Project Study on the Grand Design for Global Logistics in the Indo-Pacific Region (Second Year)

FINAL REPORT

March 2020

Japan International Cooperation Agency (JICA)

Pacific Consultants Co., Ltd. (PCKK)

EI
JR
20-037

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Table of Acronyms

Acronym	Definition
AfCFTA(CFTA)	African Continental Free Trade Area
AfDB	African Development Bank
Agardir	Agardir Agreement
ANZCERTA	Australia New Zealand Closer Economic Agreement
APTA	Asia Pacific Trade Agreement
ASEAN	The Association of Southeast Asian Nations
AU	African Union
BAU	Business As Usual
CEMAC	Communauté Économique et Monétaire de l'Afrique Centrale
CMIP6	Coupled Model Intercomparison Project version 6
COMESA	Common Market for Eastern and Southern Africa
CU	Customs Union
EC	European Community
ECO	Economic Cooperation Organization
EEA	Europe Economic Area
EPA	Economic Partnership Agreement
EU	European Union
FTA	Free Trade Agreement
GCC	Gulf Cooperation Council
GDP	Gross Domestic Products
GSTP	Global System of Trade Preferences among Developing Countries
GTAP	Global Trade Analysis Project
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
MERCOSU	Mercado Común del Sur
NCAR	National Center for Atmospheric Research
NEPAD	New Partnership for Africa's Development
NIES	National Institute for Environmental Studies
OECD	Organisation for Economic Co-operation and Development
PAFTA	Pan Arab Free Trade Area
PIDA	Program for Infrastructure Development in Africa
PIDA-PAP	PIDA Priority Action Plan
PTN	Protocol relating to Trade Negotiations among Developing Countries
RCEP	Regional Comprehensive Economic Partnership
RCP	Representative Concentration Pathways
SACU	Southern African Customs Union
SADC	Southern African Development Community
SAFTA	South Asian Association for Regional Cooperation
SC	Supply Chain
SPARTECA	South Pacific Regional Trade and Economic Co-operation Agreement
SSP	Shared Socioeconomic Pathways
TICAD	Tokyo International Conference on African Development
TPP	Trans-Pacific Partnership

Acronym	Definition
UNFCCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization

Summary

Introduction

1. Overview of the Study

1-1 Background of the Study

The Indo-Pacific region, the target territory of this project study (hereinafter, the "Study"), is a collective term that encompasses the fast-growing Asia region and the emerging African region with huge potential for economic growth. At the 2016 Tokyo International Conference on African Development (TICAD VI), the Japanese Government announced its Free and Open Indo-Pacific (FOIP) Strategy, which drew attention to Indo-Pacific as a region that can achieve high growth as a connected whole by promoting free trade and infrastructure investment to enhance economic connectivity.

To facilitate stable economic growth of each country within the region, it is essential to develop the basic logistics infrastructure, such as ports, harbors, roads, and railways. However, since separate efforts of individual countries can only generate limited effects, partnerships and concerted efforts of neighboring countries and regions, in addition to infrastructure development by individual states, are needed to develop cross-border corridors, etc. to further expand and accelerate the growth of the whole region. To this effect, formulation of an effective logistics strategy from a global and long-term perspective is urgently called for.

However, studies thus far have only projected future demands or analyzed the feasibility of individual projects for developing logistics infrastructure facilities or corridors. Accordingly, no consistent data is available to determine the outlook of global economy and trade volume or the various effects of infrastructure development on a regional scale.

Against this backdrop, JICA, prior to this Study, conducted a project study in 2017 (hereinafter, the "1st Year Study") to analyze various factors that could affect the international logistics strategy for the Indo-Pacific region, including India and the Sub-Saharan Africa where long-term future growth is expected due to population bonus. The 1st Year Study adopted the scenario planning method to create two scenarios representing a broad range of situations that take into account the high uncertainty of modern society.

1-2 Objective of the Study

This Study attempts to quantitatively project the trade trends in the Indo-Pacific region in 2040 by envisioning the future of global logistics in the region taking a wholistic approach to propose a group of transport infrastructure projects that are consistent throughout the region.

