Ministry of Transport
The Republic of the Union of Myanmar

The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar

Final Report

Feasibility Study on Inland Water Transport Facilities Improvement and Development Project

September 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

Oriental Consultants Co., Ltd.
International Development Center of Japan
ALMEC Corporation

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Exchange rate used in this Report

USD	1.00 =	JPY	99.2
USD	1.00 =	MMK	970.9
MMK	1.00 =	JPY	0.102

(As of October, 2013)

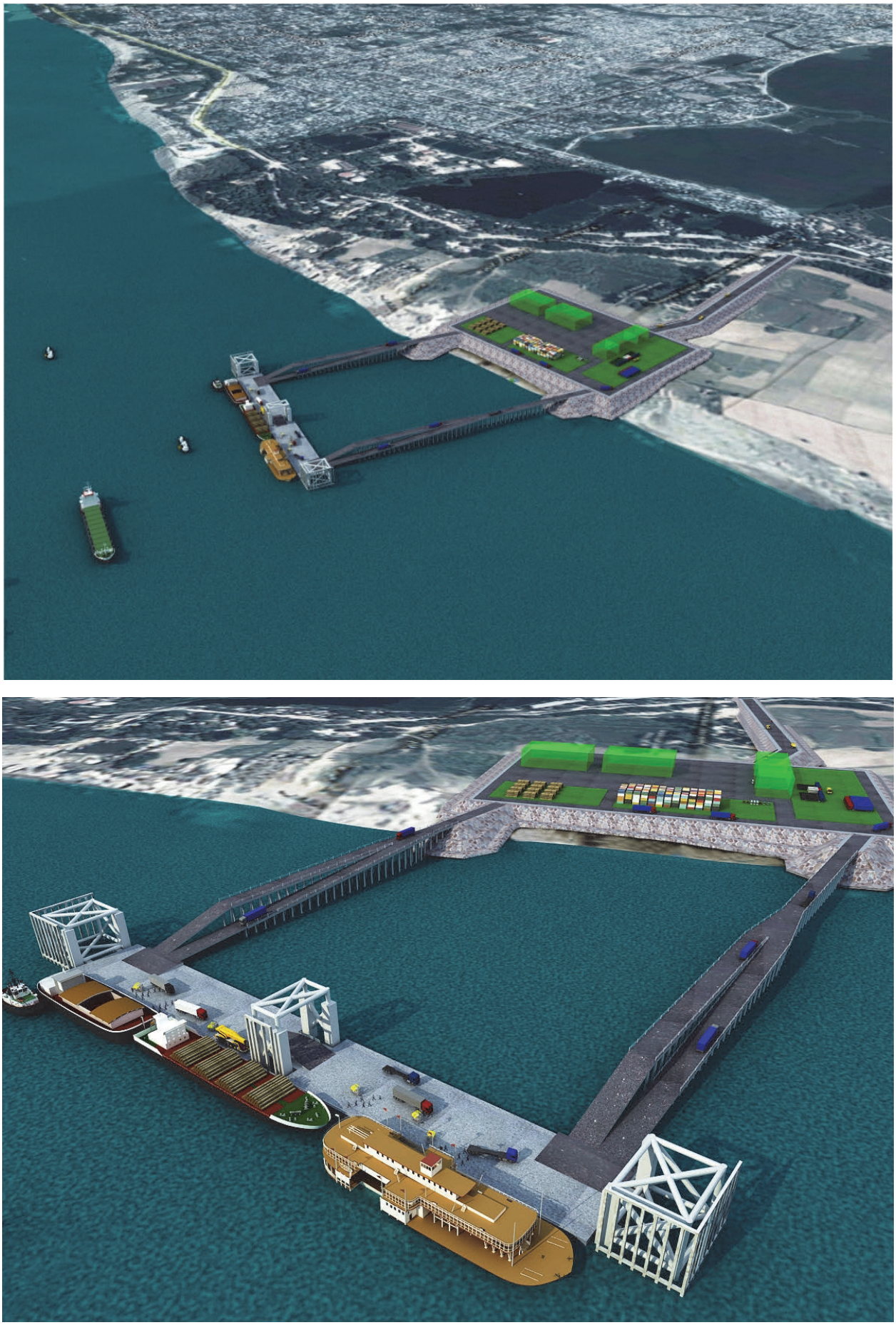

Image Bird's-eye View of Mandalay Port Development (The Case of Floating Pier)

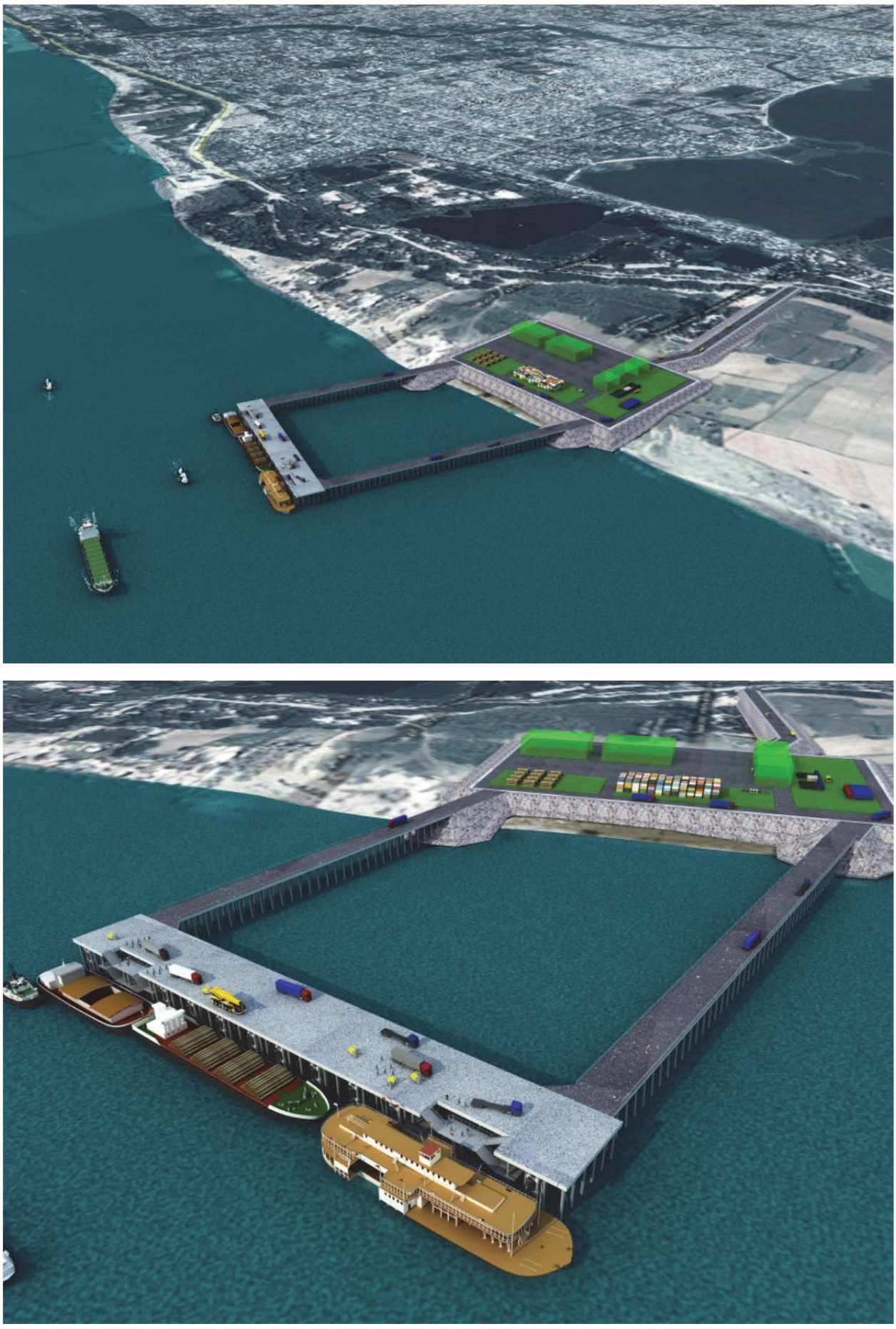

Image Bird's-eye View of Mandalay Port Development (The Case of Fixed Piled Pier)

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Feasibility Study on

Inland Water Transport Facilities Improvement and Development Project

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Table of Abbreviations

No.	Abbreviations	Official Name
1	ACD	Above Chart Datum
2	BH	Borehole
3	BHN	Basic Human Needs
4	CD, CDL	Chart Datum, Chart Datum Level
5	CEO	Chief Executive Officer
6	DAC	Development Assistance Committee, OECD
7	DMA	Department of Marine Administration (Myanmar)
8	DOT	Department of Transport (Myanmar)
9	DWIR	Directorate of Water Resources and Improvement of River Systems
10	DWT	Dead Weight Tonnage (Ship)
11	E/N	Exchange of Notes
12	EIA	Environmental Impact Assessment
13	EIRR	Economic Internal Rate of Return
14	FIRR	Financial Internal Rate of Return
15	FY	Fiscal Year
16	G/A	Grant Aid Agreement
17	GDP	Gross Domestic Product
18	GNI	Gross National Income
19	Gr.	Grade
20	H.W.L	High Water Level
21	ha	hectare, 1 ha = 10,000 m^2
22	HQ	Headquoter
23	hr	hour
24	ICD	Inland Container Depot
25	IWT	Inland Water Transport
26	JICA	Japan International Cooperation Agency
27	kh	design horizontal seismic coefficient
28	kt, knot	knot, 1 knot = 0.514444 m/s
29	kv	design vertical seismic coefficient
30	L.W.L	Low Water Level
31	L/A	Loan Agreement
32	LDC	Least Developed Country
33	LOA	Length overall (length of ship)
34	M&R	Maintenance & Repairing
35	m/s	meter/second
36	MCDC	Mandalay City Development Committee

No.	Abbreviations	Official Name
37	MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
38	MMID	Mandalay Myotha Industrial Development
39	MOC	Ministry of Construction (Myanmar)
40	MOF Japan	Ministry of Foreign Affaires Japan
41	MOT	Ministry of Transport (Myanmar)
42	MPA	Myanma Port Authority
43	N, N-value	N-Value, Standard Penetration Test
44	NGO	Non-Governmental Organizations
45	O&M	Operation & Management
46	ODA	Official Development Assistance
47	OECD	Organisation for Economic Co-operation and Development
48	PIANC	the World Association for Waterborne Transport Infrastructure
49	R/D	Record of Discussions
50	SCF	Standard Conversion Factor (Economic Analysis)
51	SEZ	Special Economic Zone
52	SPT	Standard Penetration Test
53	t, ton	tonnage
54	TEU	Twenty-foot Equivalent Unit
55	φ	Diameter

Chapter 1 Background and Objective of the Study

Republic of the Union of Myanmar (Myanmar) has a number of navigable inland waterways with a total extended length of 6,500km in the areas of the Ayearwardy River Basin, its delta regions and the Chindwin River Basin, which make them vital transportation routes for cargo and passengers. In particular, there are regions where access roads are frequently flooded during rainy season, and these waterways become the only transportation routes during that time. It is known that the waterways in Myanmar are very important for the people's common life.

However the present inland waterways sector in Myanmar has various problems to be solved such as 1) shortening travel time and 2) establishing fixed time tables for transportation services. These requirements and needs are namely due to lack of suitable port facilities and many aged ships desperately needing to be replaced. In many river ports, there are no jetties for cargo handling, and so cargo is carried by manual labor to and from ships at the natural riverside. These conditions prevent the waterway transport sector from growing by improving the swiftness of the transportation services. In addition, many outdated government-own ships are not capable of increasing speed, and they have frequent mechanical troubles. These ships are needed to be replaced by new ships.

On the other hand, inland water transport is advantageous from the standpoint that greenhouse gas emission per unit transport volume is lower than that of road transport. Generally waterway transport systems are promoted as an environmental friendly transport mode particularly in developed countries such as in the EU or Japan. Although Myanmar has a good potential for the reduction of environmental burdens with the current use of many viable river routes, the inland water transport sector has recently faced hard competition from road transportation.

During the President's speech made in March 2011, he emphasized the need to rectify the problem of poverty in the country. In the forum on Myanmar's development assistance held in January 2013, the development of river ports was nominated as a high priority project.

This project facilitates the national inland water transport system which will contribute to the rectification of the country's poverty disparity. The project also copes with Myanmar's national development policy. When the project is achieved, the national transport network will be strengthened and effectively contribute to the economic growth and achievement of a stable and convenient society for the country.

Chapter 2 Outline of the Study

2.1 Outline of the Study

Two Joint Coordinating meetings (JCC) were held in December 2012 and February 2013 respectively, in the initial stage of the National Transport Development Plan in the Republic of the Union of Myanmar (MYT-PLAN, JICA Study). In each meeting, the Myanmar side urgently requested a feasibility study to the JICA side regarding inland water transport of the Country. The request has two components; one is to develop six major river ports and the other is to update ships owned by IWT.

Sixmajor river ports are located along the Ayeyarwady and Chindwin Rivers. The former is the largest river of the Country and the latter is the biggest branch river of the Ayeyarwady. On the Ayeyarwady River, there are four major ports; Mandalay, Pakokku, Shinkhan and Magway ports. Characteristics of each port are; Mandalay port is located at the second business capital in Myanmar, Pakokku port is located at the anastomotic point of Chindwin and Ayeyarwady, Shinkhan port is the gateway for border trade with China, and Magway port is located at key point of a future west-east corridor of the Country. On the Chindwin River, there are the two remaining major ports, Kalaywa and Monywa. Kalaywa port is the gateway for border trade with India and Bangladesh, and Monywa port is located at the biggest town in Chindwin River area. MOT has proposed the necessity for the development of these ports as “Development of Inland River Ports” in past official international meetings. As for updating ships used in these waterways, the request was the same as the one already officially submitted in 2012 to Japanese Government to apply a Japanese Yen Loan scheme.

At that time, the JICA study team of MYT-PLAN had no materials to examine whether or not the proposed request was reasonable enough to apply Japanese ODA because the study had just started, therefore, the JICA study team found it necessary to review the contents and prioritize the six ports urgently. As a result, only Mandalay port, which was handling the biggest volume of inland water transport in the Country, was nominated as a candidate for an urgent feasibility study. The concept was agreed on by the Government of Myanmar soon after the counter proposal by the JICA study team. Regarding the renewal of ships, it was agreed that the scope of the work should be focused on an appropriate volume through the feasibility study.

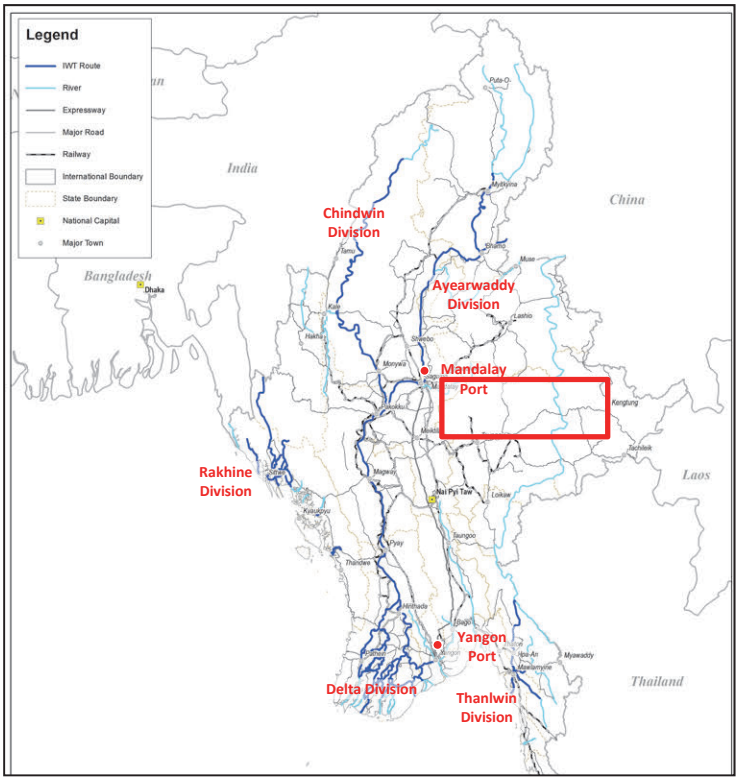
As the result, JICA decided to conduct the Feasibility Study on Inland Water Transport Facilities Improvement and Development Project urgently, and the goal of this study was to examine two requested items initially in order to apply a Japanese Yen Loan, but also the JICA study team should eye the possibility of applying Japanese Grant Aid.

2.2 Goal of the Study

The goal of study was set to contribute to the economic growth of Myanmar and enhance the level of the living conditions of Myanmar citizens through the new development of Mandalay Port and Ships Renewal by Japanese ODA.

2.3 Coverage of the Study

The coverage of the Study was shown in the following drawing.



Source: Study Team

Figure 2.1 Coverage of the Feasibility Study on Inland Water Transport

2.4 Contents of the Study

The contents of the Study are in the following.

2.4.1 Natural Condition Survey

For the basic design of Mandalay New Port, necessary natural condition surveys have been executed.

- Geographic Survey (Boring tests by local sub-contracting)

  Boring tests are conducted at the appropriate locations within the new port development area and the extracted samples are tested in a laboratory. Most of the boring works are done on the river water so safety devices for working above water should be secured.

- Geographic/ Bathymetric Survey (by local sub-contracting)

  Geographic/ Bathymetric surveys are conducted to briefly confirm the new port development area. The result should have the shape, location and height of existing facilities like existing revetment, roads along the river, and some particular structures.

- River Flow, Water Quality surveys and River bed material sampling (by local sub-contracting)

  Annual data on stream-stage variation should be collected. On the river flow survey, it should be done in the rainy season which is generally from May to October. Based on this result, river flow analysis by Japanese specialists is conducted and examined for the

influence of siltation at the planned site. Bottom samplings should be done at the particular points designated by a Japanese engineer.

2.4.2 Basic Study

Present river port activities in the Mandalay area span is exceedingly long, over 4.5km. The size of the new Mandalay port should not be in an area this long but it should be decided as an appropriate size and capacity mainly based on the present cargo handling volume and future demand forecast. The location of Mandalay New Port should be proposed based on consistency with Mandalay City Plan and it should be decided after a comparative study involving related issues on the new port development.

Although the existing cargo handling in Mandalay is so active along the very long river bank, it is pre-modernized, carried out only by manpower without any machinery. Myanmar strongly wishes to enhance the efficiency of handling cargo, therefore, to reply this request by Myanmar, The basic designing of the new port should correspond to basic machinery cargo handling. The selection of structure type should be decided after a comparative study considering natural conditions, usability by port users and so on.

2.4.3 Preliminary Construction Schedule and Cost Estimates

Based on the basic designing, a preliminary construction schedule and cost estimates are planned. In making the construction schedule, the present local construction surroundings should be largely considered and the schedule should be practical and reasonable. For preliminary cost estimates, items with assumed price surging like fuel and oil, should be set carefully.

2.4.4 Renewal of Decrepit Ships

Presently many of the IWT ships used for inland water transport are decrepit. Therefore, Myanmar had requested from Japan to renew those ships by a Japanese Yen Loan Scheme. The JICA Study Team is to review the contents of the request and aims to propose an appropriate procurement.

Regarding the procurement of passenger ships, there are two requirements to fulfill by the ODA: one is to have high publicness, and the other is not to strangle existing private businesses. On procurring cargo vessels, the size, type and number of procured vessels should match present and future demand forecasts considering the disposition of the counterpart and finally, preliminary design of the ships and vessels and the cost estimates are proposed.

Both ships and vessels should be compatible to the existing shallow river depth in the dry season as much as possible. Japanese technology in these areas should be considered when choosing ships and vessels. Furthermore, the new ships should be more efficient to run and maintain, and should have a lower effect on the environment.

2.4.5 Operation and Maintenance Organization on Port Facilities and Inland Water Transport

The operation and maintenance of the current inland water transportation organization should be carefully examined and a more effective plan should be proposed.

2.4.6 Making a Preliminary Project Execution Plan and Examination of Project Feasibility

Regarding the Mandalay New Port development and the renewal of decrepit ships, the preliminary project execution plan and project feasibility should be examined. In regards to economic analysis, the economic benefit, which will be enhanced by increasing the efficiency

of transport and the handling of cargo, should be computed. As for financial analysis, project feasibility will be analyzed with the aim of making a Japanese Yen Loan Project,; however, the examination should eye the possibility of making a Grant Aid Project as well.

2.4.7 Environmental and Social Consideration

The JICA study team will support the creation of an EIA report on the development of the Mandalay New Port project. Concrete investigation items are listed in the following. Basically, the JICA study team will employ a local consultant, who has experience in making EIA reports, and they will work, based on JICA guidelines, on environmental and social considerations under the instruction of a Japanese expert on the study team.

1) Items on Natural Environment:

- Check on the existence of animals and plants especially on aquatic ecology, and identify migration routes
- Check on the existence of national parks and protected zones

2) Social Environment:

- Confirmation of land use conditions, peripheral people, and surrounding social economic conditions
- Confirmation of existing inland water transport including pleasure boats, fisheries, and economic activities related to the river
- Check resettlement, having meetings to explain to local residents and so on

2.4.8 Making Out of Resettlement Plan

In case that resettlement is required, resettlement plans should be made out. Items to be investigated are the following:

- Confirmation of an objective number of resettlements of both persons and houses, family budgets, and their living conditions
- Confirmation of land use and landownership related to the resettlement
- Provisional calculations of the value of movable/immovable assets and confirmation of these locations, numbers, and areas
- Confirmation of procedures on the loss of assets, and examination of making life reestablishment plans
- Examination of procedures for complaint management, and a schedule for resettlement after the compensation payment
- Calculation of the related costs and confirmation of financial resources and so on

2.4.9 Recommendation on the Whole Project

Based on the above examinations, recommendation for future development of inland water transportation in Myanmar is proposed.

Republic of the Union of Myanmar (Myanmar) has a number of navigable inland waterways with a total extended length of 6,500km in the areas of the Ayearwardy River Basin, its delta regions and the Chindwin River Basin, which make them vital transportation routes for cargo and passengers. In particular, there are regions where access roads are frequently flooded during rainy season, and these waterways become the only transportation routes during that time. It is

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Chapter 3 Japan's ODA and Myanmar

3.1 Outline of the Study

In this Chapter, the system of Japan's ODA (Official Development Assistance) and current movement on the ODA for Myanmar are briefed for the purpose to bring the understanding of the counterpart clearer.

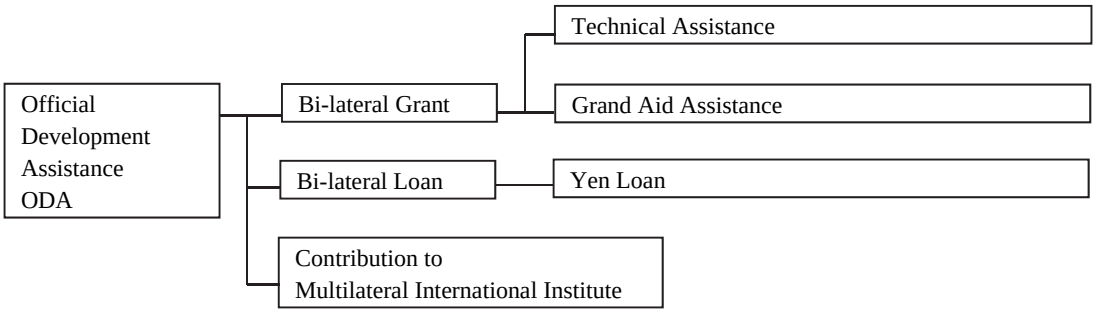
3.2 Japan's ODA

3.2.1 Brief Description of Japan's ODA

In Japan, a variety of organizations and groups, including governments as well as international organizations, non-governmental organizations (NGOs) and private companies, carry out financial assistance to developing countries for socioeconomic development. ODA, as defined by the Development Assistance Committee (DAC) of the Organization for Economic Co-operation and Development (OECD), must meet the following three requirements:

- It should be undertaken by governments or government agencies
- The main objective is to promote the economic development and welfare in developing countries
- It has concessional terms, having a grant element of at least 25%

Note: The grant element measures the concessionality or "softness" of financial terms of a loan. The lower the interest rate and the longer the maturity period, the higher the grant element, which means it is more beneficial to the borrower. The grant element for a grant is 100%. ODA is broadly divided into bilateral aid, in which assistance is given directly to developing countries, and multilateral aid, which is provided through international organizations. JICA provides bilateral aid in the form of Technical Cooperation, Japanese ODA Loans and Grant Aid. In case of executing Japanese ODA to Myanmar, it is necessary to pay attention to the condition of the Promotion of Democratization and the guarantee of fundamental human rights and freedom.



Source: JICA

Figure 3.1 Types of ODA

The three schemes of bi-lateral assistance are described as follows.

(1) Japanese Yen Loan Scheme

In many developing countries, economic and social infrastructure, such as electricity, gas, transportation and communications services, is underdeveloped. In recent years, in addition to an increasing population living in poverty in some regions, global problems have emerged, including HIV/AIDS and other communicable diseases, air and water pollution, and conflicts and terrorism. To address these issues, Japanese yen loans support developing countries by providing low-interest, long-term and concessional funds to finance their developmental efforts.

(2) Grant Aid

Grant Aid is financial cooperation implemented by the Japanese government with no obligation for repayment by the developing country concerned. This scheme aims to donate equipment, facilities, and technical cooperation contributing to further improvement of developing countries. For instance, "Facility Construction" builds hospitals, schools, and roads in the fundamental fields of medical care, rural development, and transport. In another example related to "Equipment Procurement", procurement of medical equipment and equipment for educational training and so on. Each scheme name and its summary are listed in the following.

Table 3.1 Scheme Name and Summary in Grant Aid

Scheme Name	Summary
Grant Aid for General Projects	Support for projects implemented for basic human needs, education, etc. (including the construction of hospitals, schools and roads, or the procurement of materials and equipment for public transport vehicles, etc.)
Grant Aid for Community Empowerment	Support for comprehensive skills development in communities faced with threats to human life or safe living
Non-Project Grant Aid (Grant Aid for Conflict Prevention and Peacebuilding)	Support and others for spreading the necessary economic and social infrastructures in post-conflict countries
Grant Aid for Disaster Prevention and Reconstruction	Disaster prevention assistance and post-disaster reconstruction assistance
Programme Grant Aid for Environment and Climate Change	Support for adoption of policies and planning related to global warming countermeasures, etc., and for related projects
Grant Aid for Poverty Reduction Strategies	Public financing support for developing countries implementing poverty reduction strategies
Grant Aid for Human Resource Development (Scholarship)	Support for training young administrative officials in developing countries
Grant Aid for Fisheries	Support for projects promoting the fisheries industry in developing countries
Cultural Grant Assistance	Support for equipment procurement and facilities development needed for promotion of culture, etc.
Grant Aid for Underprivileged Farmers	Support for purchase of agricultural equipment and fertilizers, etc., to support self-help efforts toward food self-sufficiency
Grant Aid for Cooperation on Counter-Terrorism and Security Enhancement	Support for strengthening piracy countermeasures and other public security policies

Source: JICA

Also, Grant Aid includes software assistance like “Technical Cooperation”. This issue is introduced in the following paragraph.

(3) Technical Cooperation

The needs of developing countries are becoming increasingly diverse and multifaceted. In addition to agricultural development and the development of the social infrastructure covering such areas as water supply and healthcare improvements, in recent years, these needs have extended to support for formulating measures against climate change, transitioning to a market economy, and developing legal systems as well as peacebuilding and reconstruction assistance in Afghanistan, Sudan and elsewhere. While some of the needs can be met by improving situations through financial cooperation for constructing facilities and providing equipment, there is also the need to pursue cooperation focused on enhancing problem-solving capabilities of developing countries for ensuring their self-reliant development and sustainable development outcomes.

Concrete items of Technical cooperation are in the following:

1) Dispatch of Experts:
Japanese experts are dispatched to developing countries to disseminate necessary technologies and knowledge to partner country government officials and engineers (counterparts).

2) Acceptance of Training Participants:
JICA invites competent personnel in developing countries, who have significant responsibility in social and economic development, to Japan as training participants.

3) Provision of Equipment:
Equipment needed by experts for implementing effective cooperation is provided to partner countries.

4) Technical Cooperation Projects:
Technical Cooperation projects, which optimally combine the "Dispatch of Experts," "Acceptance of Training Participants" and/or "Provision of Equipment" are the core operations of JICA's Technical Cooperation.

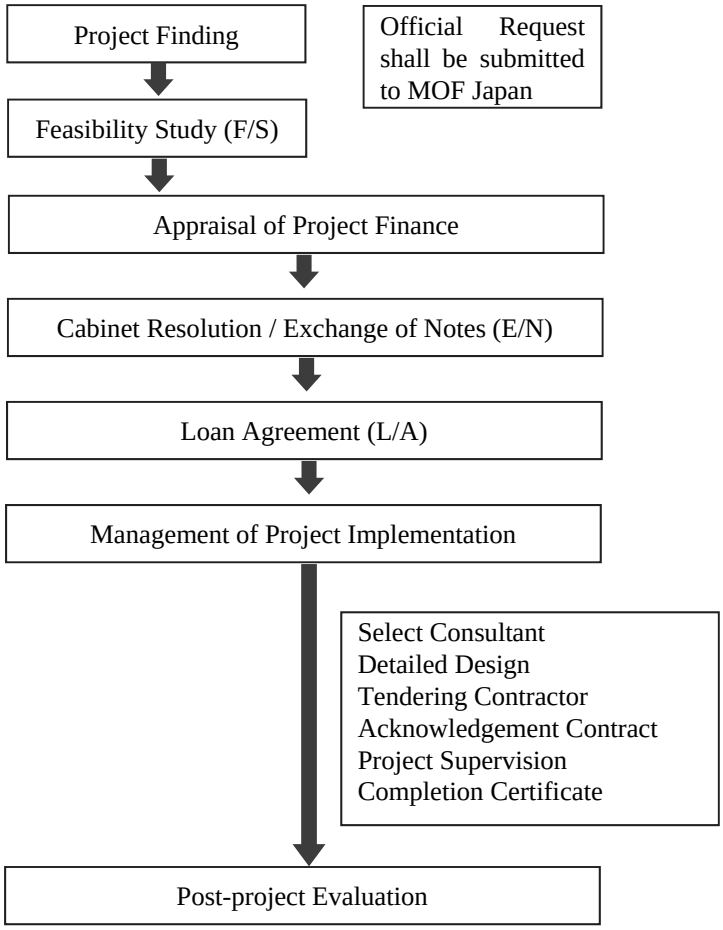
5) Technical Cooperation for Development Planning:
While supporting developing countries' policymaking and public works plans, JICA transfers technologies, including survey/analysis methods and planning methods to counterparts in the partner country. The following four features are the main contents of cooperation.

3.2.2 Schemes of Japanese ODA and Financial Arrangement

Presently Japanese ODA has categorized into two, bilateral aid and multilateral aid. JICA is in charge of bilateral aid and it has three schemes comprised of Japanese Yen Loan, Grant Aid, and Technical Assistance. Those schemes are operated integrally to support developing countries efficiently. In this paragraph, each scheme and its financial arrangement are introduced briefly.

(1) Japanese Yen Loan Scheme

The flow chart of Japanese Yen Loan Scheme is shown in the following.



Source: JICA

Figure 3.2 Flow Chart of Japanese Yen Loan

The Japanese Yen loan scheme supports developing countries by providing low-interest, long-term and concessional funds to finance their development efforts. The condition of each country is decided based on a table of terms and condition of Yen Loans, and this categorization is set in each income class referred from the World Bank/United Nations. Presently Myanmar is classified as a Least Developed Country (LDC). Terms and condition of LDC countries and the classification of income classes are shown in the following tables.

Table 3.2 Terms and Condition in LDC Countries

Category	GNI Per Capita (2011)	Terms	Fixed/ Variable	Standard/ Option	Interest Rate (%)	Repayment Period (Year)	Grace Period (Year)	Conditions for Procurement
LDC	Low-Income Countries *1				0.01	40	10	Untied
		General Terms	Fixed	Standard	0.70	30	10	
		Preferential Terms *2		Standard	0.01	40	10	

*1：For Low-Income LDCs, the term and condition of 0.01% interest rate and 40-year repayment period including 10-year grace period are applied, irrespective of sectors and fields.
*2：Preferential Terms are applied for the following sectors and fields: (i) Global Environmental Problems and Issues, (ii) Health and Medical Care and Services, (iii) Disaster Prevention and Reduction, (iv) Human Resource Development
*3：Above table is effective from April 1, 2013

Source: JICA Web-site

Table 3.3 Classification of Income Classes by World Bank/ United Nation (LCD class and neighboring countries of Myanmar)

Income Class	GNI Per Capita (2011)	Countries
Least Developed Countries	Low Income Countries	Afghanistan, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, **Myanmar**, Nepal, Niger, Rwanda, Sierra Leone, Somalia, Tanzania, Togo, Uganda
		Angola, Bhutan, Djibouti, Equatorial Guinea, Kiribati, Lao PDR, Lesotho, Samoa, Sao Tome and Principe, Senegal, Solomon Islands, South Sudan, Sudan, Timor-Leste, Tuvalu, Vanuatu, Yemen, Zambia
Low Middle Income Countries	US$ 1,026-US$ 1,945	India, Vietnam
Middle-Income Countries	US$ 1,946-US$ 4,035	Indonesia, Philippines,
Upper-Middle-Income Countries	US$ 4,036-US$ 7,035	China, Thailand,
Uppermost-Middle-Income Countries	US$ 7,036-US$ 12,475	Malaysia,
Graduated Countries from ODA		Singapore, Brunei,

Remarks： means ASEAN Countries.

Source: JICA Web-site

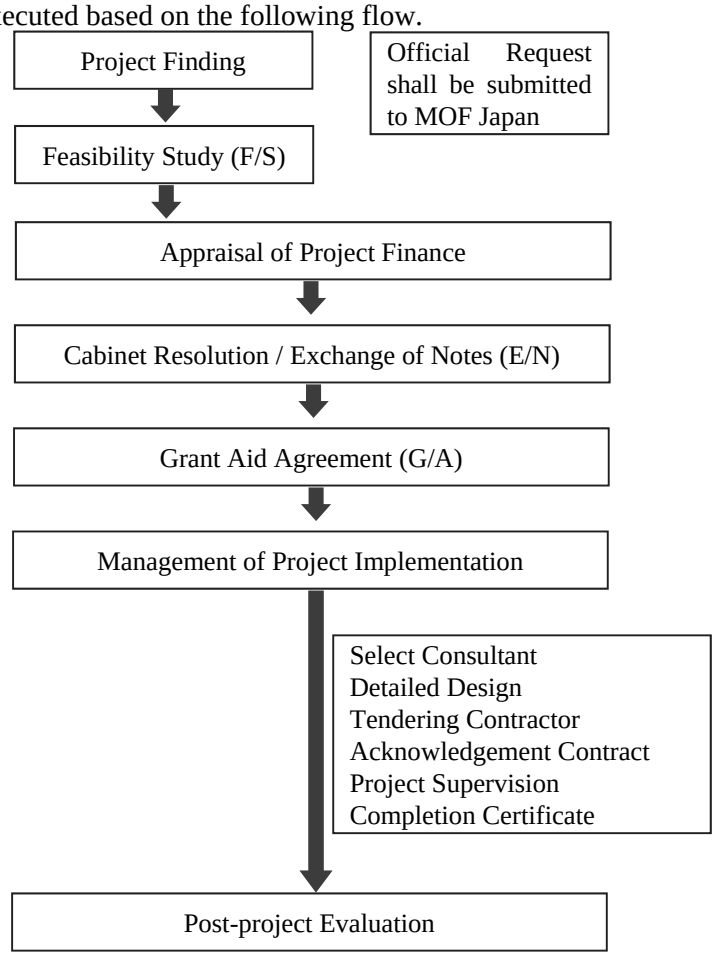
As shown in the above tables, Terms and Conditions to apply Japanese yen Loan for Myanmar are:

- Interest Rate: 0.1%, Repayment period: 40 years, Grace Period: 10 years, Condition of procurement: Untied

According to hearing investigations, Myanmar has applied for loans from China several times however, the interest rate is higher than Japanese, 4~5% according to MOT. Comparing the Japanese rate, the burden of Chinese loans is heavier. On the other hand, Japanese loans have the disadvantage of a longer process time and a complicated procedure, compared to Chinese loans.

(2) Grant Aid

Grant Aid is executed based on the following flow.



Source: JICA

Figure 3.3 Flow Chart of Grant Aid

Project Identification and Formulation

JICA conducts preparatory surveys and other surveys in discussion with the government of the partner country, while examining from a variety of perspectives on the country's current situation, objectives of project implementation, scale of cooperation, the operation and management structures if implemented and the expected outcome. Based on this information, necessary costs are calculated.

Project Examination and Approval

Concerning the implementation process and results of preparatory surveys, JICA shares all information with the Japanese government, verifies the appropriateness of implementing a project and then examines the contents of cooperation.

Based on the results of the surveys, the Japanese government conducts necessary reviews and procedures for securing budgets and then submits project proposals to the Cabinet for a final decision on implementation.

Exchange of Notes and Grant Agreements

After approval by the Cabinet, the government of the partner country and the Japanese government sign documents (Exchange of Notes) summarizing the objectives and content of cooperation for the project.

JICA then signs a "Grant Agreement" with the government of the partner country that sets the specific conditions for the grant.

Project Implementation

At the project implementation stage following the signing of the Exchange of Notes and Grant Agreement, JICA offers advice and implementation guidance to the recipient country and consultants. This advice and guidance is to ensure that facility construction as well as materials and equipment procurement proceed in an appropriate manner without delays, from the time of the agreement through transfer of the materials and equipment until completion of construction.

Post-Project Management

After cooperation is completed, the government of the partner country handles operations and maintenance. However, there will be cases when equipment breakdowns or other unexpected problems occur. In such circumstances, JICA provides Follow-up Cooperation in the form of materials and equipment procurement, dispatch of repair teams and emergency repair work in order to maintain the effectiveness of cooperation.

Myanmar is highly expected rapidly develop in the near future; however the present income class of the country is still LDC as mentioned before. Therefore, it is necessary that the possibility to apply Grant Aid should be considered at any time when project formulation is examined for the country.

(3) Technical Cooperation

Technical Cooperation project follows the following steps:

Table 3.4 Flow Chart of Technical Cooperation

Project Formulation, Request ~ Approval		Project Implementation	Project Completion	Post Project evaluation
		Dispatching Experts, Acceptance Trainees, Providing equipment/ material		Extension of the project (if necessary), follow up, phase 2, etc
Preparatory Study, (Project Formulation)	Detail Design, Sign R/D	Management Instruction Survey, Mid-term Review, Evaluation at project completion,		Post project evaluation
PLAN		PLAN		SEE

Source: JICA

Project Identification and Formulation
JICA identifies and formulates projects through discussion with the government of the partner country, information gathering by JICA's overseas offices and preparatory surveys.

Request and Approval
Based on a request from the partner country, the Ministry of Foreign Affairs of Japan, other related ministries and JICA discuss whether or not to approve the project. The approved project is reported to the partner country by the Japanese government and note verbales are exchanged by diplomatic missions abroad.

Examination/Ex-Ante Evaluation
In order to clarify details and expected outcomes of the project and comprehensively examine the appropriateness of implementation, ex-ante evaluation is conducted based on five evaluation criteria such as relevance, effectiveness, efficiency, impact and sustainability.

Project Implementation/Mid-Term Review/Terminal Evaluation

JICA and the government organization of the partner country sign a Record of Discussions (R/D) regarding project implementation, details of activities and necessary measures.

Evaluation indicators set in ex-ante evaluation are used as the basis of the mid-term review conducted at a certain point from the project inception and terminal evaluation conducted a half year prior to the project completion. Each result of evaluation is used as recommendations for improving the project.

Follow Up/Ex-Post Evaluation

In case unexpected problems emerge, Follow-up Cooperation is provided when necessary.

Ex-post evaluation is carried out several years after the project completion. Evaluation results are used as lessons learned for formulating and implementing similar projects.

There are requirements to apply for ODA which must be fulfilled when a project is formed, and it is essential to keep good communications between the counterpart and study team to form an efficient project through preparatory study.

3.3 Current Movement of Japan's ODA for Myanmar

3.3.1 Japan's Policy on ODA for Myanmar

As official financial assistance from Japan to Myanmar, Yen Loan was commenced in 1968, and Grant Aid was commenced in 1975. Within these two schemes, Yen Loan discontinued due to the political situation of international societies in 1987. However, current changes in the government of Myanmar (with the election of President Thein Sein in 2011) and observing a trend towards promoting democracy in Myanmar, the Government of Japan has decided to reinstate Yen Loan for Myanmar. The re-started Yen Loan assistance aims mainly to support the economic growth of Myanmar, while the former assistance was limited to only the field of basic human needs (BHN).

The Ministry of Foreign Affairs of Japan stipulates in the policy book for Japan's ODA that the following assistance fields have high priority for Myanmar.

1) Assistance for the improvement of people's life (medical/sanitation, disaster control/relief, agricultural development, sport for minority races, eradication of poverty, regional development, etc.)

2) Building human capacity to contribute to the economy or society, and assistance for building up laws and regulations for such purposes (including assistance for democratization).

