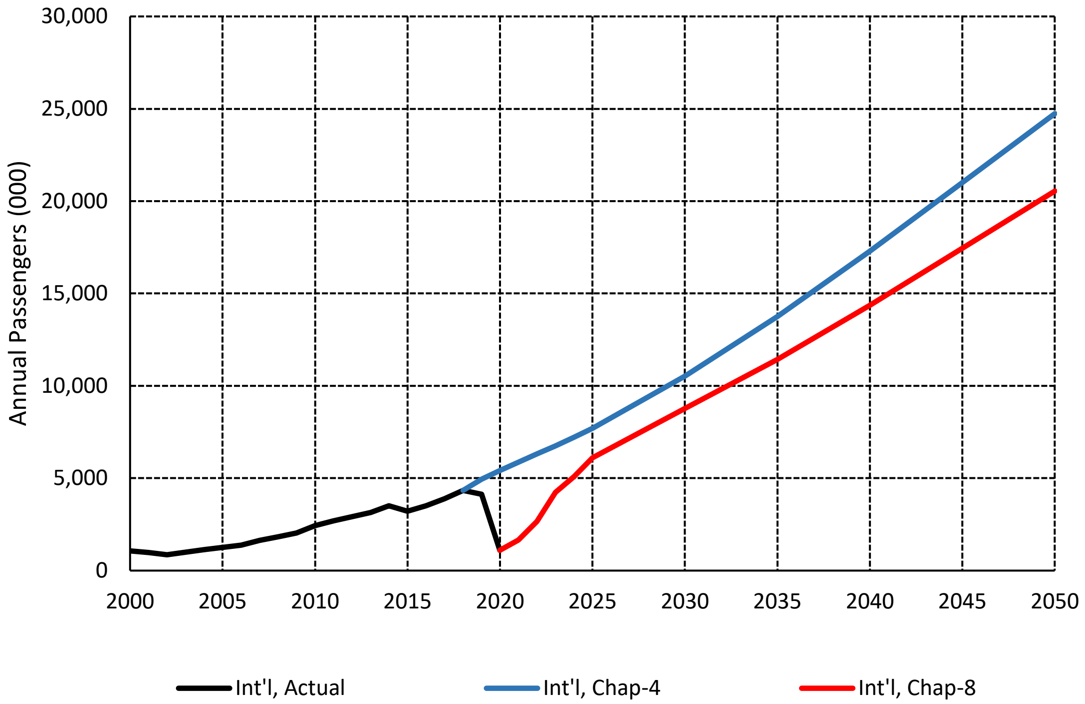
(Domestic) No difference is found in the predicted demand in Chapter 4 and 8. The reason is as indicated as below.
"In Chapter 8, the analysis period for regression analysis is extended by one year (2019 is added), as a result, a linear equation with a steeper slope than the equation in Chapter 4 was obtained. On the other hand, the GDP used in the calculation are the value taking into account the effects of COVID-19.
It is considered that these results are obtained by offsetting the demand increase factor related to the slope of the linear equation and the demand decrease factor of GDP."

Table 8.2-7 Comparison of the Year of Reach a Certain Demand

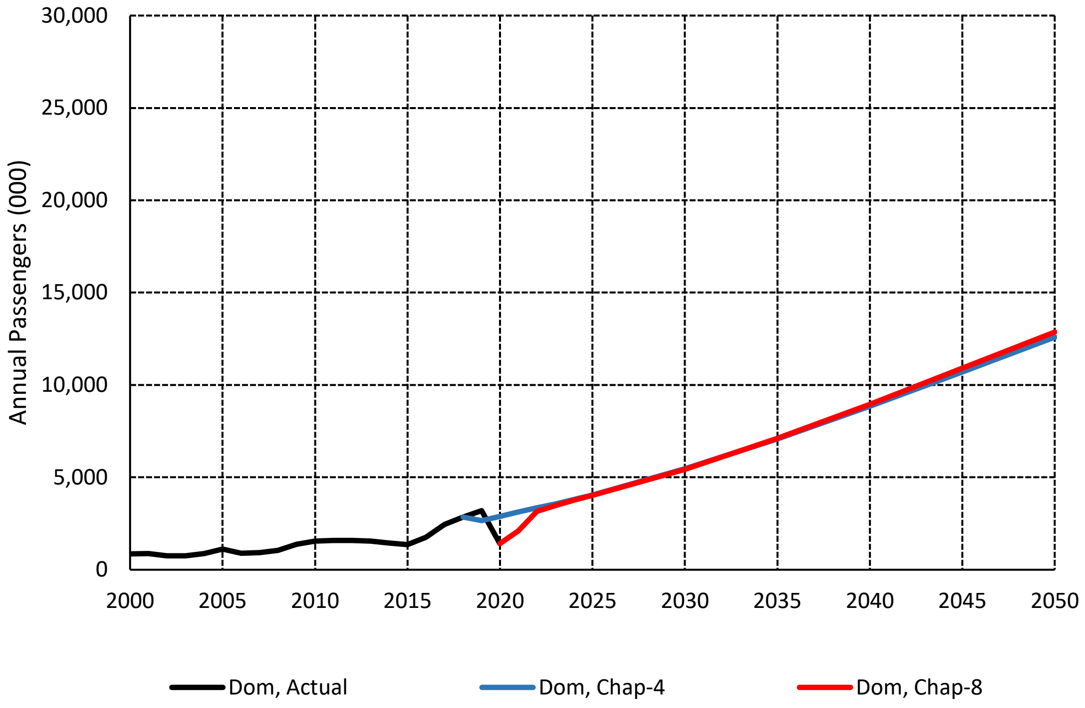
	Annual Demand (thousands)	Year of Reach		Difference in Year
		Demand in Chap-4	Demand in Chap-8	
International	10,000	2029	2032	3 years
	15,000	2037	2041	4 years
	20,000	2044	2049	5 years
Domestic	5,000	2029	2029	0 year
	10,000	2043	2043	0 year

(Source: JICA Study Team)

(International)



(Domestic)



(Source: JICA Study Team)

Figure 8.2-4 Comparison of Chapter 4 Demand Forecast and Chapter 8 Demand Review

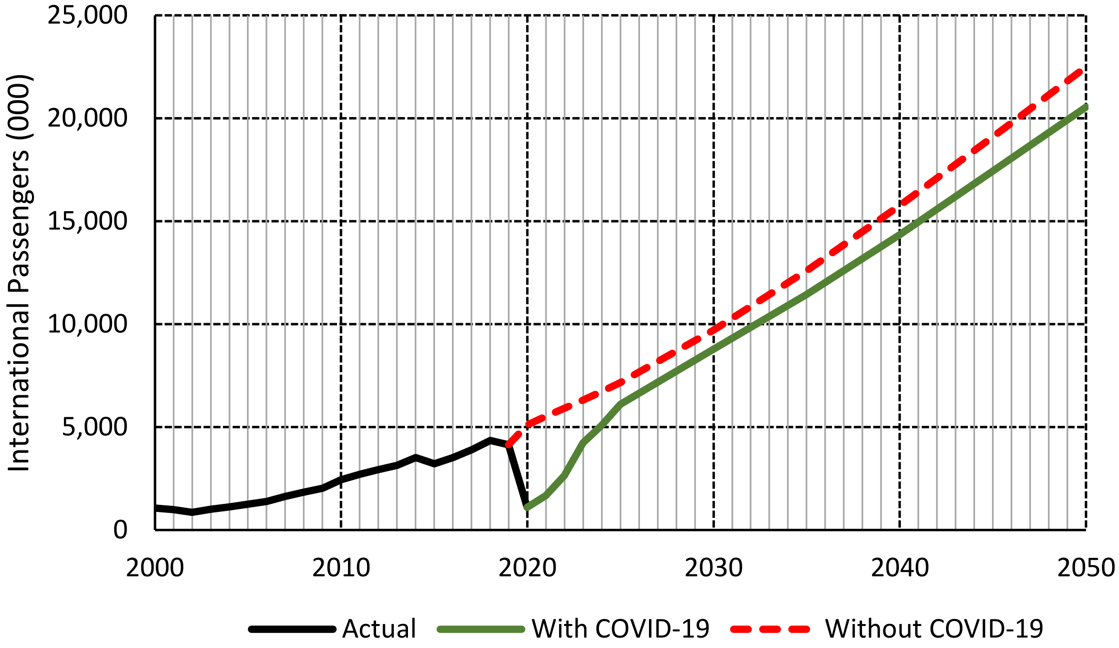
In addition, using the forecast formula obtained in the regression analysis in Chapter 8, future demand is calculated based on the GDP before COVID-19 (Without COVID-19) and affected GDP by COVID-19 (With COVID-19). The results of the differences between Without COVID-19 and With COVID-19 are shown in Table 8.2-8 and Figure 8.2-5.

Table 8.2-8 Comparison of the Year of Reach a Certain Demand for With/Without COVID-19

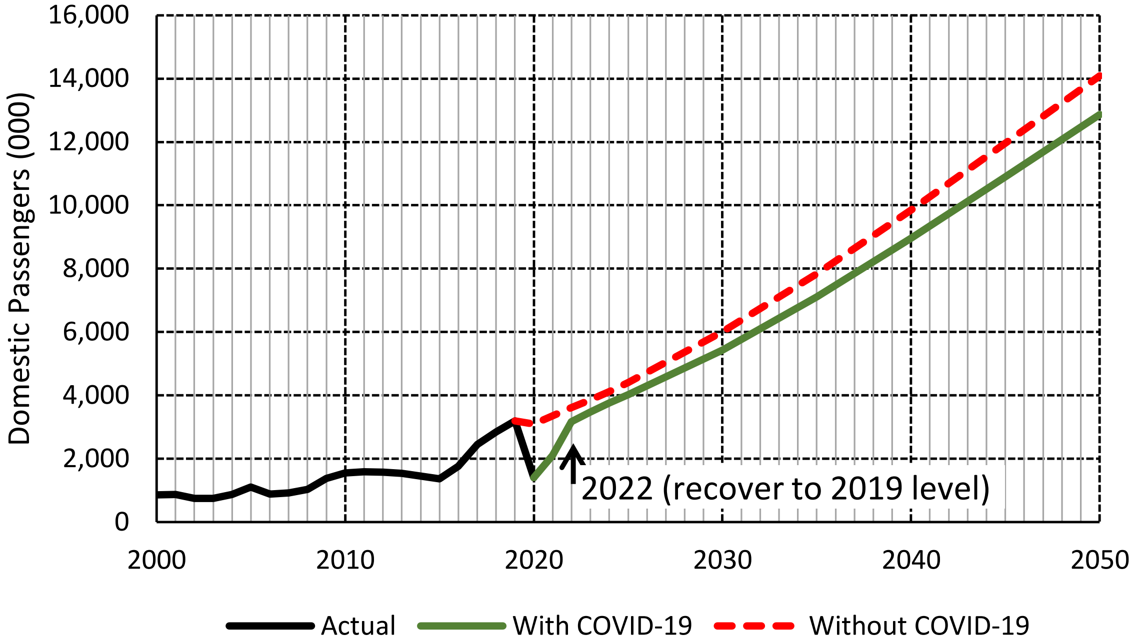
	Annual Demand (thousands)	Year of Reach		Difference in Year
		Without COVID-19	With COVID-19	
International	10,000	2031	2032	1 years
	15,000	2039	2041	2 years
	20,000	2046	2049	3 years
Domestic	5,000	2027	2029	2 year
	10,000	2040	2043	3 year

(Source: JICA Study Team)

(International)



(Domestic)



(Source: JICA Study Team)

Figure 8.2-5 Comparison of Future Demand for With/Without COVID-19

8.2.2 Aircraft Movement Forecast

The aircraft movement is basically estimated based on the daily aircraft movement by route and aircraft type, and the daily aircraft movement is calculated based on the annual passengers by route and aircraft type. Therefore, it is necessary various factors such as “route share” to allocate passengers to each route, “share of aircraft type” to allocate passengers to each aircraft type, “seat capacity and seat occupancy rate” to convert from passenger numbers to aircraft movements and “design day ratio” to convert from annual passenger number to daily passenger numbers.