2. Methodology

In this Study, several scenarios are first set, based on the prediction by the year 2040. The global trade trend is then analyzed with GTAP (Global Trade Analysis Project), which is a general applied equilibrium model. The model comprehensively incorporates economic structures or trade conditions of the 40 target countries and regions in the Indo-Pacific Region, and elsewhere around the world.

The results gained by GTAP model is subsequently inputted into the Intermodal Global Logistics Model (hereinafter referred to as Logistics Model), developed by The University of Tokyo Associate Professor Shibasaki et al. Hence using the Model, the future logistics infrastructure is analyzed chiefly for nations along the eastern coast of Africa and landlocked nations.

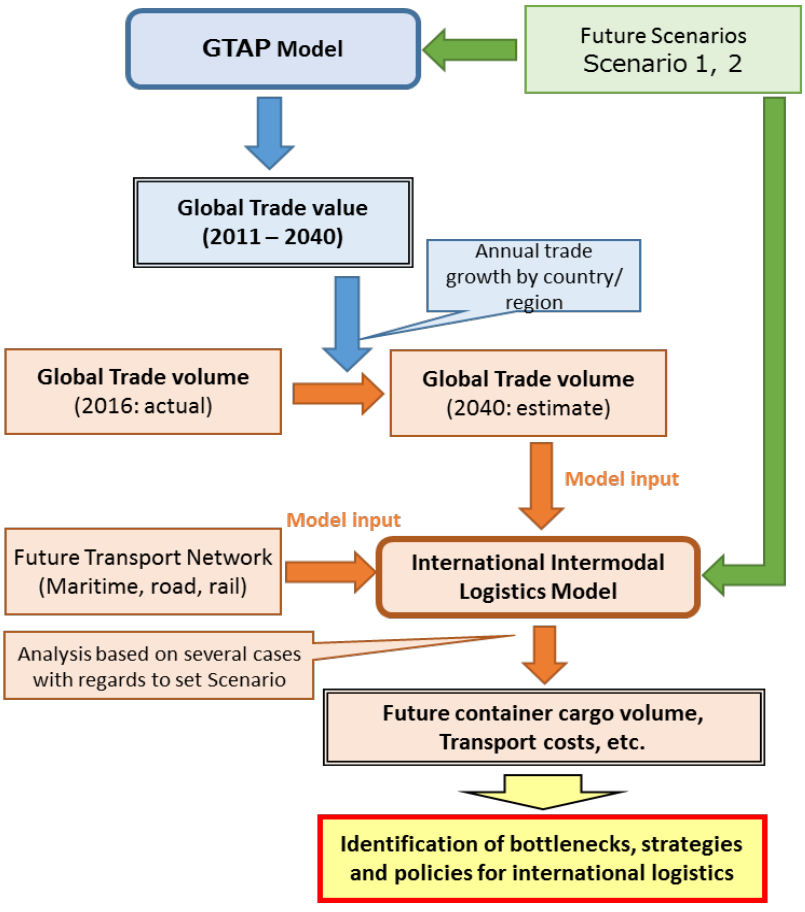


Figure 1 Study Procedure

Ch.1. Outline of Outputs of 1st Year Study

In prior to undertaking the Study, the outputs of the 1st Year Study were outlined as follows.

1. Background and objectives

The background and objective of the 1st Year Study are as follows:

Background
• Since the 2000s, the international economy has undergone dramatic changes including the advancement of globalization, and emergence of new economic powers such as China and India. It is projected that the gravity center of global economy would continue its shift towards the Indo-Pacific region. • This calls for the necessity for formulation of a long-term logistics strategy for the Indo-Pacific region, including corridor development in East African coastal countries, West Asia, South Asia, and other regions that comprise the Indo-Pacific. • It also requires projection of future scenarios which considers uncertainties in a broad range of variables that can affect global economy and trade.
Objective
• To address the above needs, this Study attempts to quantitatively project the trade trends in the Indo-Pacific region for 2030 and beyond, envisioning the future of global logistics in the region from a wholistic approach to propose a group of potential transport infrastructure projects for the region that are consistent to the projection. • The 1st Year Study adopted the scenario-planning method, one of the techniques to examine multiple possibilities of future developments, to analyze various factors that could affect international logistics infrastructure in the Indo-Pacific region. Two scenarios that represent a broad range of possible situations were thus developed.