3) Infrastructure projects and their concerned laws and regulation for the purpose to support sustainable economic growth of the country.

3.3.2 Movement to Settle the Financial Obligation of Myanmar

The Government of Myanmar is in debt to several foreign countries, which it has not paid back since 1987. The total amount of the debt against Japan was 326 billion yen and an additional 176 billion of penalty due to the delay of re-payment. In the summit conference held in April 2012 between Myanmar and Japan, it was mutually agreed to make a cooperative effort to the solution of the issue in the viewpoint that the revival of Myanmar to international society is important. The following actions are agreed to be forwarded.

(1) The Debt for that Appointed Date for Return was Before March 2003

Myanmar will receive the application of a "Bridge Loan" using a commercial loan (super-short

term loan) and return the debt of 199 billion yen. In return, Japan will provide a "Program Loan" by means of a long term Japanese Yen Loan. Myanmar and Japan will mutually monitor the policy and progress of reform in Myanmar.

(2) The Debt for that Appointed Date for Return was After April 2003

Japan will exempt this debt of 127 billion yen. This action is based on the former mutual agreement made in December 2002.

(3) Penalty Due to Delay of Re-Payment

The penalty due to the delay of re-payment amounts to 126 billion yen (March 2013) which was counted for the period of 20 years will be exempted after Myanmar and Japan mutually monitor the policy and progress of reform of Myanmar for one year.

3.3.3 Movement to Re-Start Yen Loan Assistance

On 7th June 2013, JICA and the Government of Myanmar signed on the loan agreement (L/A) whose total amount is 51.052 billion Yen. The following Table shows the details of the agreement.

Table 3.5 Detail of L/A in 2013 FY

Project Name	Loan Amount (Million Yen)	Interest (%/Year)		Return Period (Year)	Grace Period (Year)	Condition
		Project Investment	Consulting Service			
(1) Regional Development for Eradication of Poverty (Phase 1)	17,000	0.01	0.01	40	10	General Un-tied
(2) Urgent Restoration of Infrastructure (Phase 1)	14,052	0.01	0.01	40	10	General Un-tied
(3) Infrastructure Development of Thilawa District (Phase 1)	20,000	0.01	0.01	40	10	General Un-tied

Source: JICA

The following is a brief description of each project.

(1) Regional Development for Eradication of Poverty (Phase 1)

This project is for building an infrastructure for all citizens lives in Myanmar, including the regions of minority races. The government is accelerating its effort to reform the society on an amicable settlement between the government and minority races. For instance, the government of Myanmar and the Karen people signed a cease-fire agreement in January 2012 after 63 years of conflict. In order to gain support for this movement of reform, economic development and the eradication of poverty in the regional areas must be realized.

This project is to build life-infrastructures with high priority (road, power and water supply) in 7 divisions and 7 states in the whole country. The project will contribute to improve the people's standard of living.

(2) Urgent Restoration of Infrastructure (Phase 1)

The insufficient supply of electric power in Myanmar is serious problem. Particularly in the dry season (March ~ May), there are many power failures which causes inconveniences to the citizen's daily life and also an obstruction to commercial activities. In particular, since it is assumed that more commercial activities will arise in Yangon city area, the shortage of power supply shall be immediately improved.

This project is to re-build the power producing plants and the transformer stations in the Yangon city area. The project will contribute not only to the improvement of citizen's lives, but also to the regional economic development by achieving a stable power supply to the area. In

addition, the project will also provide benefits to Japanese business firm's activities in the region.

(3) Infrastructure Development of Thilawa District (Phase 1)

Myanmar is thought to be a promising country from the viewpoint of a plentiful and low cost workforce, and as a huge consumer market. However, the delay in infrastructure development is a serious bottle-neck for the promotions of direct investment of foreign countries.

The Thilawa district is designated as a SEZ (Special Economic Zone) and development is now going on, aiming to facilitate foreign direct investment, to create plenty of employment, and to accelerate the growth of international trade. It is important to develop the transportation infrastructures in the Yangon region as well, which support the commercial activities of private firms and people's daily life.

This project is to build a port terminal and power plant in Thilawa, aiming to facilitate the goals of supporting commercial activity and citizen's everyday life.

Chapter 4 Present Status & Future Subjects of the Inland Water Transport Sector

4.1 Present Status of Nayional River Ports

Inland waterways are an important transport route for Myanmar. The country has 6,650km of navigable waterways along major rivers. Ayeyarwady River, which has a 2,170km long stream line, runs in a north-south direction in the middle of the country. The river, whose navigable channel length extends 3,938km, including many branch flows in the delta area, provides waterways for cargo and passenger ships. The waterways connect Yangon city in the south to major northern cities such as Pyey, Mandalay and Bhamo. Figure 4.1 shows the navigable inland waterways in Myanmar, major river ports, and the water depth during the dry season. Along the Ayeyarwady and Chindwin Rivers, which are the longest waterways in the country, the difference in water depth between the dry and flooding seasons is very large. For instance, the water level becomes 8m in Mandalay, and 9m in Monywa during the flooding season. The water depth in the dry season is very shallow; for example, the water depth downstream from Mandalay is 1.5m, and 1.1m upstream between Mandalay and Bhamo. The water depth of the Chindwin River becomes shallower during the dry season, where it is less than 1.0m.

For river channel improvement, the UNDP conducted a survey “ILCRS：Irrawaddy and Lower Chindwin Rivers Study” and 46 constraints for navigation in Ayeyarwady and 37 constraints in Chindwin were identified. The DWIR has followed the recommendations of the IRCRS, and has been executing river training using its budget provided by the government, but progress is slow. In 1993, the UNDP conducted a further study “CTS : Comprehensive Transport Study”, in which a suitable government policy was proposed on the transport sector. This report also proposed that in regards to the inland water transport sector, improvement in government organizations, as well as the improvement of the river channels, were important.

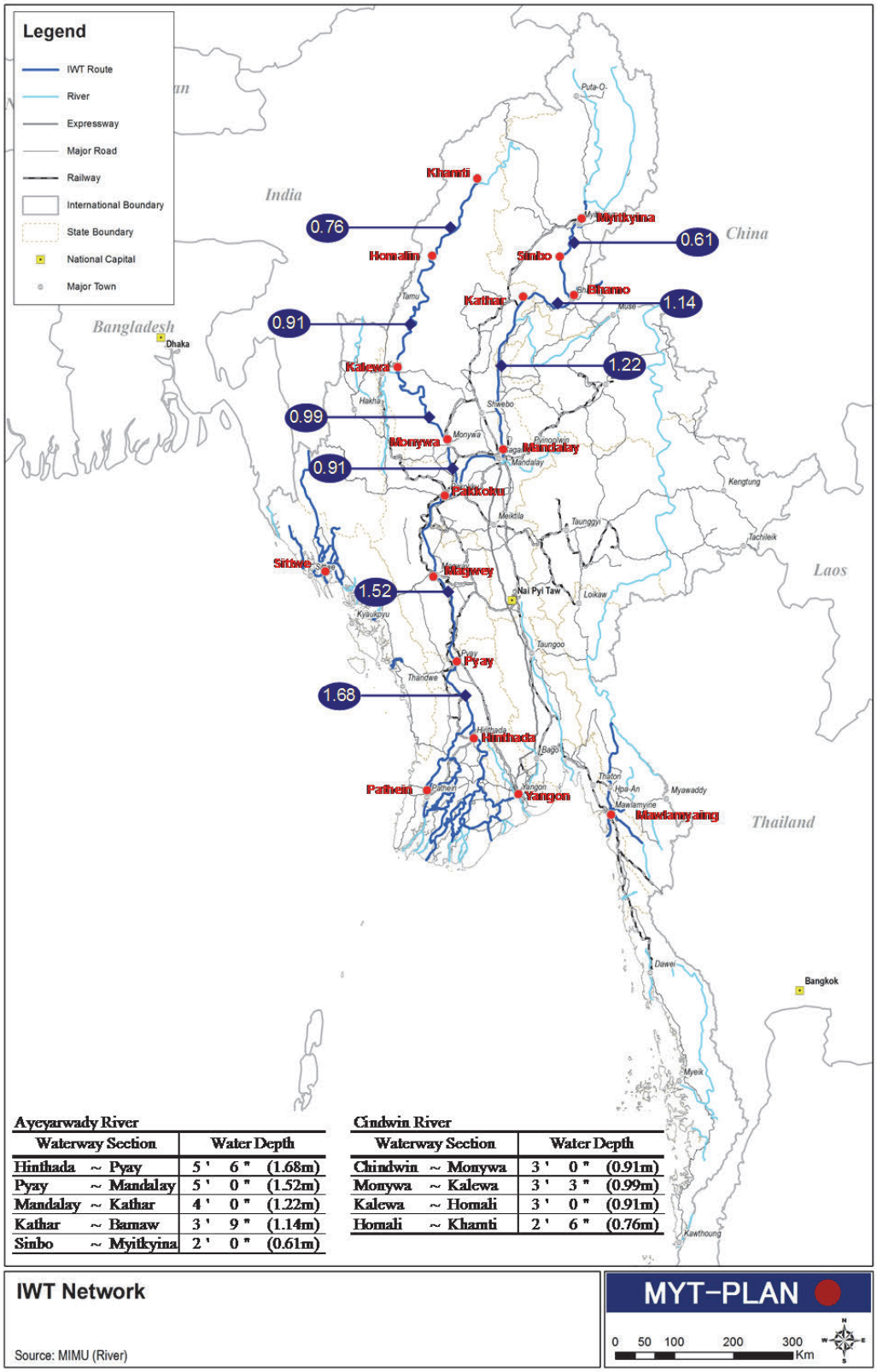


Figure 4.1 Inland Waterway Network & Water Depth

4.1.1 Overview of the Inland Waterways of Each Region

The IWT manages the inland waterways by dividing all waterways into 5 regions. Table 4.1 shows the division names and their managing waterways.

Table 4.1 IWT's Regional Division of Inland Waterways

Division Name	Waterways	Regeonal Office
Delta Division	Ayeyarwady River, Downstream from Pyey	Pathein
Ayeyarwady Division	Ayeyarwady River, Upstream from Pyey	Mandalay
Chindwin Division	Chindwin River	Monywa
Thanlwin Division	Waterways around Mawlamyaing	Mawlamyaing
Rakhine Division	Waterways around Sittwe	Sittwe

Source: IWT

(1) Delta Division

The Delta Division is one of the most active areas for inland waterway transport, which has the largest volume of passengers. In this division, the Yangon Port plays the role of hub port for domestic cargo distribution to inland waterways. IWT's regional office is located in Pathein, where a number of navigable waterways are connected. In the Delta Division, 18 regular routes are operated by IWT (2012).

(2) Ayeyarwady Division

The Ayeyarwady division has Mandalay, which is the second largest city in Myanmar. The divisional cargo transport volume of this district's waterways shares 20% of the total volume of Myanmar. Regular routes between Pyey and Mandalay, Bhamo and Mandalay, and Khata and Mandalay are operated by IWT. Cargoes, including construction material, dry-food, and fish, etc. are carried from Mandalay to ports upstream. On the other hand, Chinese goods imported through the China-Myanmar border trade are carried from upstream to Mandalay. Construction material is also carried from Mandalay downstream to Pyey. Rice, spices, and beans are carried from Pyey to Madalay.

(3) Chindwin Division

In the Chindwin Division, a regular route between Monywa and Khamti is operated by IWT. There is little waterway transport between Monywa and downstream around the meeting point of the Ayeyarwady and Chindwin Rivers because the channel route is shallow during dry season and is hard to navigate due to complicated river branches. In 2011, a private operator attempted to open waterway transport between Monywa and Mandalay running through the meeting point of Ayeyarwady and Chidwin. Monywa has the role of gateway port for northern Chin State and for further Indian border trade. General cargo is carried from Monywa to upstream mountain places, and in the other direction, agricultural products are carried from upstream to Monywa. In general, cargo from Mandalay is carried by roadway to Monywa then loaded onto ships at Monywa Port to carry to upstream towns such as Thamu, which is located near the border between India and Myanmar. The transport fee between Mandalay and Monywa by roadway is approximately 72 Kyat per ton-mile, the fee between Monywa and Thamu is approximately 20 Kyat per ton-mile. Currently the service that has a shorter travel time is gaining customers despite having a higher fee. For example, private operators are getting more customers on the route between Monywa and Homalin because IWT ships take five days for delivery, while private operators can deliver in half that time.

(4) Thanlwin Division

Most of the waterway routes in the Thanlwin Division are short routes within 10 miles of Mawlamyaing. IWT has regular routes between Mawlamyaing and Kalwi, and between Mawlamyaing and Natmaw.

(5) Rakhine Division

In the Rakhine Division, the inland waterway transport volume including passenger and cargo has been unchanged during the past 10 years. The major ports are Sittwe and Kyaukpyu. At Kyaukpyu, port development is advanced by Chinese financial investment. Because the SEZ development plan is underway at Kyaukpyu, inland water transport might be active according to future development.

4.1.2 Overview of River Ports

Figure 4.2 ~ Figure 4.7 show pictures of major river ports in Myanmar. As it is shown these pictures, there is no cargo equipment such as cranes in the river ports in Myanmar, where the all cargoes are carried by manual labor.

As for the berthing of ships, it is there are some floating jetties as shown in the picture of Pathein Port. However, in the most of river ports, passengers and cargoes come and go between ships moored near the riverbank and the natural riverside walking along small wooden walkways which are erected by hand at the time ship arrives. (Please refer to the pictures of Magwey Port, Pakokku Port, Mandalay Port and Monywa Port.)

Cargoes are temporary stored at the inclined natural riverbank in a disordered manner, as shown in the picture of Mandalay Port. There is no place with pavement at the riverbank, therefore fine dust flies at the passage of every truck, and cargoes are spoiled with the sandy dust.

Without exception, every river port has a large seasonal water depth change in the range of 6m ~ 10m. Cargo space during the dry season disappears during the flooding season due to an increase in water height, where the cargo yard has to be moved according to the movement of the water front line. At ports which are close to city roads, such as Mandalay Port, the cargo handling operation often disturbs road traffic in the flooding season because the cargo space of the riverbank shrinks due to high water level.

Pathein Port

Pathein Port

Figure 4.2 River Ports (Pathein Port, Delta Divison)

Magway Port

Figure 4.3 River Ports (Magwey Port, Ayeyarwady Divison)

Pakokku Port

Pakokku Port

Figure 4.4 River Ports (Pakokku Port, Ayeyarwady Divison)

Mandalay Port

Mandalay Port

Figure 4.5 River Ports (Mandalay Port, Ayeyarwady Divison)


Monywa Port | Monywa Port

Figure 4.6 River Ports (Monywa Port, Chindwin Divison)

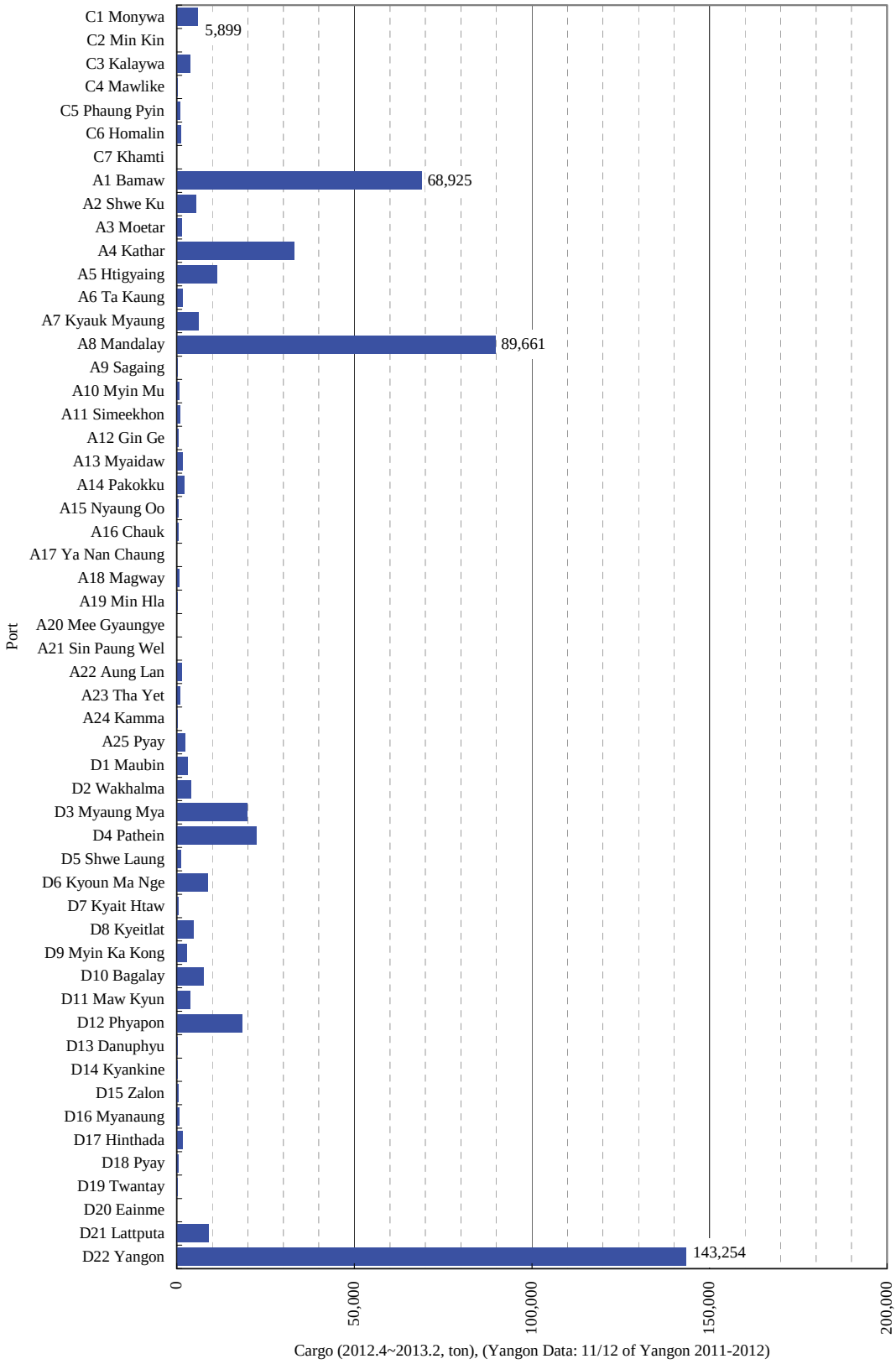

Kalewa Port | Kalewa Port

Figure 4.7 River Ports (Kalewa Port, Chindwin Divison)

4.1.3 Cargo Handling Volume of River Ports

For cargo statistics of the river port, IWT is recording its own ships' transport, but it does not include private carriers' data. It is roughly assumed that 70 ~ 80% of total inland water transport is carried by private carriers. Since 2012, the Department of Marine Administration (DMA) has started to record statistics for private carriers, however the accuracy of the statistics has not been established because regional data still vary widely.

Figure 4.8 shows the summary of IWT's records regarding cargo throughput of each river port of the Ayeyarwady, Delta and Chindwin Divisions. From this data, it can be read that the cargo transport between Yangon Port and regional ports in the Delta area, and between Mandalay Port and Bhamo Port handle a large volume. IWT's data shows that Yangon Port handles the largest volume of cargo, and Mandalay Port handles the second largest.



Source: IWT

Figure 4.8 Cargo Throughput of Each River Port by IWT Statistics（2012~2013）

4.2 Present Status of Ships for Inland Water Transport

Due to the recent spread of motorization, the use of inland water transport has been decreasing. However there are still many towns and villages which have traffic interruptions due to flooding during rainy season, in which disaster prevention measures are not adequate. Considering this situation, the role of inland water transport is important because it provides a stable transport service during all seasons.

Inland Water Transport (IWT) is a public organization under Ministry of Transport (MOT) and operates ship transportation services using domestic river waterways. These public services are important in terms of supporting local citizens, particularly along the waterway routes on the Ayeyarwady River, Chindwin River, and Delta area, including ferry service crossing the Yangon River. Nevertheless, many ships owned by IWT are too old and have inconvenient traffic operations.

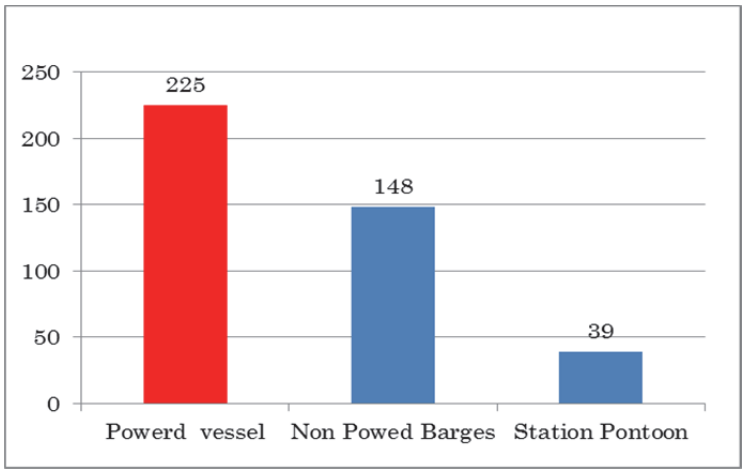
On the other hand, many privately owned ship operators are participating in the transport business, which mostly provide higher speed transportation and passenger friendly services. Some luxurious river cruise ships have been also launched for targeting foreign tourists. The private operators seem to have the intention to provide services to the upper-middle class passengers, according to the economic growth of the country.

4.2.1 Numbers of Ships Owned by IWT

Although IWT plays an important role for public transport service, the numbers of IWT owned ships have recently decreased. In 2003, IWT owned 621 ships, which decreased to 429 ships in 2012, and further decreased to 413 ships in 2013. The reason of this decrease is mainly from selling ships to private firms or abolition due to age. In addition, IWT suffered disaster damages by Cyclone Nargis in 2008, when 40 ships and barges were sunk and 32 ships and barges were run aground.

Following the former government's policy, Myanmar had a good political relationship with China, through which IWT procured 72 ships using a government loan from China during 1994 ~ 2000. (37 ships were built in China and 35 ships were built in IWT's shipyard, totaling 72 ships) Since then, IWT launched only 2 ships in 2010.

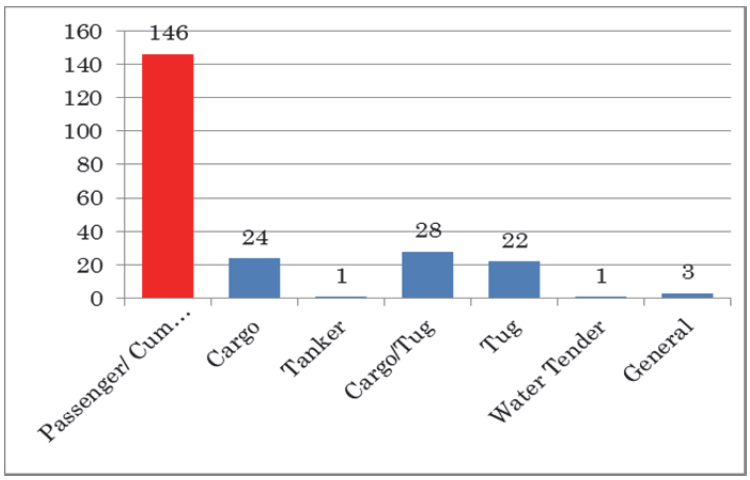
The breakdown in numbers of 413 ships owned by IWT in 2013 is,
Powered Vessel: 255 ships,
Non-powered Vessel: 148 ships, and
Stationed Pontoon: 39 ships



Source: JICA Study Team

Figure 4.9 Numbers of IWT Owned Ships

Of the 225 powered vessels, 146 vessels are "Passenger-cum-cargo Ship" which share 65% of the total, the rest are self- propelled barges and tug boats.



Source: JICA Study Team

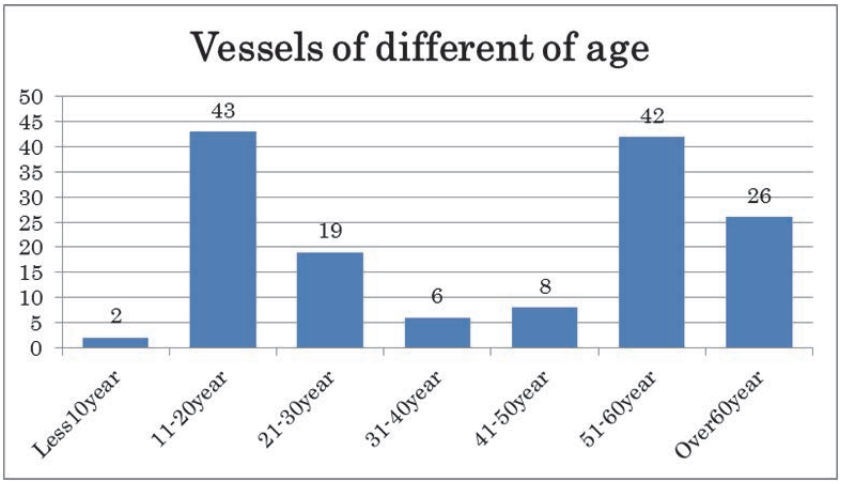
Figure 4.10 Breakdown of Powered Vessels Owned by IWT

Source: JICA Study Team

Figure 4.11 The Pictures of "Passenger-cum-cargo Ship"

4.2.2 The Ages of Passenger-cum-cargo Ships

The most of IWT owned passenger-cum-cargo ships are very old, where only 45 ships are less than 20 years old (31%), 22% of ships are 20 ~ 50 years old, 47 % of ships are older than 50 years old.



Source: JICA Study Team

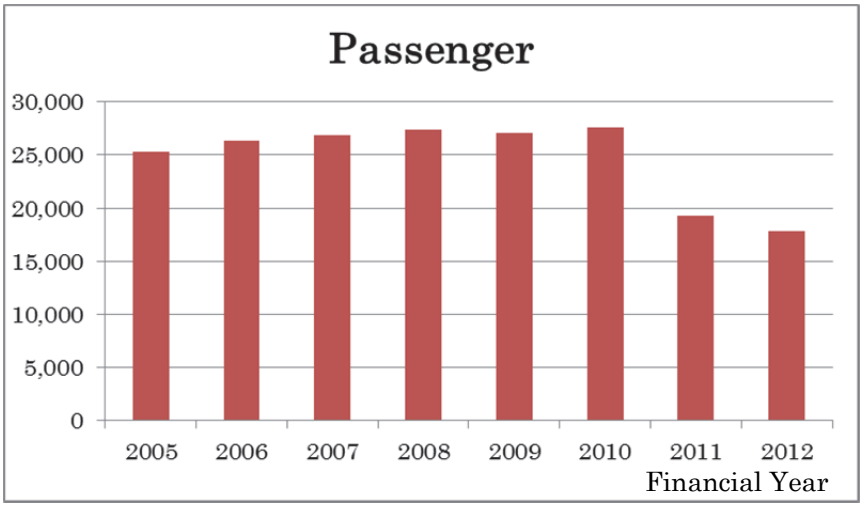
Figure 4.12 Ages of Passenger-cum-cargo Ships

4.2.3 Transport Volume of IWT Ships

(1) Passengers Transport

There is little transport data available about private operators in Myanmar. This study is based on IWT's statistics data, but it is also not very reliable for accuracy. The data is used for getting a rough estimate on the trend of transport.

According to the obtained data, the number of passengers and volume of cargo transported by IWT-owned passenger-cum-cargo ships had increased slightly every year until 2010, and it suddenly dropped in 2011. The reason of this decrease is assumed to be the modal shift from waterway to roadway based on the progress of road improvement and construction.



Source: JICA Study Team

Figure 4.13 Numbers of Passengers Transported by IWT

Private carriers have started operating on many waterway routes. The most of these private operators provide service which is two-times faster but at double the fee of IWT. Therefore the present IWT users are assumed to be lower middle class people who cannot afford to use the more expensive private service. The following pictures show the passengers of IWT ships.

Source: The Study Team

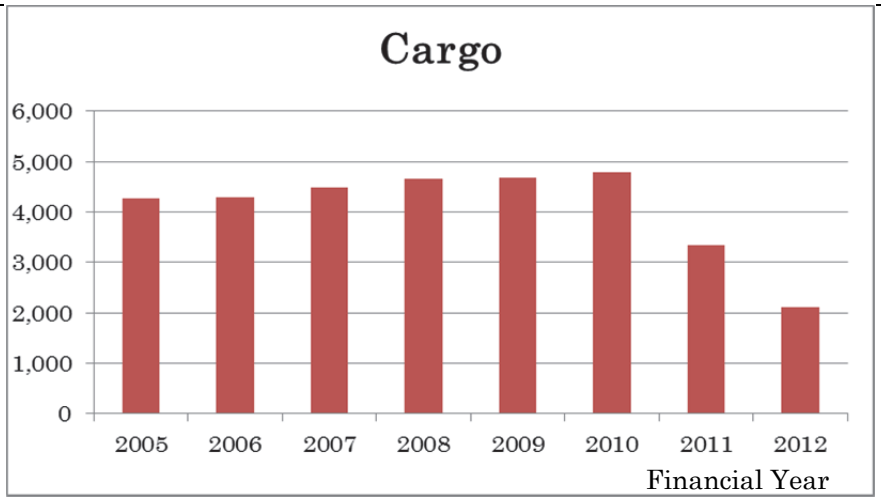
Figure 4.14 Passengers of IWT Ships

(2) Cargo Transport

IWT has a division for cargo transport, which owns tugboats, barges, and self-propelled barges. At present IWT does not directly operate cargo transport, and all cargo ships are leased out to private operators. The cargo transport statistics of these cargo ships are not available.

The following figure shows the cargo transport volume of IWT owned passenger-cum-cargo ships. Similarly to the passengers' data, the cargo volume dropped in 2010, which implies that the transport mode has moved to road transport.

According to interviews with relevant staff, cargo is mainly rice (from Delta area), beans (from north-west region), fishery & agricultural products (from west region) and cement (import) & construction material whose demand is increasing. These cargoes are transported in the form of 50kg bags or the form of pure bulk. The main reason that bagged or bulk cargo is commonly used is because cargo handling is operated by manual labor.



Source: JICA Study Team

Figure 4.15 Cargo Volume Transported by IWT

4.3 Present Status of Management on Inland Water Transport Sector

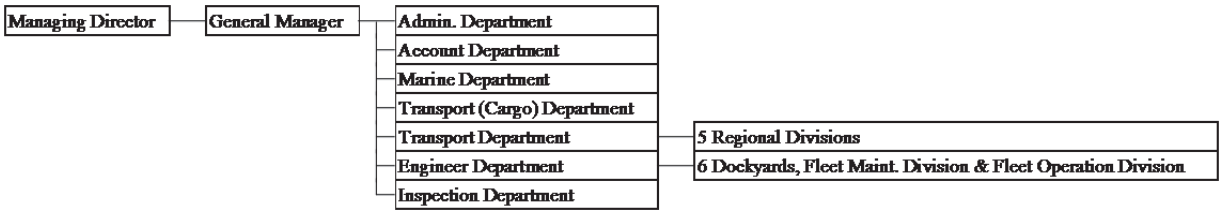
The Ministry of Transport (MOT) has four authorities related to inland water transport sector, Inland Water Transport (IWT), Directorate of Water Resources and Improvement of River System (DWIR), Myanmar Ports Authority (MPA), and Department of Marine Administration (DMA). Each authority has the following responsibilities:

4.3.1 Inland Water Transport (IWT)

(Responsibility)

- Provision of public passenger and cargo transport service using domestic inland waterways
- Own, maintenance of and repairing ships for inland water transport
- Own, operate and maintenance of public shipyards

(Organization)



Source: IWT

Figure 4.16 Organization of IWT

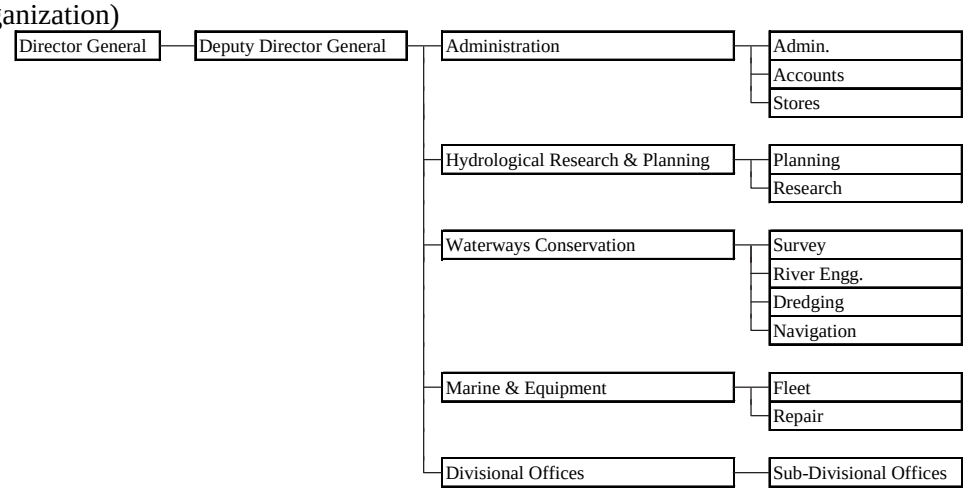
4.3.2 Directorate of Water Resources and Improvement of River System (DWIR)

(Responsibility)

- Maintenance and development of river channels and river ports
- Protection for erosion of riverbank
- Monitoring of the water level of rivers and provide warnings to relevant authorities for emergencies
- Development of water resources

・Engineering advice/recommendation for bridge design and construction river crossings
・Water quality monitoring of river water
・Maintenance dredging of river channels

(Organization)



Source: DWIR

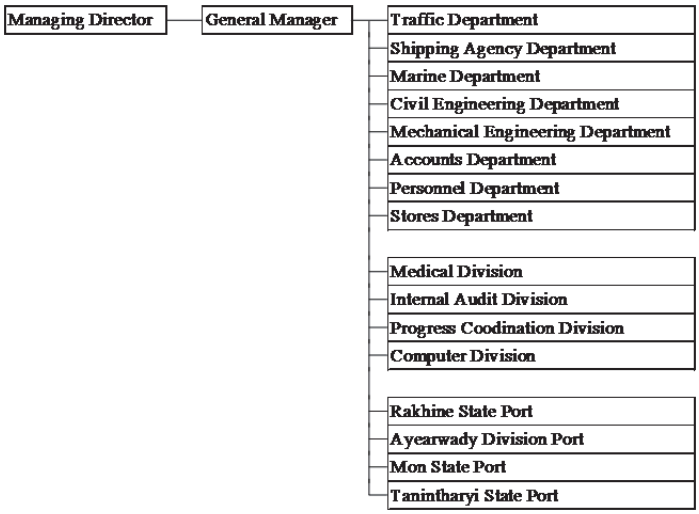
Figure 4.17 Organization of DWIR

4.3.3 Myanmar Ports Authority (MPA)

(Responsibility)

・Operation and management of international/domestic ports of Myanmar

(Organization)



Source: MPA

Figure 4.18 Organization of MPA

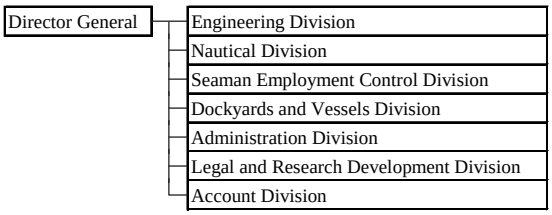
4.3.4 Department of Marine Administration (DMA)

(Responsibility)

・Safety management of registered vessels and safety management of ships' crews

- Human resources development for the marine administration sector
- Establishment and revisions of safety code for registered vessels
- Prevention measures for disasters at sea

(Organization)



Source: DMA

Figure 4.19 Organization of DMA

4.4 Future Subjects for Inland Water Transport Sector

4.4.1 River Ports

(1) Development of River Port Facilities

In Myanmar, a large volume of general cargoes, such rice and beans, are transported through inland waterways. For example, in Mandalay Port, the total volume of 600,000 tons of cargo, of which approximately 100,000 tons is handled by the IWT and 500,000 tons is handled by private operators, is handled by manual labor. The cargo is handled on the natural riverbank, but the inclined sandy riverbank is inadequate as a cargo yard.. During the flood season, the cargo yard shrinks due to the rise of the water level, which causes congestion in the public roads along the port area.

It is important to note that the main reason it is difficult to improve port facilities is because of the dramatic change in the water level between the seasons. Despite the fact that waterway transport has the important function to transport many life goods for people in the region, there is no berthing facility, nor suitable cargo yard in the river ports. The development and modernization of river ports is the most important and urgent subject for the government.

(2) Installation of Cargo Equipment

In Myanmar, 100% of cargo handling is performed by manual labor, because there is no berth on which cargo equipment can be used. Because of this, cargo must be small enough to be carried by laborers. In general, waterway transport is a useful way to transport large and heavy materials, but in Myanmar it is limited because of the lack of machinery at river ports.

It is assumed that the cargo handling efficiency of manual labor is approximately 30% of that of mechanical equipment handling. Port development requires the improvement of cargo handling efficiency from the view of getting enough revenue and for the effective use of invested properties. The change from labor handling to equipment handling is inevitable for improvement in the future.

(3) Improvement of River Channel

At present, the DWIR prohibits night sailings of cargo ships in the river channel for navigation safety reasons. The river channel is not in a stable condition as large seasonal water level changes are repeated every year. Although the river channel improvement project for the Ayeyarwady and Chindwin Rivers was recommended by the studies undertaken by UNDP in 1988 and 1993, the survey records are now old and require to be updated. Progress has been

inhibited by the annual budget granted by the government.

The improvement of the river channels is important in order to improve transportation efficiency and navigation safety. Improvement of river channels should be carried out at the same time as port development and the installation of cargo equipment.

(4) Improvement of Port Management Organization

Essentially, there are no port facilities in the river ports in Myanmar. Therefore government authorities have no experience in port management.

IWT operates ships of transportation service, and has few port facilities except for some small passenger floating pontoons. DWIR governs river channel maintenance, but it never manages river ports as the substantial meaning of the port.

In line with the port development project, the government authorities' capacity in port management should be substantially improved.

4.4.2 Ships Procurement

(1) Establish Clear Government Policy on Public Transportation Service

Though the aim of the IWT is public waterway transport service, private shipping operators are also running same services in the same routes of IWT. Passenger-cum-cargo ships of IWT are carrying only 20% of the total cargo, where private carriers are the major operators of inland water transport at present. Most of the cargo barges owned by IWT are leased to private operators, therefore cargo transport business is significantly carried only by private firms.

However, public waterway transportation still has an important function in the area of the Ayeyarwady Delta and upstream of the Chindwin as these areas do not have sufficient roadways and so the waterway is acting as people's life-line. Recent traffic record shows that the modal shift from waterway to roadway is accelerating. Passengers are changing their mind to select faster waterway service provided by private operators, although the fees are higher. The reasons of these recent changes are assumed that, first the growth of economy and second the delay in replacing of over-aged ships.

It is common and preferable during economic growth that passengers select better services, and that private operators grow and increase. However, public service with lower cost should be still important taking into account that the existing traffic volume was 1.1 million IWT ship users in 2012 in the city of Yangon.

It is important for the government to have a clear policy for improving public service with the condition that the government should not disturb or influence the sound and preferable growth rate of the private business market.

(2) Replacement of Over-aged Public Service Ships

Many of ships owned by IWT are too old and need to be replaced. About half of IWT ships are over 40 years old, including about 18% which are over 60 years old. The quality of service on passenger ships is very low, due to the lack of speed and the deteriorated condition of the passenger areas. . Similarly, cargo barges are also not suitable for safe transport service due to their age.

Although number of passengers is decreasing every year, there are still many IWT users because of cheaper fees. The over-aged ships have to be replaced as soon as possible. For cargo ships, the public service for leasing barges to private operators implies that the public sector could support financially weak small operators by leasing ships with low rental fees. It is also

important to replace old ships with new ships for cargo barges and tugs.

4.4.3 The Projects Supported by This Study

(1) River Port Development

In the second JCC (Joint Committee Meeting) of the main study "The Survey Program for The National Transport Development Plan In The Republic of The Union of Myanmar", the government of Myanmar requested to apply a feasibility study on developing six ports along Ayeyarwady and Chindwin Rivers.

・Bhamo Port (Shinkan Port)	Ayeyarwady River, Kachin State
・Mandalay Port	Ayeyarwady River, Mandalay Division
・Pakokku Port	Ayeyarwady River, Magwey Division
・Magwey Port	Ayeyarwady River, Magwey Division
・Kalawa Port	Chindwin River, Sagine Division
・Monywa Port	Chindwin River, Sagine Division

Upon receiving this request, The Study Team conducted site investigations and made a pre-evaluation of development priority based on available passenger/cargo transport statistics. The Study Team proposed the Mandalay Port development for the subject of this feasibility study and received the consent of Myanmar government.

(2) Ships Procurement

The following list is for the high priority acquisition of ships for IWT. The list was made by IWT for the purpose of making a request to the Japanese government for the application of official development assistance (ODA).