(1) Annual Air Passengers by Route

1) International

The share of international routes is categorized into Northeast Asia, Southeast Asia, Southwest Asia and the Middle East. The share of routes is based on the seat capacity by route in TIA’s 2019/2020 winter schedule.

Table 8.2-9 Share for International Route

Route	Northeast Asia	Southeast Asia	Southwest Asia	Middle East
Share	20%	15%	20%	45%

Note: Northeast Asia: Japan, China、Korea
Southeast Asia: Thailand, Malaysia, Singapore
Southwest: India, Bangladesh, Bhutan
Middle East: Qatar, UAE, Turkey
(Source: Prepared by JICA Study Team based on TIA Schedule from CAAN)

Table 8.2-10 shows the annual international passengers by route.

Table 8.2-10 Annual International Passengers by Route

	Percentage	2030	2040	2050
Northeast Asia	20%	1,755	2,872	4,108
Southeast Asia	15%	1,316	2,154	3,081
Southwest Asia	20%	1,755	2,872	4,108
Middle East	45%	3,948	6,462	9,243
Total	100%	8,774	14,360	20,541

Note: Unit in 1000 person/year
(Source: JICA Study Team)

2) Domestic

The share of domestic route is set as shown in Table 8.2-11 bassed on the current share by route of TIA in 2018.

Table 8.2-11 Share for Domestic Route

Route	Percentage	Route	Percentage
Pokhara	19.7%	Biratnagar	17.4%
Nepalgunj	13.8%	Bhairahawa	12.2%
Simara	7.5%	Bharatpur	7.4%
Chandragadhi	7.4%	Dhangadhi	5.8%
Lukla	4.0%	Janakpur	2.6%
Tumlingtar	1.0%	Surkhet	0.5%
Phaplu	0.3%	Bhojpur	0.2%
Rukum Salle	0.1%	Taplejung	0.1%

(Source: JICA Study Team)

Table 8.2-12 shows the annual domestic passengers by route.

Table 8.2-12 Annual Domestic Passengers by Route

	Percentage	2030	2040	2050
Pokhara	19.7%	1,071	1,768	2,540
Biratnagar	17.4%	944	1,559	2,240
Nepalgunj	13.8%	749	1,238	1,778
Bhairahawa	12.2%	663	1,096	1,574
Simara	7.5%	405	670	962
Bharatpur	7.4%	402	664	953
Chandragadhi	7.4%	400	661	949
Dhangadhi	5.8%	312	516	741
Lukla	4.0%	219	362	520
Janakpur	2.6%	139	229	329
Tumlingtar	1.0%	54	90	129
Surkhet	0.5%	27	45	65
Phaplu	0.3%	19	31	44
Bhojpur	0.2%	9	16	22
Rukum Salle	0.1%	4	7	10
Taplejung	0.1%	4	7	10

Note: Unit in 1000 person/year
(Source: JICA Study Team)

(2) Design Day Air Passengers by Route

The design day passengers are estimated by multiplying the annual passenger by the design day ratio, and the design day ratio is set based on the definition of "average day of peak month". The design day ratio is set based on the trend of the design day ratio obtained from the results of the past three years (see Table 8.2-13 and Table 8.2-14).

Table 8.2-13 Design Day Ratio (International)

	2016	2017	2018	Average Value
Peak Month	11-12	10-11	10-11	
Design day Ratio	1/319	1/310	1/314	1/310

(Source: JICA Study Team)

Table 8.2-14 Design Day Ratio (Domestic)

	2016	2017	2018	Average Value
Peak Month	10-11	10-11	10-11	
Design day Ratio	1/265	1/277	1/286	1/290

Note: value based on trend from 2016 to 201
(Source: JICA Study Team)

The design day passengers by route are estimated as shown in Table 8.2-15 and Table 8.2-16 for international and domestic, respectively.

Table 8.2-15 Design Day Passengers by Route (International)

	2030	2040	2050
Northeast Asia	5,660	9,260	13,250
Southeast Asia	4,250	6,950	9,940
Southwest Asia	5,660	9,260	13,250
Middle East	12,740	20,850	29,820
Total	28,310	46,320	66,260

Note: Unit in persons/day
(Source: JICA Study Team)

Table 8.2-16 Design Day Passengers by Route (Domestic)

	2030	2040	2050
Pokhara	3,690	6,100	8,760
Biratnagar	3,260	5,380	7,720
Nepalgunj	2,580	4,270	6,130
Bhairahawa	2,290	3,780	5,430
Simara	1,400	2,310	3,320
Bharatpur	1,390	2,290	3,290
Chandragadhi	1,380	2,280	3,270
Dhangadhi	1,080	1,780	2,560
Lukla	760	1,250	1,790
Janakpur	480	790	1,130
Tumlingtar	190	310	450
Surkhet	90	150	220
Phaplu	60	110	150
Bhojpur	30	50	80
Rukum Salle	20	20	40
Taplejung	10	20	30
Total	18,710	30,890	44,370

Note: Unit in persons/day
(Source: JICA Study Team)

(3) Design Day Air Passengers by Route and Aircraft Type

1) International

In order to estimate the aircraft movement by aircraft type, the international passengers by route is allocated by aircraft type. The aircraft type is categorized as shown in Table 8.2-17. The share for passenger allocation by aircraft type is shown in Table 8.2-19 in consideration of the current share (see Table 8.2-18 and upsizing of aircraft in future.

Table 8.2-17 Categorization of Aircraft Type (International)

Aircraft Classification	Seat number	Aircraft Type
Large Jet	300-350 seats	A330, B777
Medium Jet	Around 250 seats	B787, B767
Smaller Jet	Around 150 seats	A320, B737
Propeller	Around 70 seats	ATR72

(Source: JICA Study Team)

Table 8.2-18 Current Situation of Aircraft Share

	Large Jet	Medium Jet	Smaller Jet	Propeller
Northeast Asia	60%	—	40%	—
Southeast Asia	30%	—	70%	—
Southwest Asia	—	—	95%	5%
Middle East	60%	—	40%	—

(Source: JICA Study Team)

Table 8.2-19 Future Share of Aircraft Type

		Large Jet	Medium Jet	Smaller Jet	Propeller
2025-35	Northeast Asia	70%	—	30%	—
	Southeast Asia	50%	—	50%	—
	Southwest Asia	—	50%	45%	5%
	Middle East	70%	—	30%	—
2040-50	Northeast Asia	80%	—	20%	—
	Southeast Asia	60%	—	40%	—
	Southwest Asia	—	60%	40%	—
	Middle East	80%	—	20%	—

(Source: JICA Study Team)

2) Domestic Flights

In order to estimate the aircraft movement by aircraft type, the domestic passengers by route is allocated by aircraft type. The aircraft type is categorized as shown in Table 8.2-20, four domestic hub airports (Pokhara, Biratnagar, Nepalgunj and Bhairahawa) are expected introduction of jet aircraft from 2030 as shown in Table 8.2-21.

Table 8.2-20 Categorization of Aircraft Type (Domestic)

Aircraft Type	No. of Seat	Target Model
Jet	150 seats	A319, B737
ATR72-Class	75 seats	ATR72, DHC8-400
ATR42-Class	40 seats	ATR42
STOL	19 seats	DHC6, Do228

(Source: JICA Study Team)

Table 8.2-21 Assumption of Introduction of Jet Aircraft (Domestic)

Year of Introduction	Assumption of introduction ratio
FY2030	Replacing 1/2 part of ATR72 by Jet
FY2040	Replacing 2/3 part of ATR72 by Jet
FY2050	Replacing ATR72 by Jet

(Source: JICA Study Team)

(4) Design Day Aircraft Movements by Route and Aircraft Type

The aircraft movement is estimated by dividing the passenger numbers calculated in "(3) Design Day Air Passengers by Route and Aircraft Type" by the passengers per flight (multiply seat capacity by seat occupancy rate). The seat capacity and seat occupancy rate are shown inTable 8.2-22. The design day international aircraft movements is shown in Table 8.2-23, and the design day domestic aircraft movements is shown in Table 8.2-24.

Table 8.2-22 Seat Capacity and Seat Occupancy Rate

		Large Jet	Medium Jet	Small Jet	Propeller
International	Seat number	330	260	150	70
	Seat occupancy	85%			
		Jet	**ATR72**	**ATR42**	**STOL**
Domestic	Seat number	150	75	40	19
	Seat occupancy	90%			

Note: Seat capacity is set as the average of the major aircraft that correspond to each category.
(Source: JICA Study Team)

Table 8.2-23 Design Day International Aircraft Movements

		Large Jet	Medium Jet	Small Jet	Propeller	Total
2030	Northeast Asia	14	0	13	0	27
	Southeast Asia	8	0	17	0	25
	Southwest Asia	0	13	20	5	38
	Middle East	32	0	30	0	62
	Total	54	13	80	5	152
2040		**Large Jet**	**Medium Jet**	**Small Jet**	**Propeller**	**Total**
	Northeast Asia	26	0	15	0	41
	Southeast Asia	15	0	22	0	37
	Southwest Asia	0	25	29	0	54
	Middle East	59	0	33	0	92
	Total	100	25	99	0	224
2050		**Large Jet**	**Medium Jet**	**Small Jet**	**Propeller**	**Total**
	Northeast Asia	38	0	21	0	59
	Southeast Asia	21	0	31	0	52
	Southwest Asia	0	36	42	0	78
	Middle East	85	0	47	0	132
	Total	144	36	141	0	321

(Source: JICA Study Team)