2. Scenarios devised in 1st year Study

2-1 Scenarios and description

The two scenarios that were devised and configured for this Study is as follows:

I.	Senario-1: African corridor development realized under loose trade bloc.
•	In this scenario, a coordinated free trade system is established based on the following assumptions: three Mega-FTAs currently under negotiation (TPP, TTI, and RCEP) will take effect; the One Belt One Road will become public goods; and multinational giant corporations will carry out their responsibilities for respecting human rights and protecting the environment.
•	In Africa, intra-regional trade is vitalized due to the ratification of the African Continental Free Trade Agreement (AfCFTA) covering the entire continent, and growth is achieved at a faster pace than the global average due to the development of well-balanced and dispersed multi-polar corridors.
II.	Senario-2: African corridor development fails under loose trade bloc.
•	In this scenario, a coordinated free trade system is established under Mega-FTAs, as is the case with Scenario-1.
•	In Africa, however, industry would be formed in a way that intra-regional import/ export would be limited, and AfCFTA does not take place due to conflict of interest among the countries in the region, creating a situation where economic development becomes overly dependent on extra-regional imports and consumption in metropolitan areas.

2-2 Assumption for the two scenarios

Provided below are detailed descriptions of the above two scenarios.

Table 1-1 Major scenarios presented by the 1st Year Study

Item	Scenario	Description
Population	Common	• Population in 2050 reaches 9.8 billion globally, 1.36 billion in China, 1.66 billion in India, and 800 million in ASEAN.
GDP	Common	• Global GDP grows at an average annual rate of 2.6%. • Global GDP share in 2050: China (20%), India (15%), USA (12%), EU27 (9%)
	S1	• Africa grows at an average annual rate of 6.6 – 5.7% (high case)
	S2	• Africa grows at an average annual rate of 4.0 – 3.6% (low case)
Expansion of free trade	Common	• More Mega-FTAs are created to complement WTO. Horizonal international specialization progresses further in each area. Intra-regional trade becomes relatively dominant (TPP, TTIP, RCEP, etc.)
	S1	• Investment under China's One Belt One Road initiative contributes to the development of India and African countries. • Economic integration within the African continent progresses due to CFTA. • Quality growth is achieved as a result of developing corridors in Africa.
	S2	• Investment under One Belt One Road initiative does not contribute to Africa's quality growth (it only accelerates over dependence on extra-regional imports and consumption in metropolitan areas). • CFTA is not reached (due to conflict of interest within the African continent).
Global trade	Common	• Global trade increases at a similar pace to GDP (even trade).
	S1	• Trade volume within African region grows faster than GDP due to expanding intra-African trade under CFTA (fast trade).
	S2	• Intra-African trade, as is the case with global trade,

Item	Scenario	Description
		increases at a similar pace to GDP (even trade).
Realization of responsible SCs	Common	• Responsible supply chains (SCs) are realized for the most part due to creation of Mega-FTAs, etc.
Widening of disparities	S1	• Quality growth is mostly accomplished worldwide, decreasing disparity in GDP per capita. • Disparity shrinks at a faster pace in Africa, where disparity is greater, than the global average.
	S2	• Africa's external negotiating power is insufficient due to the failure of CFTA. • Disparities among regions and countries widen due to the progress of advanced horizontal international specialization by multinational giants. • Africa's disparity in GDP per capita expands to a moderate level.
Foodstuff	Common	• Food demand per capita of developed and semi-developed countries in 2050 decreases to 90% of that in 2010, whereas that of developing countries in 2050 increases slightly to 102% of the 2010 figure. • In other words, food demand in 2050 increases 1.55 and 2.06 times the 2010 demand worldwide and in developing countries, respectively while food loss gradually decreases in developed countries. • Global food demand is satisfied due to improved productivity (crop yield increases at an annual rate of 1.0% to reach 1.5 times that of 2010 in 2050).
	S1	• Green Revolution successfully takes place in Africa, enabling stable food supply (food self-sufficiency increases while transport infrastructure develops within the region).
	S2	• Green Revolution does not take root in Africa. Extra-regional imports of food increase (based on MAFF's projection).
Energy	Common	• Global energy consumption in 2050 becomes 1.5 greater than that of 2015. • Energy consumption in developing countries decreases slightly while that in non-OECD countries increases at an annual rate of 1.6% (approx. 1.75 times). Increase is particularly notable in China, India, and ASEAN