Rachine Division	High Speed Ferry 37.55m x 4.22m x 1.6m (Draft 1.24m)	2 nos
Delta Division	High Speed Ferry 37.55m x 4.22m x 1.6m (Draft 1.24m)	4 nos
Ayeyarwady Division	High Speed Ferry 37.55m x 4.22m x 1.6m (Draft 1.24m)	3 nos
Chindwin Division	High Speed Ferry 37.55m x 4.22m x 1.6m (Draft 0.8m)	2 nos
Cargo Division	PusherTug 24.8m x 7.3m x 2.9m	5 nos
Cargo Division	Barge 56.0m x 10.3m x 2.5m	4 nos
Cargo Division	Barge 65.0m x 15.0m x 3.0m	15 nos
Cargo Division	Barge 75.0m x 15.0m x 4.3m	2 nos

In this study, the above content of IWT's request is examined and the suitable sizes of the ships and their numbers are studied taking into account the existing situation of the public transportation service. The users of public waterway transport service are assumed to be people of low income. For cargo barge and pusher tugs, the development of the waterway route between Mandalay and Yangon is assumed to be in line with the proposed Mandalay Port development.

Chapter 5 Mandalay Port Development

5.1 Present Status of Mandalay Port

5.1.1 Overview of Mandalay City

Figure 5.1 shows the location of Mandalay.

Figure 5.1 Mandalay City

Mandalay was initially developed by King Mindon in 1859 and the city was the capital of the last, independent Burmese kingdom until 1885, when the country was finally conquered by British colonial forces.

Mandalay is located in the middle of Myanmar, 700km north of Yangon city. Myanmar is divided to seven Divisions and seven States. The Mandalay Division has a population of 8.6 million people. Mandalay city itself has 1.25 million, which makes it second largest city after Yangon.

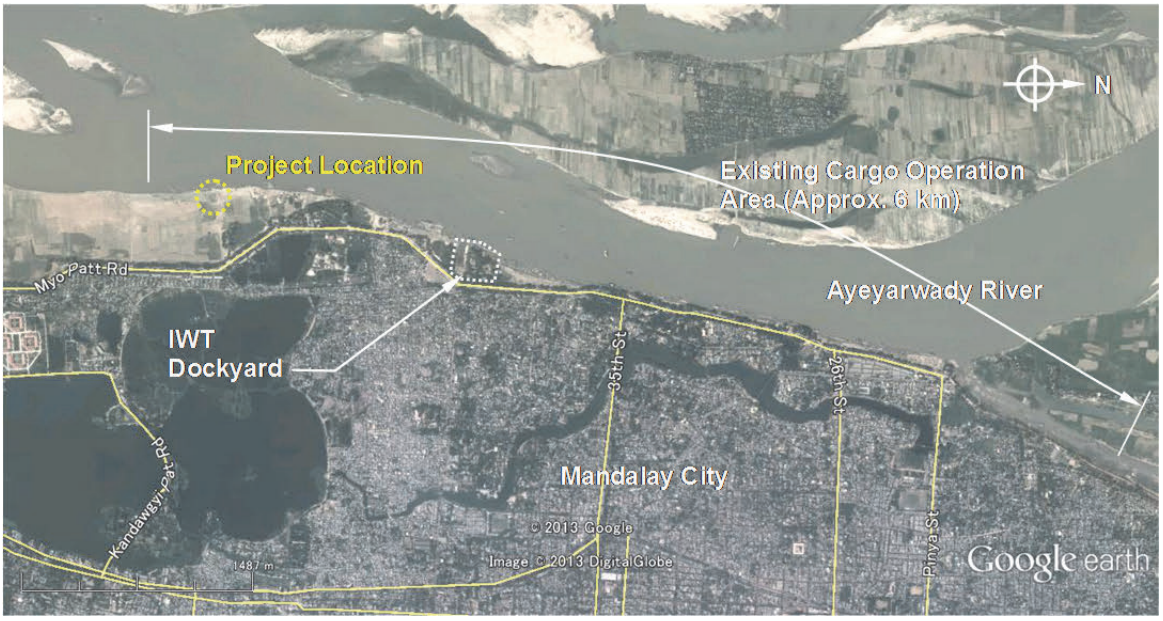
The major industries of Mandalay are, silk and its hand crafts, jade stone mining and production, hand-made statues of wood and stone, the Buddha statues made of marble and bronze, religious items of Buddhism, and brewing of beer and rum.

Mandalay is a strategically important transportation hub of the country. The city connects to national roads Rt. 1, Rt. 2 and an expressway which have access to Yangon. The railway also connects Yangon and Mandalay. Mandalay International Airport was built in 1999 and was financially supported by China. As for waterways, Mandalay is located near the Ayeyarwady River, which runs north-south in the country. The waterway carries import cargoes coming from the northern border with China. Mandalay port plays the role of a center between the waterways of the Chindwin and Ayeyarwady Rivers, as well as many regional ports along the Ayeyarwady River. Downstream, the Ayeyarwady River connects with the Yangon River by an artificial canal (Twante Canal), which allows waterway access to Yangon Port.

5.1.2 Port Facility

There are no cargo handling facilities along the Ayeyarwady River in Mandalay, except for a few floating jetties which are only for passenger use. The length of riverbank used for cargo loading and unloading is about 6km as shown Figure 5.2. Within the 6km of riverbank which is being used, the IWT operates cargo handling along 1km of riverbank between 35th street and the northern edge of the IWT dockyard. Near 35th street, IWT has a floating jetty for passengers. This station-jetty is an old ship which has been repurposed to be used as a jetty. The rest of the riverbank is used by private operators for handling cargo by manual labor, where many barges and passenger-cum-cargo ships are moored along the riverbank. Figure 5.3 shows the pictures of cargo stockpiling on the riverbank and the IWT floating jetty.

The location of the new port plan is about 1.5km south from IWT dockyard. (refer to “4.5 Selection of New Port Location” for reasons of the location)



Source: JICA Study Team draw on Google Earth Image

Figure 5.2 Location of New Port

Riverbank of Mandalay Port

Passenger Jetty of IWT

Source: JICA Study Team

Figure 5.3 Pictures of Riverbank and IWT Floating Jetty in Mandalay Port

5.1.3 Port Management

In Myanmar, there isn't a management body which controls and manages port facilities or oversees the operation of river ports. The following three authorities each have regional offices, all of whom play a different role according to the purpose of that authority.

(1) Directorate of Water Resources and Improvement of River Systems (DWIR)

DWIR is the organization under the Ministry of Transport which maintains river channels and river banks. Main management items are as follows:

- Survey and maintenance of river channels, planning and construction of river training facilities.
- Control/governing of riverbank as government owned land
- Monitoring the water level of the river and flood warnings

The riverbank is owned by the government and the area is supervised by DWIR. According to the law, the boundary between government land and city/private land is prescribed that the boundary is 15 feet from the line measured from the water line at the highest water level of the river. However, the actual boundary is not clear as no practical determination has been discussed between the government and other owners. The various facilities that have been built along the riverbank in Mandalay include the IWT dockyard, the DMA dockyard, oil jetties built by Ministry of Energy, private restaurants and Buddhist temples, including some facilities which were built before DWIR was founded in 1999. The law prescribes that permission from DWIR is needed when a new facility is built along the riverside.

(2) Inland Water Transport (IWT)

IWT owns ships (barges, tugs and passenger-cum-cargo ships) and operates public transportation services by those ships. At Mandalay Port, IWT owns a dockyard and a floating jetty (refer to Figure 5.4). IWT manages operations and the levying of passenger/cargo fees by operating passenger-cum-cargo ships. IWT cargo barges are for lending to private operators, in which IWT only takes leasing fees.

The IWT dockyard is located in the middle of the cargo handling riverbank, which has a slipway 50m wide and 180m long. The dockyard is for building and repairing of the barges and ships mainly owned by IWT, but sometimes they also take orders from private operators.

Source: JICA Study Team

Figure 5.4 Slipway of IWT Dockyard in Mandalay

(3) Department of Marine Administration (DMA)

DMA registers ships and manages the safety of waterway transport. In Mandalay, the DMA regional office inspects registration documents of all passenger and cargo ships which operate along the Mandalay riverside. DMA employs small ships to board ships for inspection and a slipway for the maintenance of the ships.

DMA started to establish the statistics of cargo and passengers for national inland waterways in 2013. The Mandalay office is collecting statistical data from private operators working along the Mandalay riverside.

5.1.4 Waterway Routes

There are various waterway routes to and from the Mandalay Port, which are operated not only by IWT but also by private operators.

Table 5.1 Waterway Routes from/to Mandalay Port

(1) IWT Routes

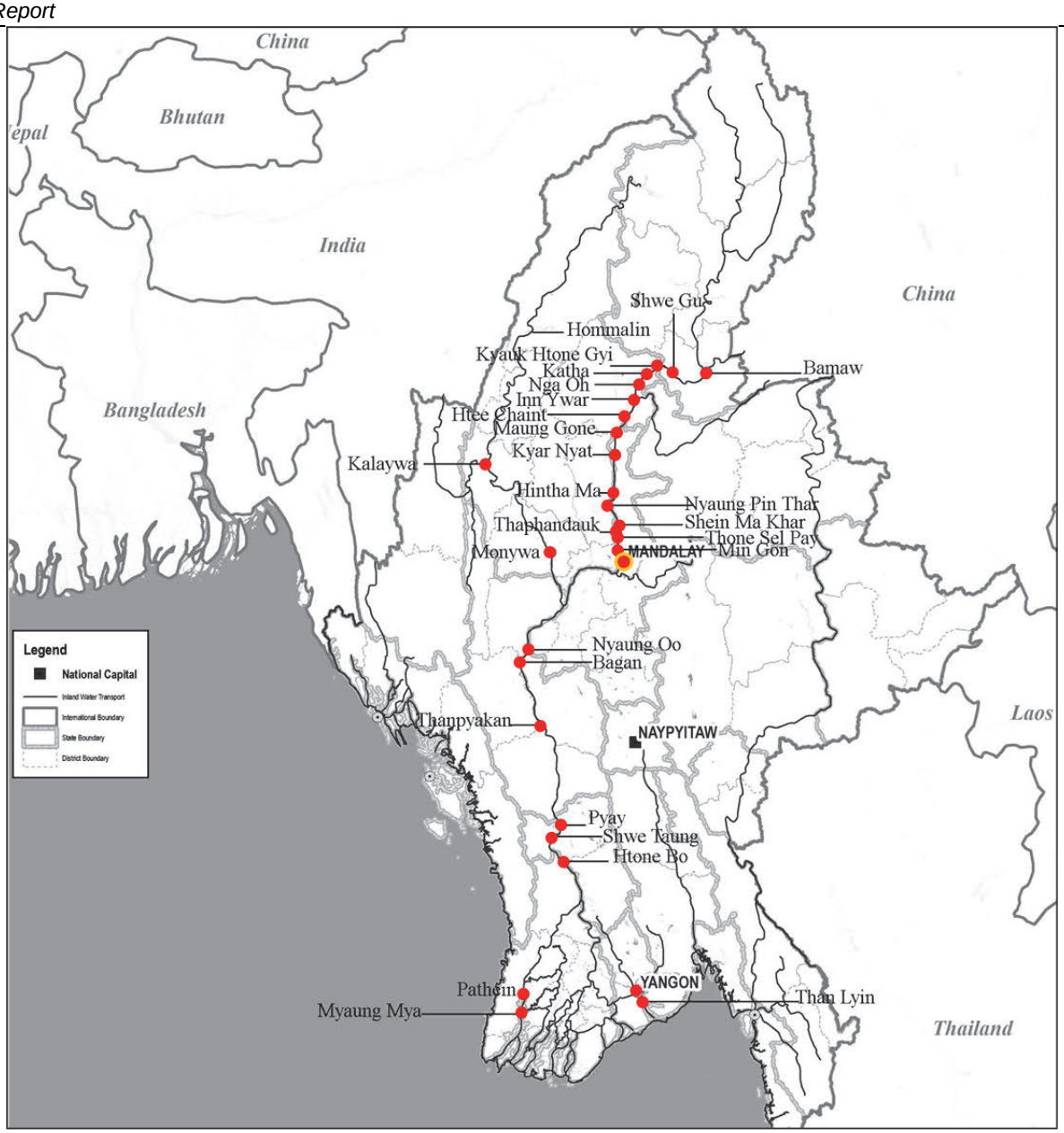
Route	Location
Mandalay - Bamaw	Ayeyarwady Upstream
Mandalay - Katha	Ayeyarwady Upstream
Mandalay - Nyaung Oo/Bagan	Ayeyarwady Downstream
Mandalay - Pyay	Ayeyarwady Downstream

Source: IWT

(2) Private Routes

Passenger		Cargo	
Route	Region	Route	Region
Mandalay-Sin Thae	Chindwin	Mandalay-Ka Lay Wa	Chindwin
Mandalay-Thaphan Daunk	Ayeyarwady Upstream	Mandalay-Homma Lin	Chindwin
Mandalay-Sheinmakar	Ayeyarwady Upstream	Mandalay-Mya Daung	Chindwin
Mandalay-Thone Sel Pay	Ayeyarwady Upstream	Mandalay-Takaung	Ayeyarwady Upstream
Mandalay-Hinthar Ma	Ayeyarwady Upstream	Mandalay-Shwe Gu	Ayeyarwady Upstream
Mandalay-Naung Pin Thar	Ayeyarwady Upstream	Mandalay-Ngar Oh	Ayeyarwady Upstream
Mandalay-Min Gyun	Ayeyarwady Upstream	Mandalay-Maung Gone	Ayeyarwady Upstream
Mandalay-Kathar	Ayeyarwady Upstream	Mandalay-Kyauk Htone Gyi	Ayeyarwady Upstream
Mandalay-Bamaw	Ayeyarwady Upstream	Mandalay-Kyar Nyuart	Ayeyarwady Upstream
Mandalay-Htone Bo	Ayeyarwady Downstream	Mandalay-Kathar	Ayeyarwady Upstream
Mandalay-Shwe Daung	Ayeyarwady Downstream	Mandalay-Inn Ywar	Ayeyarwady Upstream
Mandalay-Naung Oo	Ayeyarwady Downstream	Mandalay-Hti Chiaunt	Ayeyarwady Upstream
Mandalay-Pyay	Ayeyarwady Downstream	Mandalay-Pyay	Ayeyarwady Downstream
Mandalay-Bagan	Ayeyarwady Downstream	Mandalay-Than Payar Kan	Ayeyarwady Downstream
		Mandalay-Chauk	Ayeyarwady Downstream
		Mandalay-Yangon	Delta
		Mandalay-Myaung Mya	Delta
		Mandalay-Hinthata	Delta
		Mandalay-Shwe Daung	Delta
		Mandalay-Than Lyin	Delta
		Mandalay-Zalun	Delta
		Yangon-Kathar	Delta

Source: DMA



Source: IWT and DMA

Figure 5.5 Port Locations from/to Mandalay Port

5.1.5 Volume of Passenger and Cargo of Mandalay Port

(1) Passengers

Statistics collected by IWT shows that the number of passengers in the 2012 fiscal year (Apr. 2012 ~ Mar. 2013), including inbound and outbound to and from Mandalay Port using IWT ships, was 94,000. From statistics provided by DMA, the number of passengers on private ships in the period of Jan. ~ Jul. 2013 to and from Mandalay was 444,000. Statistics on private port users was established at the beginning of 2013, therefore a full year's data is not yet available. However, from the DMA data the number of passengers who used private ships is estimated at 761,000 in a year.

From these data, it is estimated that number of passengers using Mandalay Port is 850,000 in a year, of which 10% are IWT ship users and 90% are private ships users.

Table 5.2 Number of Passengers of Mandalay Port

(1) IWT Users

Month	By Passenger cum Cargo Ship		
	IN	OUT	TOTAL
Apr-2012	4,811	4,461	9,272
May-2012	5,392	5,402	10,794
Jun-2012	4,004	4,717	8,721
Jul-2012	5,009	5,187	10,196
Aug-2012	4,934	5,092	10,026
Sep-2012	5,543	4,190	9,733
Oct-2012	5,911	4,867	10,778
Nov-2012	4,717	3,457	8,174
Dec-2012	2,898	2,115	5,013
Jan-2013	2,433	1,340	3,773
Feb-2013	2,060	1,226	3,286
Mar-2013	2,807	1,770	4,577
TOTAL	50,519	43,824	94,343

Source: IWT

(2) Private Ships Users

Month	By Passenger cum Cargo Ship (ton)		
	IN	OUT	TOTAL
Jan-2013	34,172	34,016	68,188
Feb-2013	21,344	32,503	53,847
Mar-2013	25,320	39,574	64,894
Apr-2013	21,001	31,875	52,876
May-2013	24,139	37,435	61,574
Jun-2013	28,805	40,240	69,045
Jul-2013	29,066	44,402	73,468
TOTAL	183,847	260,045	443,892

Source: DMA

A majority of passengers traveling to and from Madalay Port are using northern routes along the Ayeyarwady River. For instance in Table 5.2 (1), 62% of passengers take the Mandalay-Bhamo route, while only 6% take the Mandalay-Pyey route. The main reason for this difference is that many passengers using downstream routes from Mandalay can use road transportation by busses because Rt.1, Rt.2 and the expressway are available. Contrary to this, the roads upstream from Mandalay are still poorly developed, and so passengers need to use the waterways.

Table 5.3 shows a comparison in travel time and ticket fees between Mandalay and Bhamo/Pyey. From this table, it can be seen why passengers might chose the bus because the travel time is shorter in spite of the fact that the ticket fee is higher for the Mandalay-Pyey route.

Table 5.3 Travel Time and Ticket Fee from Mandalay to Bhamo/Pyey

Travel Time

Trans. Mode	Operator	Mandalay - Bhamo	Mandalay - Pyey
Waterway	IWT	Mandalay→Bhamo 2~3 days Bhamo→Mandalay 1.5~2 days	Pyey→Mandalay 3 days Mandalay→Pyey 5 days
Roadway (Bus)	Private	18hrs	11hrs

Transportation Fee / Person (Kyat)

Trans. Mode	Operator	Class	Mandalay - Bhamo	Mandalay - Pyey
Waterway	IWT	Ordinary	1,930	3,340
		Upper	5,790	6,680
Roadway (Bus)	Private	Ordinary	13,000	10,000

Source: JICA Study Team

(2) Cargo

According to the data provided by IWT, the volume of cargo handled by IWT at Mandalay Port in the 2012 fiscal year was 100,000 tons. DMA data shows the cargo volume from Feb. to Jul. 2013 was 240,000 tons, and so the yearly volume of cargo handled by private operators is assumed to be 500,000 tons. From these figures, the total cargo volume (general cargo) of Mandalay Port is assumed to be 600,000 tons/year.

Table 5.4 Cargo Volume of Mandalay Port

(1) IWT

Month	By Passenger cum Cargo Ship		
	IN (t)	OUT (t)	TOTAL (t)
Apr-2012	4,203	5,171	9,374
May-2012	5,497	5,597	11,094
Jun-2012	4,717	5,486	10,203
Jul-2012	2,629	5,460	8,089
Aug-2012	2,122	4,713	6,835
Sep-2012	2,418	5,110	7,528
Oct-2012	2,068	4,970	7,038
Nov-2012	2,098	4,193	6,291
Dec-2012	2,309	4,238	6,547
Jan-2013	2,959	4,678	7,637
Feb-2013	4,473	5,804	10,277
Mar-2013	4,901	5,590	10,491
TOTAL	40,394	61,010	101,404

Source: IWT

(2) Private

Month	Passenger cum Cargo Ship			Cargo Barge			Total (t)
	In (t)	Out (t)	Total (t)	In (t)	Out (t)	Total (t)	
Feb-2013	343	11,490	11,833	33,291	1,155	34,446	46,279
Mar-2013	356	12,665	13,021	35,721	3,598	39,319	52,340
Apr-2013	651	10,478	11,129	20,838	2,985	23,823	34,952
May-2013	720	10,846	11,566	24,422	1,965	26,387	37,953
Jun-2013	621	12,898	13,519	32,547	1,685	34,232	47,751
Jul-2013	573	11,308	11,881	21,299	4,456	25,755	37,636
TOTAL	3,264	69,685	72,949	168,118	15,844	183,962	256,911

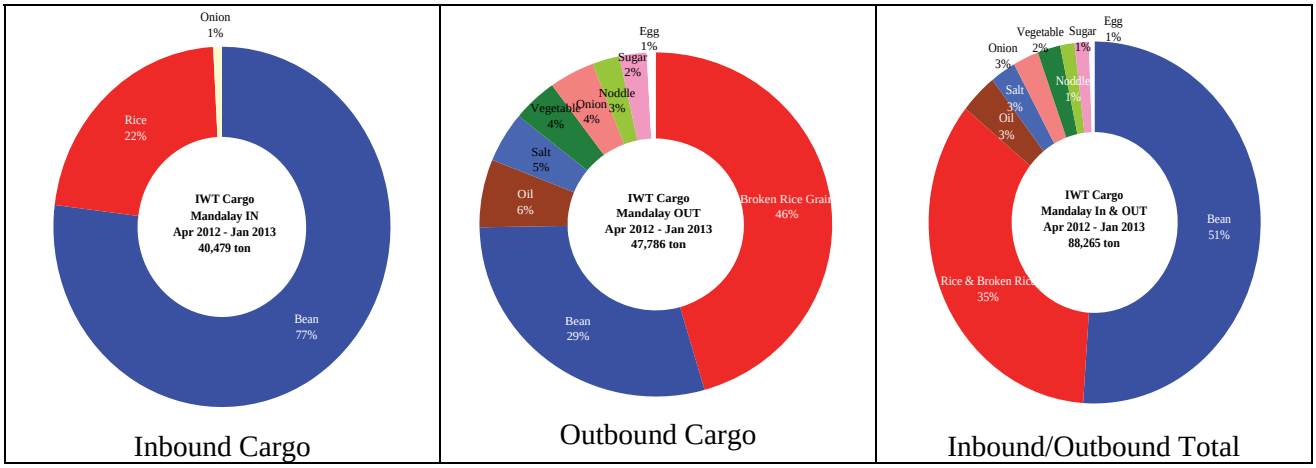
Note: Exclude liquid cargo, wooden logs, and sand/stone.

Source: DMA

With respect to the origin and destination of cargo to and from Mandalay Port, 80% of cargo is carried to and from Bhamo Port, according to IWT data. Katha Port handles the second largest share at 12%. On the other hand, Pyey, which is downstream, handles only 3%. The origin and destination of cargo carried by private operators varies over wider regions, upstream and downstream of the Ayeyarwady River within approximately 100 miles from Mandalay, up and downstream along the Chindwin River and extends into the area toward the delta region of the Ayeyarwady.

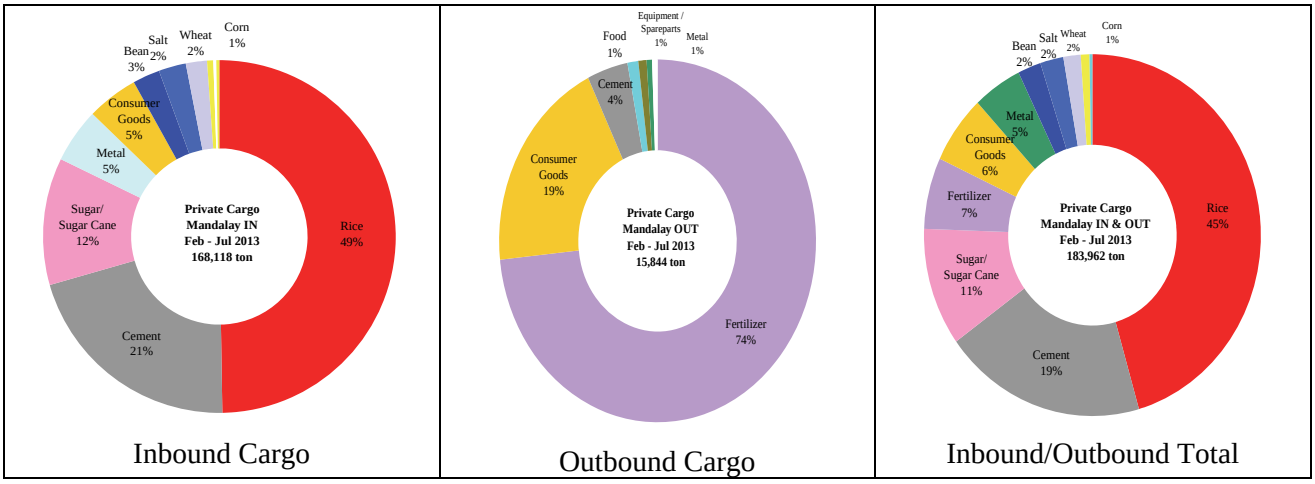
5.1.6 Cargo Types

Table 5.3 and Table 5.4 show the types of cargo handled by IWT and private operators respectively. Major cargo types carried by IWT are rice and beans. Private operators carry rice, cement, sugar/sugarcane and fertilizer. The most of these cargoes are carried in the form of 50kg bags.



Source: IWT 2012.4~2013.1

Figure 5.6 Cargo Types of Mandalay Port



Source: DMA 2013.2~2013.7

Figure 5.7 Cargo Types of Mandalay Port

5.2 Development Concept

5.2.1 Equipment Cargo Operation

In Mandalay Port, all cargo operations are carried out by manual labor using the natural riverbank of the Ayeyarwady River. The length of riverbank for cargo operation is 5 ~ 6 km. The new port development aims to introduce cargo equipment and to target the modernization of the existing port system.

In modernizing port operations, first it is important to change the current method for handling cargo into a system that will utilize a berth facility, and then introduce equipment for handling cargo. However, looking at the existing operation, it would not be practical to change over all manual operations to equipment operation within a short time scale. The reasons are as follows:

1) Rapid change to equipment operation requires huge investments on facilities and equipment in a short period. This is not practical taking into account the present government budget sources.
2) Most cargo ships are a type of "passenger-cum-cargo ship", which have a roof. Because cargoes are stored under the roof, it is not possible to lift the cargo from these ships by using a crane.
3) In general, when equipment is used in handling cargo, there is less work for laborers. Rapid change might cause an increase of unemployment for the port workers.

From these viewpoints, it is proposed that the Mandalay new port development should have a "pilot project" to achieve partial equipment operation, and it should be continued to change over a certain time period until the change is complete.

5.2.2 Introduction of Unit Cargo

In order to use cargo equipment, it is necessary to put the existing break-bulk cargo into units. Containers are the most advantageous cargo units to use, but pallets are also easy and convenient. In addition, containers are the most efficient cargo unit used in ocean transportation. However, in Mandalay (as well as in all inland waterways in Myanmar), no container cargoes are utilized at present. It is recommended that the transport industry should adjust gradually, initially changing to "palletization", and in the future, changing to "containerization".

Therefore, the proposed new port will be designed with the initial target to handle pallet cargo, and then will be made capable to handle containers.

5.2.3 Scale of Development

The types of cargo handled at Mandalay Port are divided into the following groups:

1) Liquid cargo such as oil and diesel
2) Wooden logs and its products
3) Pure bulk cargo such as sand, stones and coal
4) Bagged cargo (mainly 50kg bags) such as rice and beans
5) General cargo such as consumer goods and foodstuffs
6) General cargo such as steel and equipment spare parts

The new port will be designed for general cargo, covering the above groups 4), 5) and 6), which do not require particular cargo equipment or facilities. The volume of general cargo handled in Mandalay Port is estimated at 600,000 tons/year, of which IWT carries 100,000 tons and the rest is carried by private operators. The pilot project covers the 100,000 tons of IWT public service in the opening phase, after which the plan is pre-set to gradually include private port operators. The new port will be expanded in accordance with the increase of demand.

Therefore, the initial development scale is set with the cargo handling capacity at approximately 250,000 tons/year.

5.3 Natural Conditions Field Survey

In this Section, the geotechnical survey and the topographic survey, including the river condition survey, are summarized as a natural conditions survey result as follows.

5.3.1 Geotechnical Survey

(1) Survey Location and Quantities

Soil investigations were carried out on three candidate areas for jetty and cargo yard construction in order to understand the ground conditions. The locations of the survey points are shown in Figure 5.8. Of these seven points, three points are located on water and four points are on land as shown in Figure 5.9. Quantities of the soil investigations are shown on Table 5.6.

Figure 5.8 Location Map of Soil Investigation

Figure 5.9 Condition of Soil Investigation on Water and on Land

Table 5.5 Location of Survey Points

Item	Bore Hole Number	Co-ordinate E	Co-ordinate N	Elevation (m)
1	BH-01	21.965306°	96.054733°	60.457
2	BH-02	21.965085°	96.055976°	72.330
3	BH-03	21.961143°	96.052603°	62.889
4	BH-04	21.960900°	96.054630°	72.180
5	BH-05	21.947208°	96.049659°	63.579
6	BH-06	21.947200°	96.050510°	68.589
7	BH-07	21.948198°	96.053499°	66.649

Table 5.6 Survey Items and Quantities

No.	BH. No.	Soil drilling(m)				※ Standard Penetration Test (Nos)	※ Undisturbed Sampling (Nos)	Water sample (Nos)	Remarks
		127 mm (Ø)	115 mm (Ø)	64 mm (Ø)	Total (m)				
1	BH-01	7.0	-	23.0	30.0	30	-	1	River
2	BH-02	-	2.0	38.0	40.0	39	2	1	Land
3	BH-03	7.0	-	18.0	25.0	25	-	1	River
4	BH-04	-	2.0	34.0	36.0	33	3	1	Land
5	BH-05	3.0	-	22.0	25.0	25	-	1	River
6	BH-06	-	3.0	30.0	33.0	32	1	1	Land
7	BH-07	-	2.0	37.0	39.0	36	3	1	Land
Total		**17.0**	**9.0**	**202.0**	**228.0**	**220**	**9**	**7**	**-**

※For sampling, soil was taken by Standard Penetration Test and Undisturbed Sampling, and the following soil laboratory tests were carried out;

<Physical property test>
- Natural Moisture Content Test
- Specific Gravity Test
- Particle Size Analysis Test
- Atterberg's Limits Test

<Engineering property test>
- Consolidation Test
- Unconfined Compression Test
- Direct Shear Test

<Chemical property test>
- Water Quality Test

(2) Soil Profile

In the survey area, the following six layers were confirmed. Soil profiles are shown in Figure 5.10 to Figure 5.12. The result of Standard Penetration test (N-value) is shown in Figure 5.13.

1) Sandy Clay
2) Silty Sand-1
3) Clay-1
4) Silty Sand-2
5) Clay-2
6) Sand

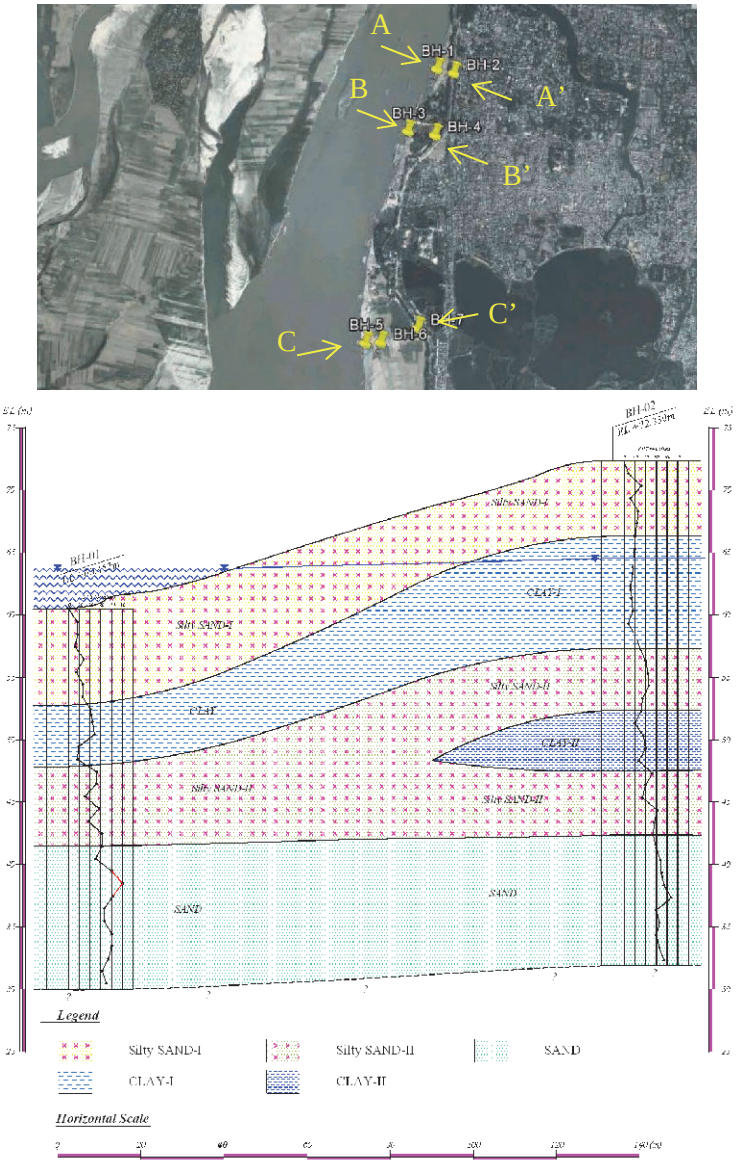


Figure 5.10 Soil profile (A –A')

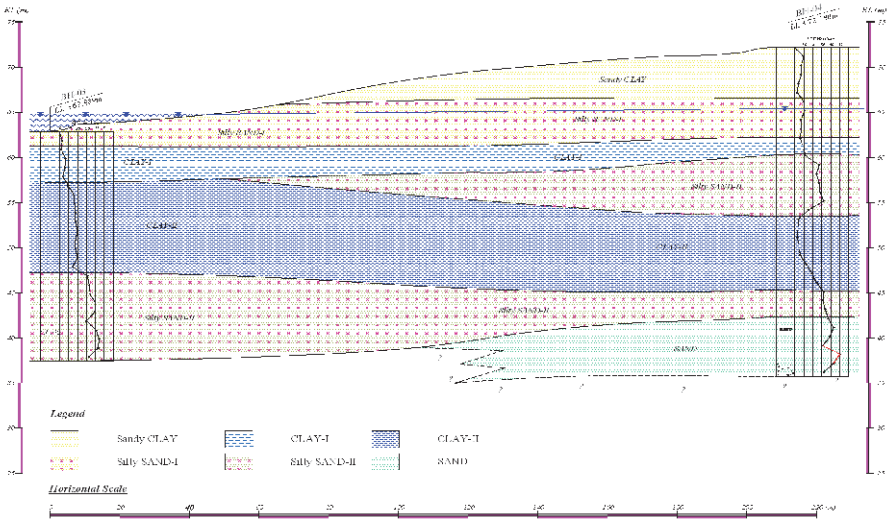
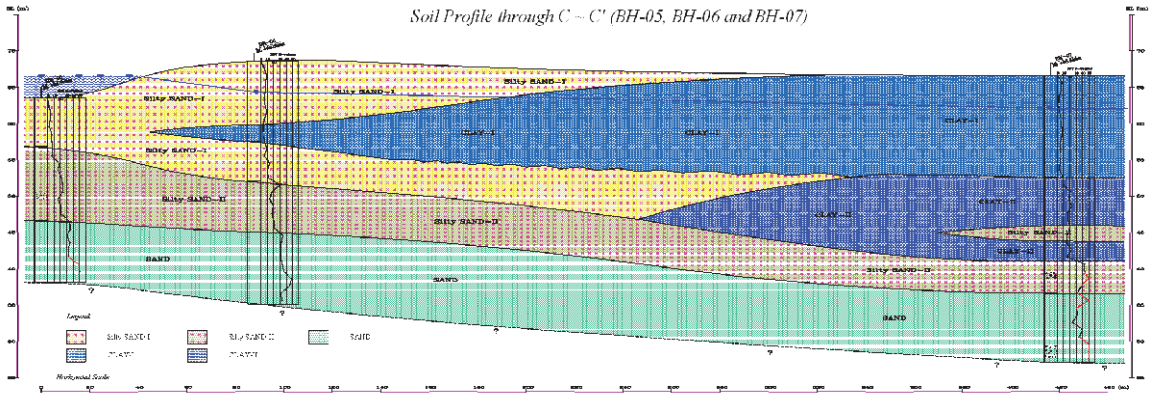


Figure 5.11 Soil profile (B –B')



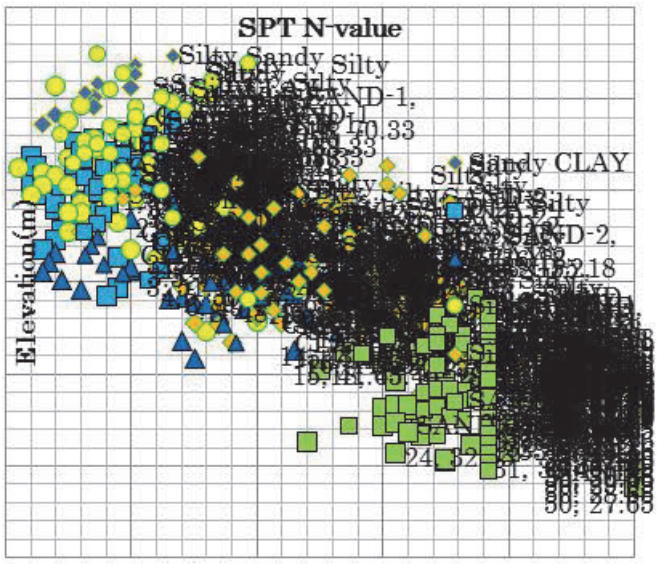


Figure 5.12 Soil profile (C –C')

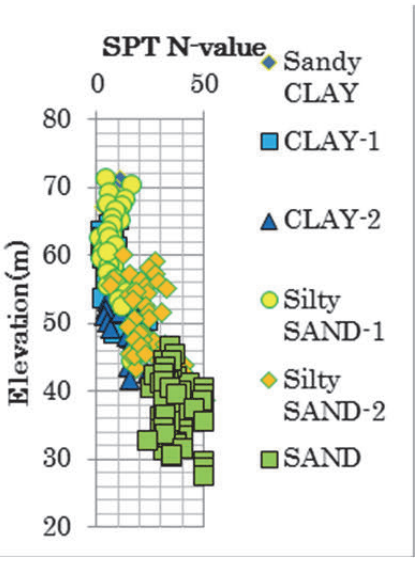


Figure 5.13 Result of Standard Penetration Test (N-value)

(3) Soil test Result

The soil test results for the physical property and the engineering property tests are shown in Figure 5.14 to Figure 5.21.