Table 8.2-24 Design Day Domestic Aircraft Movements

Year		Jet	ATR72	ATR42	STOL	Total
2030	Pokhara	12	25	10	0	47
	Biratnagar	12	22	5	0	39
	Nepalgunj	10	17	4	0	31
	Bhairahawa	8	15	3	0	26
	Simara	0	0	39	0	39
	Bharatpur	0	0	39	0	39
	Chandragadhi	0	19	2	0	21
	Dhangadhi	0	15	2	0	17
	Lukla	0	0	0	44	44
	Janakpur	0	7	0	0	7
	Tumlingtar	0	0	5	0	5
	Surkhet	0	0	3	0	3
	Phaplu	0	0	0	4	4
	Bhojpur	0	0	0	2	2
	Rukum Salle	0	0	0	1	1
	Taplejung	0	0	0	1	1
	Total	42	120	112	52	326
2040		**Jet**	**ATR72**	**ATR42**	**STOL**	**Total**
	Pokhara	27	27	17	0	71
	Biratnagar	26	24	7	0	57
	Nepalgunj	21	19	6	0	46
	Bhairahawa	18	17	5	0	40
	Simara	0	0	64	0	64
	Bharatpur	0	0	64	0	64
	Chandragadhi	0	32	3	0	35
	Dhangadhi	0	25	2	0	27
	Lukla	0	0	0	73	73
	Janakpur	0	12	0	0	12
	Tumlingtar	0	0	9	0	9
	Surkhet	0	0	4	0	4
	Phaplu	0	0	0	6	6
	Bhojpur	0	0	0	3	3
	Rukum Salle	0	0	0	1	1
	Taplejung	0	0	0	1	1
	Total	92	156	181	84	513
2050		**Jet**	**ATR72**	**ATR42**	**STOL**	**Total**
	Pokhara	58	0	24	0	82
	Biratnagar	54	0	11	0	65
	Nepalgunj	43	0	9	0	52
	Bhairahawa	38	0	8	0	46
	Simara	0	0	92	0	92
	Bharatpur	0	0	91	0	91
	Chandragadhi	0	46	5	0	51
	Dhangadhi	0	36	4	0	40
	Lukla	0	0	0	105	105
	Janakpur	0	17	0	0	17
	Tumlingtar	0	0	13	0	13
	Surkhet	0	0	6	0	6
	Phaplu	0	0	0	9	9
	Bhojpur	0	0	0	5	5
	Rukum Salle	0	0	0	2	2
	Taplejung	0	0	0	2	2
	Total	193	99	263	123	678

(Source: JICA Study Team)

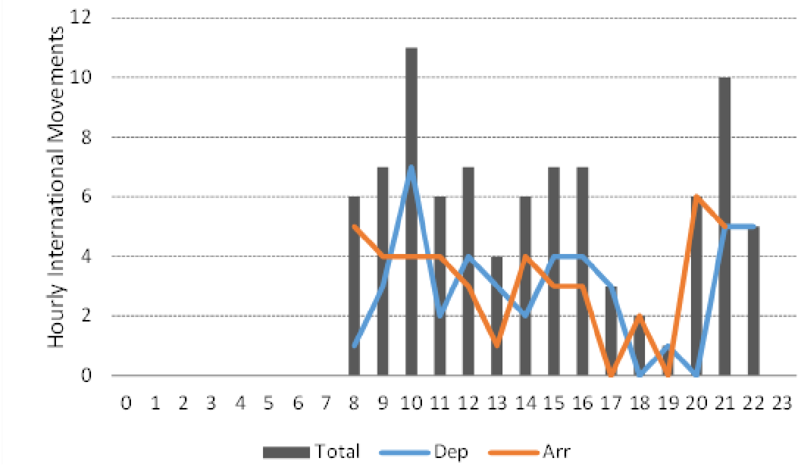
8.2.3 Peak Hour Demand Forecast

(1) Peak Characteristics Analysis

The peak hour passengers and aircraft movements are estimated by multiplying the design day passengers and aircraft movements by peak hour ratio.
The peak hour ratio is set by the ratio of the movements during peak hour to the daily movements, based on the schedule of departure and arrival of aircraft at TIA (the flight log of October 26, 2019).

1) International

The peak of the internatonal flight is between 10 and 11 am and between 9 and 10 pm, and the peak time zone is considered to be 5 hours from 8 to 12 o'clock. The peak hour ratio is set to 0.080 based on the average number of flights over these 5 hours and the number of daily flights (Figure 8.2-6).

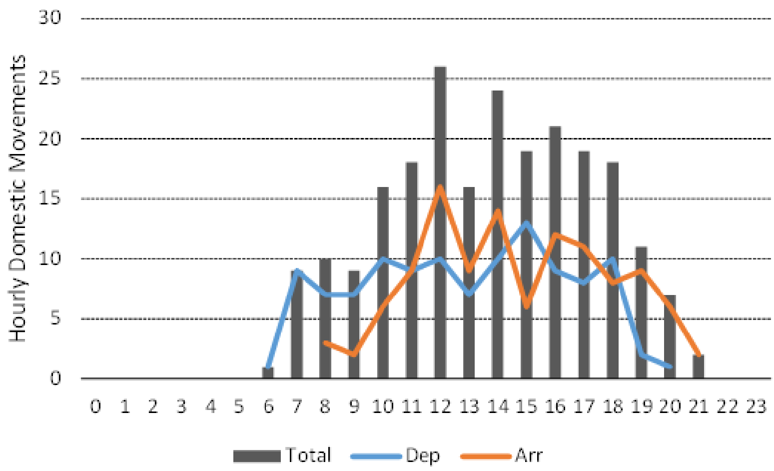


(Source: JICA Study Team)

Figure 8.2-6 Time Fluctuation of International Flight

2) Domestic

The peak of the domestic flight is between 12 am and 1 pm, and there are also many flights in the afternoon. The peak time zone is considered to be 5 hours from 12 am to 4 pm , and the peak hour ratio is set to 0.093 based on the average number of flights over these 5 hours and the number of daily flights(Figure 8.2-7).

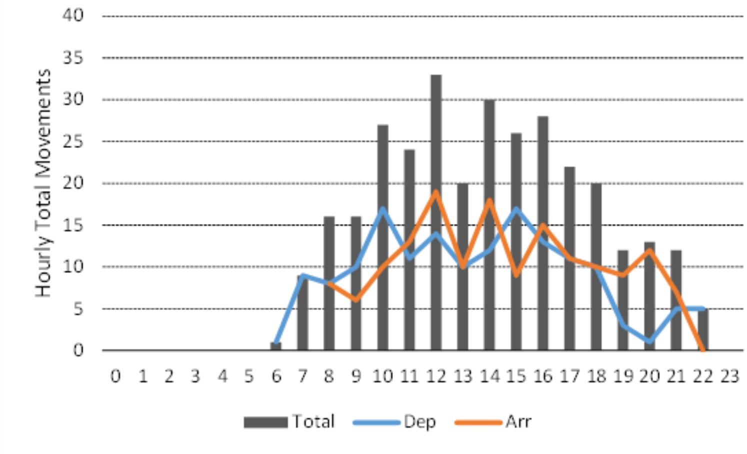


(Source: JICA Study Team)

Figure 8.2-7 Time Fluctuation of Domestic Flight

3) International plus Domestic

The peak of the International plus domestic flight is between 12 am and 1 pm, and there are also many flights before and after the peak time. The peak time zone is considered to be 7 hours from 10 am to 4 pm, and the peak hour ratio is set to 0.086 based on the average number of flights over these 7 hours and the number of daily flights (Figure 8.2-8).



(Source: JICA Study Team)

Figure 8.2-8 Time Fluctuation of International plus Domestic Flight

(2) Peak Hour Passenger

From the result of design day passengers and peak hour ratio, peak hour passengers are estimated as shown in Table 8.2-25 and Table 8.2-26.

Table 8.2-25 Peak Hour International Passengers

	2030	2040	2050
Design Day Passengers (person/Day)	28,310	46,320	66,260
Peak hour ratio	0.080	0.080	0.080
Peak Hour Passengers (person/hour)	2,260	3,710	5,300

(Source: JICA Study Team)

Table 8.2-26 Daily Peak Hour Domestic Passengers

	2030	2040	2050
Design Day Passengers (person/Day)	18,710	30,890	44,370
Peak hour ratio	0.093	0.093	0.093
Peak Hour Passengers (person/hour)	1,740	2,870	4,130

(Source: JICA Study Team)

(3) Peak Hour Aircraft Movements

From the result of design day aircraft movements and peak hour ratio, peak hour aircraft movements are estimated as shown in Table 8.2-27, Table 8.2-28, and Table 8.2-29.

Table 8.2-27 Peak Hour Aircraft Movements (International)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	152	224	321
Peak hour ratio	0.080	0.080	0.080
Peak Hour Aircraft Movements (times/hr)	12	18	26

(Source: JICA Study Team)

Table 8.2-28 Peak Hour Aircraft Movements (Domestic)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	326	513	678
Peak hour ratio	0.093	0.093	0.093
Peak Hour Aircraft Movement (times/hr)	30	48	63

(Source: JICA Study Team)

Table 8.2-29 Peak Hour Aircraft Movements (International plus Domestic)

	2030	2040	2050
Peak Day Aircraft Movement (times/day)	478	737	999
Peak hour ratio	0.086	0.086	0.086
Peak Hour Aircraft Movement (times/hr)	41	63	86

(Source: JICA Study Team)

8.2.4 Annual Aircraft Movement Forecast

(1) Seasonal Variation Analysis

Annual aircraft movement is estimated by following formula.

Annual aircraft movements = Design day aircraft movements / Design day ratio for movement

The design day ratio for movement is set as the ratio of the design day aircraft movement to the annual movement. Table 8.2-30 and Table 8.2-31 shows design day ratio for movement.

Table 8.2-30 Design Day Ratio for Movement (International)

	2016	2017	2018	Design Value
Peak Month	11	10	10	
Design day ratio	1/298	1/327	1/329	1/320

Note: design values are based on average of three years 2016-18

(Source: JICA Study Team)

Table 8.2-31 Design Day Ratio for Movement (Domestic)

	2016	2017	2018	Design Value
Peak Month	10	10	10	
Design day ratio	1/206	1/254	1/258	1/260

Note: design values are based on 2018 results

(Source: JICA Study Team)

(2) Annual Aircraft Movement

The annual aircraft movement is estimated by dividing the design day aircraft movement by the design day ratio.Table 8.2-32, Table 8.2-33, and Table 8.2-34 show the estimated annual aircraft movements.