Item	Scenario	Description
		countries, as well as in Middle East, North Africa, and Sub-Saharan Africa (due to population and economic growth). • 79% of energy demand is satisfied by fossil fuels (30% petroleum, 26% natural gas, and 23% coal) and the remaining 21% by other fuels. There is no depletion of resources. • Production of fossil fuels in 2050 increases to 1.35 times that of 2015 (at an annual rate of 0.9%) for petroleum, 1.76 times (1.6%) for natural gas, and 1.18 times (0.5%) for coal. However, if conversion to electric cars and other ZEVs accelerates, petroleum demand will be about 99% of that in 2015.
Consumer awareness	Common	• While over-consumerism accelerates due to increased income, the "sustainable consumption" concept gradually gains awareness and popularity toward the achievement of SDGs (reaching a halfway point).
Technological innovation	Common	• Productivity of horticulture, livestock farming, and fisheries, as well as storage/transport technologies, continue to improve and become more sophisticated. • Super-large container ships (40,000 TEU class) will not emerge (They will stay at the current 20,000 TEU level due to navigation restrictions in the Suez Canal and the Straits of Malacca).
Climate change risk	Common	• International horizontal specialization progresses under a loose trade bloc. Stable economic growth is achieved while maintaining the supply-demand balance of food and energy. • Climate change risk equivalent to a medium stabilizing scenario (RCP4.5) as a result of certain mitigation measures is assumed.
Risk of war, conflict, and terrorism	S1	• The risk of war, conflict, and terrorism remains "low" due to formation of a loose trade bloc.
	S2	• While international horizontal specialization progresses based on comparative advantage under a loose trade bloc, corridor development fails. • Multinational giants accumulate wealth by leading the trade market while nations and citizens are deprived

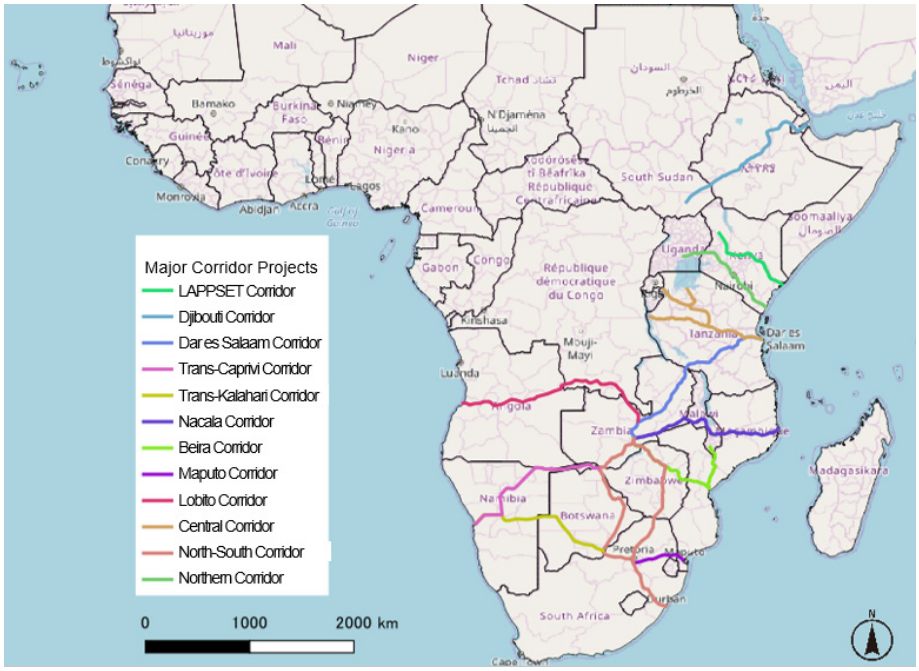
Item	Scenario	Description
		of their fair shares, posing a “high risk” for conflict and terrorism.
Impact on global logistics	Common	• Global trade increases at a similar level to GDP (even trade). • Size of large container vessels remains at the current 20,000TEU level. • Two types of ocean freight networks (hub-and-spoke and point-to-point) develop at multiple levels. • Medium to small container ships (4,000TEU – 8,000TEU) are predominant in the Intra-Asia trade. • Advancement of international horizontal specialization heightens the importance of warehouse facilities as storage and inland gateways. • Transshipment services via hub ports in Asia, Sub-Saharan Africa, and Islamic region (Port of Colombo, Port Luis, Port Salalah, and Port Mombasa) are prevalent.