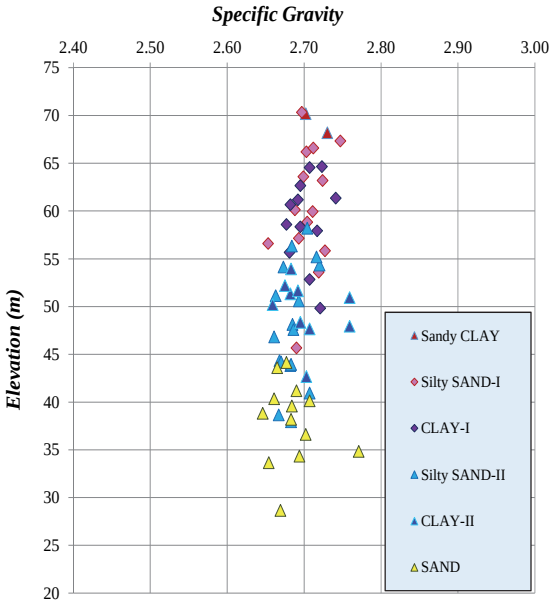


Figure 5.14 Depth Vs Specific Gravity

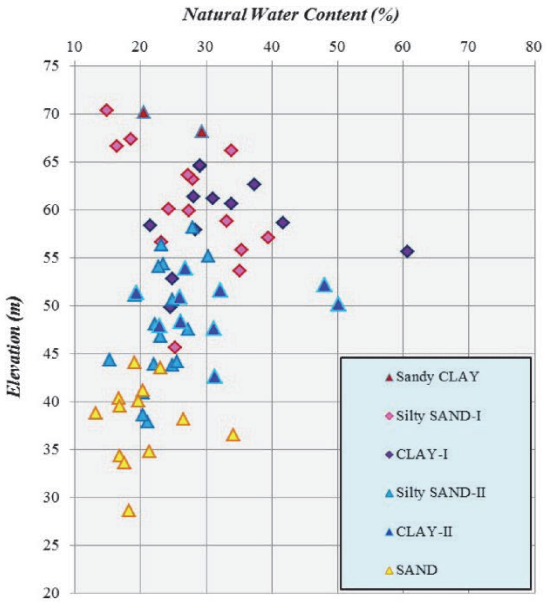


Figure 5.15 Depth Vs Natural Water Content

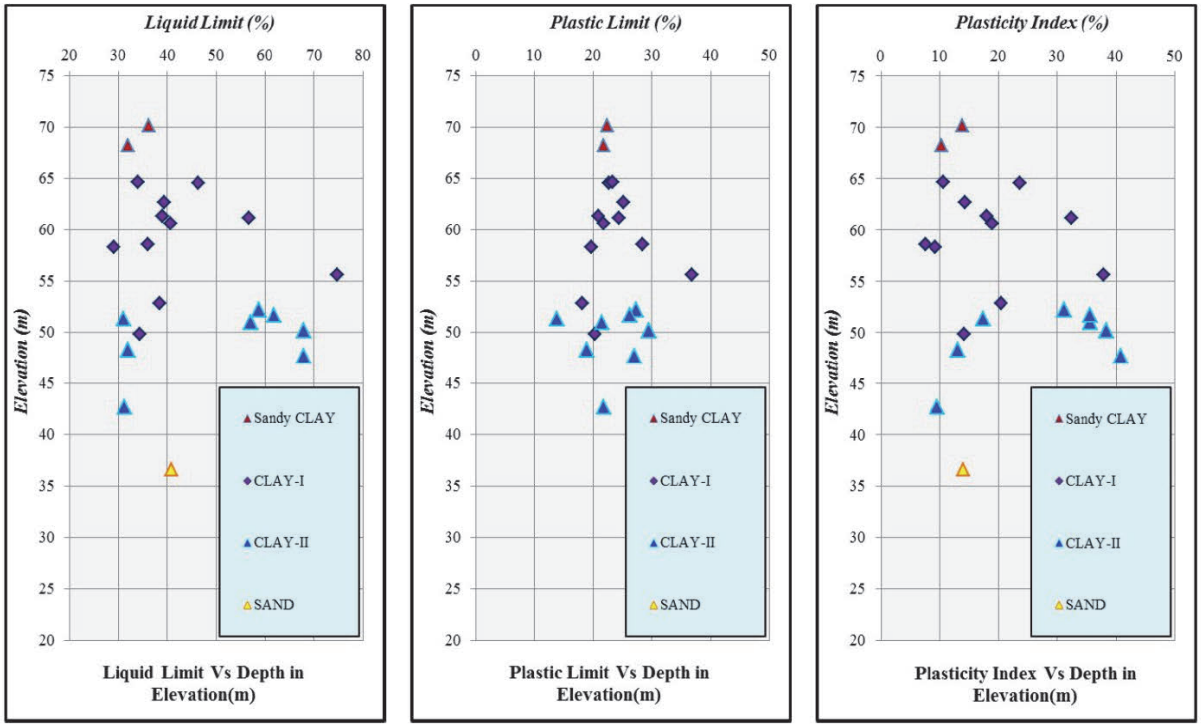


Figure 5.16 Depth Vs Atterberg's Limit Test Result

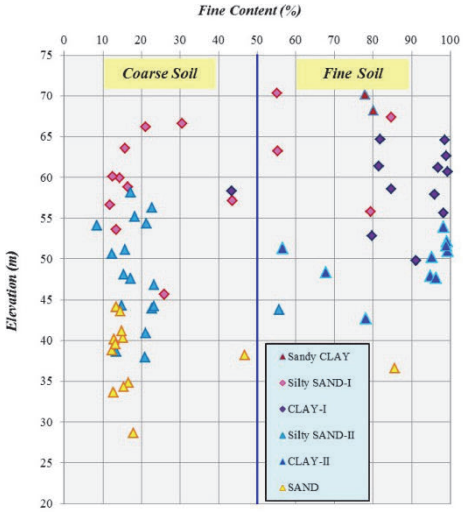


Figure 5.17 Depth Vs Fine Content of Soil

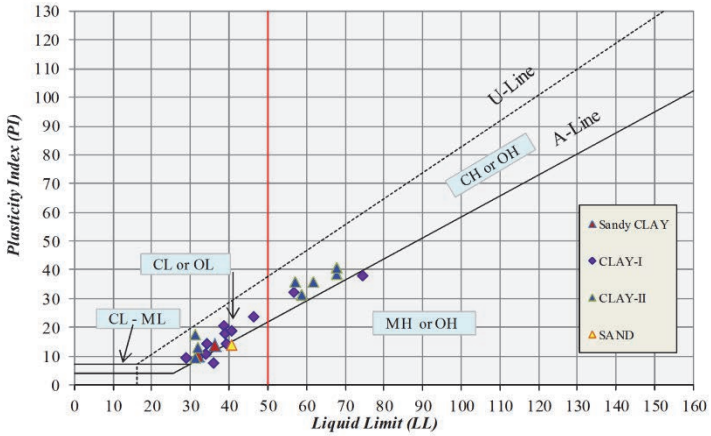


Figure 5.18 Soil Classification Chart

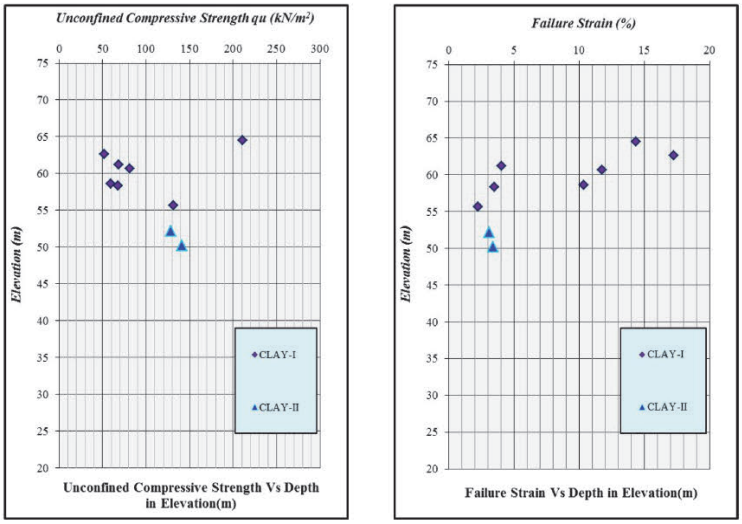


Figure 5.19 Depth Vs Unconfined Compression Test Result

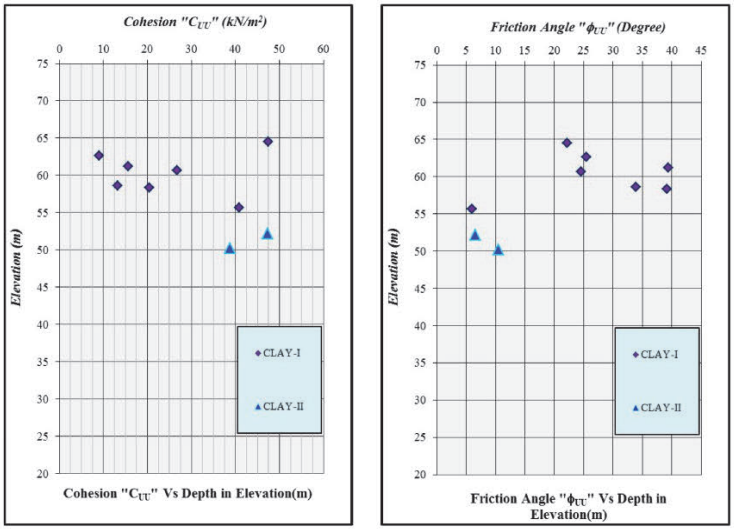


Figure 5.20 Depth Vs Direct Shear Test Result

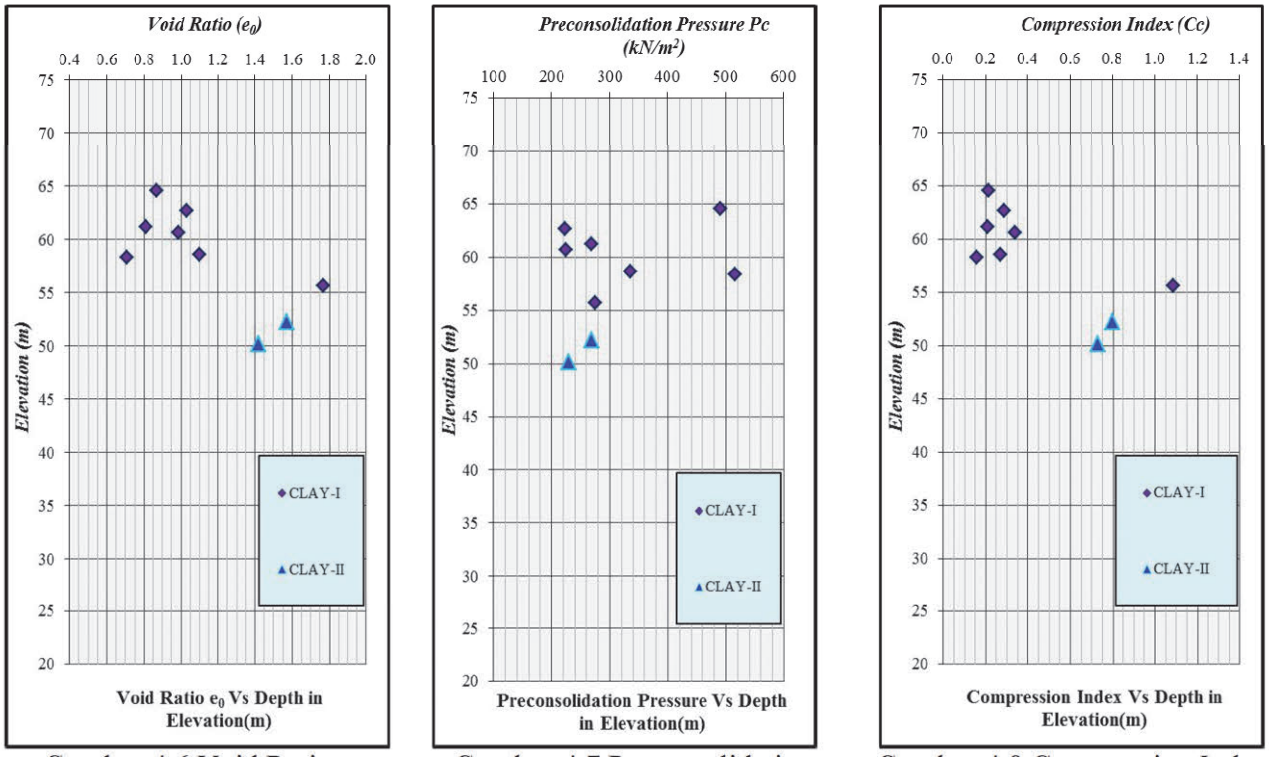


Figure 5.21 Depth Vs Consolidation Test Result

5.3.2 Topographic and Bathymetric Survey

(1) Survey Items

- Topographic and Bathymetric Survey: Three (3) candidate locations for the jetty and cargo yard, and the existing cargo and passenger yard as shown in Figure 5.22.
- River Cross Section Survey : 18 km along the river at 1,000m or 250m interval as shown in Figure 5.23.
- River Condition Survey: Seven (7) points of river flow survey as shown in Figure 5.25. Three (3) points of river bottom sediment survey.

(2) Work Quantity

1) Topographic Survey on land

Table 5.7 Topographic Survey on Land

Survey Area	Work Volume	Remarks
Upper Area (Existing cargo/passenger yard including Port Location Option-1)	16 Ha (3200m * 50m)	Refer to Figure 5.22
Lower Area (Including Port Location Option-2, 3)	34 Ha (1700m * 200m)	

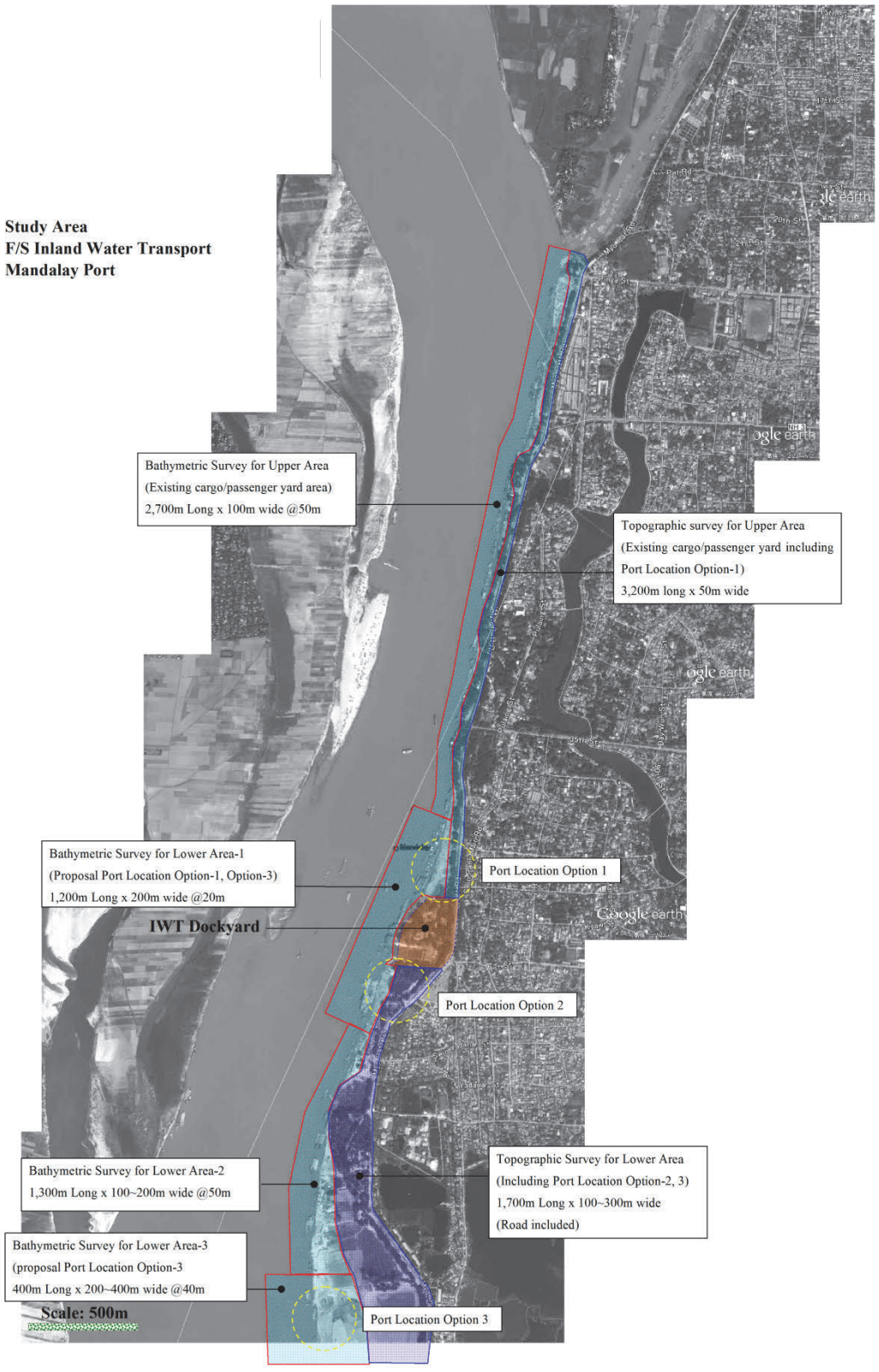


Figure 5.22 Location Map of Topographic Survey

2) Bathymetric Survey

Table 5.8 Bathymetric Survey

Survey Area	Work Volume	Remarks
Upper Area (Existing cargo/passenger yard)	13.6 km (2700m *100m @50m)	Refer to Figure 5.22
Lower Area -1 (Proposal port location Option -1 and Option - 2)	18.2 km (1200m *200m @20m)	
Lower Area -2	9.25 km (1300m *150m @50m)	
Lower Area -3 (Proposal port location Option -3)	6.1 km (400m *300m @40m)	

3) River Cross Section Survey

18 km along the river at 1,000m or 250m intervals as shown in Figure 5.23.

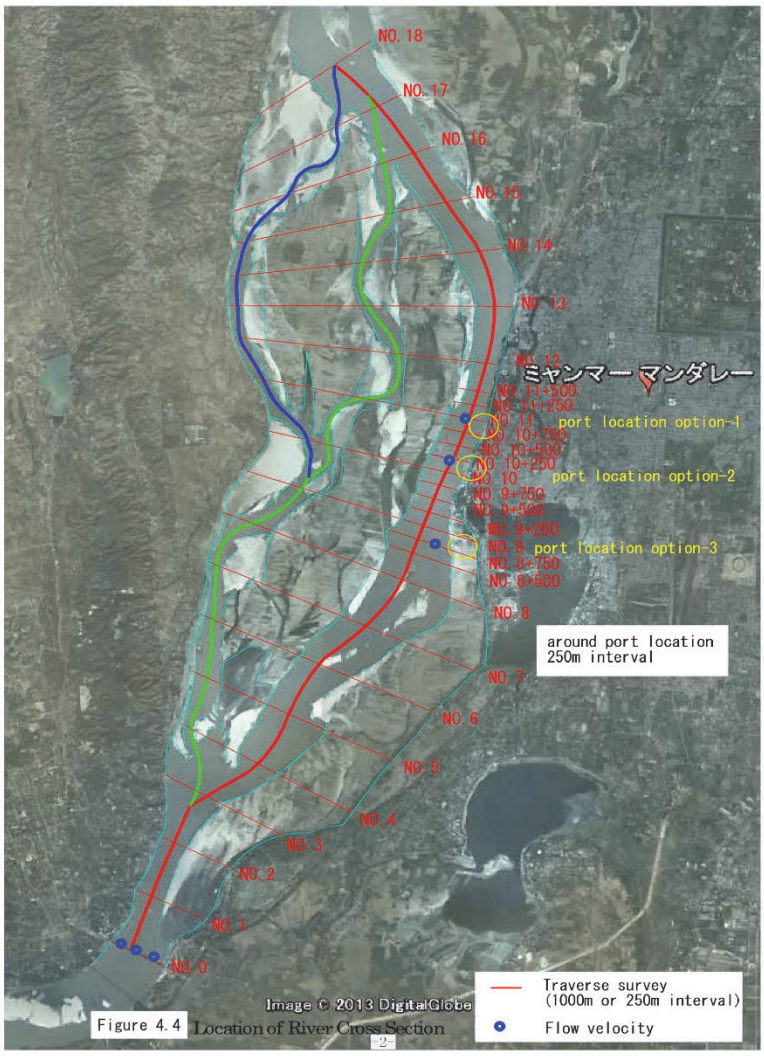


Figure 5.23 Location Map of Cross Section Survey

4) River Condition Survey

The three (3) points of river bottom sediment survey and seven (7) points of river flow survey as shown in Table 5.9 and Table 5.10.

a) River Bottom Sediment Survey

Table 5.9 Coordinate of Sediment Sampling Points

Sr.No.	Sampling Point	Co-ordinate (Lati)	Co-ordinate (Long)
1	RBS-01	21.96134°	96.04976°
2	RBS-02	21.91766°	96.02308°
3	RBS-03	21.87739°	96.99657°

Figure 5.24 Location Map of River Bottom Soil Sampling

b) River Water Velocity Survey

Table 5.10 The Coordinates of River Velocity Flow Survey

Point No.	Latitude	Longitude	Depth to river bed (m)*
option1	21.96830833	96.05383333	12.4
option2	21.96132500	96.05119444	10.8
option3	21.94619444	96.04833056	6.9
option4	21.90514167	96.01447778	10.2
NO.0_1	21.87610833	95.99924167	9.3
NO.0_2	21.87739167	95.99656944	12.4
NO.0_3	21.87862500	95.99396944	10.6

Figure 5.25 Location Map of Cross Section Survey

(3) Survey Result

The topographic survey and bathymetric survey results are referred to in the report submitted by a local subcontractor. In this section, the river condition survey result is described.

1) River Bottom Sediment Survey

The bucket sampler is Rigo Brand, mouth trap type 5141 AW stainless steel. Working procedure includes soil sampling with the performing of laboratory tests associated with grain size distribution.

The grain size distribution curve is shown from Figure 5.27 to Figure 5.29.

Figure 5.26 Sediment Soil Sampling Condition

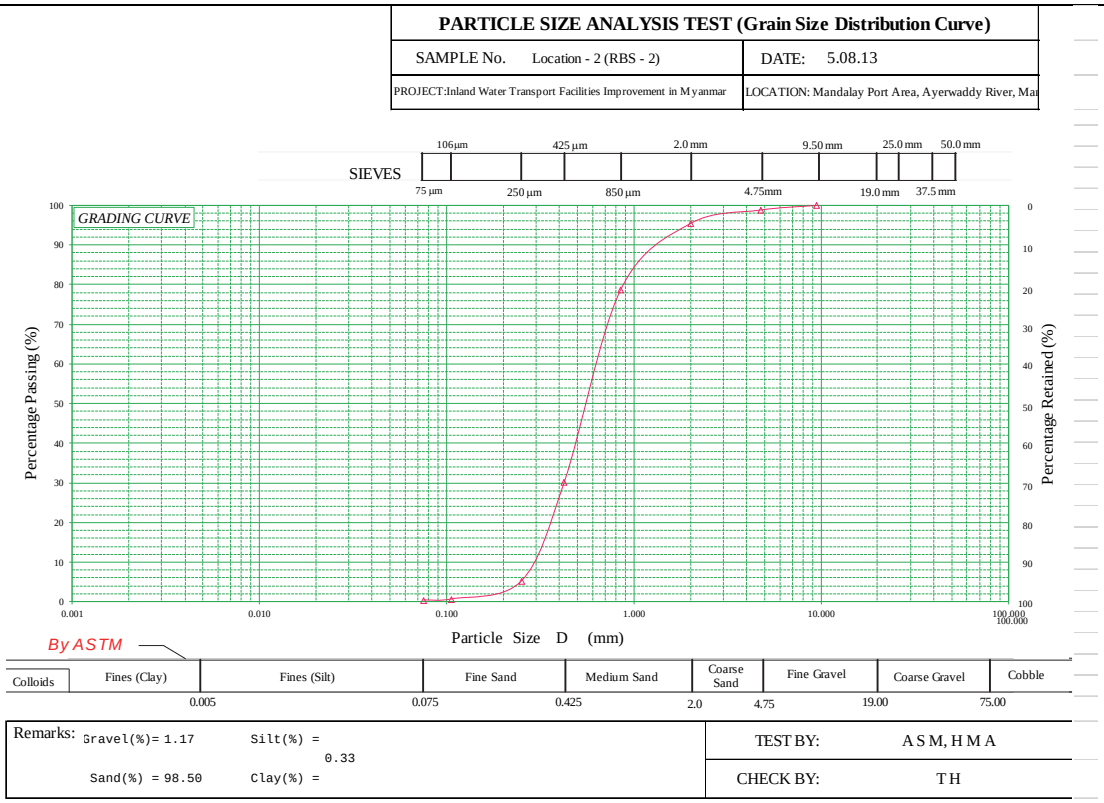


Figure 5.27 Grain Size Distribution Curve of Sediment Soil

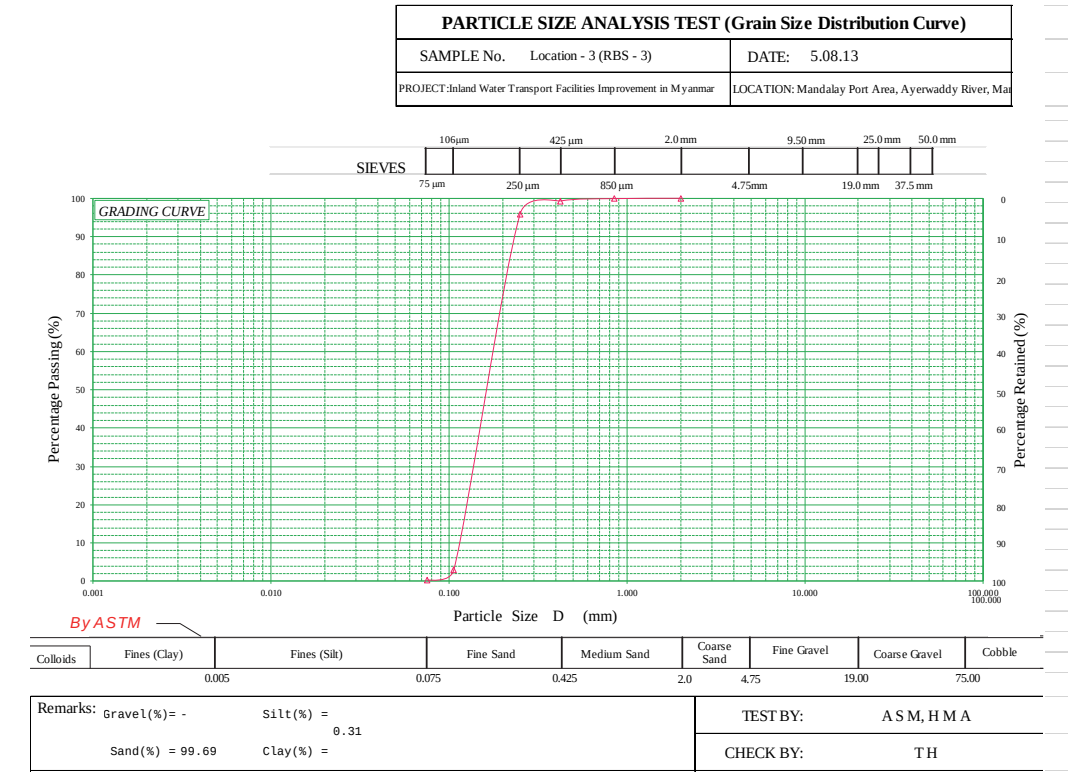


Figure 5.28 Grain Size Distribution Curve of Sediment Soil

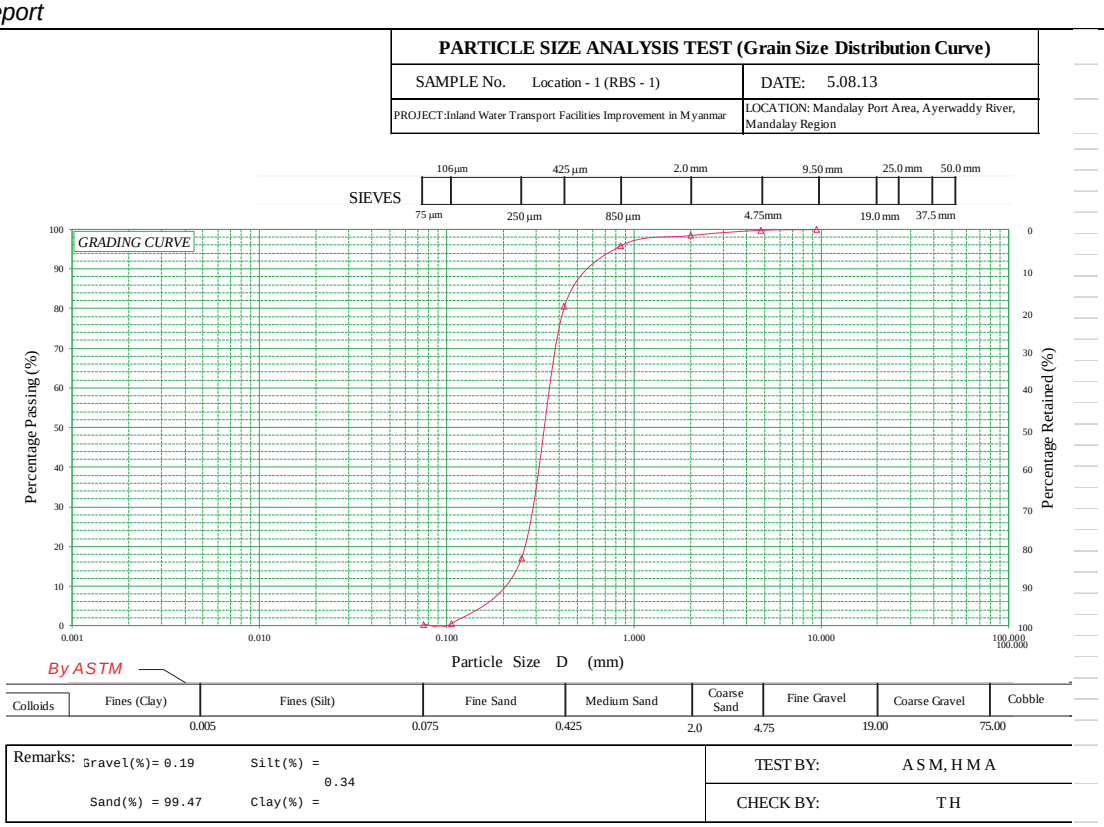


Figure 5.29 Grain Size Distribution Curve of Sediment Soil

2) River Water Velocity Survey

The river velocity work was carried out along the Ayeyarwaddy River near Mandalay Port to upstream of the Sagaing Bridge. The river velocity survey was done by a Kenker river velocity survey instrument of LP 30 model. The survey condition is as shown in Figure 5.30 and the survey result is as shown in Table 5.11.

Figure 5.30 Work condition of River water Velocity Survey

Table 5.11 River Water Velocity Survey Result

Station No	Depth of measure-m)	Trial	Velocity	Average Velocity	Units	Water depth (m)
OP-1	2.5	1st	1.796		m/s	12.3, 12.2, 12.7
OP-1	2.5	2nd	1.812		m/s	
OP-1	2.5	3rd	1.868	1.825	m/s	
OP-1	4.0	1st	1.552		m/s	
OP-1	4.0	2nd	1.651		m/s	
OP-1	4.0	3rd	1.549	1.584	m/s	
OP-2	2.0	1st	1.599		m/s	11.0, 10.6, 10.7
OP-2	2.0	2nd	1.545		m/s	
OP-2	2.0	3rd	1.576	1.573	m/s	
OP-2	4.0	1st	1.579		m/s	
OP-2	4.0	2nd	1.613		m/s	
OP-2	4.0	3rd	1.582	1.591	m/s	
OP-3	1.5	1st	1.347		m/s	7.0, 6.9, 6.9
OP-3	1.5	2nd	1.316		m/s	
OP-3	1.5	3rd	1.294	1.319	m/s	
OP-3	4.0	1st	1.169		m/s	
OP-3	4.0	2nd	1.249		m/s	
OP-3	4.0	3rd	1.246	1.221	m/s	
OP-4	2.0	1st	1.323		m/s	10.3, 10.1, 10.2
OP-4	2.0	2nd	1.305		m/s	
OP-4	2.0	3rd	1.311	1.313	m/s	
OP-4	4.0	1st	1.330		m/s	
OP-4	4.0	2nd	1.366		m/s	
OP-4	4.0	3rd	1.289	1.328	m/s	
Location No.0_1	2.0	1st	0.565		m/s	9.3, 9.3, 9.2
Location No.0_1	2.0	2nd	0.491		m/s	
Location No.0_1	2.0	3rd	0.484	0.513	m/s	
Location No.0_1	4.0	1st	0.387		m/s	
Location No.0_1	4.0	2nd	0.411		m/s	
Location No.0_1	4.0	3rd	0.462	0.420	m/s	
Location No.0_2	2.5	1st	1.829		m/s	12.4, 12.5, 12.4
Location No.0_2	2.5	2nd	1.983		m/s	
Location No.0_2	2.5	3rd	1.972	1.928	m/s	
Location No.0_2	4.0	1st	1.674		m/s	
Location No.0_2	4.0	2nd	1.830		m/s	
Location No.0_2	4.0	3rd	1.789	1.764	m/s	
Location No.0_3	2.0	1st	1.818		m/s	10.7, 10.6, 10.6
Location No.0_3	2.0	2nd	1.864		m/s	
Location No.0_3	2.0	3rd	1.904	1.862	m/s	
Location No.0_3	4.0	1st	1.555		m/s	
Location No.0_3	4.0	2nd	1.486		m/s	
Location No.0_3	4.0	3rd	1.798	1.613	m/s	

5.4 Demand Forecast of Cargo Volume

Domestic cargo transport, excluding marine transport, is mainly performed by inland water, railway and road transport in Myanmar. To consider future cargo transport in Myanmar, therefore, those three transport modes and coastal cargo transport should be considered.

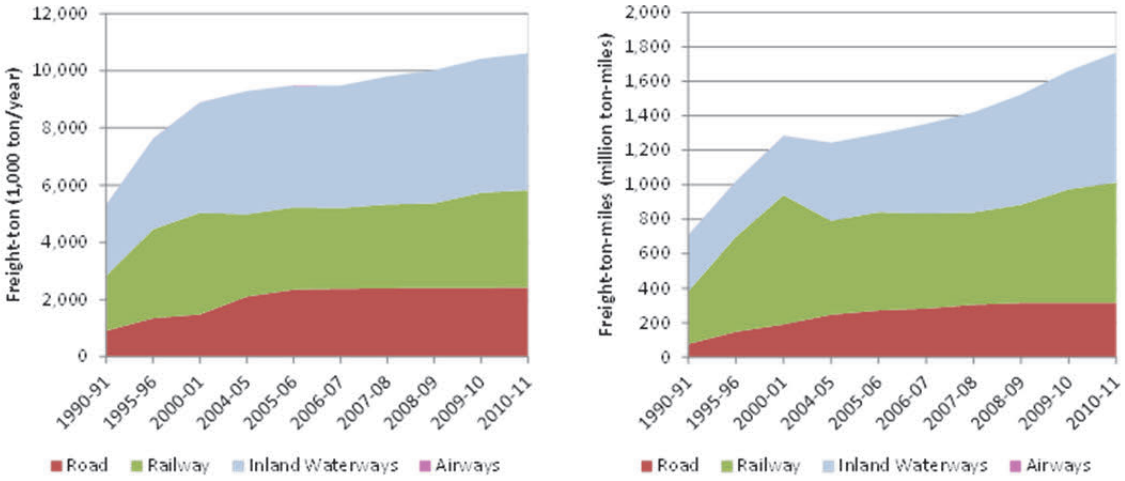


Figure 5.31 Freight Traffic by Principle Means of Public Transport

Source: Myanmar Statistical Yearbook 2011

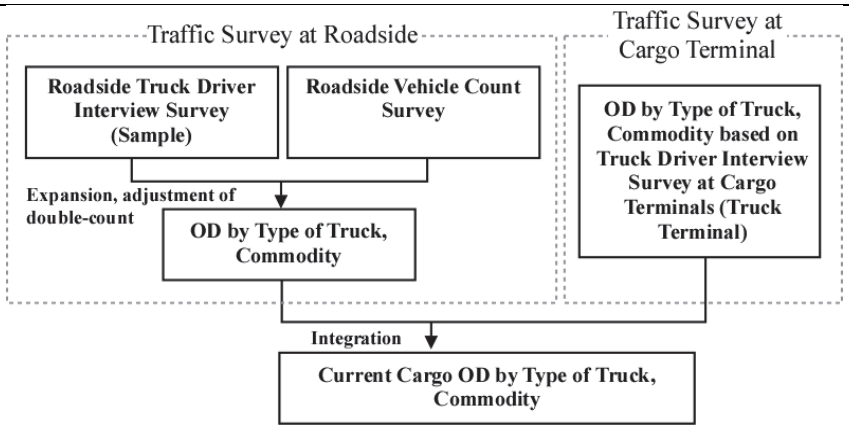
5.4.1 Estimation of Current Cargo Flow by Mode

(1) Cargo by Truck

The current cargo transport OD volume by truck and commodity is estimated by traffic surveys at the roadside and at truck terminals. Roadside traffic surveys consisting of vehicle count surveys by type of vehicle, and driver interview surveys including type of vehicle, origin and destination of trip, carrying commodity and volume etc., were carried out at major inter-city arterial roads. The driver interview survey is a sampling survey and it is expanded by the observed number of vehicle by vehicle count survey. As the result of analysis survey, not only commodity flow by truck, but also characteristics of truck transport such as average loading tons by truck and commodity, empty truck ratio, average travel time by OD etc. were obtained.

Truck driver interview surveys carried out at cargo terminals such as major river ports, railway stations and truck terminals, include the same survey items as the roadside interview survey on both directions (incoming/out-going to/from facility).

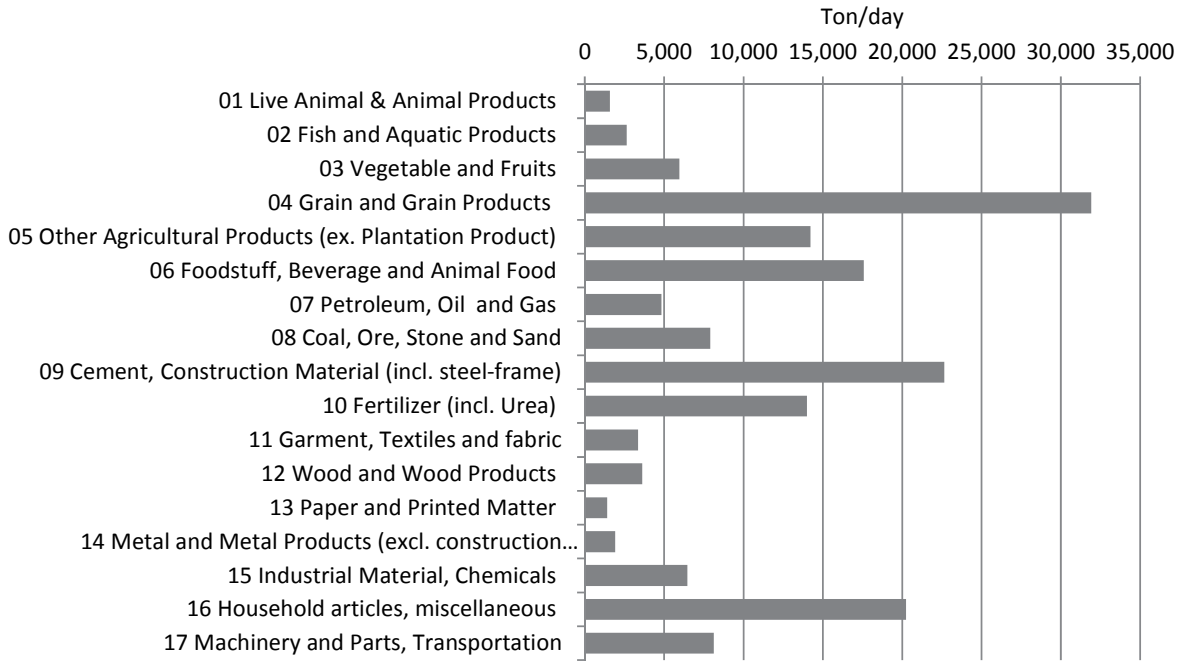
By combining the results of the roadside surveys and cargo terminal surveys, current cargo OD by truck, which covers almost all of the commodity flow relevant to major cities, was estimated.



Source: The Study Team

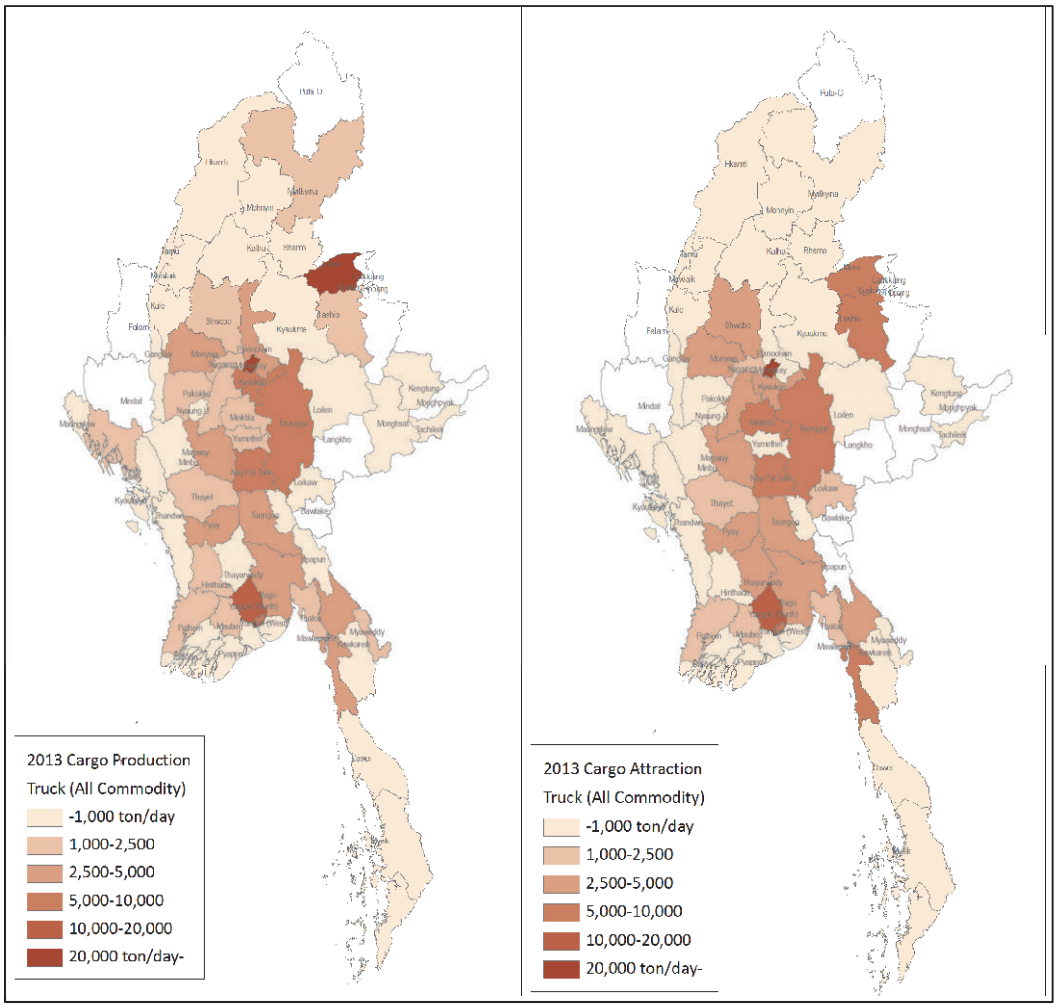
Figure 5.32 Workflow of Current Truck Freight OD Estimation

Estimated current cargo flow transported by truck is about 168,000 tons per day, consisting of grains such as rice (19%), construction materials such as cement (13%), miscellaneous (12%), foodstuff and beverage (10%), as shown in following figure.