Table 8.2-32 Annual Aircraft Movements (international)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	152	224	321
Design day ratio	1/320	1/320	1/320
Annual Aircraft Movement (times/year)	48,600	71,700	102,700

(Source: JICA Study Team)

Table 8.2-33 Annual Aircraft Movements (Domestic)

	2030	2040	2050
Design Day Aircraft Movement (times/day)	326	513	678
Design day ratio	1/260	1/260	1/260
Annual Aircraft Movement (times/year)	84,800	133,400	176,300

(Source: JICA Study Team)

Table 8.2-34 Annual Aircraft Movements (International plus Domestic)

	2030	2040	2050
Annual Aircraft Movement (times/year)	133,400	205,100	279,000

(Source: JICA Study Team)

8.3 Policy for Expansion of Airport Capacity of Kathmandu Metropolitan Area

(1) Relationship between TIA Capacity and Future Demand

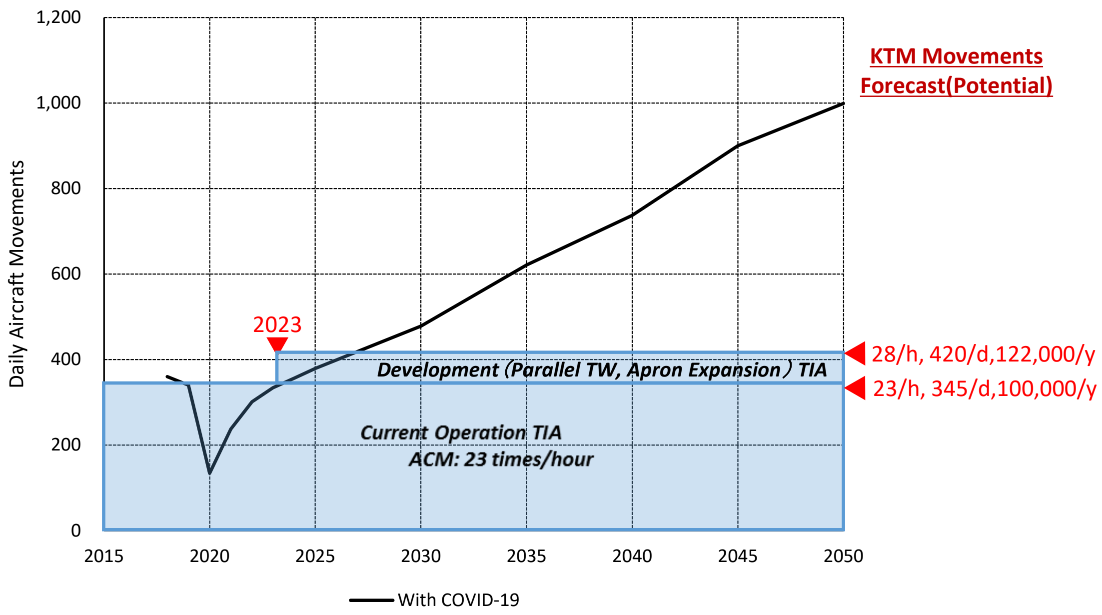
Design day aircraft movements in TIA is estimated as in Table 8.3-1.

Table 8.3-1 Design Day Aircraft Movements in TIA

	2018 (Actual)	2025	2030	2035	2040	2045	2050
International	109	105	152	196	224	272	321
Domestic	251	273	326	425	513	628	678
Total	360	378	478	621	737	900	999

Note: Unit, Movement/day
(Source: JICA Study Team)

The capacity of TIA is currently expected to be 23-24 times/hour and estimated to be 28 times/hour after completion of parallel taxiway. Regarding the daily capacity of TIA, in the case of assumption of consecutive peak duration of 15 hours, current capacity will be 345-360 times/day, and 420 times/day after completion of parallel taxiway. As shown in Figure 8.3-1, it is expected that the daily aircraft movements will reach the airport capacity in around 2027.

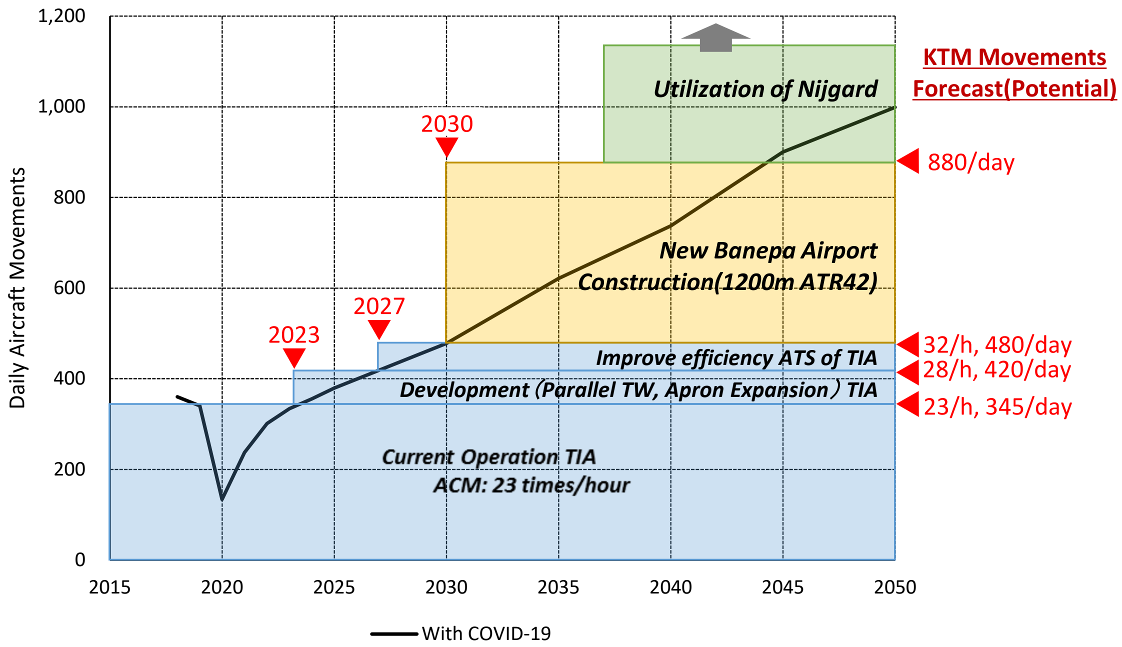


(Source: JICA Study Team)

Figure 8.3-1 Relationship between Aircraft Movements and Airport Capacity of TIA

(2) Outline of Policy for Expansion of Airport Capacity

As mentioned above, since it is expected that the aircraft movements of TIA will reach the airport capacity in the future, it is necessary to urgently take measures to expand the airport capacity in Kathmandu Metropolitan Area. Figure 8.3-2 shows the relationship between aircraft movement in TIA and the expansion of airport capacity, and the policies for expansion of capacity are detailed below.



(Source: JICA Study Team)

Figure 8.3-2 Relationship between Capacity expansion Policy and Demand

1) Development of Parallel Taxiway at TIA

At the time of completion of parallel taxiway currently under construction, the runway capacity of TIA is estimated to be 28 times/hour (420 times/day) besed on the results of the runway occupancy time survey conducted in this study.
However, since it is expected that the aircraft movements will exceed the runway capacity after 2027, it is necessary to take measure for expansion of airport capacity.

2) Development of Banepa New Airport

In case of introducing new flight procedure design and improvement of air traffic control operation, the runway capacity of TIA will increase to 32 times/hour. Therefore, even if increasing of air traffic demand fall down temporally due to the impact of COVID-19, the demand of ACM in TIA will exceed to maximum runway capacity at 2030.
According to mentioned before, it is favorable to develop Banepa airport up to 2030 for maximizing slot of large aircraft and decreacing ACM of small aircraft in TIA which are proceeded as measure of airport volume expansion in Kathmandu Metropolitan Area.

(3) Evaluation of Policy for Expansion of Airport Capacity in Kathmandu Metropolitan Area

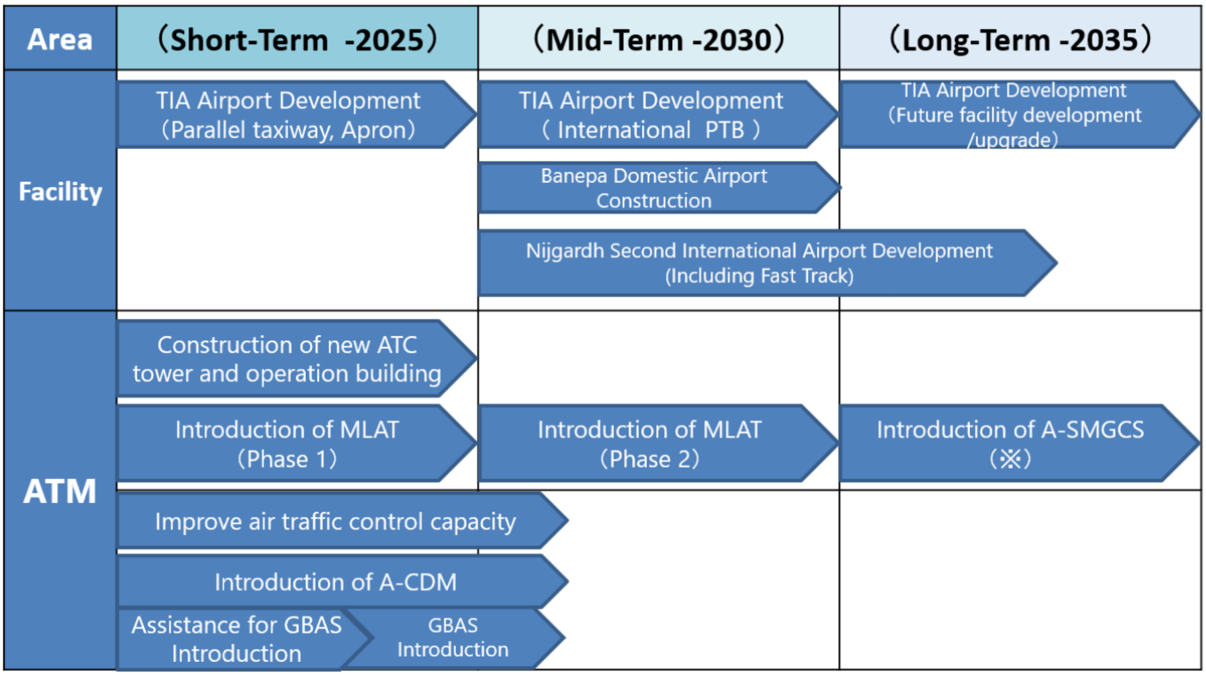
The policy for expanding airport capacity in Kathmandu Metropolitan Area is described as above step by step.
As shown in Figure 8.3-2, the effect of capacity expansion by the development of Banepa Airport is great. The measurement of airport capacity expansion in the Kathmandu Metropolitan area is reconsidered based on the result of demand forecast by considering the impact of COVID-19. At result, if current TIA upgrade project, which is parallel taxiway development, and improvement of air traffic operational efficiency are proceeded, our result of demand forecast shows that runway capacity in TIA will be exceeded in 2030. Therefore, start year of Banepa airport project will be delay abour three years which is compared with former plan, however, positive impact which is provided by new Banepa airport construction will be quite big for expanding airport capacity in Kathmandu Metropolitan Area.

8.4 Review of Japan's Future Support in the Aviation Sector

The review of the demand forecast taking into account the impact of COVID-19 shows that the time of reaching the maximum airport processing capacity at TIA is expected to be delayed by about three years compared to the demand forecast based on the actual results up to 2018. Therefore, based on the results of the new demand forecast, the timing of the implementation of measures to expand airport capacity in the Kathmandu Metropolitan area will be reviewed.