Ch.2. Infrastructure Development in the Indo-Pacific Region

The related development plans and masterplans of logistics infrastructure were reviewed in order to collect information to develop a viable analysis case for Intermodal Global Logistic Model aimed at simulating freight transport.

1. Overview of Economic Corridors

- Figure 2-1 shows the economic corridors which are located in the target countries for the Study. Maputo Corridor, North-South Corridor, Dar es Salaam Corrido, Beira Corridor, Nacala Corridor, Trans-Caprivi Corridor, Trans-Kalahari Corridor, and Lobito Corridor are the major corridors in eastern and southern Africa regions.
- Further, parts of the Nacala Corridor, Djibouti Corridor, and East Africa Northern Corridor were included in the five priority areas for Africa economic corridor development assistance at TICAD V, held in Yokohama in 2013 by the Japanese government.

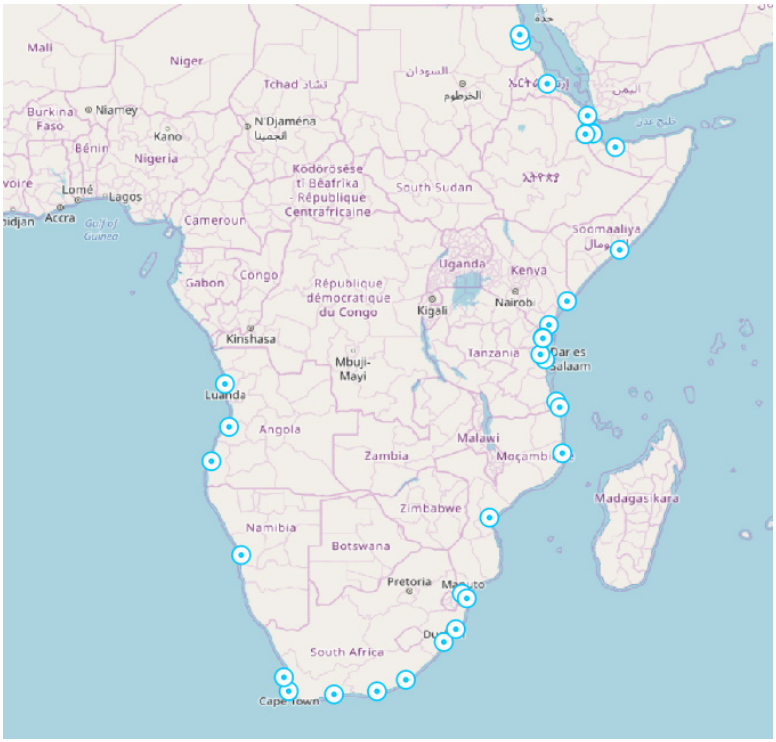


Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-1 Map of Corridor Plan Locations

2. Logistics Infrastructure Development Plans by Sector

- Information regarding the logistics infrastructure including ports, roads, railways, inland water transport, and dry ports were collected and reviewed.
- Figure 2-2 shows the location of ports whose development plan were reviewed



Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-2 Location of reviewed ports

Ch.3. GTAP Model Analysis

For the economic analysis, several scenarios are first set, based on the prediction by the year 2040. The global trade trend is then analyzed with GTAP (Global Trade Analysis Project), which is a general applied equilibrium model. The model comprehensively incorporates economic structures or trade conditions of the 40 target countries and regions in the Indo-Pacific Region, and elsewhere around the world.