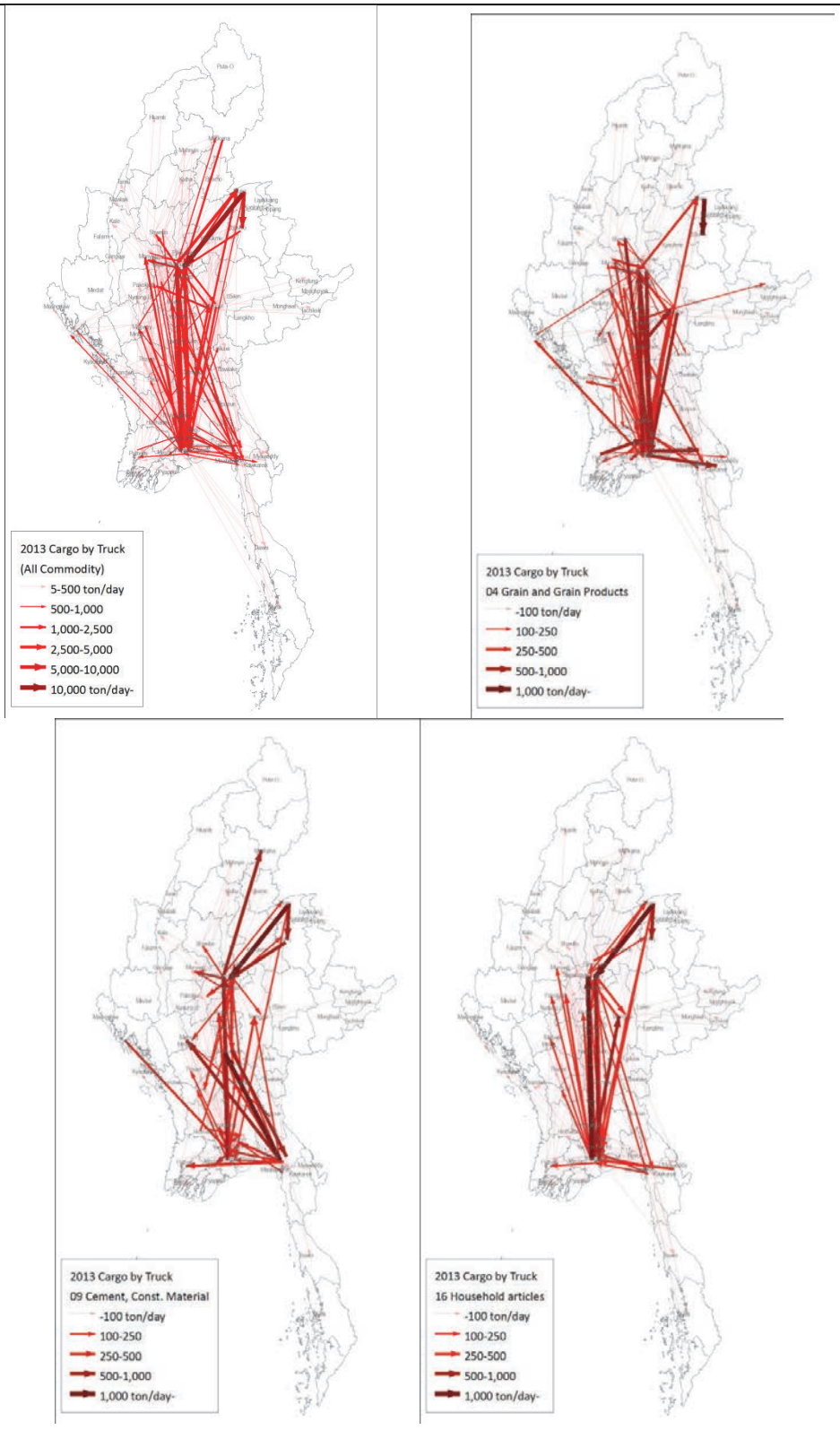
Source: The Study Team

Figure 5.33 Estimated Current Cargo Volume by Truck



Source: The Study Team

Figure 5.34 Estimated Current Truck Cargo Generation



Source: The Study Team

Figure 5.35 Desire Line of Current Truck Cargo (Total and Major Three Commodities)

(2) Cargo by Railway

Current cargo flow transported by railway is estimated to contribute to the master plan of railway such as the improvement of existing railway operation and construction and operation of new lines.

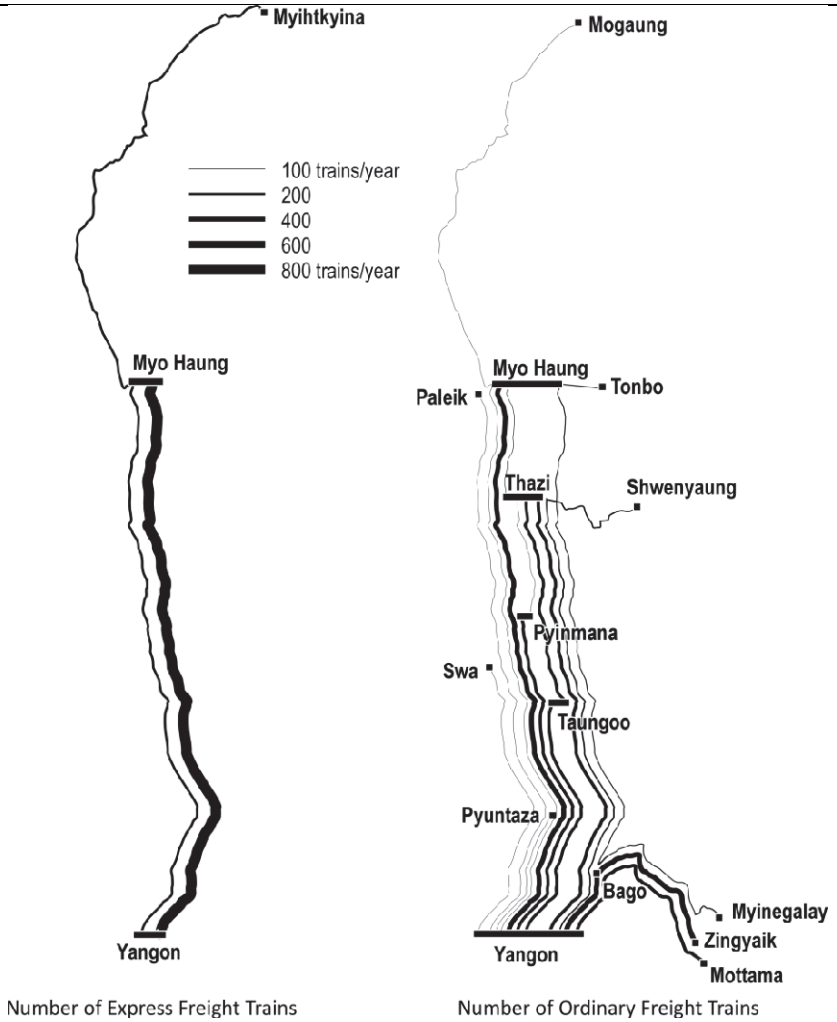
Cargo transport by Myanmar Railway is performed by freight trains and other freight-passenger trains. Freight train consists of ordinary train and express train was operated 3,522 trains in 2011-2012 (excluding Departmental Train) as shown in following table.

Table 5.12 Number of Freight Train in 2011-2012

Class	No. of Freight Trains	Ave. No of Train per day
Express Freight Train		
(a) Yangon-Myohaung	873	
(b) Uangon-Myohaung-Myitkyna	176	
Total	1,049	2.9
Ordinary Freight Train		
(a) Yangon-Myohaung	428	
(b) Yangon-Pyinmana	262	
(c) Yangon-Taungoo	250	
(d) Taungoo-Thazi	245	
(e) Yangon Thazi-Shwenyaung	122	
(f) Yangon-Thazi	273	
(g) Pyinmana-Thazi	10	
(i) Thazi-Myohaung	41	
(j) Yangon-Bago-Zinkyaik	420	
(k) Swa-Yangon	30	
(l) Paleik-Yangon	2	
(m) Yangon-Pyuntaza	10	
(n) Yangon-Myohaung-Moegaung	17	
(o) Thonbo-Myohaung-Bago-Myaingalay	83	
(p) Yangon-Bago-Mottama	280	
Total	2,473	6.8
Departmental Train (BMR+Ballast)	520	1.4
Grand Total	4,042	11.1

Source: Myanmar Railway

The following figure shows the number of freight train described in above table. Most of the freight trains are operated between Yangon and Mandalay (Myohaung).



Source: Myanmar Railway

Figure 5.36 Number of Freight Trains in 2011-2012

Freight volume by freight train in past five years was shown in following table. In 2011, total freight volume was 3.58 million tons/year (2.56 million tons/year except Military and Departmental).

Table 5.13 Railway Freight Volume of Myanmar Railway

unit: 1,000 tons/year

Commodities	2007-08	2008-09	2009-10	2010-11	2011-12
Rice & Rice Products	74	81	93	103	98
Sugar Cane	3	0	1	3	1
Forest Products	121	106	170	242	259
Beans	19	18	18	33	18
Other Agricultural Products	6	26	5	7	3
Coal & Coke	12	11	9	9	6
Oil	84	75	100	108	128
Mine Products	42	50	34	26	21
Stone	111	97	89	118	120
Salt	72	69	64	70	48
Others	376	482	713	583	745
Military	56	48	39	71	56
Departmental	1,067	985	1,045	1,033	966
Parcels	887	905	949	1,001	1,112
Total	2,929	2,952	3,327	3,408	3,580

Source: Myanmar Railway

As shown in following table, the average daily freight volume by freight train is 1,571 tons between Yangon and Mandalay and 1,338 tons between Mandalay and Myitkyina respectively (excluding military, departmental and parcels). Forest products and others (miscellaneous etc.) are the major commodities in Yangon-Mandalay and Mandalay- Myitkyina.

Table 5.14 Average Daily Freight Volume in Yangon-Mandalay Line

unit: tons/day

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Rice & Rice Products	33	88	101	112	118
Sugar Cane	4	0	1	4	4
Forest Products	131	115	184	259	276
Beans	20	19	20	36	38
Other Agricultural Products	6	7	5	7	7
Coal & Coke	13	12	10	10	10
Oil	91	82	108	117	123
Mine Products	46	54	36	28	30
Stone	120	105	96	128	135
Salt	78	74	69	75	80
Others	476	567	795	658	750
Sub Total	1,019	1,123	1,425	1,434	1,571
Military	61	52	42	77	81
Departmental	1,158	1,068	1,134	1,121	1,050
Parcels	941	959	1,008	1,065	1,188
Grand Total	3,178	3,202	3,610	3,697	3,890

Source: Myanmar Railway

Table 5.15 Average Daily Freight Volume in Mandalay-Myitkyina line

unit: tons/day

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Rice & Rice Products	32	88	82	92	90
Sugar Cane	0	0	0	5	0
Forest Products	216	185	372	497	527
Beans	3	15	12	15	13
Other Agricultural Products	6	46	8	7	6
Coal & Coke	4	2	0	0	3
Oil	3	1	2	5	9
Mine Products	21	25	23	51	19
Stone	26	11	1	12	1
Salt	0	5	8	4	5
Others	264	422	699	649	664
Sub Total	576	802	1,208	1,337	1,338
Military	6	7	12	9	2
Departmental	467	412	447	486	140
Parcels	682	727	604	618	739
Grand Total	1,732	1,948	2,271	2,449	2,219

Source: Myanmar Railway

Based on the statistics of MR between 2007-2012, freight volume in 2012-2013 is estimated by elastic model with GDP as shown in following table.

Table 5.16 Forecasted Freight Traffic by Major Commodity

unit: 1,000 tons/year

Yangon-Mandalay Line	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Est. 2012-2013
Rice & Rice Products	12.2	32.2	36.7	40.8	43.0	48.4
Sugar Cane	1.3	0.0	0.2	1.3	1.3	1.3
Forest Products	47.9	41.9	67.3	94.6	100.9	117.9
Beans	7.3	7.0	7.3	13.1	13.7	13.8
Other Agricultural Products	2.3	2.6	1.9	2.6	2.7	2.7
Coal & Coke	4.6	4.3	3.5	3.7	3.8	3.4
Oil	33.1	29.9	39.5	42.6	44.9	47.7
Mine Products	16.8	19.7	13.2	10.4	10.9	9.5
Stone	43.9	38.3	35.0	46.9	49.4	46.2
Salt	28.6	27.1	25.3	27.5	29.1	27.5
Others	173.9	207.0	290.3	240.0	273.6	311.5
Parcels	343.3	350.0	367.9	388.8	433.8	445.8
Total	715.2	760.0	888.1	912.3	1,007.1	1,075.8

Source: Myanmar Railway, The Study Team

Table 5.17 Forecasted Freight Traffic by Major Commodity

unit: 1,000 ton/year

Mandalay-Myitkyina line	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Est. 2012-2013
Rice & Rice Products	11.8	32.1	30.0	33.5	32.8	35.4
Sugar Cane	0.0	0.0	0.0	1.7	0.0	0.0
Forest Products	79.0	67.7	135.8	181.4	192.2	241.6
Beans	1.1	5.5	4.5	5.4	4.9	7.6
Other Agricultural Products	2.3	16.8	2.8	2.6	2.3	3.6
Coal & Coke	1.3	0.8	0.0	0.0	1.2	1.1
Oil	1.2	0.5	0.9	1.9	3.2	6.2
Mine Products	7.8	9.3	8.4	18.6	6.8	7.2
Stone	9.4	4.1	0.5	4.4	0.5	0.5
Salt	0.0	2.0	3.0	1.5	2.0	1.7
Others	96.5	154.0	255.0	236.9	242.4	349.4
Parcels	248.9	265.3	220.6	225.4	269.9	243.0
Total	459.3	558.1	661.5	713.3	758.2	897.4

Source: Myanmar Railway, The Study Team

The following tables indicate the freight volume based on results of truck driver interview surveys at 4 railway stations. Freight transported by freight train is divided into direction, namely, up or down in accordance with the ratio of inbound/outbound freight volume by trucks at the station. Classification of freight in the statistics of MR is re-categorized in 17 commodity classification based on the results of truck driver interview surveys at stations.

Table 5.18 Observed Incoming/Outgoing Freight to/from Station

unit: ton/day

	Yangon Botahtaung Railway Station		Yangon Setsan Railway Station		Myohaung Railway Station		Taungoo Railway Station		Thazi Railway Station	
	in	out	in	out	in	out	in	out	in	out
1 Live Animal & Animal Products	-	-	-	-	-	-	-	-	-	-
2 Fish and Aquatic Products	-	-	-	-	-	-	-	-	-	-
3 Vegetable and Fruits	-	-	-	-	-	-	-	-	-	-
4 Grain and Grain Products	-	10	9	-	6	16	-	-	-	-
5 Other Agricultural Products	-	-	9	15	-	6	-	-	-	-
6 Foodstuff, Beverage and Animal Food	132	10	126	20	14	155	-	-	1	1
7 Petroleum, Oil and Gas	-	-	3	-	61	30	-	-	-	-
8 Coal, Ore, Stone and Sand	1	-	-	-	-	8	135	-	-	-
9 Cement, Construction Material	6	8	7	7	6	18	-	-	-	-
10 Fertilizer	-	-	-	-	-	18	-	-	-	-
11 Garment, Textiles and fabric	-	-	-	-	-	4	-	-	-	-
12 Wood and Wood Products	-	-	-	-	6	-	-	-	-	-
13 Paper and Printed Matter	2	-	-	-	-	12	-	-	-	-
14 Metal and Metal Products	9	-	-	-	15	38	-	-	-	-
15 Industrial Material, Chemicals	26	33	-	13	4	18	-	-	-	-
16 Household articles, miscellaneous	57	18	2	-	7	54	-	-	-	2
17 Machinery and Parts, Transportation	7	2	-	-	3	9	-	-	-	-
Total	239	81	156	55	122	384	135	0	1	3

Note: "in" means incoming truck to railway station. "out" means out-going truck from railway station.

Source: The Study Team

On the other hand, freight volume transported by freight-passenger train is 168 tons/day by express train, 560 tons/day by mail delivery train and 810 tons/day by ordinary train in May 2013.

Table 5.19 Freight Volume of Freight-Passenger Train in May 2013

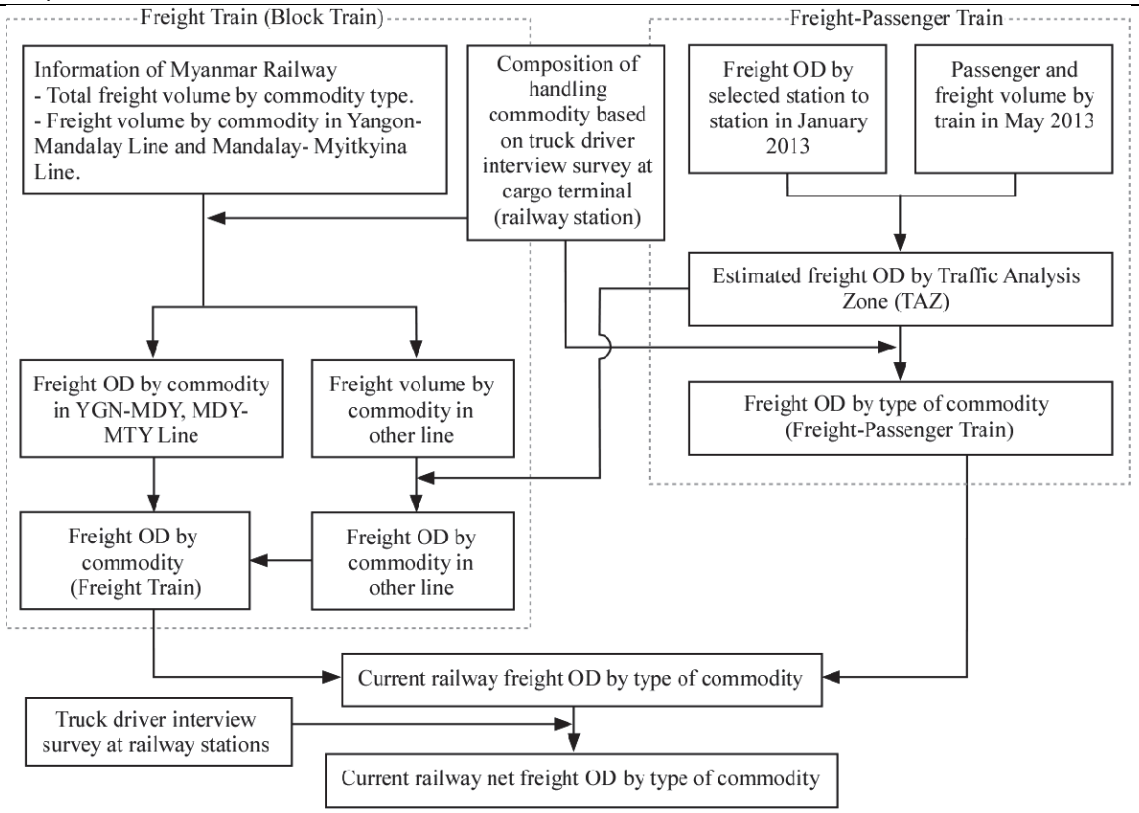
Train Type	ton/month	Ave. ton/day	Est. 1,000 ton/year
Express	5,042	168	60.5
Mail	16,793	560	201.5
Ordinary	24,285	810	291.4
Total	46,120	1,537	553.4

Source: Myanmar Railway

The current freight OD by railway carried by freight trains and freight-passenger trains is estimated separately. Freight OD by passenger-freight train is estimated by total freight volume calculated by cargo volume by train in May 2013, and inter-zonal distribution estimated by selected station to station cargo OD in January 2013. The estimated commodity is classified into 17 commodities based on the results of truck driver interview surveys at railway station. Freight OD by freight train between Yangon and Mandalay is estimated by reclassification of actual cargo transport by MR. Other cargo by freight train on other lines is distributed by OD pattern of freight-passenger train.

The cargo OD by type of commodity is estimated by integration of freight OD by freight train and passenger-freight train.

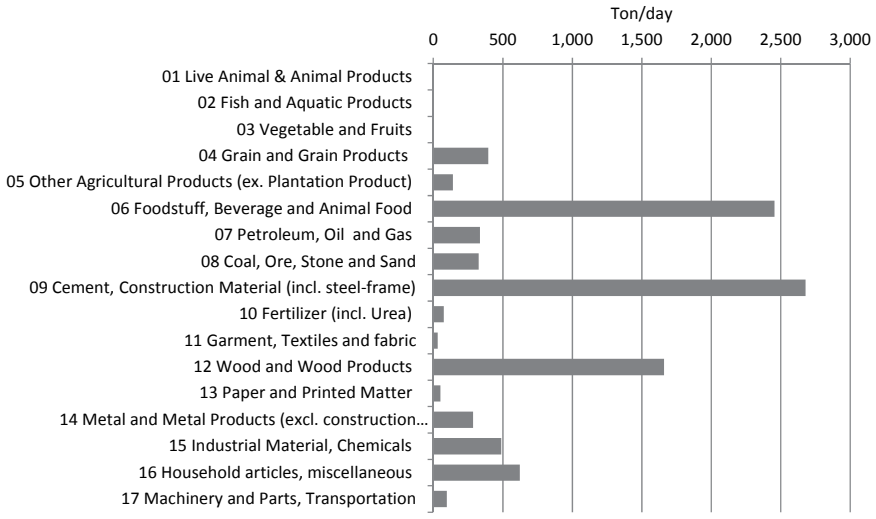
The forecasted freight OD by train is a gross flow which excludes access/egress by trucks between railway stations and origins/destinations. Based on the truck driver interview surveys at major railway stations, net freight OD by railway was produced.



Source: The Study Team

Figure 5.37 Workflow of Current Railway Freight OD Estimation

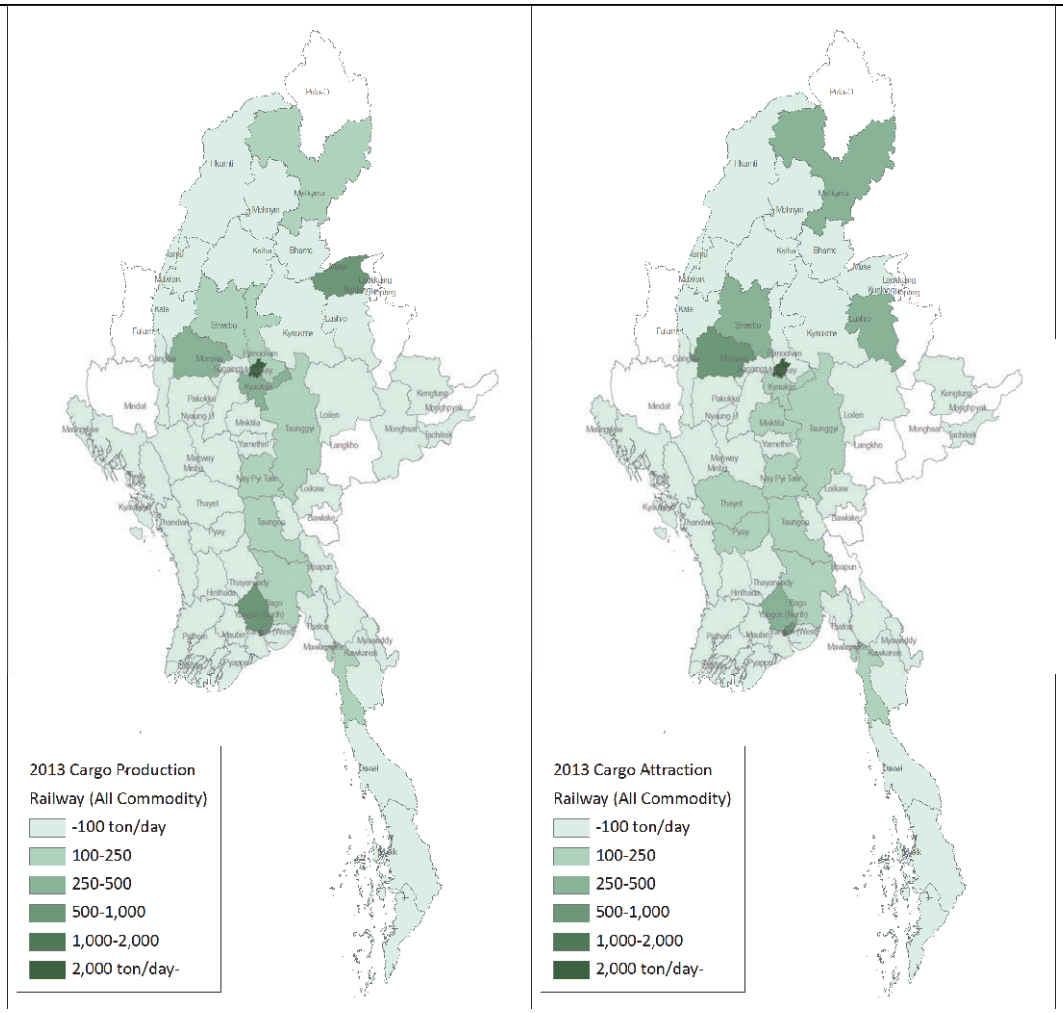
The estimated current cargo flow transported by rail is about 9,600 tons per day, consisting of construction materials such as cement (28%), foodstuff and beverage (25%) and wood/wood products (17%) as shown in following figure.



Source: The Study Team

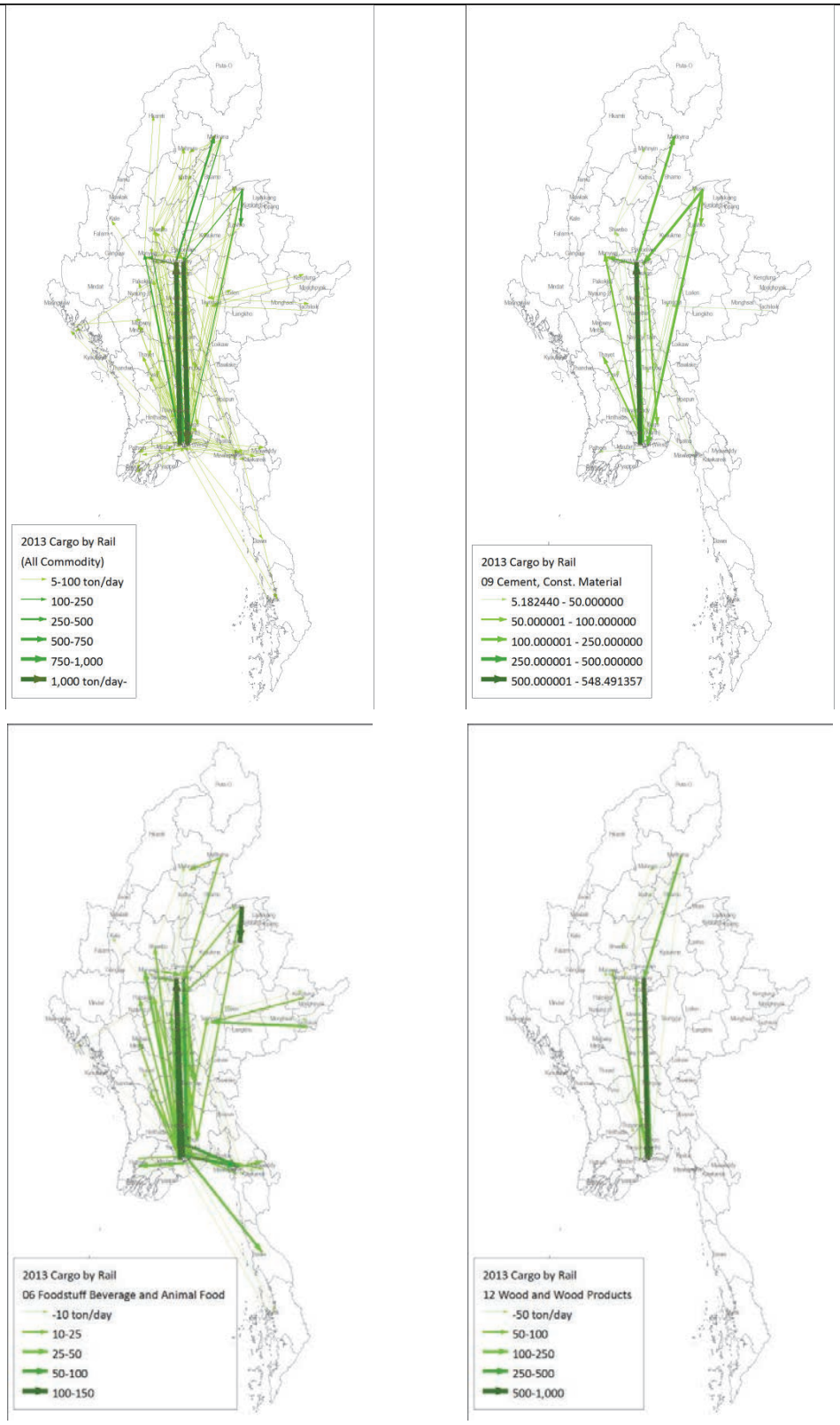
Figure 5.38 Estimated Current Cargo Volume by Railway

The following figure shows the estimated current cargo flow of major commodities transported by railway. Yangon - Mandalay - Myitkyina is the spine of existing freight transport system of Myanmar Railway.



Source: The Study Team

Figure 5.39 Estimated Current Railway Cargo Generation



Source: The Study Team

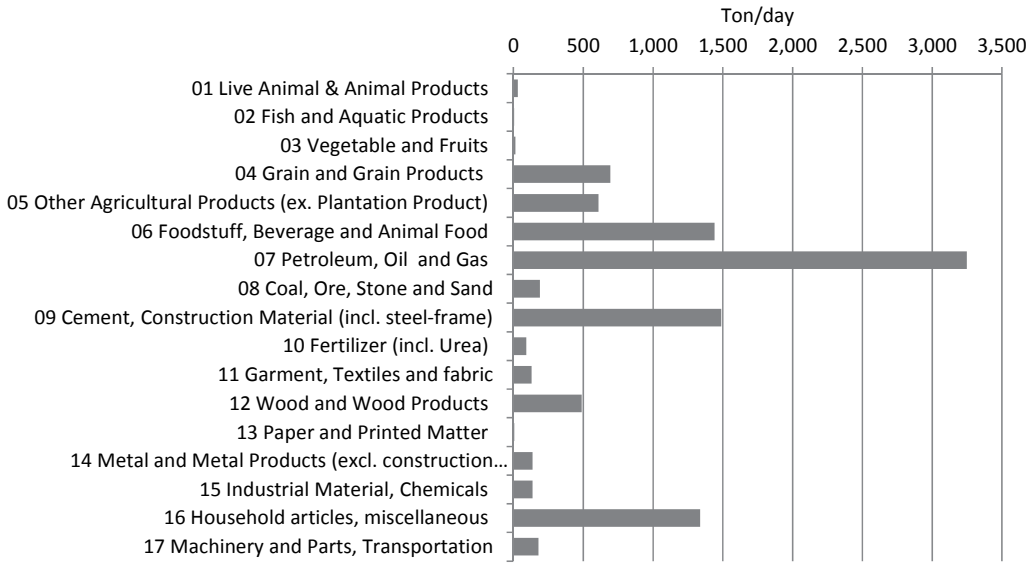
Figure 5.40 Desire Line of Current Railway Cargo (Total and Major Three Commodities)

(3) Cargo by Inland Water Transport

Existing major freight transport service by inland water transport is available on the Ayeyarwady River, the Ayeyarwady Delta and the Chindwin River. Collected information and data for the estimated current cargo flow by inland water transport is i) monthly cargo volume by line, direction and region in April 2012-March 2013 including private vessels, ii) cargo volume by each IWT vessels in FY 2012 at Yangon, Mandalay and Monywa ports. Estimated cargo OD by inland water transport is classified into 17 commodities based on the share of commodities calculated by truck driver interview surveys at major river ports.

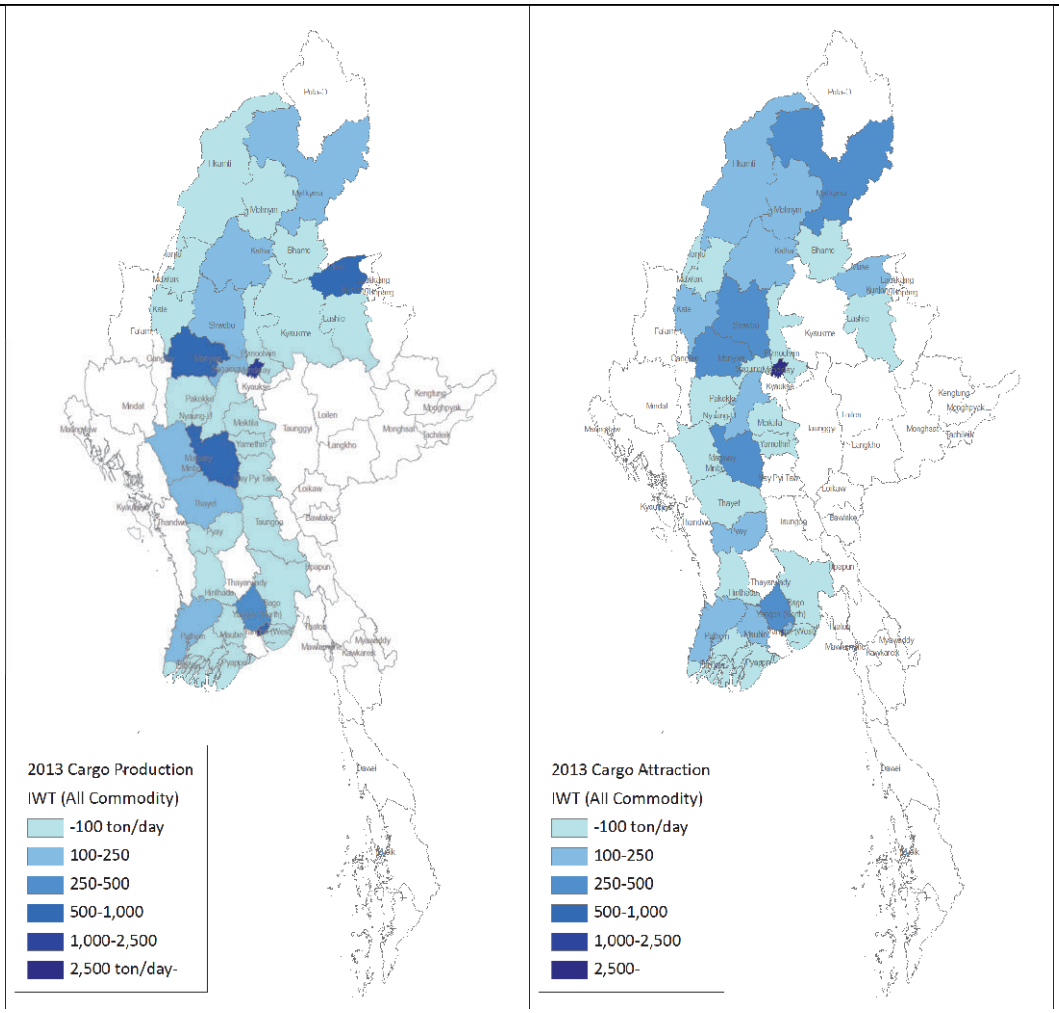
The forecasted freight OD by inland water transport is a gross flow which excludes access/egress by trucks between river ports and origins/destinations. Based on the truck driver interview surveys at major river ports, net freight OD by inland water transport is produced.

The estimated current cargo flow transported by inland water transport is about 10,200 tons per day, consisting of petrol (32%), construction material (15%), foodstuff and beverage (14%) and miscellaneous (13%) as shown in following figure.



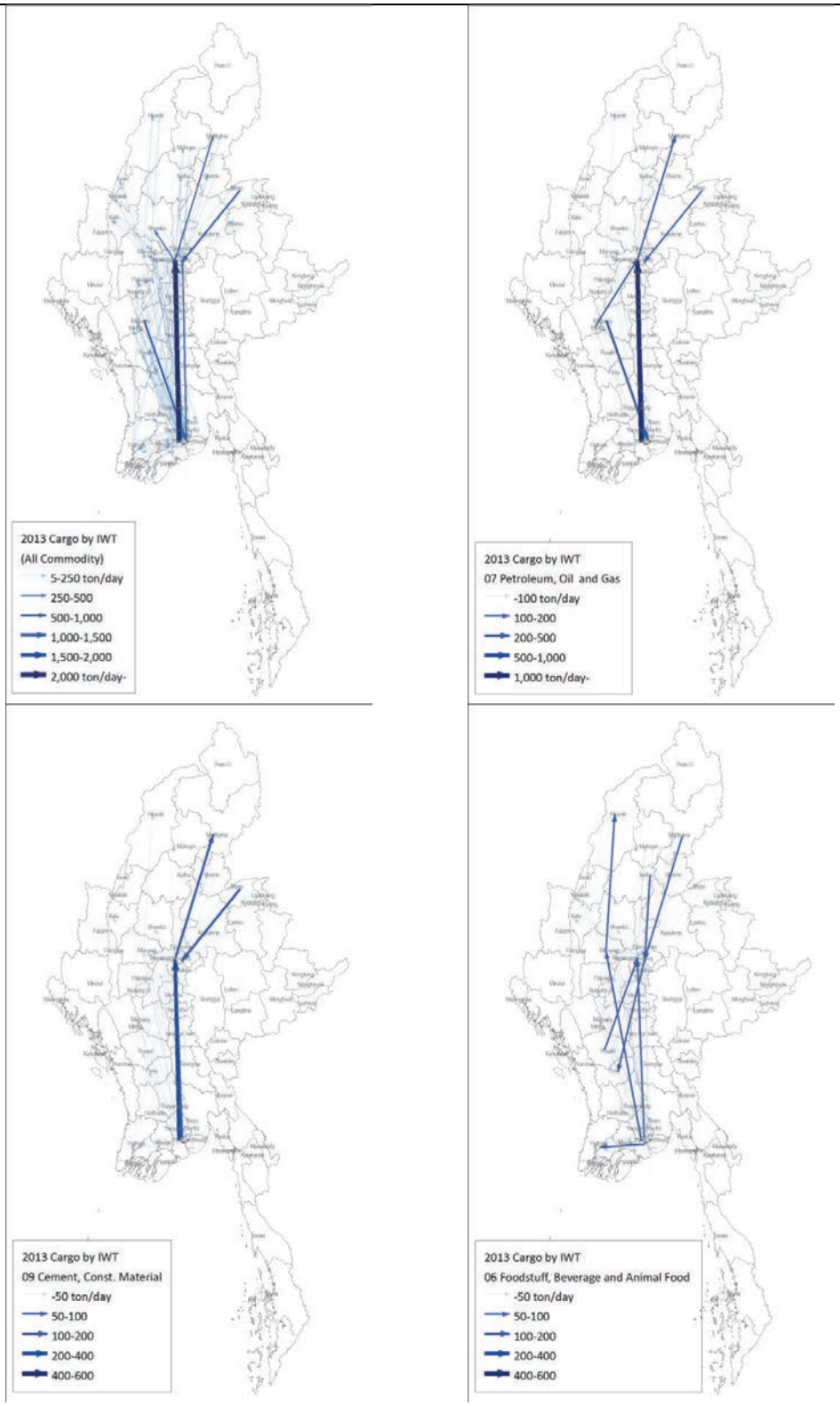
Source: The Study Team

Figure 5.41 Estimated Current Cargo Volume by Inland-Water



Source: The Study Team

Figure 5.42 Estimated Current Inland-Water Cargo Generation



Source: The Study Team

Figure 5.43 Desire Line of Current Inland-Water Cargo (Total and Major Three Commodities)

(4) Cargo by Coastal Transport

The following tables show the coastal domestic cargo between Yangon and other domestic seaports. Cargo transported by sea is dominated by consumer goods such as fuel and foodstuffs.