8.4.1 Roadmap for Aviation Capacity Enhancement in Kathmandu Metropolitan Area

The airport capacity for the future demand in the Kathmandu metropolitan area is expected to exceed the runway processing capacity by 2027 after the completion of the current development projects such as the parallel taxiways, even after taking into account the impact of COVID-19. Furthermore, even if the efficiency of control operations is improved, the runway handling capacity of TIA is expected to be exceeded by 2030. From this, it is proposed that the timing of implementation of some of the short-term measures described in Chapter 7 needs to be revised and implemented as medium-term measures, considering the temporary drop in aviation demand due to the impact of COVID-19 and international movement restrictions in 2021.



※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source: JICA Study Team)

Figure 8.4-1 Roadmap for Aviation Capacity Enhancement of Kathmandu Metropolitan Area

8.4.2 Roadmap for Improvement of Mountain Airport Safety/Aviation Safety System

The measures to improve the mountain airport safety/air navigation system are proceeded by considering improvement of air transport safety. Those measures do not relate with change of air traffic demand which is affected by COVID-19, therefore, it is necessary for aviation safety improvement in Nepal.

Area	（Short-Term -2025）	（Mid-Term -2030）	（Long-Term -2035）
Facility	Simkot and Jomson Runway Extension	Lukla new airport development	
Com	Introduction of RCAG Introduction of VSAT at major airport Introduction of AMHS at major airport	Development Air Navigation NW (IP)	Development Air Navogation NW (Intl') Development Digital Voice Com.
Nav	Introduction of Cloud Break Education on GNSS RAIM Recommendation	Expansion of RNP (RNP 1, RNP APCH, RNP-AR) Introduction of RNP2 GBAS Introduction Make RAIM Mandatory	Introduction of Adv. RNP SBAS Introduction
Sur	Introduction of Enroute Surveillance Radar ADS-B recommendation	Education on Satellite based ADS-B Making ADS-B Mandatory Introduction of MLAT at mountain Airport	Introduction of Satellite base ADS-B
ATM	Improve ATC operational efficiency Education on ATFM Satellite com. recommendation (small aircraft)	Introduction of ATFM (domestic) Making Satellite com. Mandatory (small aircraft)	Introduction of ATFM (International)
Weather	Install Wind Shear detector Introduction of X-Band radar Develop Aviation Weather Forecast model	Introduction of Doppler radar High-altitude Weather Information sharing with A/L Develop Mountain A/P Weather Forecast model	Mountain Weather Information sharing with A/L

(Source JICA Study Team)

Figure 8.4-2 Roadmap for Mountain Airport Safety/Avigation Safety System

8.4.3 Measures to Expand Facility Capacity in Kathmandu Metropolitan Area

As for the measures to enhance the aviation capacity of Kathmandu Metropolitan area, Table 8.4-1 shows the result of review for the improvement measures considering short term requirements.
Regarding GBAS, which was requested by CAAN, after considering the impact of COVID-19, the inclusion of GBAS as a short-term measure was considered since TIA runway processing capacity was delayed by about three years.

Table 8.4-1 Proposal for Future Area of Cooperation in Nepal Aviation Sector

Area	No	Short-term (~5yrs)	Expected Outcome	Detail /Issues of Measures	Evaluation Criteria	Remark	
ATMl	⑯	Introduxtion of GBAS at TIA	Increase Service rates without introducing expensive equipment like ILS	✈ Analyze the ionosphere and build a model to correct for disturbances caused by the ionosphere. ✈ In order to build the model, a joint research project will be set up between research institutes in the two countries and Japanese research institutes. ✈ Since it is necessary to learn the basic concepts of GNSS, it is necessary to consider implementing this program in conjunction with support by technical professionals. ✈ Need to consider the possibility of introducing SBAS using GAGAN in India. →Confirm communication with India. →Consider the possibility of introducing GAGAN ground stations	Urgency/ Significance of the Task	A	In order to maximize TIA'sairport capacity, measure to reduce flight cancellation rate and delay are important.
					Coherence with Aviation Sector Policy	A	It will reduce flight cancellation and delay in bad weather, contributing to improved operational efficiency and safety.
					CAAN's Requirement	A	CAAN requested the introduction of GBAS to achieve precision approach from both sides of the runway.
					Technical Difficulty	A	Analysis of the current situation and development of a model through joint research between research institutes in Nepal and Japan is necessary and will take time. Human resource development is also necessary
					Cost	B	Operating costsand Equipment costs: 100 million
					Comprehensive Evaluation	A	CAAN requested the establishment of GBAS. Japan has an advantage in terms of technology for the installation of GBAS in low latitude regions.

(Source: JICA Study Team)

8.4.4 Measure to Improve Safety at Mountain Airporrt

In case of considering the impact of COVID-19, measurement for improvement of Mountain airport safety is required to proceed continuously. Therefore, those measurements should not be changed and the necessity of measurement are considered based on final criteria which is prioritized by comprehensive evaluation.

8.4.5 Measures to Improve Aviation Safety and Airport Security

In case of considering the impact of COVID-19, measurement for improvement of aviation safety and airport security is required to proceed continuously. Therefore, those measurements should not be changed and the necessity of measurement are considered based on final criteria which is prioritized by comprehensive evaluation.

8.4.6 Re-organization of Evaluated Result

In addition to the results of the evaluation on the future support of the aviation sector conducted in 7.4.2-5, the results of the evaluation as shown in Due to delay of exceeding runway processing capacity in TIA abour three years, GBAS installation project could proceed after technical assistance for GBAS introduction immediately.

1) It is expected that the rate of cancel and delay flight will decrese under low visibility conditions by introduction of GBAS. It means improvement of airport capacity, including terminal area of TIA.
2) The total airport capacity in Kathmandu metropolitan area will be able to increase by maximizing TIA airport capacity and Banepa airport construction.

Table 8.4-2 from section 8.4.1-2 considering the impact of COVID-19. As a result of the reassessment, there is a change from the previous study, the construction of Banepa Airport will be implemented as a medium-term and the project related to the introduction of GBAS will be started within 5 years. The period of exceeding runway processing capacity in TIA will shift around three years behind. Therefore, GBAS will be able to deploy in TIA based on following reasons.

3) Due to delay of exceeding runway processing capacity in TIA abour three years, GBAS installation project could proceed after technical assistance for GBAS introduction immediately.
4) It is expected that the rate of cancel and delay flight will decrese under low visibility conditions by introduction of GBAS. It means improvement of airport capacity, including terminal area of TIA.
5) The total airport capacity in Kathmandu metropolitan area will be able to increase by maximizing TIA airport capacity and Banepa airport construction.

Table 8.4-2 Evaluation Results of Future Cooperation in Aviation Sector

Area	No	Short term (~5yrs)	Evaluation Points					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
ATM	①	Construction of new control tower and MLAT at TIA (Aircraft Position monitoring)	A	A	A	A	B	A
	②	Improvement of airport capacity of TIA (ATS Improvement)	A	A	A	B	A	A
	③	Introduce airport CDM (A-CDM) at TIA (Considering some system introduction support)	A	A	A	B	A	A
Facility	④	Runway Extension	A	B	B	C	B	B
Communication	⑤	Introduction of RCAG (3 location)	A	A	B	B	B	A
	⑥	Introduction of Digital HF (6 Major Airports)	B	B	B	B	A	B
	⑦	Introduction of VSAT (5 airports, Lukla installed)	A	A	B	A	A	A
	⑧	Introduction of AMHS (5 airports, Lukla Installed)	A	A	A	A	B	A
Navigation	⑨	Recommendation of GPS equipped with RAIM function	B	B	C	A	B	C
	⑩	Design support for flight procedure (Cloud Break) for mountain airports	A	A	A	B	B	B
Surveillance	⑪	Satellite communication recommended for tracking device	A	B	B	B	B	B
	⑫	Introduction of MLAT (6 mountain airports)	A	A	C	C	C	C
Weather	⑬	Introduction of wind shear detector	A	A	A	B	A	A

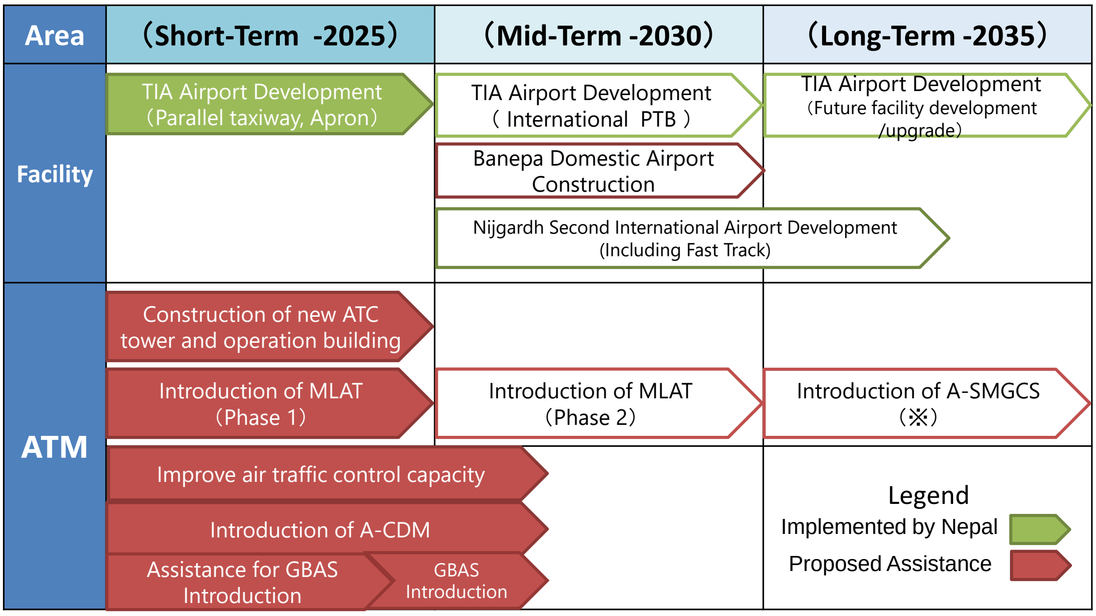
Area	**No**	**Short term (~5yrs)**	**Evaluation Points**					
			Urgency/ Significance of the Task	Coherence with Aviation Sector Policy	CAAN's Requirement	Technical Difficulty	Cost	Comprehensive Evaluation
	⑭	Introduction of ITV (around 6 major airports)	A	A	A	B	C	B
ATM	⑮	Assistance for introducing GBAS	B	A	A	A	C	A
		Introduction of GBAS in TIA	A	A	A	A	B	A
Surveillance	⑯	Introduction of air route monitoring radar (MSSR)	A	A	C	B	B	B
Weather	⑰	Introduction of weather radar (X-band radar)	A	A	A	B	A	A
ATM	⑱	Introduction of ATFM (Considering some system introduction support)	B	A	A	A	A	B