1. Initial Setting for Model Analysis

1-1 Country/Region Classifications

The 140 countries and regions of the GTAP9 Data Base are consolidated into the 31 countries and regions in the GTAP Model analysis for the Study.

The Study focuses on global logistics in the Indo-Pacific; therefore, countries in East Africa and South Asia that border the Indian Ocean are the targets of the analysis, and are treated as individual countries. Countries in other regions are consolidated into regional units, with each treated as a hypothetical country in the GTAP Model.

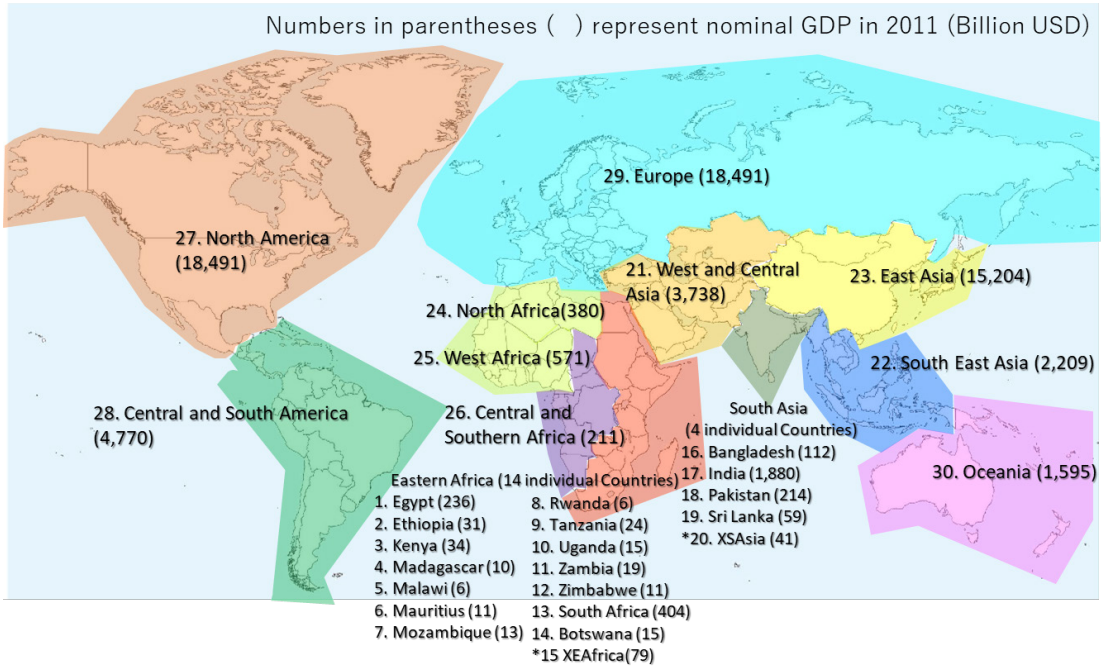


Figure 3-1 Image of GTAP Model Country/Region Classification

1-2 Industry Classifications

The GTAP9 Data Base used for the Study contains 57 different industrial sectors (goods) that are aggregated into the following 10 industrial sectors for the GTAP Model for the Study.

Based on the assumption that analysis on bulk freight transport is conducted separately, primary resource industries that involve a lot of bulk cargo are subdivided to the highest degree. Conversely, given that the main purpose of the Study is to gain a full understanding of trends in international trade, non-tradable goods are aggregated into the “10. Services” sector.