Table 5.20 Coastal Trade between Yangon and other Domestic Seaports by Type of Commodity (Out-Shipment 2012)

unit: million Kyat

	Sittwe	Myeik	Mawla-myine	Thandwe	Dawei	Kawthaung	Total
Food, Drink and Edible Oil	77	920	0	0	4	290	1,292
Textiles	0	0	0	0	0	2	2
Medicine	0	0	0	0	0	3	3
Fuel	2,526	917	5,993	1,185	3,160	1,429	15,209
Materials Raw and Semi-Manufactured	0	11	0	0	1	165	177
Others (Including Tires and Tubes)	0	354	0	2	65	143	564
Sub Total (Consumer Goods)	2,603	2,202	5,993	1,187	3,230	2,032	17,247
Building Materials	0	14	0	0	12	37	64
Machinery, Appliance and Apparatus	0	0	0	0	0	14	14
Private Motorcars	5	17	0	0	8	8	37
Bicycle and Parts	0	0	0	0	0	0	0
Other Transport Equipment	29	21	0	0	0	5	55
Others (Including Tires and Tubes)	0	0	0	0	0	8	8
Sub Total (Capital Goods)	33	53	0	0	20	72	178
Total	2,637	2,255	5,993	1,187	3,250	2,104	17,425

Source: MPA

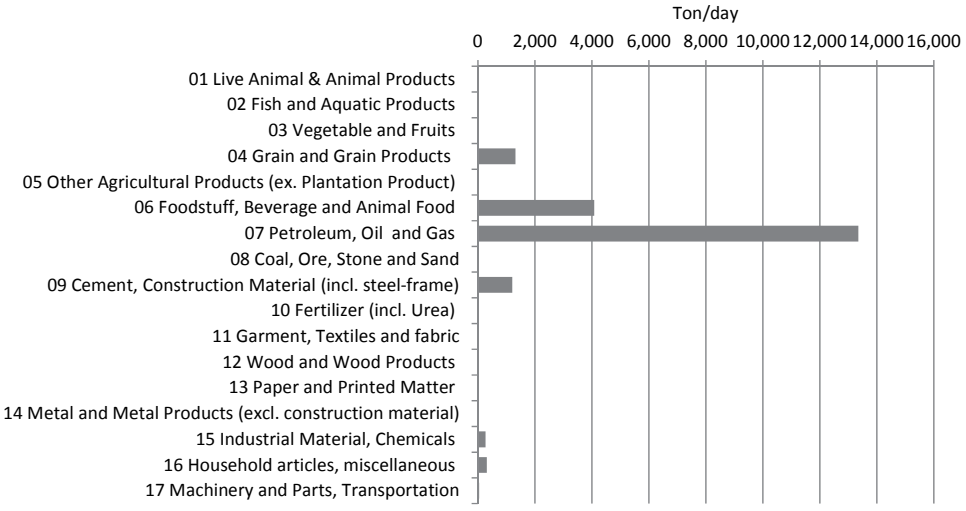
Table 5.21 Coastal Trade between Yangon and other Domestic Seaports by Type of Commodity (In-Shipment 2012)

unit: million Kyat

		Sittwe	Myeik	Mawla-myine	Thandwe	Dawei	Kawthaung	Total
	Food, Drink and Edible Oil	210	2,172	0	0	5	2,637	5,024
	Textiles	0	0	0	0	0	4	4
	Medicine	0	0	0	0	0	0	0
	Fuel	0	151	0	0	0	4	155
	Materials Raw and Semi-Manufactured	193	1	0	0	0	253	447
	Others (Including Tires and Tubes)	27	119	0	0	13	1,847	2,005
Sub Total (Consumer Goods)		430	2,443	0		17	4,745	7,636
	Building Materials	240	2	0	0	0	168	410
	Machinery, Appliance and Apparatus	1	0	0	0	0	49	50
	Private Motorcars	13	6	0	0	0	48	67
	Bicycle and Parts	0	0	0	0	0	0	0
	Other Transport Equipment	0	0	0	0	0	15	15
	Others (Including Tires and Tubes)	5	8	0	0	0	149	163
Sub Total (Capital Goods)		259	16	0	0	0	429	705
Total		689	2,459	0	0	18	5,174	8,341

Source: MPA

Cargo OD by type of commodity is estimated by re-classifying the classifications of commodities and converted to weight by weight-value factor which is calculated by import/export value and volume in Myanmar. The estimated current cargo flow transported by coastal trade is about 20,600 tons per day, consisting of petrol (65%), foodstuff and beverage (20%), grain (6%) and construction material (6%) as shown in following figure.



Source: The Study Team

Figure 5.44 Estimated Current Cargo Volume by Coastal Shipping

(5) Current Cargo Flow

The current total domestic cargo flow is estimated by the merging of freight OD with transport mode. As shown in following table, the current total domestic cargo flow is about 209,000 tons per day and it is dominated by trucks (81%).

Table 5.22 Estimated Current Freight Volume by Mode and Commodity

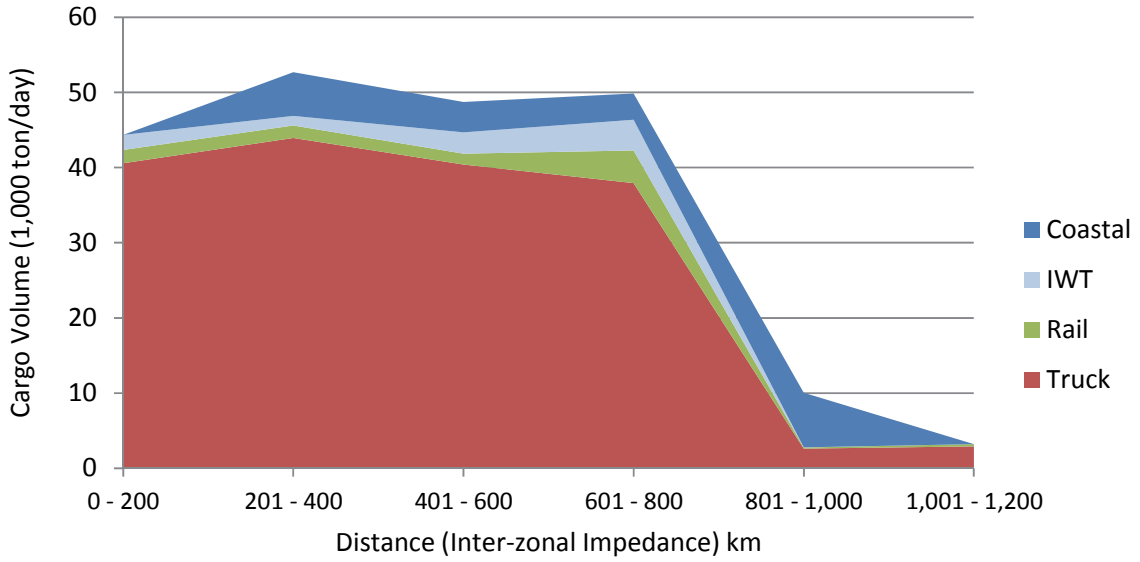
unit: thousand tons/day

Commodity	Truck	IWT	Railway	Coastal	Total
1 Live Animal & Animal Products	1.6	0.0	0.0	0.0	1.6
2 Fish and Aquatic Products	2.6	0.0	0.0	0.0	2.7
3 Vegetable and Fruits	6.0	0.0	0.0	0.0	6.0
4 Grain and Grain Products	31.9	0.7	0.4	1.3	34.3
5 Other Agricultural Products (ex. Plantation Product)	14.2	0.6	0.1	0.0	15.0
6 Foodstuff, Beverage and Animal Food	17.6	1.4	2.5	4.1	25.6
7 Petroleum, Oil and Gas	4.8	3.2	0.3	13.4	21.8
8 Coal, Ore, Stone and Sand	7.9	0.2	0.3	0.0	8.4
9 Cement, Construction Material (incl. Steel-frame)	22.7	1.5	2.7	1.2	28.0
10 Fertilizer (incl. Urea)	14.0	0.1	0.1	0.0	14.2
11 Garment, Textiles and fabric	3.3	0.1	0.0	0.0	3.5
12 Wood and Wood Products	3.6	0.5	1.7	0.0	5.8
13 Paper and Printed Matter	1.4	0.0	0.1	0.0	1.5
14 Metal and Metal Products (excl. Construction Material)	1.9	0.1	0.3	0.0	2.3
15 Industrial Material, Chemicals	6.5	0.1	0.5	0.3	7.4
16 Household articles, miscellaneous	20.3	1.3	0.6	0.3	22.5
17 Machinery and Parts, Transportation	8.1	0.2	0.1	0.0	8.4
Total	168.4	10.2	9.6	20.6	208.9
Share	81%	5%	5%	10%	100%

Source: The Study Team

As shown in the following figure, 94% of domestic cargo volume is transported less than 800 km, and the

share of cargo shipped less than 200 km is 21% of the total domestic cargo, 201-400 km is 25%, 401-600 km is 23% and 601-800 km is 24%.



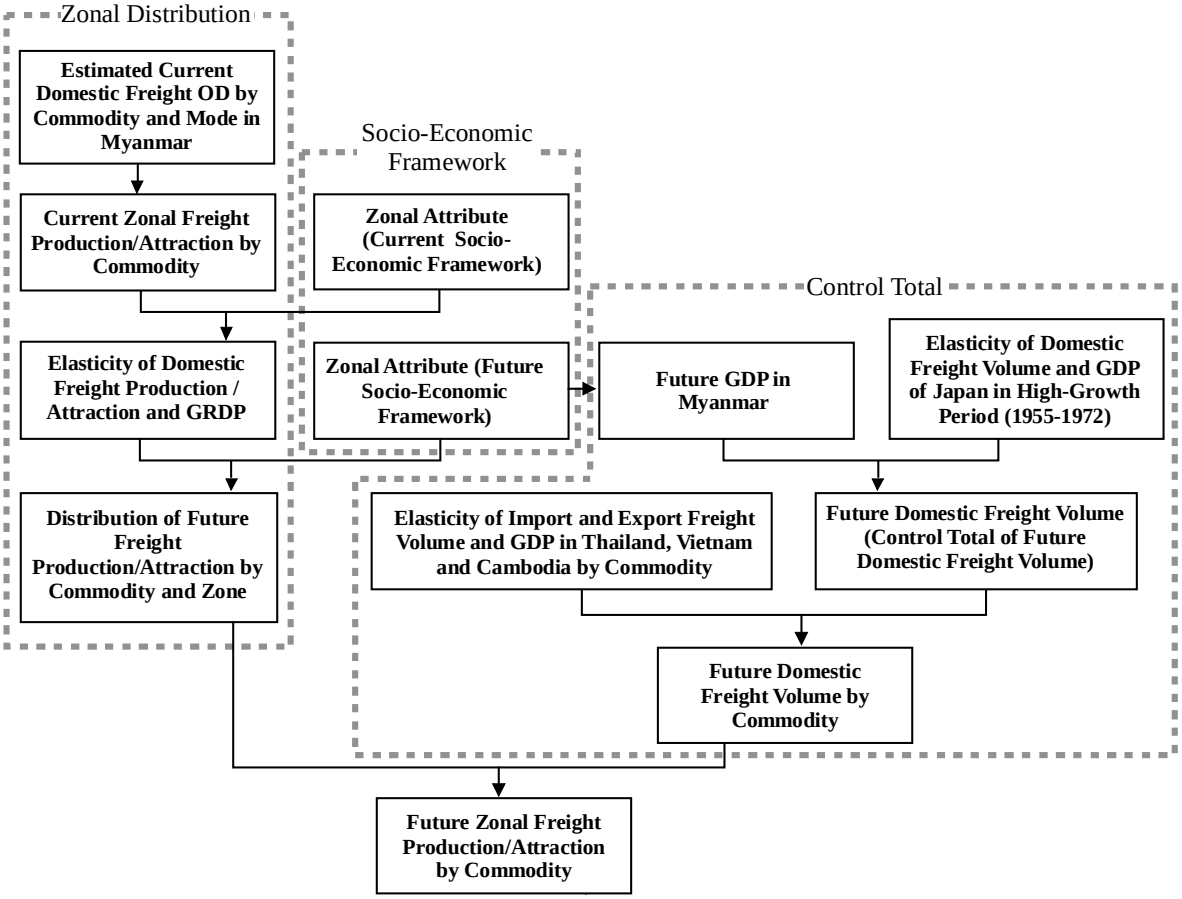
Source: The Study Team

Figure 5.45 Cargo Trip Distribution by Mode

5.4.2 Future Cargo Flow

(1) Future Cargo Generation

Future cargo generation in the study area is estimated as in the following figure. Future cargo generation consists of two steps, namely, (i) control total which is the total domestic cargo volume of the entire study area by type of commodity and (ii) zonal distribution which is the cargo production and attraction by the type of commodity and the traffic analysis zone.



Source: The Study Team

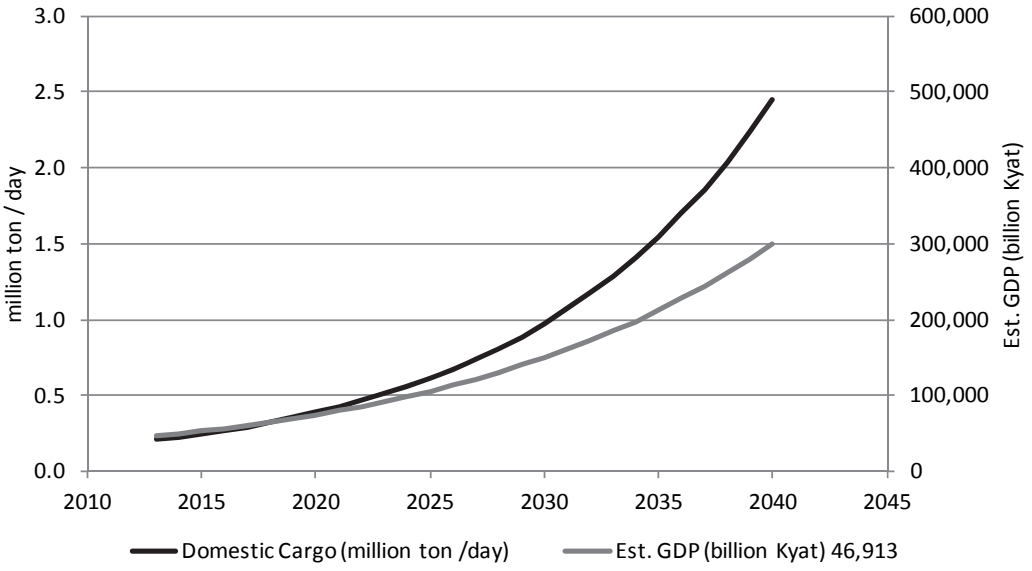
Figure 5.46 Workflow of Future Zonal Cargo Generation

1) Control Total

Control total is the total domestic cargo flow volume of all transport modes and of all types of commodities, which is estimated by the existing total domestic cargo flow volume and the expansion factor calculated by the future GDP growth rate and the elasticity of the domestic cargo volume to GDP.

The elasticity of the domestic cargo volume to GDP is calculated by regression model in Japan during a high-economic growth period (1960 - 1972) which is 1.342 (R^2 = 0.993).

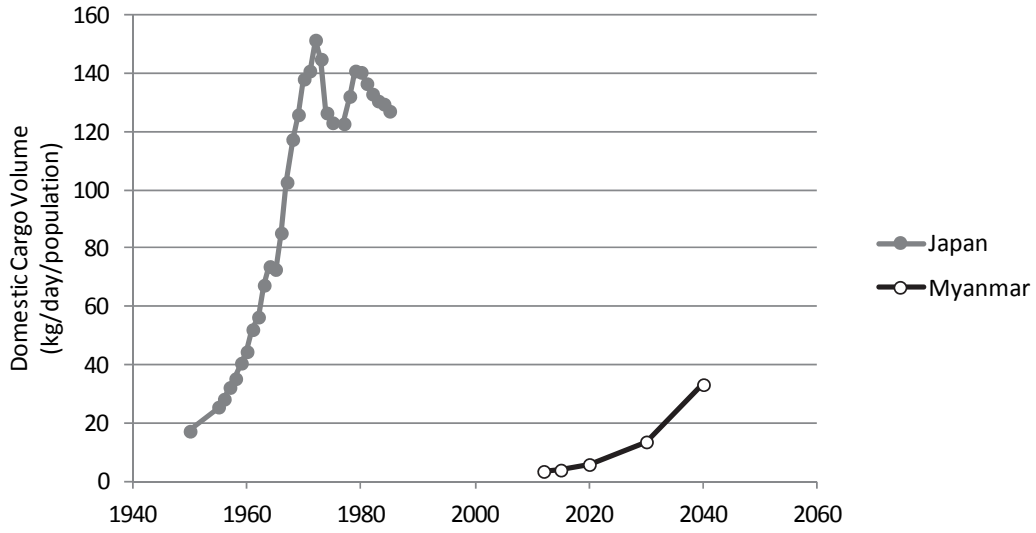
Based on the forecasted future GDP and elastic factor of domestic cargo flow, future domestic cargo flow in Myanmar is forecasted as shown in following figure. In 2040, the total domestic cargo flow in Myanmar is expected to be 11.7 times that of domestic cargo in 2013.



Source: The Study Team

Figure 5.47 Estimated Future Domestics Cargo Flow in Myanmar

The following figure shows the average domestic cargo flow volume per population in Japan and in Myanmar. In 2040, the average domestic cargo flow per capita in Myanmar is expected to be 33kg/day/population which is almost equal to what it was in 1957 in Japan.



Source: The Study Team

Figure 5.48 Forecasted Domestics Cargo Volume per Population in Myanmar

The control total by type of commodity is also estimated by the elasticity of import/export volume to GDP in Thailand, Vietnam and Cambodia. The defined elasticity is indicated in following table.

Table 5.23 Elasticity of EXIM Volume by Type Commodities

Commodity	Elasticity to GDP
1 Live Animal & Animal Products	1.22
2 Fish and Aquatic Products	1.76
3 Vegetable and Fruits	1.18
4 Grain and Grain Products	1.74
5 Other Agricultural Products (ex. Plantation Product)	2.13
6 Foodstuff, Beverage and Animal Food	1.30
7 Petroleum, Oil and Gas	1.84
8 Coal, Ore, Stone and Sand	2.21
9 Cement, Construction Material (incl. Steel-frame)	1.93
10 Fertilizer (incl. Urea)	1.09
11 Garment, Textiles and fabric	1.24
12 Wood and Wood Products	1.14
13 Paper and Printed Matter	1.05
14 Metal and Metal Products (excl. Construction Material)	1.29
15 Industrial Material, Chemicals	1.33
16 Household articles, miscellaneous	1.80
17 Machinery and Parts, Transportation	1.40

Source: The Study Team

Based on the calculated control total of future domestic cargo flow volume and the elasticity of each commodity, future domestic cargo flow volume by commodity is forecasted as shown in following table.

Table 5.24 Forecasted Future Domestic Cargo Flow in Myanmar

unit: 1,000 tons/day

Commodity	2013	2015	2020	2030	2040
1 Live Animal & Animal Products	3.6	1.8	2.4	4.4	7.7
2 Fish and Aquatic Products	7.6	3.2	5.1	13.2	32.6
3 Vegetable and Fruits	14.5	6.7	8.9	15.7	26.5
4 Grain and Grain Products	84.1	41.0	65.7	167.0	408.1
5 Other Agricultural Products (ex. Plantation Product)	40.0	18.7	33.9	110.0	343.6
6 Foodstuff, Beverage and Animal Food	51.7	28.9	40.1	76.3	139.3
7 Petroleum, Oil and Gas	14.4	26.2	43.4	117.3	304.6
8 Coal, Ore, Stone and Sand	18.0	10.6	19.7	67.1	219.7
9 Cement, Construction Material (incl. Steel-frame)	55.8	34.2	58.2	166.8	459.7
10 Fertilizer (incl. Urea)	41.1	15.6	20.3	33.7	53.9
11 Garment, Textiles and fabric	10.2	3.9	5.4	9.9	17.4
12 Wood and Wood Products	11.2	6.4	8.4	14.5	24.0
13 Paper and Printed Matter	4.5	1.6	2.1	3.3	5.2
14 Metal and Metal Products (excl. Construction Material)	5.0	2.6	3.7	7.0	12.7
15 Industrial Material, Chemicals	19.8	8.4	11.8	22.9	42.9
16 Household articles, miscellaneous	62.1	27.0	44.3	116.9	296.9
17 Machinery and Parts, Transportation	25.9	9.7	13.9	28.4	55.7
Total	208.9	246.5	387.3	974.2	2,450.4

Source: The Study Team

2) Zonal Distribution

Based on the estimated current total cargo production/attraction and zonal attributes, the elasticity of cargo production/attraction by commodity to GRDP is calculated as shown in following table.

Future cargo production and attraction by zone is adjusted to the control total after computed by current cargo production and attraction, future GRDP by zone and the elasticity of cargo production and attraction to GRDP.

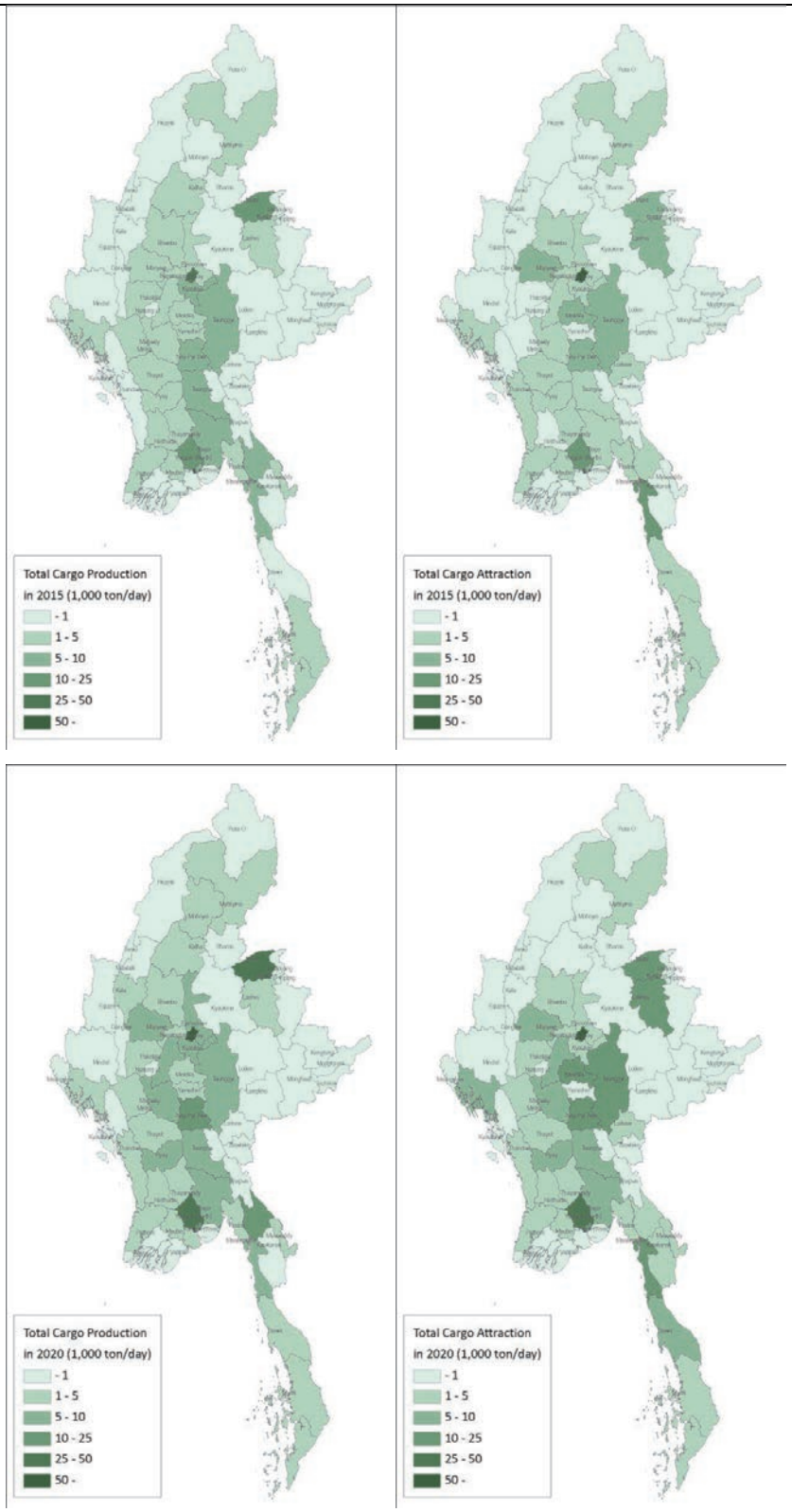
Table 5.25 Elasticity of Domestic Cargo Production and Attraction to GRDP

	Cargo Production	Cargo Attraction
1 Live Animal & Animal Products	0.315	1.560
2 Fish and Aquatic Products	0.554	2.552
3 Vegetable and Fruits	0.803	0.819
4 Grain and Grain Products	1.274	0.771
5 Other Agricultural Products (ex. Plantation Product)	1.304	0.988
6 Foodstuff, Beverage and Animal Food	0.942	0.961
7 Petroleum, Oil and Gas	1.178	1.170
8 Coal, Ore, Stone and Sand	0.400	1.512
9 Cement, Construction Material (incl. Steel-frame)	1.024	1.663
10 Fertilizer (incl. Urea)	1.663	1.831
11 Garment, Textiles and fabric	0.850	1.644
12 Wood and Wood Products	0.462	1.757
13 Paper and Printed Matter	0.858	0.579
14 Metal and Metal Products (excl. Construction Material)	1.621	0.384
15 Industrial Material, Chemicals	1.698	0.685
16 Household articles, miscellaneous	1.252	1.030
17 Machinery and Parts, Transportation	0.950	1.013

Source: The Study Team

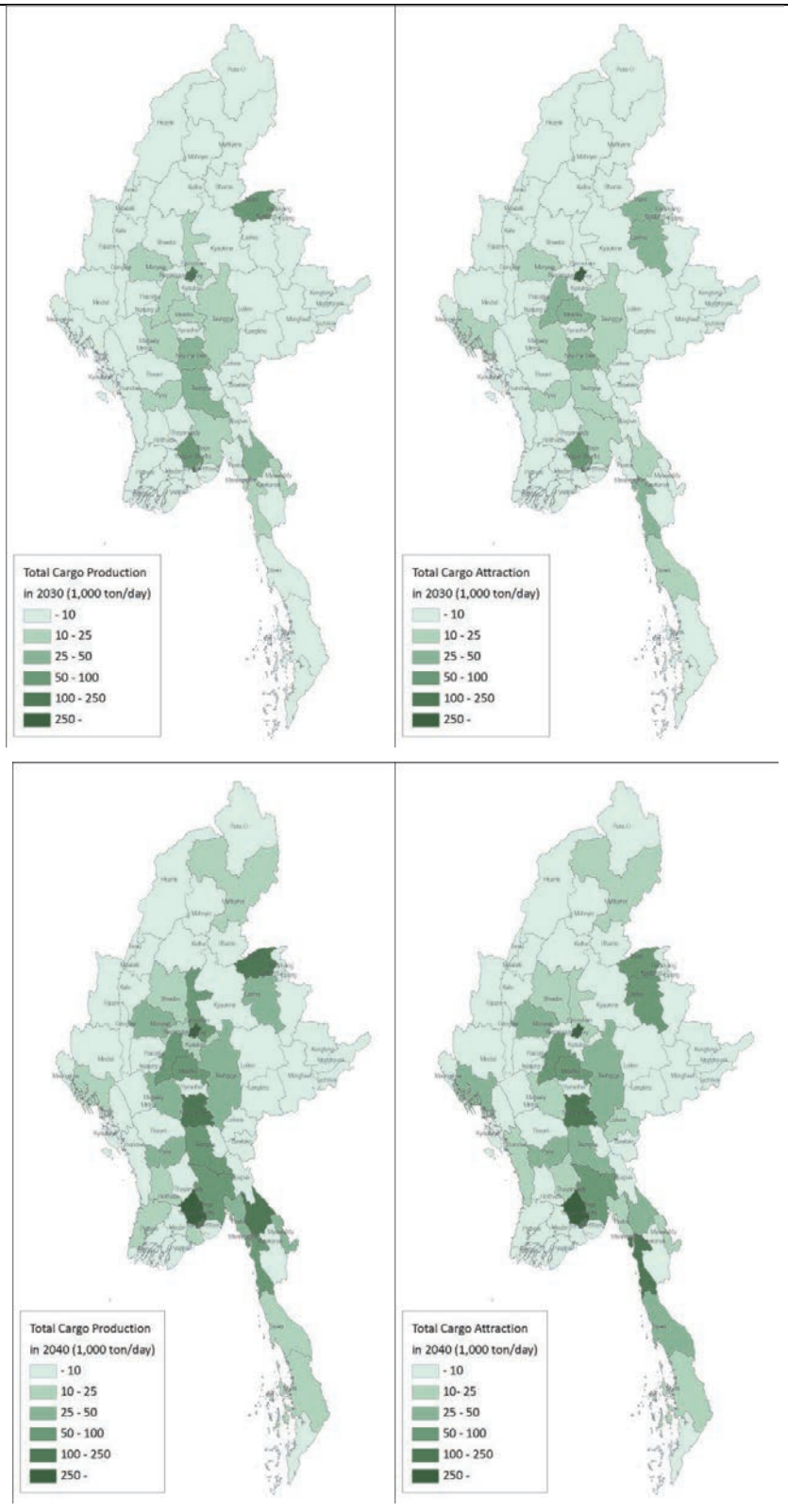
3) Future Cargo Production and Attraction

Future cargo production and attraction by commodity is distributed as shown in following figures.



Source: The Study Team

Figure 5.49 Forecasted Future Cargo Generation



Source: The Study Team

Figure 5.50 Forecasted Future Cargo Generation (cont'd)

(2) Future Cargo Distribution

The Fratar growth factor method, as shown in following formula, was applied to the forecast future cargo OD by type of commodity.

$$T_{ij} = t_{ij} \cdot \frac{G_i}{g_i} \frac{A_j}{a_j} \cdot \frac{1}{2} \left(\frac{g_i}{\sum_j t_{ij} \cdot A_j / a_j} + \frac{a_j}{\sum_i t_{ij} \cdot G_i / g_i} \right)$$

where, *Tij*: Future cargo distribution at zone i to j,

Gi: Future cargo production at zone i,

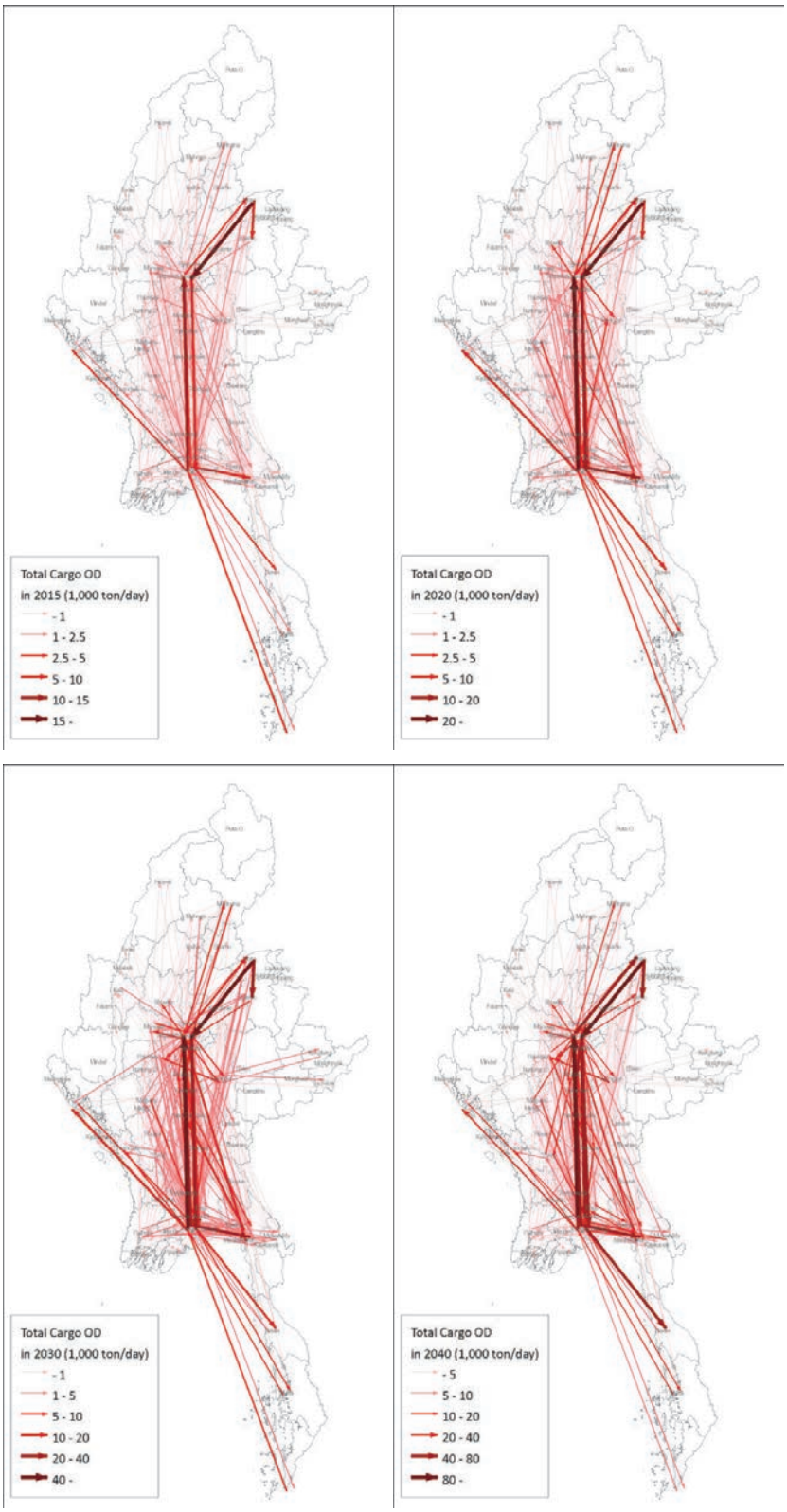
Aj: Future cargo attraction at zone j,

tij: Current cargo distribution at zone i to jl

gi: Current cargo production at zone i, and

aj: Current cargo attraction at zone j.

The estimated future cargo ODs are indicated following figures.



Source: The Study Team

Figure 5.51 Forecasted Future Cargo OD (All Commodities)

(3) Future Modal Split

Forecasted future cargo by type of commodity is divided into each transport mode, namely, costal, inland water transport, railway and truck by following logit model.

$$P_i = \frac{\exp(U_i)}{\exp(U_i) + \exp(U_j)}$$

where, $U_i = a \cdot time_i + b \cdot cost_i$

$Uj = a \cdot time_j + b \cdot cost_j$

Ui: Utility of mode i,

$time_i$: Travel time of mode i,

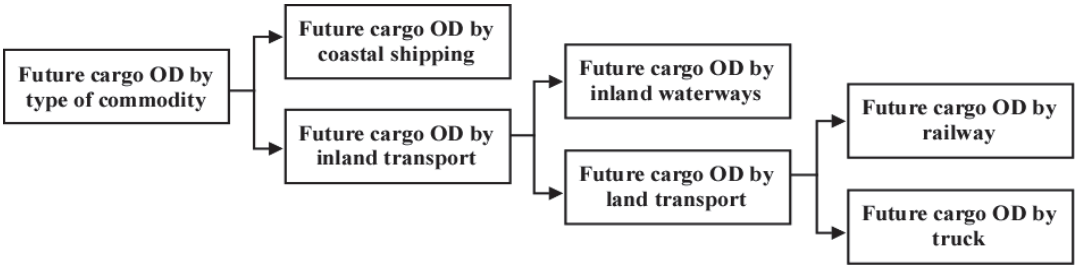
$cost_i$: Cost of mode i,

Uj: Utility of mode j,

$time_j$: Travel time of mode j, and

$cost_j$: Cost of mode j,

The modal split model is estimated by type of commodity and the following binary choice type, (i) coastal shipping - inland transport, (ii) inland waterways and land transport, and (iii) railway and truck.



Source: The Study Team

Figure 5.52 Binary Choice Type Modal Split Model

The following tables indicate the estimated parameters for the modal split model computed by current cargo OD by commodity and transport mode.

Table 5.26 Parameters for Modal Split Model 1 (Coastal - Land Transport)

Commodity	intercept	(Time_Land) -(Time_Coastal)	(Cost_Land) -(Cost_Coastal)	R2
1 Live Animals & Animal Products	-	-	-	-
2 Fish and Aquatic Products	-	-	-	-
3 Vegetables and Fruits	-	-	-	-
4 Grains and Grain Products	-4.5860	-0.2244	-0.0001	0.8504
5 Other Agricultural Products (ex. Plantation Product)	-	-	-	-
6 Foodstuffs, Beverages and Animal Food	0.8766	-0.0004	-0.0004	0.7852
7 Petroleum, Oil and Gas	-	-	-	-
8 Coal, Ore, Stone and Sand	-	-	-	-
9 Cement, Construction Material (incl. Steel-frame)	-10.8428	-0.2622	-0.0002	0.8223
10 Fertilizer (incl. Urea)	-	-	-	-
11 Garments, Textiles and fabric	-	-	-	-
12 Wood and Wood Products	-	-	-	-
13 Paper and Printed Matter	-	-	-	-
14 Metal and Metal Products (excl. Construction Material)	-	-	-	-
15 Industrial Material, Chemicals	-1.4294	-0.0858	-0.0004	0.5360
16 Household articles, miscellaneous	1.4364	-0.0355	-0.0004	0.5738
17 Machinery and Parts, Transportation	-9.1314	-0.0847	-0.0001	0.9584

Source: The Study Team

Table 5.27 Parameters for Modal Split Model 2 (IWT - Land Transport)

Commodity	intercept	(Time_Land) -(Time_River)	(Cost_Land) -(Cost_River)	R2
1 Live Animals & Animal Products	1.2754	-0.0314	0.0000	0.5787
2 Fish and Aquatic Products	2.3079	-0.0601	-0.0001	0.6536
3 Vegetables and Fruits	3.7516	-0.0142	0.0000	0.4659
4 Grains and Grain Products	1.6748	-0.0194	-0.0001	0.4280
5 Other Agricultural Products (ex. Plantation Product)	0.7821	-0.0158	-0.0001	0.6127
6 Foodstuffs, Beverages and Animal Food	-0.4133	-0.0387	-0.0004	0.6713
7 Petroleum, Oil and Gas	-1.2808	-0.0386	-0.0008	0.6969
8 Coal, Ore, Stone and Sand	0.5921	-0.0741	-0.0006	0.9647
9 Cement, Construction Material (incl. Steel-frame)	1.6728	-0.0087	-0.0003	0.5192
10 Fertilizer (incl. Urea)	2.9320	-0.0283	-0.0003	0.4003
11 Garments, Textiles and fabric	1.6906	-0.0219	-0.0004	0.5049
12 Wood and Wood Products	2.0427	-0.0169	-0.0004	0.9789
13 Paper and Printed Matter	3.9057	-0.0172	-0.0003	0.6502
14 Metal and Metal Products (excl. Construction Material)	-1.1756	-0.0412	-0.0001	0.5042
15 Industrial Material, Chemicals	-0.6727	-0.0732	-0.0006	0.7014
16 Household articles, miscellaneous	0.6300	-0.0173	-0.0001	0.5060
17 Machinery and Parts, Transportation	-0.1859	-0.0628	-0.0006	0.6602

Source: The Study Team

Table 5.28 Parameters for Modal Split Model 3 (Railway - Truck)

Commodity	intercept	(Time_Truck) -(Time_Rail)	(Cost_Truck) -(Cost_Rail)	R2
1 Live Animals & Animal Products	-	-	-	-
2 Fish and Aquatic Products	-	-	-	-
3 Vegetables and Fruits	-	-	-	-
4 Grains and Grain Products	-0.8966	-0.3892	-0.0008	0.5338
5 Other Agricultural Products (ex. Plantation Product)	-4.7785	-0.6994	-0.0015	0.5116
6 Foodstuffs, Beverages and Animal Food	-0.7408	-0.2078	-0.0003	0.6553
7 Petroleum, Oil and Gas	-14.4599	-1.2397	-0.0026	0.6679
8 Coal, Ore, Stone and Sand	2.8238	-0.0121	-0.0001	0.5394
9 Cement, Construction Material (incl. Steel-frame)	-3.0991	-0.1828	-0.0010	0.5839
10 Fertilizer (incl. Urea)	1.4067	-0.1803	-0.0006	0.5132
11 Garments, Textiles and fabric	-0.2128	-0.1772	-0.0010	0.5916
12 Wood and Wood Products	-16.5696	-0.5941	-0.0034	0.7840
13 Paper and Printed Matter	-1.3076	-0.1718	-0.0012	0.5996
14 Metal and Metal Products (excl. Construction Material)	-9.2513	-0.6487	-0.0022	0.5597
15 Industrial Material, Chemicals	-1.5760	-0.1760	-0.0008	0.5230
16 Household articles, miscellaneous	-1.9646	-0.5891	-0.0006	0.6127
17 Machinery and Parts, Transportation	2.5323	-0.0287	-0.0004	0.7430

Source: The Study Team

5.4.3 Forecasted Future Cargo Transport

The following tables show the results of the forecasted future domestic cargo OD in the case of "without any project". The modal share is decided by transport time and cost between different modes, therefore, the modal share and OD by mode will be changed depending on the improvement of future transport networks.