(Source: JICA Study Team)

8.5 Review of Future Proposal for Support in Aviation Sector

8.5.1 Overview

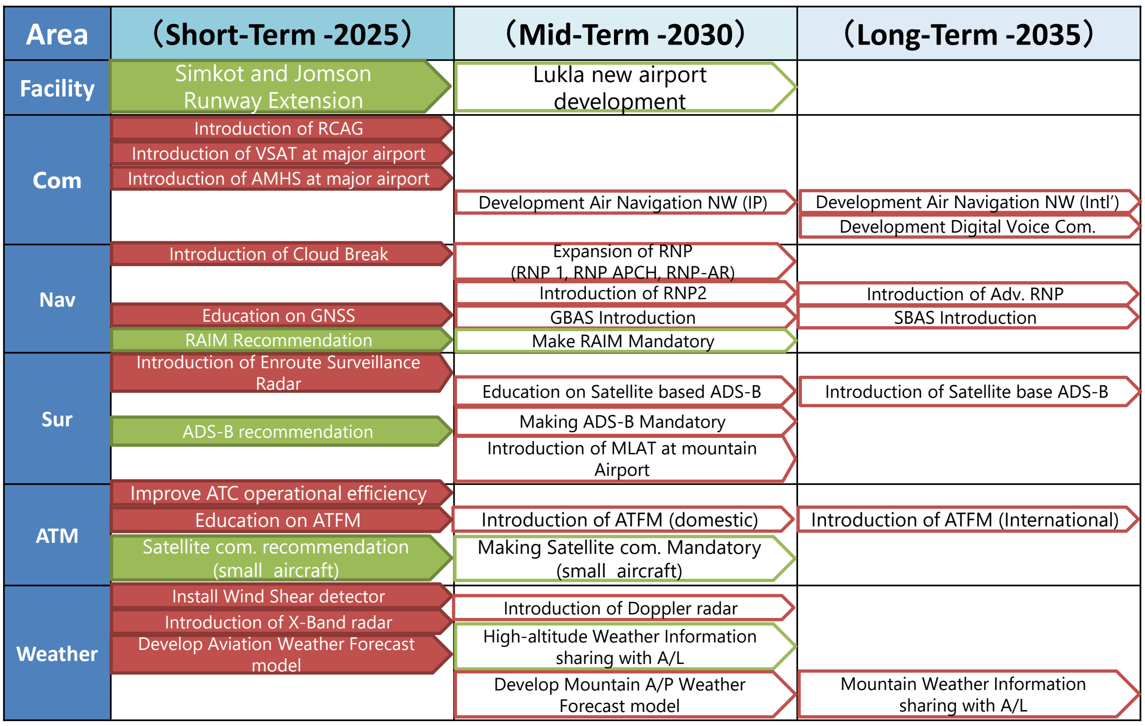
Regarding the short-term measures necessary to address the issues in the aviation sector in Nepal, which were reviewed in 8.4 in consideration of the impact of COVID-19, the content of proposal for future support in the aviation sector is further summarized. However, the following measures are presented as proposals in this study, as they require consultation with the Japanese side.



※ Guidance system for improving ground operational efficiency at airport (ICAO recommended)

(Source: JICA Study Team)

Figure 8.5-1 Roadmap for Aviation Capacity Enhancement of Kathmandu Metropolitan Area



(Source: JICA Study Team)

Figure 8.5-2 Roadmap for Safety improvement of Mountain Airport/ Aviation Safety Systems

The Table 8.5-1 provides an overview of the proposed measures, including the changes made due to the review. As for the details, the capacity enhancement of the Kathmandu metropolitan area has been reviewed, and the description of the details will be discussed.

Table 8.5-1 Proposal For Future Cooperation in Nepal Aviation Sector

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
ATM	①	Construction of new ATC tower and introduction of MLAT at TIA (Aircraft position monitoring on airport surface)	Track the movement of aircraft and GSE around domestic terminal	✈ In consideration to airport master plan, the new ATC tower needs to be constructed at the height entire airport can be seen. ✈ Along with the the above, a management building and facility management building needs to be built. ✈ Necessary to carry out phase development in line with expansion of TIA →Phase1：Around domestic terminal →Phase2：entire airport	Grant Aid
	②	Improvement of airport capacity of TIA (ATS Improvement)	Increase aircraft movement in TIA	✈ 3 years of technical cooperation ✈ Reduce radar separation minima by improvement of radar control technique ✈ Design flight procedure to shorten separation minima ✈ Increase airport capacity by shortening the separation minima	Technical Cooperation
	③	Introduce airport CDM (A-CDM) at TIA (Considering some systems introduction support)	By sharing of necessary information between stakeholders will lead to smooth airport operation and reduce delay of flight	✈ Regarding A-CDM, technical assistance is provided to air traffic service provider (including TIA operation departments) and airlines. ✈ Support in development of operation manuals, considering that the operation will start in actual ✈ Introduce an evaluation system and conduct trial operation so that effect of operation can be sensed.	Technical Cooperation
Communication	⑤	Introduction of RCAG (3 locations)	Ground-to-air communication will be possible (eliminating blind spot)	✈ Install near Nepal Telecom's communication base stations (3 locations, on the mountain) near Lukla, Simikot/ Rara and Jomson Airport ※ Necessity to confirm the capability of continuous maintenance ※ It is necessary to check whether it can satisfy the coverage requirement for operation ※ Installation of solar panels as a back-up source is required	Grant Aid
	⑦	Introduction of VSAT (5 airports other than Lukla)	Redundancy in communication between mountain airports, ACC and hub airports	✈ AMHS is available by introducing VSAT to major mountain airports. ✈ Possible to Exchange information more reliably than digital HF. ※ Construction of ground equipment such as antennas is required ※In order to use a satellite communication line, it is necessary to pay a usage fee constantly.	Grant Aid
	⑧	Introduction of AMHS (5 airports other than Lukla)	Accelerate information sharing and exchange by data communication between airports	✈ Reliable information sharing platform by shifting from telephone and mobile phone communication to data base communication ✈ Huge amount of data exchange possible ✈ Redundancy of ground-to-ground communication can be ensured ✈ Automatic notice of weather information by linking with weather systems ※Moutainous airports except for Lukra and Jomsom are connected by microwave network, VSAT and optic fiber must be introduced	Grant Aid
ATM	⑮	Assistance for introducing GBAS	Increase Service rates without introducing expensive equipment like ILS	✈ GNSS education with two years of technical Assistance ✈ Education on GBAS theory, operation method and system configuration ✈ Training for airlines through stakeholder meetings.	Technical Cooperation
	⑯	Introduction of GBAS at TIA	Increase Service rates without introducing expensive equipment like	✈ Analyze the ionosphere and build a model to correct for disturbances caused by the ionosphere. ✈ In order to build the model, a joint research project will be set up between research institutes in the two countries and Japanese research institutes.	Grant Aid

Area	No	Short term (~5yrs)	Expected Outcome	Detail/Issues of Measures	Expected Scheme
			ILS	✈ Since it is necessary to learn the basic concepts of GNSS, it is necessary to consider implementing this program in conjunction with support by technical professionals. ✈ Need to consider the possibility of introducing SBAS using GAGAN in India. →Confirm communication with India. →Consider the possibility of introducing GAGAN ground stations	
Weather	⑭	Introduction of wind shear detector	The system will be able to detect dangerous sudden changes in airflow and notice it to landing aircraft.	✈ Introduced to four airports, Lukla, Jomsom, Simikot and Rara where have strong winds blow often and install near the end of the runway. ✈ Initially, it is installed at Lukla Airport only. ✈ For technical cooperation, CAAN will be the main counterpart, but it is considered that DHM staff will also participate in the training.	Grant Aid Technical Cooperation
	⑱	Introduction of weather radar (X-band radar)	Perform high-precision weather observations around airports and enroute to improve the accuracy of weather forecast	✈ Technical cooperation for enroute weather forecasts model development. ✈ Assuming gradual installation, in the first stage, it will be installed around TIA, hub airports, and some points where weather condition changes drastically on the routes of small aircraft. ※Need to consider on the coordination between DHM and CAAN. ※Necessary to discuss with DHM jointly with CAAN regarding type of weather data which is required to airlines. ✈ For technical cooperation, DHM will be the main counterpart, but it is considered that the training will also be attended by air traffic controllers.	Grant Aid Technical Cooperation

(Source: JICA Study Team)

8.5.2 Measures for the enhancement of Aviation Capacity of Kathmandu Metropolitan Area

(1) Grand Aid

In order to improve the safety and efficiency of aircraft operations at TIA, GBAS will be introduced in addition to the details described in 7.5.2. This will improve the on-time operation rate of aircraft. Furthermore, since the facility management building is scheduled to be established in conjunction with the construction of the new control tower, the timing of the project implementation will also be considered, such as the installation of new aircraft there.

Table 8.5-2 Project Outline for Improvement of ATC in TIA

Subject	Improvement of Air Traffic Control Capacity in TIA
Implementation Period	4 years
Background of Project	TIA has expanded its airport facilities to meet increasing passenger demand until now. On the other hand, due to the expansion, the apron in front of the domestic terminal is no longer visible from the ATC tower, the safety and efficiency of air traffic control operation in airport are impaired. Furthermore, the ATC tower in TIA has been more than 30 years old since its construction. The building has become obsolete and the VFR room, the office rooms required for operation and the rooms where systems are installed are becoming small, which is also one of the causes of the decrease in operational efficiency.
Purpose	In this project, the safety and operational efficiency of control operation in TIA will be improved by construction of a new ATC tower and introducing airport surface surveillance system. Furthermore, by constructing a new administration building and facility management building will ensure the expandability of facilities which is necessary for future operation and system improvement.
Project Content	<u>1：New ATC tower (②)</u> In consideration to the TIA expansion plan currently being implemented, a new ATC tower will be constructed at a height that ensure the visibility for monitoring entire airport. <u>2：New construction of administration and facility building (②)</u> At the same time, by constructing new administration currently being and facility management building, regarding some systems are currently operated will reach renewal time, it will be replaced, and it is necessary for preparing to start new operation by upgraded system. <u>3：Introduction of MLAT (②)</u> Upon establishing new ATC tower, the entire airport will be visible, at the same time MLAT will be installed to monitor the position of aircraft and GSEs on airport surface in order to improve the operational efficiency of airport surface movement.
Project Partner	CAAN
Project Outcome	<u>Quantitative effect</u> ✈ It will be able to monitor the movement status of aircraft and vehicles on domestic aprons. (0% → 100%) ✈ It will be able to confirm the movement status of aircraft and vehicles on entire airport surface by surveillance system. (0% → 100%) <u>Qualitative effect</u> ✈ The operational safety and efficiency of flight scenes in TIA are improved. ✈ The introduction of next-generation air navigation systems in Nepal becomes easily.
Prerequisite/External condition	■Prerequisite ✈ For smooth transition of operation and system, the system to be installed in the new facility will be newly installed and the system to be transferred from the old facility will be minimized. ✈ Not only will visibility be increased by raising the control tower, but the system will also be introduced to ensure that the moving aircraft and GSEs can be grasped. ✈ The system introduced in the project will be soft-part and the basic know-how necessary for operation and maintenance will be provided in it, while at the same time working with technical professionals to increase the capacity of the Kathmandu metropolitan area is considered.