Table 3-1 Settings for Industrial Sectors (goods)

Aggregated sectors	Original sectors code
1. Agriculture (agriculture, forestry, and fisheries)	PDR, WHT, GRO, V_F, OSD, C_B, PFB, OCR, CTL, OAP, RMK, WOL, FRS, FSH
2. Coal	COA
3. Oil (crude oil)	OIL
4. Gas (LNG)	GAS
5. Minerals (mining)	OMN
6. Consumption goods (consumer goods)	CMT, OMT, VOL, MIL, PCR, SGR, OFD, B_T, TEX, WAP, LEA, LUM, OMF
7. Industrial materials (industrial input goods)	PPP, P_C, CRP, NMM, I_S, NFM, FMP
8. Motor vehicles (automobiles)	MVH
9. Processing/Assemblings (industrial machinery/assembly)	OTN, ELE, OME
10. Services (other services)	Industrial sectors other than the above

1-3 Analysis Period and Point of Time

For analysis, the base year is 2011—the base year of GTAP9—and the target years are set at 2016, 2020, 2025, 2030, 2035, and 2040.

The base year of the logistics model is 2016; setting 2016 as an analysis section aligns the results of the calculations, which are used as input data for the logistics model, with the assumptions of the logistics model.

2. Scenario Configuration

In the GTAP Model, scenario-based shocks are applied to the exogenous variables, and the impacts on endogenous variables are analyzed with and without the shocks.

In the Study, the future scenario resulting from 1st Year Study is the basis for setting the baseline scenario and two long-term scenarios: the “Africa Economic Corridor Development Success Scenario”; and the “Africa Economic Corridor Development Failure Scenario”.

It is worth noting that the results of 1st Year Study contain parts that are conceptual, and parts that do not fully consider the calculation possibilities of the GTAP Model. Therefore, in this research, the details of each scenario—specifically, the settings in the GTAP Model—are defined. Outlines of each scenario are as follows.

Table 3-2(1) Scenario Configuration (Population)

1. Population (1st Year Study results) All scenarios: Population in 2050 reaches 9.8 billion globally, 1.36 billion in China, 1.66 billion in India, and 800 million in ASEAN	
Population Settings	
BL	■Global: SSP2 population growth rate
S1	■Africa: SSP2 population growth rate plus an additional 0.33% per year (envisioning a population 10% greater than the SSP2 population in 2040) ■Rest of the world: (Same as BL) SSP2 population growth rate
S2	■Africa: SSP2 population growth rate minus 0.33% per year (envisioning a population 10% less than the SSP2 population in 2040) ■Rest of the world: (Same as BL) SSP2 population growth rate
Labor Settings	
BL S1 S2	■Global: (Same as BL) The overall workforce fluctuates at the same rate as the population. The ratio of skilled to unskilled workers remains in the present state until 2040.

Table 3-2(2) Scenario Configuration (GDP)

2. GDP (1st Year Study results) All scenarios: Global GDP grows at an average annual rate of 2.6% All scenarios: Global GDP share in 2050: China (20%), India (15%), USA (12%), EU27 (9%) S1: Africa grows at an average annual rate of 6.6 – 5.7% (high case) S2: Africa grows at an average annual rate of 4.0 – 3.6% (low case)	
GDP/Rate of Technological Innovation Settings	
BL	■Global: Rate of technological innovation for total factor productivity (Afereg) to achieve SSP2 GDP growth rate
S1	■Africa: GDP growth rate set to the BL GDP growth rate for African countries plus 1.5% (the difference of 1.5%/year between the SSP2 GDP growth rate of 5.1%/year for 2010-2040 and the maximum envisioned growth rate of 6.6%/year from 1st Year Study). ■Rest of the world: (Same as BL) SSP2 GDP growth rate.
S2	■Africa: GDP growth rate set to the BL GDP growth rate for African countries minus 1.5% (the difference of 1.5%/year between the SSP2 GDP growth rate of 5.1%/year for 2010-2040 and the minimum envisioned growth rate of 3.6%/year from 1st Year Study). ■Rest of the world: (Same as BL) SSP2 GDP growth rate.