Table 5.29 Forecasted Future Cargo Volume in 2015

unit: 1,000 tons/day

Commodity	Truck	IWT	Railway	Coastal	Total
1 Live Animal & Animal Products	1.7	0.0	0.0	0.0	1.8
2 Fish and Aquatic Products	3.1	0.0	0.0	0.0	3.1
3 Vegetable and Fruits	6.6	0.0	0.0	0.0	6.6
4 Grain and Grain Products	38.7	0.5	0.2	1.5	40.9
5 Other Agricultural Products (ex. Plantation Product)	18.0	0.6	0.0	0.0	18.6
6 Foodstuff, Beverage and Animal Food	22.0	0.5	2.1	4.4	28.9
7 Petroleum, Oil and Gas	8.8	1.7	0.0	15.8	26.2
8 Coal, Ore, Stone and Sand	10.1	0.1	0.4	0.0	10.6
9 Cement, Construction Material (incl. Steel-frame)	30.9	0.7	1.1	1.4	34.1
10 Fertilizer (incl. Urea)	15.5	0.0	0.0	0.0	15.6
11 Garment, Textiles and fabric	3.9	0.0	0.0	0.0	3.9
12 Wood and Wood Products	5.9	0.2	0.2	0.0	6.3
13 Paper and Printed Matter	1.6	0.0	0.0	0.0	1.6
14 Metal and Metal Products (excl. Construction Material)	2.5	0.1	0.1	0.0	2.6
15 Industrial Material, Chemicals	7.6	0.3	0.1	0.4	8.4
16 Household articles, miscellaneous	25.3	1.0	0.4	0.3	27.0
17 Machinery and Parts, Transportation	9.5	0.0	0.1	0.0	9.7
Total	211.7	5.7	4.7	23.8	246.0
Share	86%	2%	2%	10%	100%

Source: The Study Team

Table 5.30 Forecasted Future Cargo Volume in 2020

unit: 1,000 tons/day

Commodity	Truck	IWT	Railway	Coastal	Total
1 Live Animal & Animal Products	2.3	0.0	0.0	0.0	2.4
2 Fish and Aquatic Products	5.0	0.0	0.0	0.0	5.1
3 Vegetable and Fruits	8.8	0.0	0.0	0.0	8.9
4 Grain and Grain Products	62.7	0.6	0.3	2.1	65.7
5 Other Agricultural Products (ex. Plantation Product)	32.8	1.0	0.0	0.0	33.8
6 Foodstuff, Beverage and Animal Food	31.7	0.3	2.9	5.2	40.1
7 Petroleum, Oil and Gas	15.6	3.0	0.0	24.7	43.3
8 Coal, Ore, Stone and Sand	18.7	0.2	0.7	0.0	19.6
9 Cement, Construction Material (incl. Steel-frame)	53.5	0.7	2.0	2.0	58.2
10 Fertilizer (incl. Urea)	20.2	0.0	0.0	0.0	20.2
11 Garment, Textiles and fabric	5.3	0.0	0.0	0.0	5.3
12 Wood and Wood Products	7.9	0.3	0.2	0.0	8.4
13 Paper and Printed Matter	2.0	0.0	0.0	0.0	2.0
14 Metal and Metal Products (excl. Construction Material)	3.4	0.1	0.1	0.0	3.6
15 Industrial Material, Chemicals	10.4	0.1	0.2	0.5	11.2
16 Household articles, miscellaneous	41.9	1.3	0.6	0.4	44.2
17 Machinery and Parts, Transportation	13.7	0.0	0.1	0.1	13.9
Total	336.0	7.7	7.3	34.9	386.0
Share	87%	2%	2%	9%	100%

Source: The Study Team

Table 5.31 Forecasted Future Cargo Volume in 2030

unit: 1,000 tons/day

Commodity	Truck	IWT	Railway	Coastal	Total
1 Live Animal & Animal Products	4.3	0.1	0.0	0.0	4.3
2 Fish and Aquatic Products	13.0	0.0	0.0	0.0	13.0
3 Vegetable and Fruits	15.5	0.0	0.0	0.0	15.6
4 Grain and Grain Products	161.1	0.8	0.6	4.4	166.9
5 Other Agricultural Products (ex. Plantation Product)	107.4	2.4	0.1	0.0	109.9
6 Foodstuff, Beverage and Animal Food	62.1	0.1	5.2	8.9	76.2
7 Petroleum, Oil and Gas	46.6	6.6	0.0	63.9	117.1
8 Coal, Ore, Stone and Sand	64.1	0.4	2.4	0.0	66.9
9 Cement, Construction Material (incl. Steel-frame)	158.2	0.4	4.0	4.2	166.7
10 Fertilizer (incl. Urea)	33.6	0.0	0.1	0.0	33.7
11 Garment, Textiles and fabric	9.8	0.0	0.0	0.0	9.8
12 Wood and Wood Products	13.9	0.4	0.1	0.0	14.4
13 Paper and Printed Matter	3.2	0.0	0.0	0.0	3.2
14 Metal and Metal Products (excl. Construction Material)	6.7	0.1	0.1	0.0	6.9
15 Industrial Material, Chemicals	21.1	0.0	0.4	0.9	22.3
16 Household articles, miscellaneous	113.0	1.5	1.5	0.8	116.8
17 Machinery and Parts, Transportation	28.1	0.0	0.1	0.1	28.3
Total	861.6	12.7	14.6	83.1	972.1
Share	89%	1%	2%	9%	100%

Source: The Study Team

Table 5.32 Forecasted Future Cargo Volume in 2040

unit: 1,000 tons/day

Commodity	Truck	IWT	Railway	Coastal	Total
1 Live Animal & Animal Products	7.5	0.1	0.0	0.0	7.5
2 Fish and Aquatic Products	32.2	0.0	0.0	0.0	32.2
3 Vegetable and Fruits	26.3	0.1	0.0	0.0	26.4
4 Grain and Grain Products	397.2	0.8	1.2	8.8	408.0
5 Other Agricultural Products (ex. Plantation Product)	338.2	4.8	0.2	0.0	343.2
6 Foodstuff, Beverage and Animal Food	116.3	0.0	8.6	14.3	139.2
7 Petroleum, Oil and Gas	137.1	15.3	0.1	151.6	304.1
8 Coal, Ore, Stone and Sand	210.4	0.9	7.9	0.0	219.2
9 Cement, Construction Material (incl. Steel-frame)	443.9	0.1	7.8	7.6	459.5
10 Fertilizer (incl. Urea)	53.7	0.0	0.1	0.0	53.8
11 Garment, Textiles and fabric	17.3	0.0	0.0	0.0	17.3
12 Wood and Wood Products	23.1	0.6	0.1	0.0	23.9
13 Paper and Printed Matter	5.0	0.0	0.0	0.0	5.0
14 Metal and Metal Products (excl. Construction Material)	12.4	0.1	0.1	0.0	12.6
15 Industrial Material, Chemicals	40.4	0.0	0.6	1.4	42.3
16 Household articles, miscellaneous	290.8	1.5	3.2	1.3	296.8
17 Machinery and Parts, Transportation	55.2	0.0	0.2	0.1	55.5
Total	2,207.2	24.2	30.0	185.2	2,446.5
Share	90%	1%	1%	8%	100%

Source: The Study Team

5.4.4 Demand Forecast for Feasibility Study on Mandalay Port Development

Based on the freight demand forecast model developed in the MYT-Plan, cargo demand of Mandalay Port by inland water transport is estimated to provide input data for the feasibility study on the Mandalay port improvement. The forecasted future cargo generation in Mandalay transported by inland water transport is shown in following tables.

"Without" case is the case of without any improvement, namely, results of modal split by existing inter-zonal impedance such as transport time and cost of all modes.

"With Express train and truck" case is the results of modal split model by inter-zonal impedance changed by i) travel time by railway between Yangon and Mandalay is reduced by the improvement of track by 2020 (existing average speed 16.7 km/h is increased to 52.5 km/h), ii) truck and trailer are able to travel on the Yangon-Mandalay Expressway at 70km/h in 2020.

Table 5.33 Forecasted Future Cargo Generation in Mandalay (without case)

unit: tons/day

Commodities	2015		2020		2030		2040	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1.Live Animal & Animal Products	8	1	10	1	13	1	17	1
2.Fish and Aquatic Products	0	0	0	0	0	0	0	0
3.Vegetable and Fruits	5	2	8	4	17	12	33	25
4.Grain and Grain Products	153	100	201	142	298	227	306	243
5.Other Agricultural Products (ex. Plantation Product)	226	115	406	221	1,133	671	2,621	1,478
6.Foodstuff, Beverage and Animal Food	150	84	97	57	22	14	3	2
7.Petroleum, Oil and Gas	789	199	1,575	399	3,806	1,557	7,908	5,490
8.Coal, Ore, Stone and Sand	11	92	21	131	61	312	173	670
9.Cement, Construction Material (incl. Steel-frame)	368	162	416	176	213	123	17	55
10.Fertilizer (incl. Urea)	13	16	7	10	0	3	0	1
11.Garment, Textiles and fabric	15	14	9	9	1	1	0	0
12.Wood and Wood Products	43	85	61	118	98	201	155	319
13.Paper and Printed Matter	1	0	1	0	0	0	0	0
14.Metal and Metal Products (excl. Construction Material)	45	39	41	51	41	54	38	36
15.Industrial Material, Chemicals	72	0	45	0	8	0	0	0
16.Household articles, miscellaneous	418	213	551	311	684	508	614	623
17.Machinery and Parts, Transportation	11	4	4	2	0	0	0	0
Total	2,329	1,127	3,452	1,633	6,397	3,685	11,884	8,942

Source: Study Team

Note: "IN" is incoming cargo by vessel to river port in Mandalay (TAZ 33). "OUT" is out-going cargo by vessel from river port in Mandalay (TAZ 33).

Table 5.34 Forecasted Future Cargo Generation in Mandalay (with Express train and truck)

unit: tons/day

Commodities	2015		2020		2030		2040	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1.Live Animal & Animal Products	8	1	9	1	13	1	14	1
2.Fish and Aquatic Products	0	0	0	0	0	0	0	0
3.Vegetable and Fruits	5	2	8	4	17	12	32	22
4.Grain and Grain Products	153	100	186	131	276	210	286	226
5.Other Agricultural Products (ex. Plantation Product)	226	115	370	199	1,052	626	2,488	1,390
6.Foodstuff, Beverage and Animal Food	150	84	87	49	21	12	3	2
7.Petroleum, Oil and Gas	789	199	867	285	2,141	931	4,778	3,166
8.Coal, Ore, Stone and Sand	11	92	19	131	57	312	161	669
9.Cement, Construction Material (incl. Steel-frame)	368	162	371	173	193	122	17	55
10.Fertilizer (incl. Urea)	13	16	7	9	0	3	0	1
11.Garment, Textiles and fabric	15	14	8	7	0	1	0	0
12.Wood and Wood Products	43	85	59	84	95	143	151	228
13.Paper and Printed Matter	1	0	1	0	0	0	0	0
14.Metal and Metal Products (excl. Construction Material)	45	39	38	50	40	54	36	36
15.Industrial Material, Chemicals	72	0	43	0	8	0	0	0
16.Household articles, miscellaneous	418	213	478	281	617	478	573	608
17.Machinery and Parts, Transportation	11	4	4	2	0	0	0	0
Total	2,329	1,127	2,556	1,408	4,531	2,905	8,540	6,403

Source: Study Team

Note: "IN" is incoming cargo by vessel to river port in Mandalay (TAZ 33). "OUT" is out-going cargo by vessel from river port in Mandalay (TAZ 33).

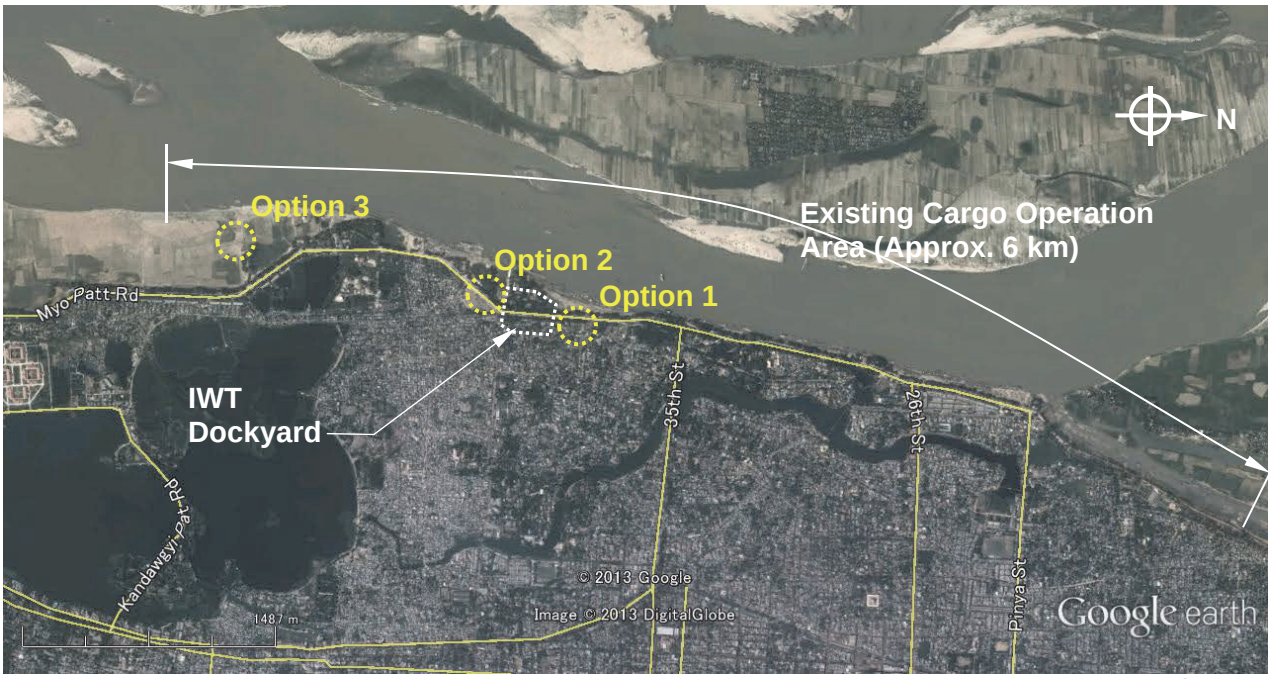
5.5 Suitable Port Location

5.5.1 Candidate Port Locations

In Mandalay Port, cargo handling operations are carried out on the natural riverbank of the Ayeyarwady River. The cargo handling area is approximately 6 km of riverbank located on the left-side of the river and west of the city center. In order to select candidate port locations, the following points were considered.

1) From the viewpoint of the development concept, which is to change manual cargo handling to equipment handling phase by phase, candidate locations were selected in the area where the handling of cargo are presently carried out.
2) The Mandalay City Plan issued by the Ministry of Construction (2013) and the Project Finding Report prepared by MLIT Japan (2013) were referred to.
3) In order to reduce the influence on private operators' activity due to new port development, the location where the Inland Water Transport (IWT) presently holds cargo operation activities was included in the candidate locations.
4) In view of social environment impact, locations with fewer households along the riverside were selected.

Three candidate locations were selected as shown in Figure 5.53. In the figure, the IWT cargo operation area is located between 35th street and the IWT dockyard. MLIT Report (2013) proposed Location 1 as shown in the figure for the new port location. The Mandalay City Plan (MOC 2013) proposes the new port location to be on the wide southern riverbank swamp area near by Option 3. Option 2 is located on the south side of the IWT dockyard which has a little wider land space and assumed to have fewer households. The riverbank north from 35th street is observed to have many small shop huts, where private cargo operators are working.



Source: The Study Team Plots on Google Earth® Image

Figure 5.53 Candidate Port Locations

5.5.2 Method of Evaluation

The evaluation items are shown below. For each evaluation item, five grades were used. Because the items contain very essential characteristics for port location or risks which will be improved with the appropriate countermeasures, the final assessment will be made considering the most important factors and through discussions with Myanmar (MOT, DWIR, IWT) officials.

Table 5.35 Evaluation Items and Criteria

Evaluation Item	
1. Natural Condition	
1.1	Size of Space
1.2	Soil Condition
1.3	Water Depth & Navigation
2. City Plan & Industry	
2.1	Matching with Existing Activity
2.2	City Plan
2.3	Closed Hinterland
2.4	Industrial Area
3. Construction Cost	
3.1	Berth
3.2	Cargo Yard
3.3	Access Road
4. Future Expansion Potential	
4.1	Expansion of Berth
4.2	Expansion of Yard
5. Environment	
5.1	Social Environment
5.2	Natural Environment
5.3	Pollution

Evaluation Criteria	
Grade	Criteria
5	Exceptionally Suitable
4	Suitable
3	Possible
2	Better to Avoid
1	Not Suitable

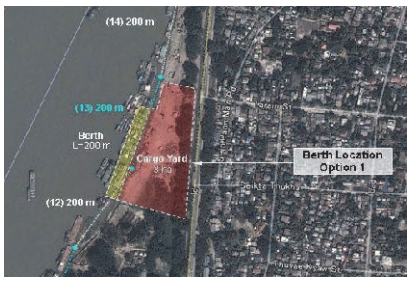
Source: The Study Team

5.5.3 Evaluation of Candidate Locations

(1) Natural Condition

1) Size of Space

The following Figure shows the assumed port layout plot for each optional location. It is assumed that the berth length is to be 200m and the yard space is to be 3 ha. The shown images (Google Earth) are the pictures in dry season in which water lines show the features of the low water level.



Berth Location Option 1

Berth Location Option 2

Berth Location Option 3

Source: The Study Team Plots on Google Earth® Image

Figure 5.54 Berth & Yard Plot for 3 Candidate Locations

Option 1 is located to the north of the IWT dockyard. The yard space is rather smaller when compared to the other options. The distance between the existing road and the waterline in the dry season is 55~115m. (Gr. 3)

Option 2 is located to the south of the IWT dockyard. The yard space is wider than that of Option 1. The distance between the existing road and the waterline in the dry season is 80~160m. The yard space will become trapezoidal in shape as the existing road does not run parallel to the waterline. (Gr. 4)

Option 3 is located 1,500m south from Option 2, which has a wide swamp area in the vicinity. The distance between the existing road and waterline in dry season is 400m. The yard space can be plotted as a square shape, in which facilities can be placed for effective positions. (Gr. 5)

2) Soil Condition

For soil condition, the depth of foundation strata, assuming piles construction and the distribution of silt/clay strata which will cause long-term consolidation settlement, are considered for evaluation. Figure 5.55shows the soil profiles of the three Options. The following Table shows the summary of the depth of the founding strata and the thickness of soft strata.

The depths of hard strata at each jetty location vary in the range of -16m~-18m, which are suitable conditions for the construction of pile foundations.

Comparison of the soft strata distribution at the yard locations shows that Option 1 has no soft strata. (Gr. 5)

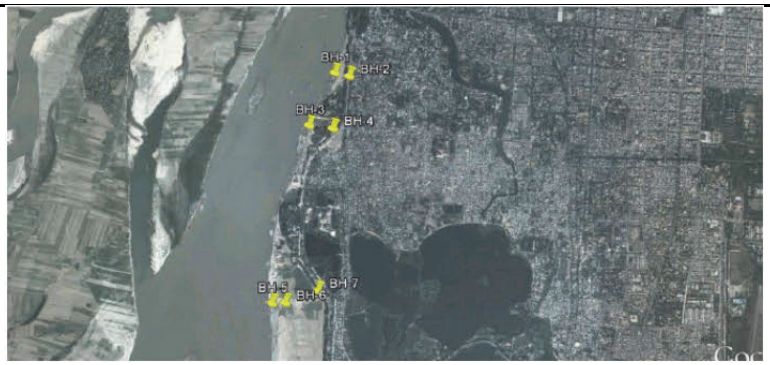
At Option 2, 4~6m thick soft strata is observed near the ground surface. Although there is not enough soil boring available, there is a pond in the middle of the yard location, where it is assumed that very soft soil might be distributed there. (Gr. 4)

At Option 3, there is no soft layer at the yard area, but an approximately 14m thick clay layer is observed below the access road. (Gr. 4)

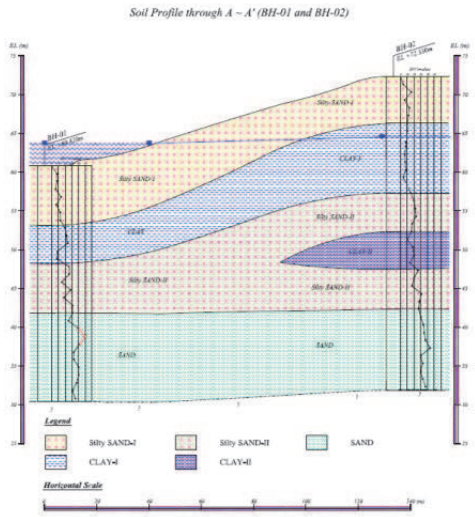
Table 5.36 Depth of Founding Strata and Thickness of Soft Strata

Option	BH No.	Elevation of Founding Strata N>30 (m)		Thickness of Soft Strata N<10 (m)	Remark
		AMSL	ACD(Mandalay)		
1	BH-1	+42.8	-18.5	0.0	Jetty
	BH-2	+44.3	-17.0	0.0	Yard
2	BH-3	+45.0	-16.3	4.1	Jetty
	BH-4	+45.4	-15.9	5.6	Yard
3	BH-5	+45.1	-16.2	0.0	Jetty
	BH-6	+45.0	-16.3	0.0	Yard
	BH-7	+41.0	-20.3	14.0	Access Road

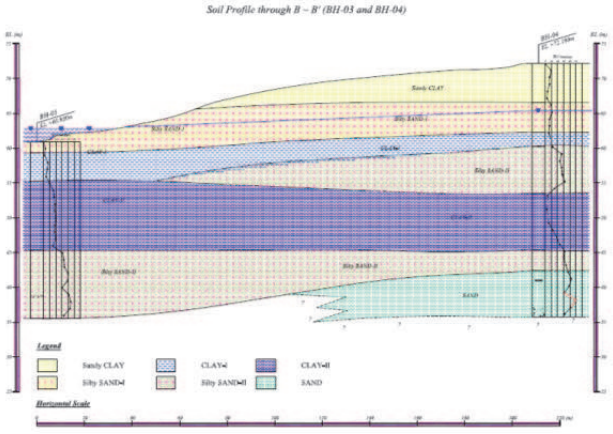
Source: The Study Team



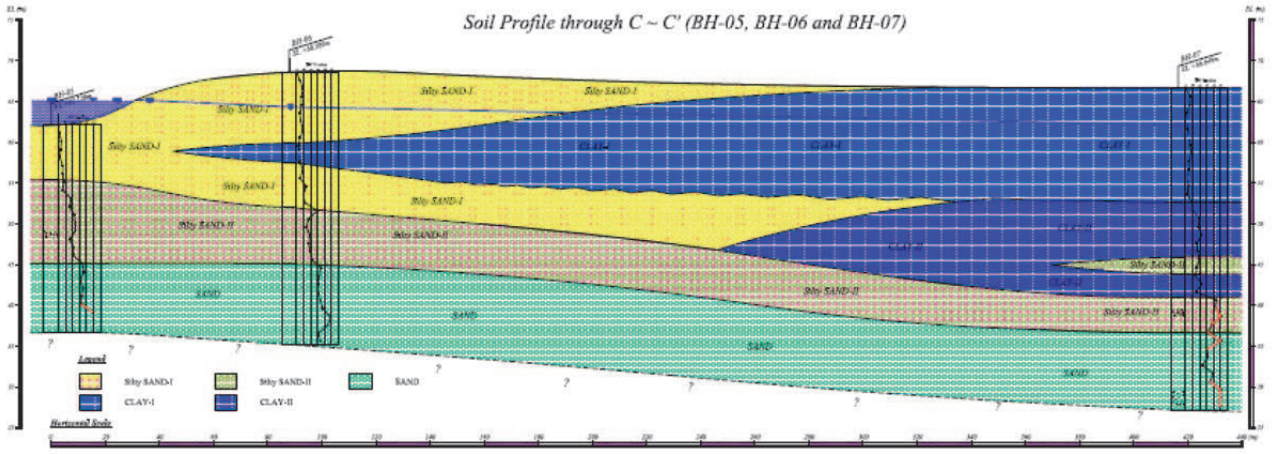
Locations of Soil Boring



Option 1 Soil Profile



Option 2 Soil Profile



Option 3 Soil Profile

Source: The Study Team

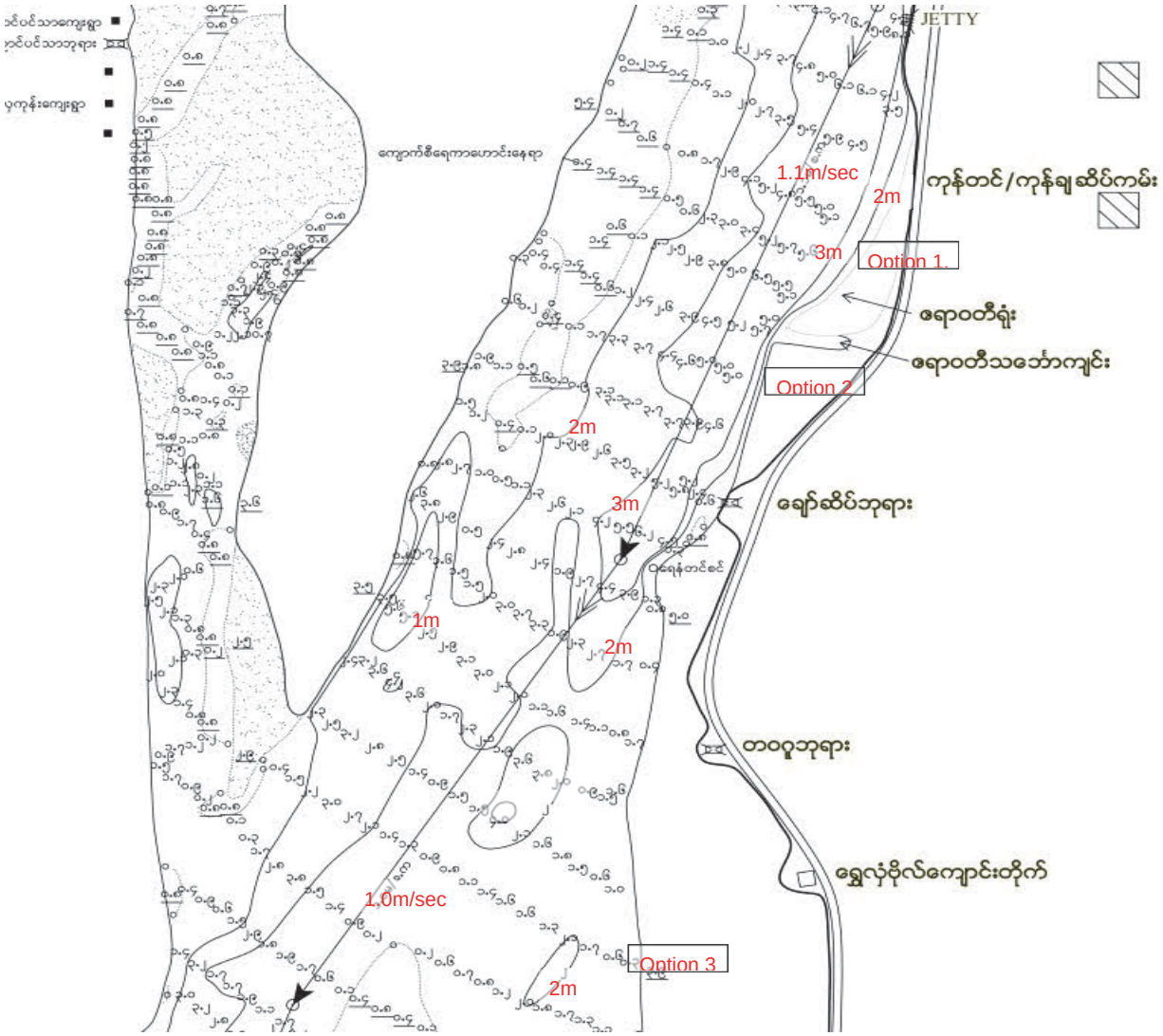
Figure 5.55 Result of Soil Investigation

3) Water Depth at Jetty and Ship Maneuvering

Figure 5.56 shows the bathymetric survey record which was carried out by DWIR in December 2012. Option 1 and Option 2 shows the water depth is 3~6m at the jetty location which is suitable for jetty construction.

Option 1 shows no obstructions for ship maneuvering. (Gr. 5) But Option 2 is located at the mouth of the slipway of the IWT dockyard, and so the jetty location should be moved southward approximately 100m so that dockyard operations should not influence to the ship berthing activities. (Gr. 4)

For Option3, the water depth is shallower than the other two Options (-1.0m). Initial/maintenance dredging will be needed for port operations. (Gr. 3)



Source: DWIR December 2012

Figure 5.56 Bathymetric Survey Record

(2) City Plan and industry

1) Matching with Existing Activities

One of the aims of the new port construction is to change present labor handling of cargo to equipment handling. Traditionally, cargo has been handled by manual labor for a considerable long time (perhaps more than 100 years) and it should be important to plan the change from manual to machine handling in a slow and careful manner. Therefore, the choice of the new port location should be where current cargo operation takes place and should be recognized as a pilot project.

Option 1 and Option 2 both operate during both the dry and rainy seasons, which are suitable to allot the model port facilities. (Gr. 5)

Option 3 only operates in the dry season because the water depth is shallow during the rainy season. (Gr. 4)

2) City Plan

Figure 5.57 shows the city development plan issued as the result of a joint study by MOC (Ministry of Construction) and MCDC (Mandalay City Development Committee) in March 2013. From this plan, the city of Mandalay is assumed to be expanded southward and a secondary center will be created. Therefore the future port development area is placed at the wide riverbank swamp area at the south end of the city. Two port development locations are shown in the city plan, of which the northern point is for a passenger port and the southern point is for a cargo port.

Option 1 and Option 2 are located outside of the city plan's port development circle. (Gr. 2)

Option 3 is located at the north circle of the port development area of the city plan. Although the northern circle is assumed to be for a passenger port, the port investment for Option 3 will not be wasting expenses taking into account that the future city growth will extend in the southern direction. (Gr. 4)

Source: Ministry of Construction

Figure 5.57 Mandalay City Development Plan

Figure 5.58 shows the wider regional development plan including Mandalay. The plan shows the plan of industrial estate development with the cargo port (MMID) downstream on the Ayeyarwady River about 70km from the Mandalay city center. This plan is a joint development with a private developer and the Mandalay Regional Government, in which the government will award a private operator the developmental right.

The new port development undertaken by this study aims to support economic activities of Mandalay by public investment. The MMID project is located far from the city center, whose port will be used exclusively by the industrial park. It is understood that the new port for Mandalay industry near the city center will be needed separately from the MMID development.

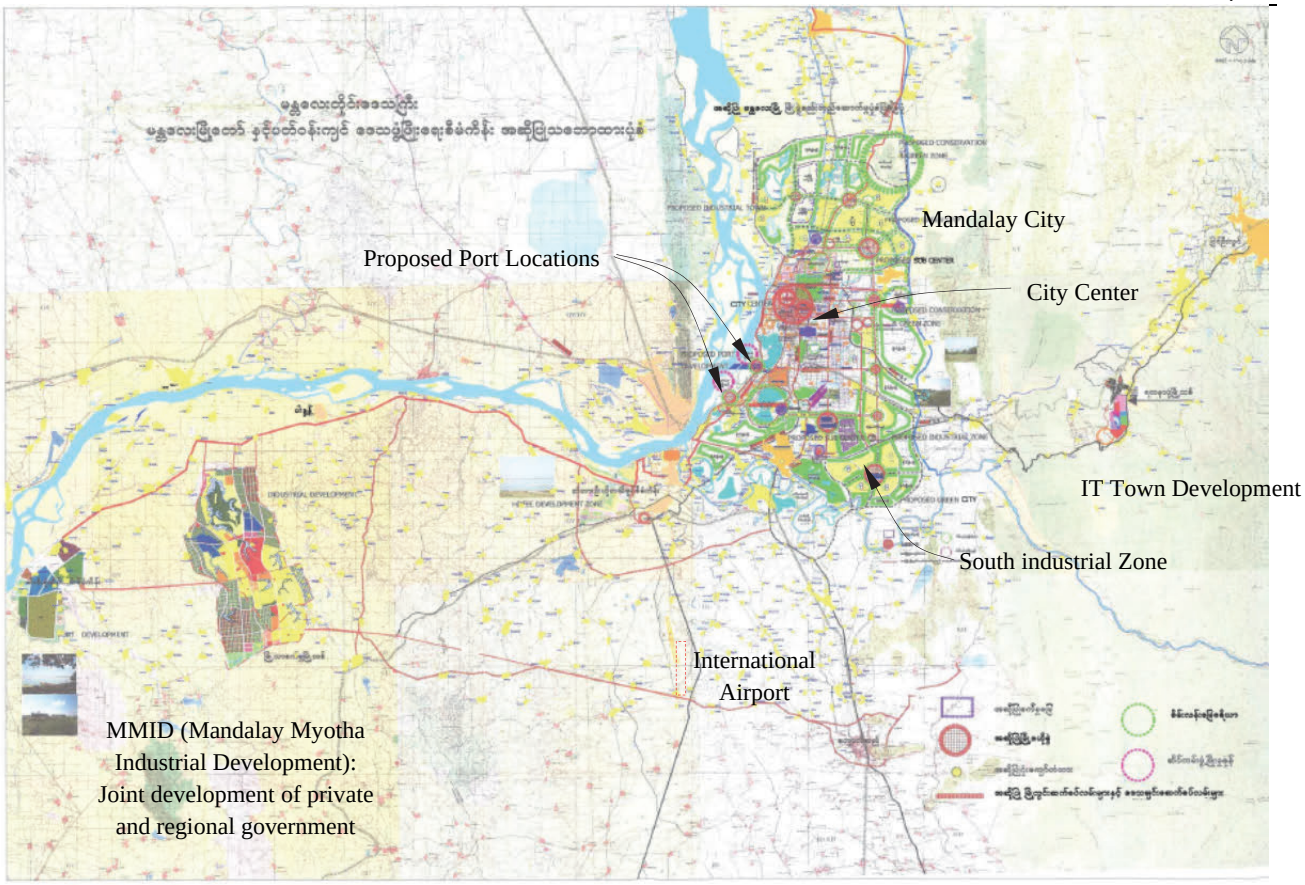


Figure 5.58 Wider Regional Development Plan Mandalay

Source: Ministry of Construction

3) Closed Hinterland

In general, port development plans avoid places near residential or commercial areas because they run the risk of traffic accidents where the port road is always congested with heavy trucks carrying cargoes. Source: The Study Team plots on Google Earth Image

Figure 5.59 shows the existing land use of port hinterland.

Option 1 adjoins to the residential area. It has the risk of increasing traffic congestion and accidents. (Gr. 3)

Option 2 also adjoins a residential area, but the density of houses is a little sparse compared to Option 1. The space (1.1ha) at the opposite side of Option 2 across the existing road has been used as a night market where many vendors have gathered since 2012. If it can be assumed that this place can be used for port related industry in future, the development potential of Option 2 is considered to be higher than Option 1. (Gr. 4)

Option 3 is 400m from the existing road and there are few houses in the vicinity. There is a wide spread of riverbank area for future expansion at Option 3. (Gr. 5)

Option 1	Option 2	Option 3
		

Source: The Study Team plots on Google Earth Image

Figure 5.59 Existing Land Use at Close Hinterland

4) Industrial Area

Figure 5.60 shows the locations of existing passenger and cargo terminals and the commercial area of the city is referred to in the locations of candidate port sites. Table 5.37 shows the summary of the distance between each port candidate and these city spots.

The existing industrial area of Mandalay is located 15km from the candidate port locations. The three port options are located at the southwest end of the city, where access to the industrial area should go through Myo Patt Rd (riverside road) to avoid an increase in traffic on the major roads of the city. In addition, Mandalay is developing a “Highway Bus and Merchandise Center Project” in the south area of the city, which is also a good location for the candidate port locations.

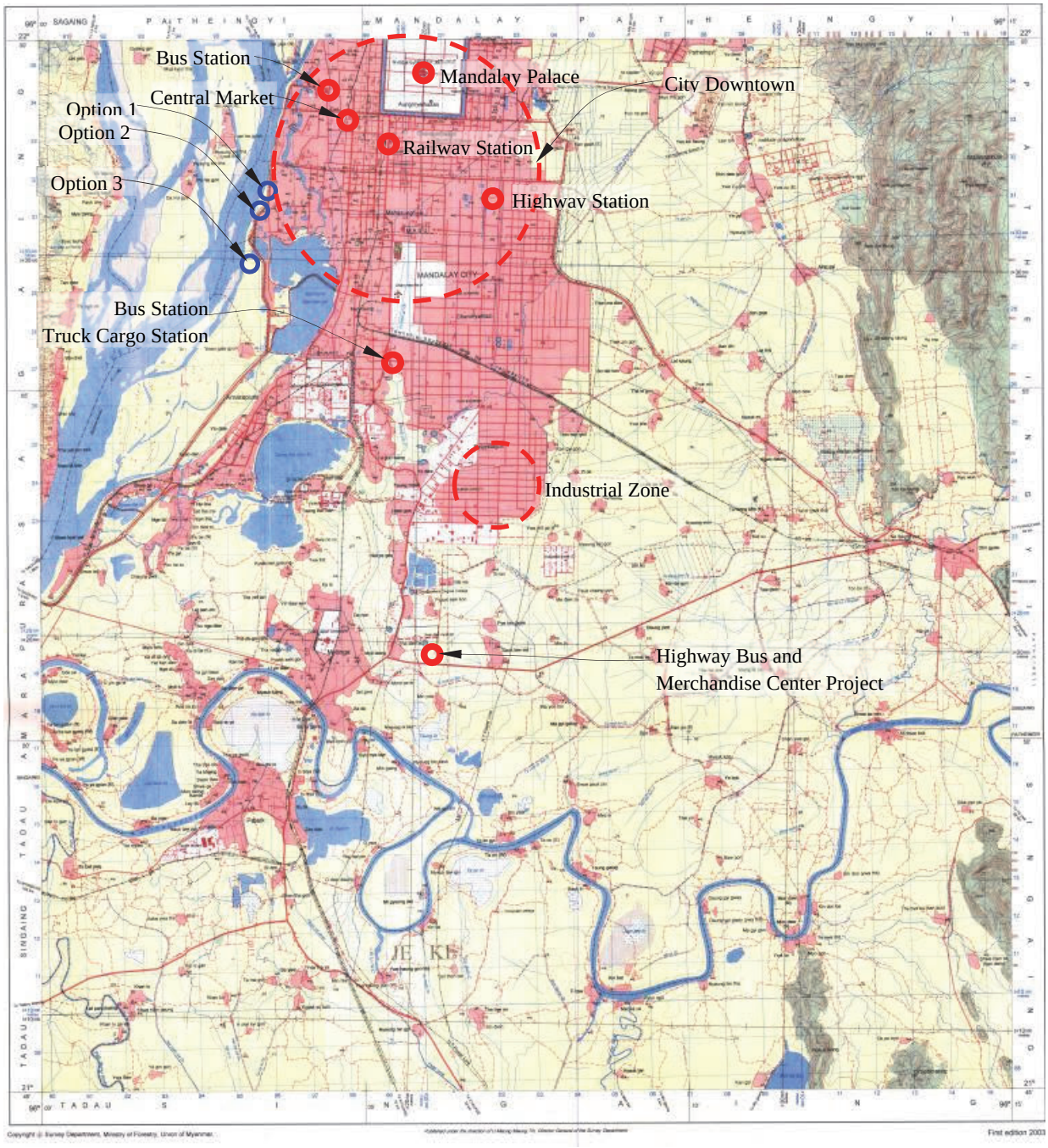
According to the report “review of dry ports in Asia and prefeasibility study, 2012” conducted by UNSCAP, it proposes to develop ICD near the place of the “Highway Bus and Merchandise Center Project”, which is also well matched to the candidate port locations. (Option 1 ~ 3, Gr. 5)

Table 5.37 Distance from Candidate Port Locations to City Spots

Place	Distance from Port Options (km)		
	Option 1	Option 2	Option 3
Central Market	4.3	4.9	6.9
Railway Station	4.6	5.3	7.1
Existing Bus & Truck Cargo Terminal	8.0	7.7	7.7
Highway Bus & Merchandise Center Project	17.4	17.1	17.1
Existing Industrial Zone	15.3	15.0	15.0
International Airport	34.2	33.7	32.6

note: Distance is measured along city major road

Source: The Study Team



Source: The Study Team plots on the Map issued by Ministry of Forestry

Figure 5.60 Locations of City Industrial Spots and Candidate Port Locations

(3) Construction Cost

1) Berth

The evaluation is assumed that the berth will be built by piled deck structure as the most typical type. The construction cost mainly depends on the soil condition, i.e. the depth of the founding strata. The results of the soil survey shows the depth of hard strata (N>30) is distributed -16.2 ~ -18.5 ACD Mandalay, in which no difficulties in pile building are found. (Option 1 ~ 3, Gr. 5)

2) Yard

The reclamation volume for each yard location is calculated as follows.

Option 1 : 150,000 m^3
Option 2 : 102,000 m^3
Option 3 : 176,000 m^3

Regarding ground soil condition, Option 1 and Option 3 are generally good as a sand layer with 5~10m thick is distributed near the ground surface. However at Option 2, there is a pond in the middle of the reclamation area, in which it is foreseen that a soft soil layer might be distributed near the ground surface. Some soil improvement might be required at Option 2. (Option 1: Gr. 5, Option 2: Gr. 3, Option 3: Gr. 5)

3) Access Road

Although Option 1 and Option 2 face the existing road, Option 3 requires building an access road approximately 350m in length. In addition, the soft soil layer is distributed under the location of the access road, so soil improvement might be necessary for consolidation settlement. (Option 1: Gr. 5, Option 2: Gr. 5, Option 3: Gr. 3)

(4) Future Expansion Potential

1) Expansion of Berth

The berth length of this project is assumed at L=200m which is capable to accommodate two of the longest type of barges (LOA = 70m). The expansion spare length of berth length is estimated as follows taking into account the topographic conditions and existing riverbank facilities.