(Source: JICA Study Team)

Table 8.5-3 Project Outline for the Implementation of GBAS

4Subject	Improvement of Air Traffic Control Capacity in TIA
Implementation Period	3 years
Background of Project	At TIA, delays have become the norm as the airport capacity and the surrounding airspace capacity have become crowded due to the increase in air traffic demand. In addition, since TIA is not equipped with the necessary equipment for precision approach, delays and flight cancellations due to waiting and diverting of arriving aircraft occurs during bad weather. Under these circumstances, CAAN hopes to introduce GBAS for precision approach to reduce the flight cancellation rate and delay time and is requesting Japan to introduce the system.
Purpose	The introduction of GBAS in this project will enable precision approach at TIA, reduce the rate of aircraft cancellations and delays, and improve the on-time operation rate.
Project Content	1: GBAS Feasibility Study at TIA (⑯) Before GBAS implementation in TIA, research of technical validation and cost benefit for implementation of GBAS will be proceeded. 2: GBAS Implementation at TIA (⑯) To achieve precision approach at TIA, GBAS will be introduced in TIA.
Project Partner	CAAN, Airlines
Project Outcome	Quantitative effect ✈ Decrease in the number of flights delayed by 30 minutes or more in terms of scheduled departure and arrival times at TIA. (100% → 70%: over 30 minutes delayed flights decrease 30%) ✈ The cancellation rate of flights at TIA will be reduced during bad weather such as rain. (100% → 50%) Qualitative effect ✈ Reduce flight cancellation rates and delays at TIA, thereby improving the overall operational efficiency of TIA. ✈ Achievement of precision approach will improve the safety and efficiency of aircraft operations.
Prerequisite/External condition	■Prerequisite ✈ In the technical cooperation project, the effects of the ionosphere have been analyzed, and based on the results, model equations have to be developed to correct the effects of ionospheric disturbances.

(Source: JICA Study Team)

(2) Technical Cooperation

In order to enhance airport capacity in Kathmandu metropolitan area, a new flight procedure system will be designed for TIA and technical cooperation for the introduction of A-CDM will be implemented to improve the operational efficiency of the airport.

Table 8.5-4 Technical Cooperation to Enhance Airport Capacity in Kathmandu Metropolitan Area

Subject	Technical Cooperation Project to Enhance Airport Capacity in Kathmandu Metropolitan Area
Implementation Period	3 years
Background of Project	In Nepal, the limit of runway capacity of TIA located in the kathmandu metropolitan area is approaching as the air traffic demand increases. Although there is only one runway at present, it is difficult to develop a second runway within the current airport site, so consideration for the development of a new airport to meet air traffic demand in the metropolitan area has been carried out. On the other hand, in order to enhance the overall airport capacity in the future, it is essiential to improve not only in the tangible elements of airport facilities development but also in the intabgible elements of improving efficiency of air traffic control operation and introducing new technologies in TIA. Additionlly, improving services for aircraft using TIA and improving operational efficiency are important measures that lead to capacity enhancement. Under these circumstances, CAAN worry about improvement technologies for (1) the introduction of A-CDM at TIA, (2) improvement the air traffic control efficiency of TIA and (3) air navigation systems (CNS/ATM as such GBAS, MLAT, High Speed Data Network, etc.), and considers to request Japan's technical cooperation to realize those technologies.
Purpose	With this project, the air traffic control capability in the Kathmandu metropolitan area will be improved by introducing A-CDM, improving the air traffic control capability in TIA, and improving the technology related to next-generation air navigation systems.
Project Content	1: Introduction of A-CDM at TIA (④) In order to expand the capacity of TIA, it is necessary to improve efficiency of ATC and airport operations. introduction of A-CDM is considered as a precondition. 2: Promotion of airspace operational efficiency to improve air traffic control capacity at TIA (③) In order to expand the throughput and capacity in the Kathmandu metropolitan area, a new flight procedure will be designed with the aim of improving the air traffic control capacity of the TIA. 3: Improvement of air traffic control technology by introducing air navigation systems (⑯) The basic knowledge about the systems and required training and education for operation and maintenance when introducing GBAS, MLAT and high-speed data network,
Project Partner	CAAN (ATCO, ATSEP), DHM, Airline (operation manager)
Project Outcome	Quantitative effect ✈ The existing flight delay of 30 mins or more at TIA will be decreased. (0% → 30%) ✈ Shorten the average separation minima for approach control. (10NM → 7NM) Qualitative effect ✈ By proper information exchange, air traffic control and airport operations will be smooth, the delay time at the time of departure will be shortened, and at the same time the congestion of TIA will be solved. ✈ By redesigning flight procedures at TIA, we will reduce separation minima for landing aircrafts and increase the number of aircraft movement in TIA. ✈ Acquire the knowledge about the basic air traffic control system and the technique for operation and maintenance, which are necessary for the introduction of new air navigation systems.
Prerequisite/External condition	■Prerequisite ✈ Regarding the introduction of A-CDM, it is introduced a system that allows trial operation, and it is developed required operational rules and set up necessary system parameters for utilizing the system. ✈ The system to consider for starting operation in A-CDM is premised on a system that streamlines departure and arrival at airports such as DMAN and AMAN. ✈ It proceeds to design new departure/arrival or miss-approach procedures and create an environment that can shorten separation minima in terminal approach area. ✈ For GBAS, the system necessary to study the effect of ionosphere will be established and research on the correction coefficient due to effect of the ionosphere needs to be conducted.

(Source: JICA Study Team)

1) Introduction of A-CDM in TIA

In order to enhance the airport capacity of Kathmandu metropolitan area and improve the efficiency of air traffic control and airport operations, the activities for introduction of A-CDM are carried out such as stakeholders' meeting for CAAN, airport operator, airlines etc. that presupposes to introduce A-CDM. The technical cooperation is necessary to develop the operational manuals and regulations and support for implementation of A-CDM.

Table 8.5-5 Technical Cooperation on A-CDM

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
ATM	In order to expand the capacity of TIA, it is necessary to improve efficiency of ATC and airport operations. introduction of A-CDM is considered as a precondition.	➢ Implementation of smooth air traffic control and airport operations through appropriate information exchange. ➢ Reducing delay at the time of departure by improving air traffic control efficiency. ➢ Solve TIA congestion	➢ CDM basic training ➢ Establishing A-CDM team (ANSP, Airline etc.) ➢ Prepration of A-CDM introduction plan ➢ Development A-CDM operation manual and regulation ➢ Having practical training of A-CDM ➢ Building capability to implement A-CDM training by CAAN	✈ Air traffic controller ✈ Flight information service 12MM	Air traffic controller Flight information officer Airlines Aviation meteorologist Administration manager	N/A

(Source: JICA Study Team)

2) Streamlining Airspace Operation of TIA

For the purpose of enhancing the airport capacity in Kathmandu metropolitan area, specifically, improving air traffic control capacity of TIA, it is considered the effective utilization of airspace and provide technical support for designing new flight procedures to solve the issue.
In addition to the flight procedure design, it is supported the implementation of flight inspection and if necessary, flight approval can also be done from installation of new flight procedures and start operation of it. At the same time, in order to operate the new flight procedures efficiently and effectively, training for air traffic controllers using simulators, especially for the purpose of shortening the separation minima will be conducted. Furthermore, the study of the requirements for airspace to introduce ATFM in the future is needs to be carried.

Table 8.5-6 Technical Cooperation on Airspace Operation Efficiency at TIA

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
ATM	In order to expand the throughput and capacity in the Kathmandu metropolitan area, a new flight procedure will be designed with the aim of improving the air traffic control capacity of the TIA.	➢ Effective use of airspace in TIA ➢ Reduction of separation minima of arrival aircraft ➢ Increase in number of aircraft movement in TIA ➢ Improve safety of large aircraft landing ➢ Reduce workload of air traffic controllers	➢ Update PBN roadmap ➢ Study airspace management ➢ Study flight procedure design ➢ Examine flight procedures of TIA ➢ Design new flight procedure ➢ Proceed desk verification and flight inspection ➢ Issuance of PBN flight procedure ➢ Operation approval of aircraft equipment ➢ Implementation of air traffic controllers training ➢ Study ATFM	✈ Flight procedure design ✈ ATC operation ✈ ATC technique 16MM	Air traffic controller Airline operator Flight procedure designer	N/A

(Source: JICA Study Team)

3) Improvement of Air Traffic Control Technology by Introducing Air Navigation Systems

As a measure to improve the air navigation systems, the following technical cooperation needs to be implemented in each area of CNS, so that the effects of introduced system will be maximized.

Table 8.5-7 Technical Cooperation on Aviation Security System

Area	Overview	Expected Outcome	Main Activity	Experts	Target	Equipemnt
N	It should be proceeded that the effectiveness of GBAS introduction, airport surveys, ionospheric impact assessment, antana installation site assessment and the system designe of GBAS is based on those outcomes on the assumption that the introduction of GBAS can enhance GPS signal leading to precise landing.	➢ Improving service rate and safety in TIA after introducing GBAS. ➢ Shortening of separation minima for approaching flight at TIA after GBAS introduction. ➢ Promote introduction of GBAS and SBAS to improve the reliability of GPS navigation.	➢ Learning GNSS basic theory and introducion process ➢ Airport survey and obstacle survey for GBAS introduction ➢ Ionosphere analysis study ➢ Implementation of ionosphere analysis ➢ Cost-effectiveness study ➢ Certification ➢ Flight procedure design ➢ Development of GBAS introduction plan	✈ ATC technique ✈ WGS84 survey, 20MM	Implementation plan ATSEP Ailine operator	Ionosphere Invistigation equipment (JPY): 1 Million
S	It is lectured that operation principle of MLAT, maintenance management and ATC operation by utilizing MLAT on the assumption that the introduction of MLAT which can monitor the position of aircrafts on airport surface in TIA.	➢ Enhancement of throughput and capacity in TIA after the introduction ➢ Assist visibility of aircrafts for air traffic controllers in visualizing and lead to smooth air traffic control, and improving the safety ➢ Eliminate TIA congestion and increasing the number of aircraft movement	➢ Training of MLAT operation principle, operation processing and display method ➢ Development of MLAT installation plan at TIA ➢ Training. of MLAT demonstration ➢ Training of MLAT maintenance method ➢ Training on apron control ➢ MLAT operation manual development and operation training	✈ ATC technique 10MM	Implementation plan ATSEP ATCO	Assuming MLAT installation with grant aid
C	It intends to improve air traffic control operations by connecting TIA and other airports in Nepal through high-speed data network and promote to exchange operation and weather information.	➢ CAAN, major airports, mountain airports, and operators can share operation and weather information to improve efficiency and safety of air traffic control. ➢ Improve the service rate by providing information necessary for operation, including AMHS information before flight ➢ TIA safety improvement	➢ Formulation of introduction plan for High Speed Data Network ➢ Support for maintenance ➢ Network theory training and setting of operation, technology and performance requirements ➢ Technical cooperation until AMHS operation manual formulation and implementation Flight information management training for flight information officers ➢ Maintenance training	✈ ATC technique ✈ Flight Information 12MM	Implementation plan ATCO Flight Information Officer Airline Operator Aviation Meteorologist ATSEP	Flight information management tool (JPY): 1 Million

(Source: JICA Study Team)

8.5.3 Measures to Improve Safety at Mountain Airports

(1) Grant Aid Projects

The implementation of projects shown in Table 8.5-8 is considered to be effective in promoting CAAN's ability to improve operation of mountain flights.