Option 1: 450m (north from IWT dockyard to the existing riverbank for cargo operation)
Option 2: 350m (south from IWT dockyard to an existing temple)
Option 3: more than 1,000m

Option 1 has a 450m future extension length from the north edge of the IWT dockyard to the point where the water line is close to the existing road. (Gr. 3)

Option 2 has a 350m future extension length from the point 100m south of IWT slipway's mouth to the northern edge of an existing temple. (Gr. 3)

Option 3 faces a wide riverbank southward, which is assumed to be an infinite spare length for the future. (Gr. 5)

2) Expansion of Yard

Spare expansion space for a cargo yard is quite important for the future when the cargo volume will increase. When it is assumed that the cargo yard will be expanded by reclaiming riverbank between the water line and the existing road, Option 1 and Option 2 has a little disadvantage as the expansion space is smaller. If we assume the space of the night market in the vicinity of Option 2 could be used for port related yard space, Option 2 will have a little more advantage than Option 1. Option 3 has a wide space for future yard expansion. (Option 1: Gr. 3, Option 2: Gr. 3.5, Option 3: Gr. 5)

(5) Environment

1) Social Environment

The most important issue of the social environment is the requirement of the resettlement of houses scattered along the riverbank. These houses are recognized to belonging to squatters because the riverbank is legally owned by the government. The main activities of these squatters are related to port operations such as manual cargo handling, or street vendors supplying food or beverages to port workers. The houses are generally small wooden tents or huts. It is foreseen that these squatters will be reduced as the port operation will be changed from manual labor to equipment. But careful attention is required during the initial development period for these squatters to avoid spending too much time on negotiations for compensation, or on their possible campaign against the development. The guidelines of JICA stipulate that special care will be necessary if the total number of squatters exceeds 200 people.

The following table shows the numbers of households at the project area which was surveyed by the Study Team in June and July 2013.

Table 5.38 Number of Households in the Candidate Port Locations

Port Candidate Location	Number of Household
Option 1	61
Option 2	70
Option 3	0

Source: The Study Team

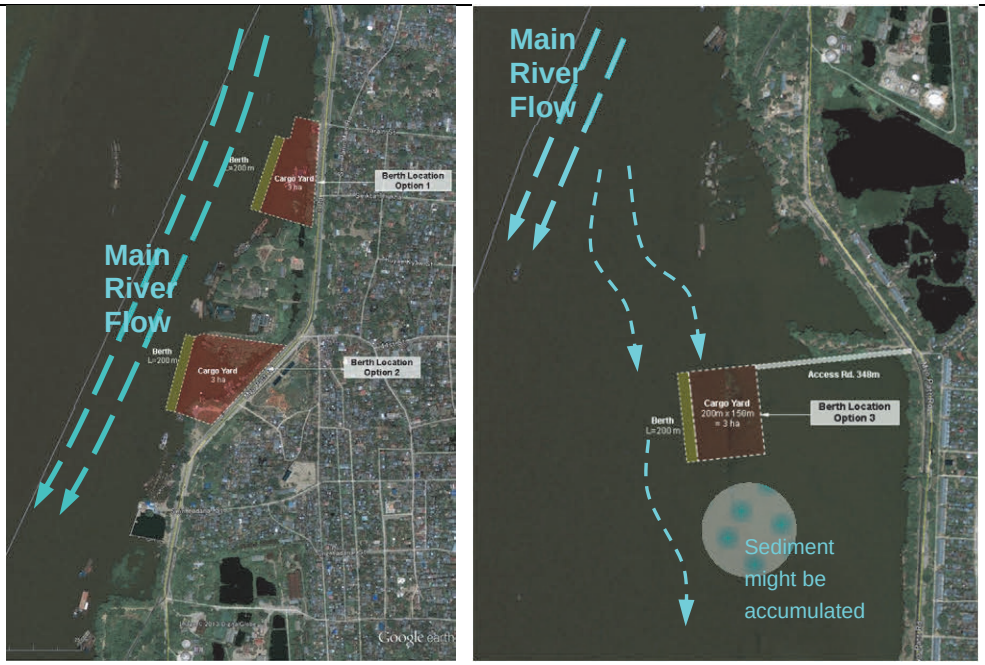
Assuming 4 squatters live in one household, the numbers of squatters in option 1 and Option 2 are foreseen to exceed 200 people. (Option 1: Gr. 2, Option 2: Gr. 2, Option 3: Gr. 5)

2) Natural Environment

The important issue on the natural environment is the change in the river flow due to yard reclamation and the topographical change downstream caused by the change in the river flow. Figure 5.61 shows the reclamation plots of each Option on a Google Earth image taken during the high-water season (August 2009).

It is foreseen for Option 1 and Option 2 that the reclamation will give very little influence on the river flow, because the way the river flows close to the reclamation yard, and the riverside topographical shape will not change much. (Gr. 5)

However, Option 3 might cause some change in the river flow. The surrounding area of Option 3's reclamation is flooded every year, where gentle water flow will be observed. It is foreseen that some sedimentation downstream from the reclamation might occur because the reclamation land will block the river flow at the location. It is required to estimate the possible impact by means of numerical analysis and necessary measures should be proposed. (Gr. 3)



Source: The Study Team plots on Google Earth Image

Figure 5.61 Image of Change in River Flow due to Reclamation

3) Pollution

In general, pollution due to execution of the project is itemized as water pollution, air pollution, and noise, etc. It is estimated that the environmental impact from such pollution should be small.

5.5.4 Result of Evaluation

The evaluation results are summarized in the following table.

Table 5.39 Result of Evaluation

Evaluation Item	Evaluation		
	Option 1	Option 2	Option 3
1. Natural Condition	(4.3)	(4.0)	(4.0)
1.1 Size of Space	3	4	5
1.2 Soil Condition	5	4	4
1.3 Water Depth & Navigation	5	4	3
2. City Plan & Industry	(4.0)	(4.3)	(4.8)
2.1 Matching with Existing Activity	5	5	4
2.2 City Plan	3	3	5
2.3 Closed Hinterland	3	4	5
2.4 Industrial Area	5	5	5
3. Construction Cost	(5.0)	(4.3)	(4.0)
3.1 Berth	5	5	5
3.2 Cargo Yard	5	3	4
3.3 Access Road	5	5	3
4. Future Expansion Potential	(3.0)	(3.3)	(5.0)
4.1 Expansion of Berth	3	3	5
4.2 Expansion of Yard	3	3.5	5
5. Environment	(4.0)	(4.0)	(4.3)
5.1 Social Environment	2	2	5
5.2 Natural Environment	5	5	3
5.3 Pollution	5	5	5
Average Grade	(4.1)	(4.0)	(4.4)

Source: The Study Team

From the result of the evaluation, Option 3 shows the highest average grade. It is understood that the evaluation items,

1) Mandalay city plan
2) Future extension potential, and
3) Social environment (numbers of squatters)

are the most important factors. The Study Team recommends selecting the project location at Option 3 from view of these important factors.

5.6 Terminal Planning

5.6.1 The Aim of Terminal Planning

(1) Present Cargo Handling Method and Things to be Changed

The following pictures show the existing cargo handling conditions. Many kinds of cargo are placed on the natural riverbank in a disordered fashion. All cargoes are carried by port workers without any equipment.

Existing River Bank

Manual Cargo Handling

Source: The JICA Study Team

Figure 5.62 Existing Cargo Handling Conditions

Figure 5.63 shows a series of cargo handling patterns which start from the existing handling method to several patterns of modernized methods. The existing method of cargo handling is that the cargo barges stay near the river bank, and trucks that belong to the owners of the cargo receive the cargoes while parked on the natural riverbank. The cargoes are carried by port workers by hand. Part (1) of the Figure 5.63 shows an image of the existing cargo handling method which will be continued after the berth and yard are constructed. The problems on the existing method are summarized as follows.

1) Low Efficiency of Manual Handling

Manually handling cargo is generally inefficient because the work depends on the number of workers and their own abilities. The work is sometimes interrupted due to inclement weather. Also, it takes time to carry a large volume of cargo when the number of walkways between barge and riverbank are limited. Presently it takes 1 or 2 days to complete handling the cargo of an approximately 500 tons loaded barge, where the barge continues to be stationary at the riverbank.

According to the field survey made by the Study Team, the efficiency rate of the manual labor is as follows:

- Survey period: 23 June 2013 ~ 27 June 2013 (5days)
- Numbers of workers per barge: 20 ~ 40 workers
- Average cargo handling rate: 34 tons/hr

This data was measured at the riverbank, taking about 1 hour each day during the survey. The rate does not include a long enough rest time. For planning purposes, 17 tons/hr is used which is a 50% reduced figure taking into account the common rest time of workers.

2) Passenger-cum-cargo Ship does not Allow Equipment Handling

Because the existing passenger-cum-cargo ships have roofs, it is not possible to lift cargo by equipment, as shown in Figure 5.62. The number of the passenger-cum-cargo ships owned by IWT is shown below. 41% of IWT's ships are passenger-cum-cargo ships.

- Passenger-cum-cargo ships 138 ships
- Barge, self-propelled 57 ships
- Barge, no engine 138 ships

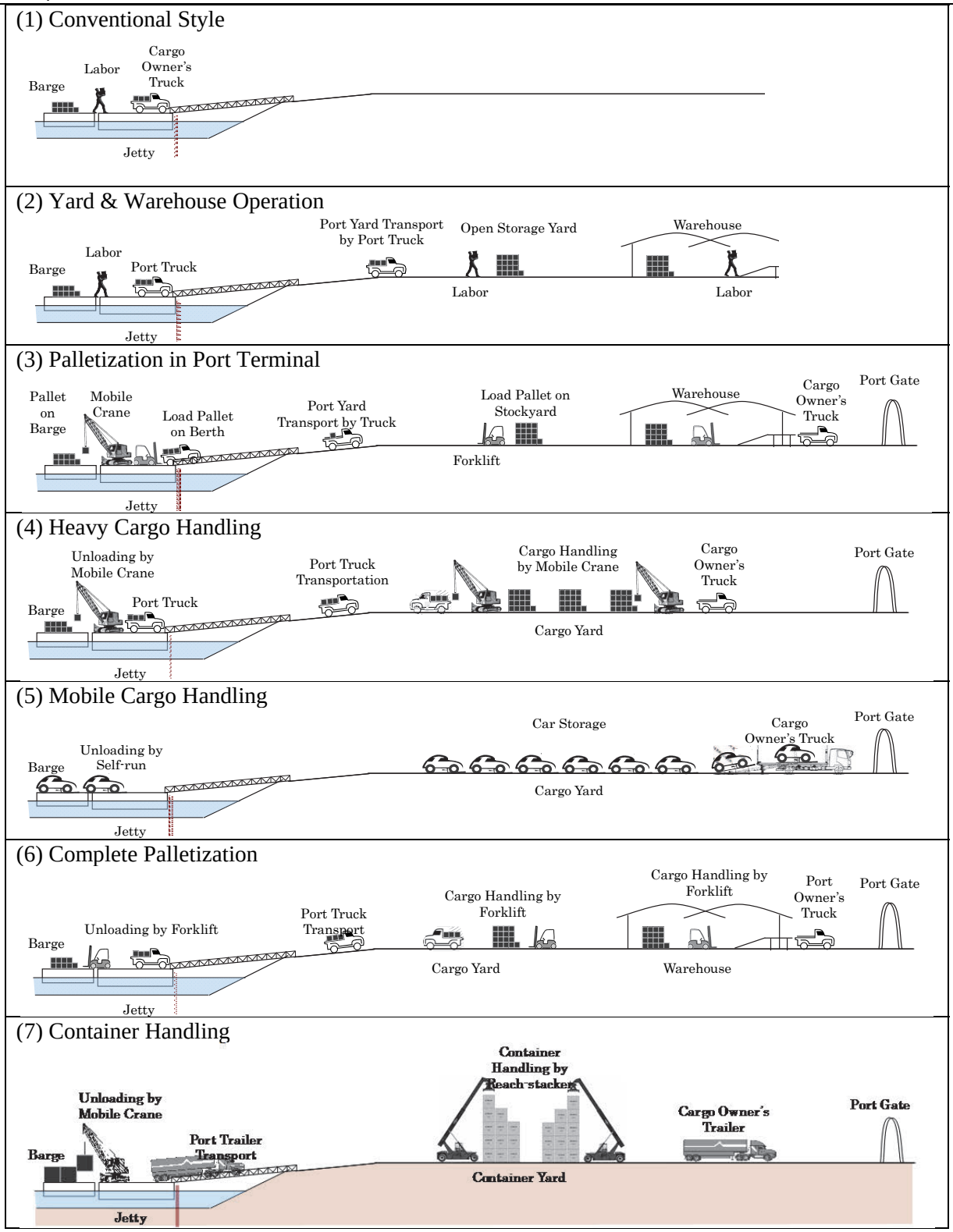
It is preferable to separate cargo and passengers in future operations, but more time will be required to completely replace the ships. The proposed terminal plan should be capable of allowing access to the existing passenger-cum-cargo ships for the time being.

3) Cargo Efficiency is Affected by the Rate of Cargo Owners Transport Capacities

At present cargoes are directly carried from the barges to trucks. However, the number trucks owned by the cargo owners are limited, and the workers are often left waiting for cargo trucks, thus the number of trucks and workers are not balanced. If this scenario of cargo handling is applied to the newly built berth, as shown in Figure 5.63 (1), berth efficiency will not be increased as the berthing time becomes extended due to an insufficient supply of trucks.

4) Barges are Waiting for the Cargo Owners at Riverbank

After unloading cargo, barges generally wait for the next customer in order to carry cargo on the return journey. But it is usually not easy to fulfill the cargo capacity on both the outward and return journey. Therefore, empty barges often wait until customers for the return journey appear. In order to obtain enough cargo for a full capacity, ship owners will wait for several customers, and so the waiting time is longer. If there is no cargo on return journey, the transportation cost will be high for the owners of the outbound cargo, because the cost of an empty journey will be charged to them.



Source: The JICA Study Team

Figure 5.63 Patterns of Terminal Services

(2) Terminal Operation and Equipment

Considering the existing cargo handling operation as well as the cargo ships and barges, the Study Team recommends the following measures on port development in order to modernize river port operations step by step.

1) Function of Terminal Operation

To begin with, the establishment of an agency which is responsible for port construction, operation and maintenance will be required. Throughout the discussions during the study period between MOT, DWIR, IWT and the Study Team, it was deemed practical that the DWIR will be responsible for port construction, and the IWT or a private operator will take charge of operation and maintenance. Operation of the terminal will create the following improvements (improvement from (1) to (2) in Figure 5.63)

- Port operators unload cargo from barges or ships, and then the cargo is stored in the port yard or storehouses. The owners receive their cargo at the port yard or warehouses, not directly from the cargo barges. Consequently the berthing time for a barge or ship will be shortened. The berth efficiency will be increased where one berth can handle many ships.
- The port operator manages the storage of the cargo and effectively sorts them according to their destinations, which in turn makes it easier to load the cargo of many owners onto one barge. When the barge occupancy increases, it becomes easier to introduce a shuttle transport service with a fixed time schedule. The use of larger barges and the establishment of a fixed time service will provide benefits not only to the owners of the cargo, but also to the port operator and ship owners. The increase of barge occupancy brings about the reduction of transportation costs. The port operator has the benefit of raising revenue due to the improvement of berth occupancy.

2) From Break Cargo to Unit Cargo

The first step of equipment cargo operation is to make the existing system of packaging cargo into large cargo units. In Mandalay Port, presently major cargoes are bagged cargo (50kg) of rice or beans Although the typical way to introduce cargo units is by using cargo containers, pallets are recommended for Mandalay Port during the period of transition, because cargo containers are not used at all in Mandalay. When the use of pallets becomes common, it will be easier to house the palletized cargo in containers. The advantages for using pallets and containers are explained in general, as follows:

(Advantage of Pallet)

- It becomes possible to use cranes and forklifts for handling, and the cargo handling speed will be highly improved. The berthing hours of a barge or ship will be reduced.
- Quick and trustworthy cargo management becomes possible by using equipment such as forklifts for receiving, storage, sorting and the delivery of cargo. This is advantageous for port operators to gain port users.

(Advantage of Container)

- Larger units provide an increase of handling efficiency.
- Safe transportation is achieved as damage and loss of cargo are reduced.
- Cargo operation is not interrupted by rain. The handling efficiency is therefore increased.
- Direct import/export becomes easy by use of transshipment through the Yangon or Thilawa Ports.
- High quality transport is possible such as the transport of fresh foods by using reefer containers. It has the possibility to gaining a new demand for water transport.

The main reason why pallets or containers are not used in the Mandalay region is because of the present condition of the warehouses in Mandalay, which have no equipment such as cranes or forklifts. Currently the labor cost for warehouse cargo handling is cheap and the volume of cargo does not seem

very large. Under these circumstances, it is not practical to circulate pallets for inbound and outbound cargo in the port. It will take some time to achieve the most effective use of cargo pallets. It is important for the public sector to begin handling large cargo units in the port, which will lead to the wider use of pallets by private cargo owners and warehouse operators.

3) Berth Operation and Quay-cranes

Figure 5.63 (3), (4), and (5) show the images of handling cargo when berth operation and the use of equipment have been achieved. These are the states of the transition period for full equipment cargo handling in the future as shown on the same Figure (5) and (6) where full palletization and containerization have been accomplished. In this study, the improvement of port terminal which targets Figure 5.63 (3), (4) and (5) is recommended. The advantages for each improvement pattern are described as follows:

(Palletization in Port Terminal)

This method is to load the small cargo units onto a pallet at the berth apron. Port operation will be improved by the use of palletized cargo units. Forklifts are used to move the pallets. They make it easier to manage temporary storage and cargo inventory, and consequently the time to move cargo for delivery will be saved. The cargo carried by the existing passenger-cum-cargo ships will be handled by this method for the time being.

(Heavy Cargo Handling)

By the means of berth operation and the use of cranes, heavy cargo handling will be possible, which so far has been difficult by the current method of manual labor on the natural riverside. It is assumed that heavy cargoes, such as steel and reinforcement material, have been transported by road due to the lack of port facilities, but water transport is much more suitable for moving these cargoes. A new demand might be created when a sufficient facility is installed in the port. It is suitable in the initial modernization period to use common truck cranes or crawler cranes for quay-cranes, taking into account the investment cost and the multi-purpose usage of equipment.

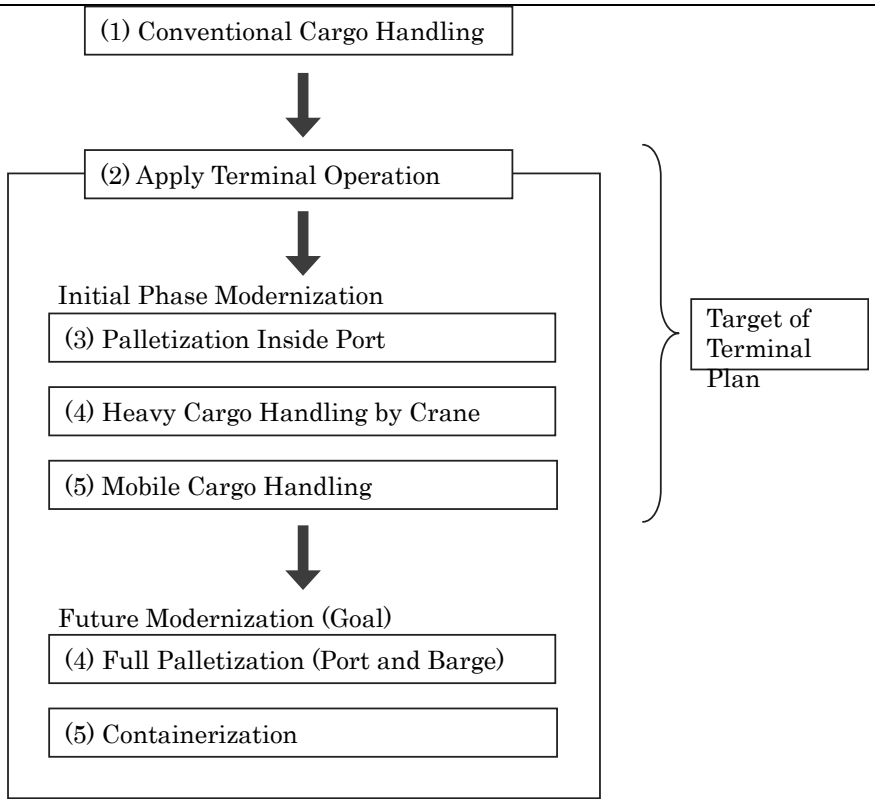
(Mobile Cargo Handling)

If the berth is designed as floating type, mobile cargo handling will be very easy, even at Mandalay Port, which has quite a large difference in the water level between the dry and rainy seasons. Mobile cargo includes not only conventional cars, but also cranes, agricultural equipment and excavators for mining. It is possible that the demand for transporting mobile cargo will increase in the future. Perhaps there will be a new demand for water transport; despite the longer transport time.

At present, mobile cargoes are driven over roads to their destination. Being driven has the risk of damage due to bad road conditions, and also uses fuel for transportation. Moving mobile cargoes by water transport decreases the risk of damage to the cargoes, and also saves on fuel and transportation costs.

(3) The Aim of Terminal Planning

From the previous review and analysis, the aim of the terminal planning is to promote the use of equipment and to introduce unit cargo operation. The following Figure shows the target of the terminal development on a flowchart of general modernization processes. The terminal plan focuses on (2) applications of terminal operation, and building facilities which are suitable for the improvement of cargo handling patterns (3), (4) and (5) on the Figure.



Source: The Study Team

Figure 5.64 The Aim of Terminal Planning

(4) For Further Modernization

This feasibility study is for the port of Mandalay. The importance on the next step or parallel development for sister ports and a shuttle transport service with a fixed time schedule is described as follows. The aim of the development of this study should be harmonized with future development.

1) Development of Sister Ports

Looking through the existing river ports in Myanmar, there are no facilities with equipment for handling cargo at present. With respect to the modernization of all of the river port systems in the country, the development of only Mandalay Port is not sufficient. For instance, handling heavy cargo (refer to Figure 5.64 (4)) requires the development of ports of cargo origin or destination at the same time. For palletization, if other ports are improved similarly, it makes it possible to load palletized cargo on the barges, which improves the efficiency of the total transportation system.

2) Shuttle Transport Service

To counter-act the downside of the longer travel time for water transport, it is important to promote a shuttle service with a fixed time schedule. At present most of the cargo transport services are only subject to each order, and not to a time schedule. It is assumed that a shuttle service with a timetable will be possible when the efficiency of handling cargo is increased by proper terminal operation and the use of equipment. If the terminal can receive the cargoes of many owners at the port yard, and can load them on the barge of a shuttle service, the occupancy of barges will be improved which will push the trans-cost down. The use of equipment makes the shipment schedule accurate.

5.6.2 Planned Cargo Volume of New Port

In Section 5.4, cargo demand was estimated assuming the current economic growth rate will continue for the next 20~30 years. In the plan of the new Mandalay Port, the initial development aims to create a

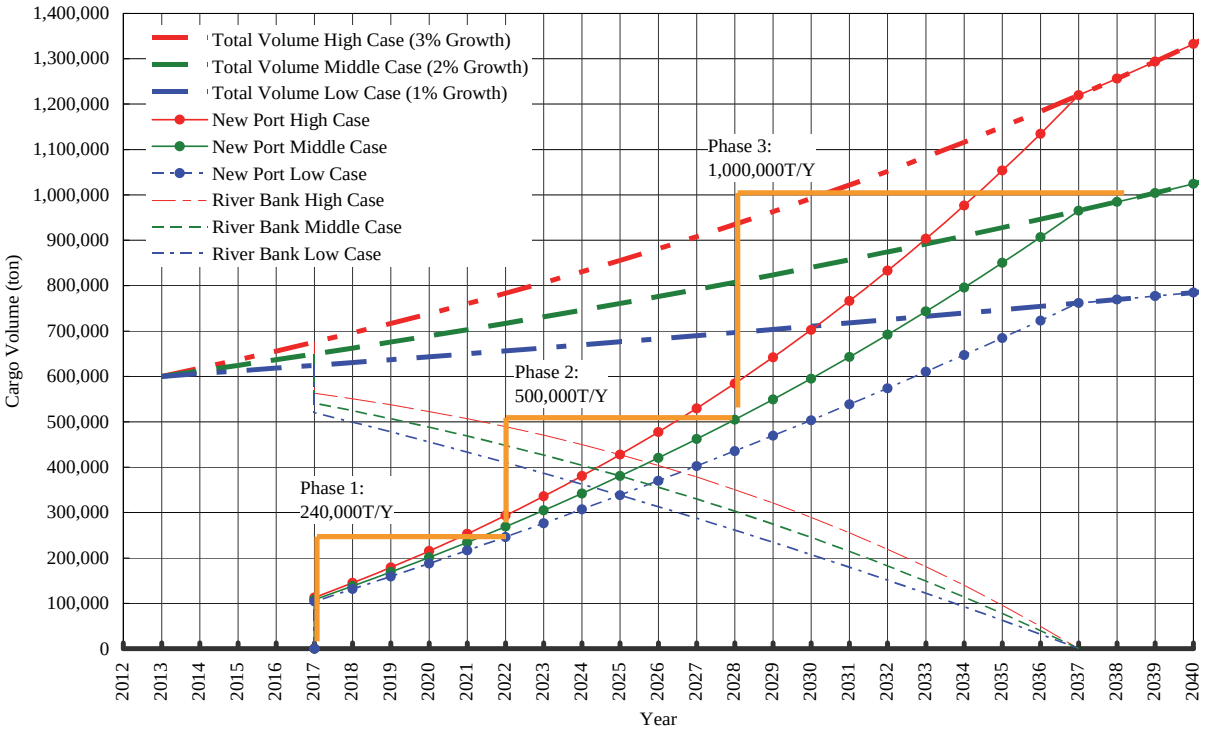
pilot project for changing the existing handling of cargo by manual labor to moving cargo with equipment. In this context, the initial development should start on a smaller scale, which will not assume all of the cargo volume will be handled with equipment from the beginning.

The demand forecast of the new Mandalay Port contains uncertain factors as follows:

- When the capability of the road and rail transport systems increase, generally a modal shift of transport arises away from waterway to road and rail transport. However it is not easy to forecast the volume of movement accurately (factor of decrease demand for waterway transport).
- When handling cargo with equipment is begun in the river port, the demand for cargo which was not transported before will be created. However it is not easy to forecast the demand for those cargoes (factor of increase demand for waterway transport).
- The newly developed port will levy cargo handling fees or port charges to the port users. But it is uncertain how many users will use the port when they have used the riverbank for cargo handling without any fee or charges in the past (factor of decrease demand for waterway transport).

The plan for the pilot project is for medium-scaled development, and the port should be expanded phase by phase while observing the growth of cargo volume after opening the new port. Figure 5.66 shows the relationship between the assumed demand and the port development phases. The plan holds the following conditions:

- The cargo volume of Mandalay Port in 2013 is assumed at 600,000 tons (including 100,000 tons handled by IWT).
- The growth of cargo demand is assumed at 1 ~ 3 % per year.
- All cargo handled by IWT will be moved to the new port when it is opened.
- After opening the new port, cargo handled on the riverbank will be taken to the new port at a rate of 5% every year. It will take approximately 20 years to change over all handling by manual labor to equipment at the new port.
- The initial capacity of the port is assumed to be 250,000 tons/year. The port will be expanded observing the future growth of demand.



Source: The Study Team

Figure 5.65 Assumed Demand and the Port Development Phases

5.6.3 Berth Capacity

(1) Efficiency Rate of Cargo Handling

(For the case of manual handling)

The average rate of cargo handling is assumed at 17 tons/hr which is based on the field monitoring survey at the riverbank of Mandalay Port. The efficiency coefficient is assumed at 0.75 taking into consideration the rest time for workers.

Average rate of handling = 17 t/hr/gang x 8 hr/shift x 0.75 = 102 t/shift/gang
Number of workers per gang: Foreman: 1
Workers: 25

(For the case of equipment handling)

Equipment handling is assumed to be carried out by cranes mounted on the jetty with a rope-net. The average rate of cargo handling is assumed at 50 tons/hr.

Average rate of handling = 50 t/hr/gang x 8 hr/shift x 0.75 = 300 t/shift/gang
Number of workers per gang: Crane operator 1
Foreman: 1
Workers: 10

(2) Berth Occupancy

The berth occupancy ratio is assumed at 50 %, which is the standard rate for a general local port.

(3) Average Numbers of Gang

The following Figure shows the number of ships owned by IWT for each group of ship length (LOA). The average length of passenger-cum-cargo ships is 36m, and average length of cargo barges is 40m. The maximum length of barges is 64m. There are longer privately owned barges which are 70 ~ 75m long. From these data, the berth length is designed at 90m for one berth, and two berths are planned for initial development. The gangs for cargo handling are assumed as follows.

(For the case when two long barges are docked)

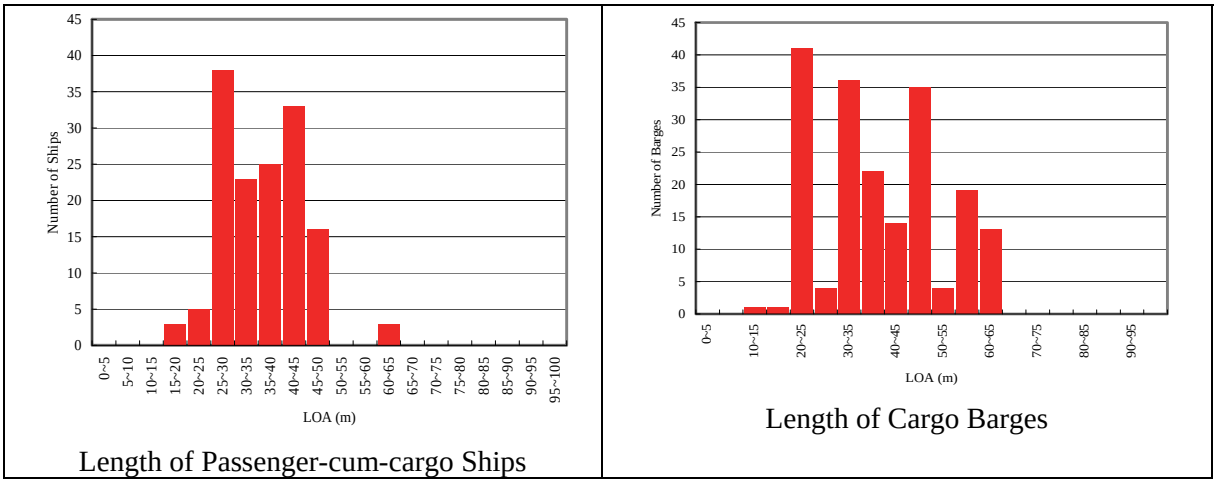
Assuming 2 gangs work for one barge, 4 gangs are required for 2 barges.

(For the case of one long barge and 2 passenger-cum-cargo ships are docked)

2 gangs for one barge and 2 gangs for 2 passenger-cum-cargo ships.

(For the case of 4 passenger-cum-cargo ships are docked)

4 gangs in total for 4 ships.



Length of Passenger-cum-cargo Ships

Length of Cargo Barges

Source: IWT

Figure 5.66 Number of Ships Distribution for each Ship Length (IWT owned)

(4) Work Hours

It is assumed that cargo handling will be carried out by 8 hour shifts, and that work shifts will be increased to 2 shifts when the cargo volume increases. The work efficiency for night work is assumed to drop to 75% of that of the day shift.

(5) Numbers of Workdays in One Year

On the Mandalay riverside, cargo is handled every day of the week, even on Saturday and Sunday. There are 14 national holidays and the New Year Holidays are 10 days long, so the typical work year is usually 341 days.

(6) Berth Capacity

The calculated berth capacities for each case are summarized as follows. It is assumed that half of the ships are passenger-cum-cargo ships for the initial operation period, which means 50% is for manual labor and the rest is for equipment handling. The berth capacity is designed at 240,000 tons/year.

Table 5.40 Berth Capacity

Item	Unit	One Shift Work (Day)			Two Shift Work (Day/Night)		
		Manual 100%	Equipment 50%	Equipment 100%	Manual 100%	Equipment 50%	Equipment 100%
Work Efficiency per Gang (Manual)	t/shift/gang	102	102	-	102	102	-
Work Efficiency per Gang (Equipment)	t/shift/gang	-	300	300	-	300	300
Berth Occupancy	-	0.5	0.5	0.5	0.5	0.5	0.5
Average Numbers of Gang (Manual)	-	4	2	-	4	2	-
Average Numbers of Gang (Equipment)	-	-	2	4	-	2	4
Numbers of Shift (Day)	-	1	1	1	1	1	1
Numbers of Shift (Night)	-	-	-	-	1	1	1
Work Efficiency for Night Shift	-	-	-	-	0.75	0.75	0.75
Numbers of Workday in One Year	Days	341	341	341	341	341	341
Berth Length	m	164	164	164	164	164	164
Work Efficiency per Unit Berth Length	t/m/year	424	836	1,248	742	1,463	2,183
Berth Capacity	t/year	69,564	137,082	204,600	121,737	239,894	358,050

Source: The Study Team

5.6.4 Terminal Plan

(1) Warehouse

The terminal capacity is designed for 300,000 tons/year versus the berth capacity which is for 240,000 tons/year. Warehouses are assumed to have a capacity of 200,000 tons/year. The types of cargo stored in the warehouses are assumed to be rice and beans, which are in the form of 50 kg bags. These cargoes are stored temporarily for an average of one week until the cargo owner takes them for delivery.

Storage (tons) = (Yearly Vol.) x (Av. Storage Days)/(365 Days) x (Coefficient for Peak Vol.)

= 200,000tons x 7days/365days x 1.3 = 4,986tons (5,000tons)

Storage (m^3) = (Storage tons) x (Unit Vol./ton)

= 5,000tons x 1.6m^3/ton = 8,000m^3

Storage (m^2) = (Storage m^3) / (Storage Height)

= 8,000 m^3 / 5m = 1,600 m^2

Floor Area = (Storage m^2) x (Coefficient for additional work space)

= 1,600m^2 x 1.4 = 2,240m^2

From above estimate, it is proposed to include in the pilot project one warehouse to be constructed.

(2) Open Storage Yard

An open storage yard will be designed for handling 100,000 tons/year. The cargo will most likely be pallets placed in a single layer. The unit area of a pallet is assumed to be 1.5m^2. The unit weight per one pallet is assumed at 1 ~ 2 tons. The cargo is assumed to be taken by owners within three days after its arrival to the port.

Storage (tons) = (Yearly Vol.) x (Av. Storage Days)/(365 Days) x (Coefficient for Peak Vol.)

= 100,000tons x 3days/365days x 1.3 =1,068tons

Storage (m^2) = (Storage tons) x (Pallet Unit Area) x (Coefficient for additional work space)

= 81,068tons x 1.5m^2 x 1.2 = 1,922 m^2

Floor Area = 35m x 60m = 2,100m^2

(3) Container Yard Space (Optional)

For future demand of container transport, a spare space for container storage is planned. The plan assumes that 150,000 tons of cargo will be carried in a container and placed in the open storage yard.

Yearly container throughput = 150,000tons ÷ 13tons/TEU = 11,540 TEU/year

The required yard space is calculated as follows:

Table 5.41 Container Yard Space

TEU Over the QUAY (TOQ)	11,540	TEU
MOVES OVER the QUAY (MOQ)	-	MOVES
TIME	365	DAYS
OPERATIONAL STACKING HEIGHT (OSH)	2	
DWELL	3	DAYS
PEAK FACTOR (PF)	1.3	
TRANS-SHIPMENT PERCENTAGE (TS)	0	%
TEU FACTOR (TF)	1.2	
Twenty Feet Ground Slot TGS = (TOQ x DWELL x PF x (1-TS/2))/TIME/OSH	62	
Required Area for Reach-stacker Container Yard / TGS	45.5	m^2
Required Yard Area	2,805	m^2

Source: The Study Team

5.6.5 Required Cargo Equipment

The required equipment for handling cargo in each case is indicated on the Table 5.42 and is estimated as follows:

Table 5.42 Required Equipment for Each Handling Pattern

Cargo Operation Pattern (refer to Figure 4.6.2)		Quay Crane[note1)]	Port Truck[note2)]	Forklift		Reach Stucker	Yard Crane[note3)]	Remark
				3 t	10 t			
(2)	Yard & Warehouse Operation	-	4 (+ 1 for spare)	-	-	-	-	Manual Handling
(3)	Palletization in Port Terminal	-	5 (+ 1 for spare)	5	-	-	Rental	Initial Port Planning
(4)	Heavy Cargo Handling	2	4 (+ 1 for spare)	-	-	-	1 (+ 1 Rental)	
(5)	Mobile Cargo Handling	-	-	-	-	-	-	
(6)	Complete Palletization	-	6 (+ 1 for spare)	5 (+ 1 for spare)	1	1	-	Future
(7)	Container Handling	2	6 (+ 1 for spare)	1	1	3	1 (+ 1 Rental)	

note1) Crawler Crane, or Truck Crane
note2) Flat-bed Trailer & Tracter-head, or Truck
note3) Crawler Crane, or Truck Crane

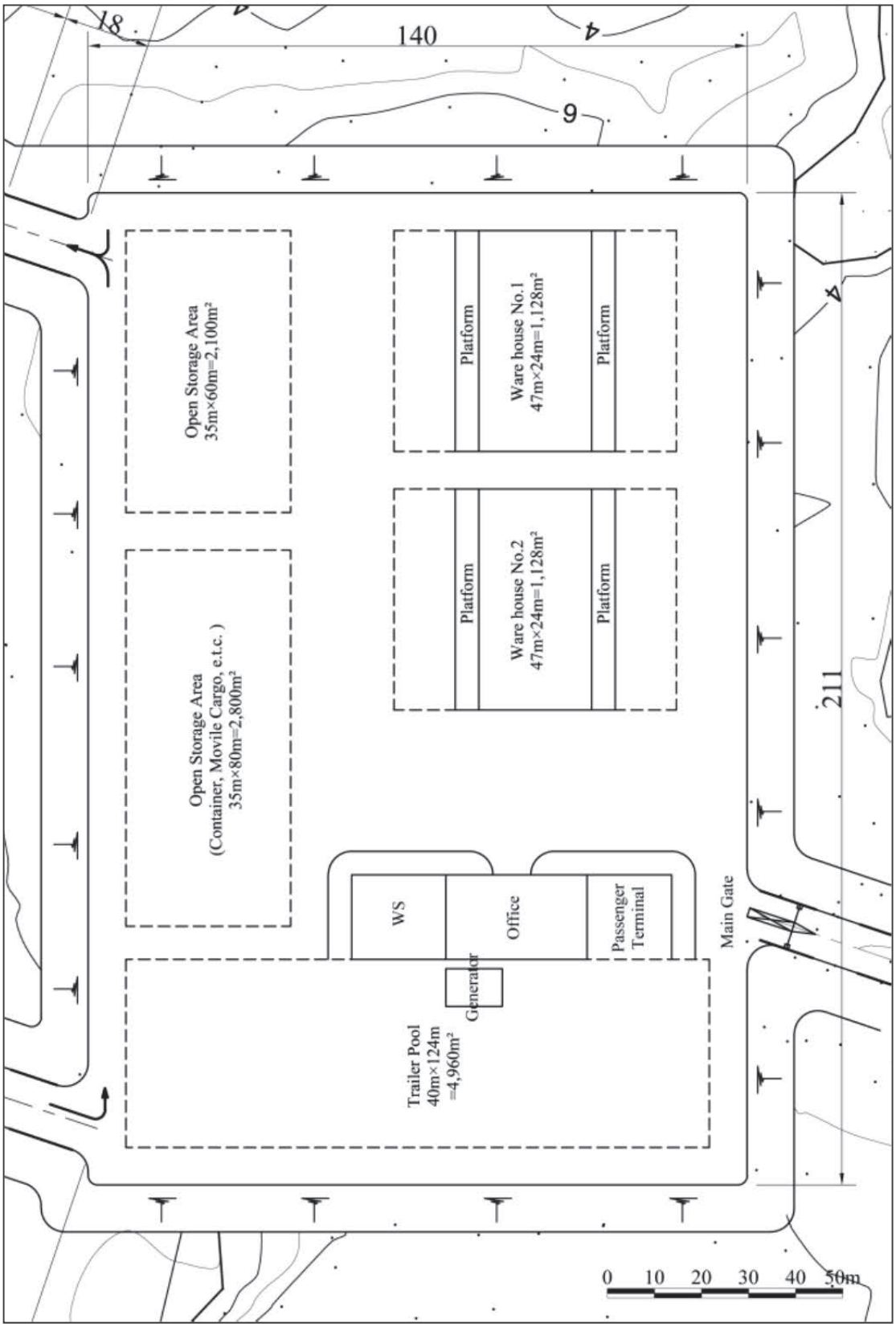
Source: The Study Team

For initial opening of the port as a pilot project, the following minimum numbers of equipment is planed to be purchased.

- Truck Crane (50t) 2
- Forklift (3t) 3
- Flat-bed Trailer & Tractor-head 1
- Port trucks (10t) 3

5.6.6 Layout Plan

The terminal layout plan is shown in the following figure:



Source: The Study Team

Figure 5.67 Terminal Layout Plan