Table 8.5-8 Project Outline for Safety Improvement at Mountain Airport

Subject	Improvement of flight safety at mountain airports
Implementation Period	2 years
Background of Project	In Nepal, flights to the mountain airport face the problem with communication in mountainous area, therefore, pilots cannot obtain essential information for operational safety of flight. At the same time, air traffic controller could not provide essential information to pilots for operational safety of flight. Additionally, the air traffic controllers at mountain airport uses only voice communication, usually through telephone or mobile for information exchange to another airport or ACC, so that this leads to lack for rapid information sharing of flight plan and weather information.
Purpose	This project focuses on introducing air-to-ground communication system and ground-to-ground communication system, which will ensure communication between pilots and air traffic controllers in mountainous area. Moreover, information sharing between controllers will be facilitated smoothly to improve safety of mountain flights.
Project Content	1：Introduction of RCAG (⑥) The ground station for RCAG will be installed near Nepal Telecom's base stations which are established in Chitresthan, Maithapla and Bharta Lagna, it will be able to communicate between air traffic controllers and pilots as per the mountain flights of Lukla, Simikot, Rara, Dolpa, Jumla and Jomsom. 2：Introduction of VSAT (⑧) Satellite communication antennas will be installed at Simikot, Rara, Jomson, Jumla, and Dolpa airport and digital communication line will be secured between mountain airports, hub airports and ACC to share flight plan information and weather information at high speed. 3：Introduction of AMHS（⑨） AMHS network and terminals will be installed at Simikot, Rara, Jomson, Jumla and Dolpa airport to enable reliable transmission of arrival/departure information, flight plan information, and weather information at mountain airports.
Project Partner	CAAN
Project Outcome	Quantitative effect: The pilots will be able to communicate with the air traffic controllers on all flights to the six mountain airports. (0% → 100%) The arrival/departure information of all flights at the six-mountain airport can be sent/received through AMHS. (0% → 100%) Qualitative effect: ✈ The safety of mountain flight will be improved by being available constant communication between the mountainous flight pilots and the air traffic controllers. ✈ Similar accidents and incidents which occured at past time could be reduced.
Prerequisite/External condition	■Prerequisite ✈ The RCAG installation site is preferable location, where maintenance can be performed, by installing it near the communication station of Nepal Telecom. ✈ When installing RCAG, it is necessary to install solar panels and storage batteries to ensure a backup power source. ✈ AMHS introduction is required high-speed digital network and it must be introduced together with VSAT. ✈ Soft component for installed systems shall be conducted for CAAN's staff in order to enhance their skill to operate or manage the systems. This will lead to ensure their reliable maintence performance. ✈ Replacement parts are delivered together with the main unit that can cope with failures that may occur within about three years after the system installation. The future procurement method for the replacement parts is decided considering the customs of the Nepalese government.

(Source: JICA Study Team)

8.5.4 Measures Improve Aviation Safety and Airport Security

(1) Grand Aid Projects

By implementing the project shown in Table 8.5-9 through Japan’s cooperation, DHM's meteorological observation and forecasting accuracy will be improved, resulting in the improvement of the safety of aircraft operation in Nepal, such as, the occurrence of sudden weather changes. This will reduce the number of accidents that have been happening.

Table 8.5-9 Project Outline for Improvement of Aviation Weather Information

Subject	Improve of Weather Forecast Capability
Implementation Period	2 years
Background of Project	In Nepal, meteorological radars have been introduced to observe and predict high-altitude weather related to aircraft operations. A project has been implemented to install meteorological radars for observing high-altitude meteorological conditions at three locations in Nepal. One has already been installed in western Nepal. On the other hand, the plan is still in progress and has not yet achieved the safety and efficiency improvements in aircraft operation. Further, there is a collision has occurred on a mountain during flight to the destination airport due to sudden change in the weather conditions in mountain areas, which is called by CFIT (Controlled Flight into Terrain), it is one of characteristics in aircraft accident in Nepal.
Purpose	In this project, introducing X-band radar and wind shear detector will be possible to grasp the current situation in the mountainous areas, where weather conditions change drastically in Nepal, and it will be possible to acquire necessary data for weather forecast. Furthermore, the safety of mountain flights is improved by detecting wind shear that occurs near the end of the runway before aircraft landing at mountain airports.
Project Content	1：Introduction of X-band Radar X-band radars will be installed at a total of three locations on the east, west and south sides of the Kathmandu basin. With the introduction of the X-band radar, technical cooperation will be provided to DHM based on the local meteorological observation data for the development of a highly accurate aviation weather forecast model. 2：Introduction of Wind Shear Detector Wind shear detectors will be installed at four airports, Lukla, Jomsom, Simikot and Rara. However, since it may be necessary to verify the effectiveness of the wind shear detector and establish a method for providing information to the pilot, it will be introduced firstly at Lukla Airport, which has the highest demand in this project, and prceed to establish operational procedures.
Project Partner	DHM, CAAN
Project Outcome	Quantative effect: ✈ Regarding aircrafts entering and leaving the airspace within the Kathmandu basin, air traffic controller will be able to notify the pilot in advance of changes in local weather conditions. (0% → 100%) ✈ Wind shear which occurs near the end of the runway will be detected early at Lukla airport and can be notified to pilots and controllers. (0% → 100%) Qualitative effect: ✈ The accuracy of aviation weather information will be improved and the safety of flight operations on air routes will be improved. ✈ By building a model for aviation weather forecast, the forecasting accuracy will be improved, pilots will be able to obtain weather forecast information before departure and will be able to fly safely depending on the weather conditions on the flight route, thereby, reducing the occurance of accidents.
Prerequisite/External condition	■Prerequisite ✈ In order to achieve much safer operation using aviation weather information, CAAN has to establish operational procedures how to use pre-flight and in-flight weather information together with airlines and be implement information sharing and notification thoroughly. ✈ Soft component for installed systems is conducted to train how to operate or manage the system. In addition, weather forecast model using X-band ladar is constructed taking into account the cooperation with technical cooperation programs. ✈ Replacement parts are deliverd together with the main unit that can cope with failures that may occur within about three years after the system instllation. The future procurement

	method for the replacement parts is decided considering the customs of the Nepalese government. ■External Condition ✈ It is necessary to organize weather information that will finally be available, along with the progress status of the ongoing World Bank project (introduction of C-band radar and automatic weather observation device). ✈ Based on the above, it is necessary to proceed with discussion on what kind of weather forecast model can be developed in consultation with DHM.

(Source: JICA Study Team)

(2) Technical Cooperation

For implementing weather observation and accuracy of weather forecast, it is necessary to develop new forecast model which is based on acquired data by introduction of weather observation radar and wind shear detector. At result, it will be expected to improve operational safety of flight by supporting to develop weather forecast model by technical cooperation of Japanese experts.

Table 8.5-10 Project Outline for Improvement of Aviation Weather Information

Subject	Technical Cooperation Project to Improve Precise Weather Information
Implementation Period	3 years
Background of Project	In Nepal, the installation of aviation weather observation equipment is not enough, and the accuracy of aviation weather forecast is low, which is regarded as a major problem. In addition, due to the lack of accuracy of aviation weather forecast, it is not sufficient for airlines to consider operational plans using the weather forecasts prior to flight, the sudden change of weather conditions during flight on en-route impairs the flight safety and service. This situation is a common factor leading to frequent accidents. So, it is necessary to improve aviation weather observation and forcast accuracy in order to reduce aircraft accidents in Nepal. With the support of the World Bank, DHM is installing a high-altitude weather observation radar and a ground-based weather observation system, but it is necessary to install an X-band radar, which is necessary to catch local weather changes. Furthermore, it is necessary to develope a more accurate weather forcast model based on all these meteorological observation data.
Purpose	In this project, the introduction of wind shear detection equipment will improve the safety of landing at mountain airports. In addition, the flight safety on enroute can be improved by introducing a radar that can observe local weather conditions. At the same time, improved forecast accuracy can lead to confirm the risk due to changes in weather conditions prior to flight operation, and it is able to reduce the possibility of accidents by changing and/or coordinating of flight plan.
Project Content	<u>1：Establishment operational method with wind shear detector(⑭)</u> It is developed an operational method including notification method to the pilot when wind shear is detected using the wind shear detector. In addition, it is provided necessary education and training on the maintenance method of the newly introduced wind shear detector. <u>2：Developing weather forcast model (⑱)</u> By combining multiple data such as C-band radar and high-altitude meteorological wind data including the observation results by X-band radar, it will be developed a model that can predict the state of aviation weather that changes rapidly locally. Furthermore, education and training will be provided to air traffic controllers and flight managers regarding aircraft operation methods using the weather forcast data.
Project Partner	DHM, CAAN (ATCO and ATSEP) and Airline (operation manager)
Project Outcome	<u>Quantaive effect:</u> ✈ It will be possible to check the occurrence of wind shear at airports equipped with wind shear detector. (0% → 100%) ✈ It becomes possible to know in advance weather condition changes such as rainfall at the location, where the X-band radar is installed. (0% → 100%) <u>Qualitative effect:</u> ✈ Accidents due to sudden weather changes such as wind shear at mountain airports will be reduced. ✈ In Nepal, the accuracy of aviation weather forecast will be improved and the number of accidents due to changes in weather conditions on enroute will be reduced. ✈ By acquiring aviation weather forecast information prior to flight and establishing a habit of

	operating based on its information, the number of accidents in Nepal will decrease and the safety of aircraft operation will be improved.
Prerequisite/External condition	■Prerequisite ✈ The wind shear detector will be installed at Lukla Airport, its performance will be evaluated, at the same time, the operation method such as the notification method to the pilot will be examined. ✈ The introduction of X-band radar will be limited to the Kathmandu basin and it will be verified what kind of data can be acquired and what kind of forcast model can be developed. ✈ As the location where local weather forecast information is required, it will be considered to other candidate sites where are preferable location for introduction of X-band radar and considered future development plans.

(Source: JICA Study Team)