Table 3-2(3) Scenario Configuration (Expansion of Free Trade)

3. Expansion of Free Trade (1st Year Study results) All scenarios: (1) More Mega-FTAs are created to complement WTO. Horizonal international specialization progresses further in each area. Intra-regional trade becomes relatively dominant (TPP, TTIP, RCEP, etc.) S1: (1) Investment under China's One Belt One Road initiative contributes to the development of India and African countries, (2) Economic integration within the African continent progresses due to CFTA, and (3) Quality growth is achieved as a result of developing corridors in Africa S2: (1) Investment under One Belt One Road initiative does not contribute to Africa's quality growth (it only accelerates over dependence on extra-regional imports and consumption in metropolitan areas), and (2) CFTA is not reached (due to conflict of interest within the African continent)	
Tariff Rate Settings	
BL	■Global: FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA
S1	■Africa: (Same as BL) The development of economic corridors in Africa enhances opportunities for free trade, and FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA ■Africa: In addition to the above, all tariffs between African countries that have not yet discussed FTAs/EPAs are phased out starting in 2020. (Envisioning the transcontinental reach of the Africa Continental Free Trade Area (AfCFTA) put into effect in May 2019) (2020 to 2025 (Stage 1): 25% reduction: 2025 to 2030 (Stage 2): 33% reduction, 2030 to 2035 (Stage 3): 50% reduction, 2035 to 2040 (Stage 4): 100% reduction) ■Rest of the world: (Same as BL) The development of economic corridors in Africa enhances opportunities for free trade, and FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA
S2	■Africa: Stalemates, suspensions, and other problems with negotiations for FTAs/EPAs planned/discussed as of 2019 cause tariff rates to remain at the present level in and after 2020 to 2025 (Stage 3). ■Rest of the world: (Same as BL) FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA

Table 3-2(4) Scenario Configuration (Food)

7. Foodstuff (1st Year Study results) All scenarios: (1) Food demand per capita of developed and semi-developed countries in 2050 decreases to 90% of that in 2010, whereas that of developing countries in 2050 increases slightly to 102% of the 2010 figure.(2) In other words, food demand in 2050 increases 1.55 and 2.06 times the 2010 demand worldwide and in developing countries, respectively while food loss gradually decreases in developed countries.(3) Global food demand is satisfied due to improved productivity (crop yield increases at an annual rate of 1.0% to reach 1.5 times that of 2010 in 2050). S1: (1)Green Revolution successfully takes place in Africa, enabling stable food supply (food self-sufficiency increases while transport infrastructure develops within the region). S2: (1) Green Revolution does not take root in Africa. Extra-regional imports of food increase (based on MAFF's projection).	
Agricultural and Fisheries Factor Productivity Settings	
BL	■Global: Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources).
S1	■Africa: Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 3.04% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources) (set based on the average productivity rate increase between factors in Africa in the GTAP Data Base from 2004 to 2011). ■Rest of the world: (Same as BL) Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources).
S2	■Africa: Remains in the present state (no change). ■Rest of the world: (Same as BL) Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources).

Table 3-2(5) Scenario Configuration (Energy)

8. Energy (1st Year Study results) All scenarios: (1) Global energy consumption in 2050 becomes 1.5 greater than that of 2015. (2)Energy consumption in developing countries decreases slightly while that in non-OECD countries increases at an annual rate of 1.6% (approx. 1.75 times). Increase is particularly notable in China, India, and ASEAN countries, as well as in Middle East, North Africa, and Sub-Saharan Africa (due to population and economic growth). (3) 79% of energy demand is satisfied by fossil fuels (30% petroleum, 26% natural gas, and 23% coal) and the remaining 21% by other fuels. There is no depletion of resources. (4) Production of fossil fuels in 2050 increases to 1.35 times that of 2015 (at an annual rate of 0.9%) for petroleum, 1.76 times (1.6%) for natural gas, and 1.18 times (0.5%) for coal. However, if conversion to electric cars and other ZEVs accelerates, petroleum demand will be about 99% of that in 2015.	
Natural Resource Reserve Settings	
BL	■Global: Natural resource reserves increase 1.2% per year (set based on the annual average rate of increase in the GTAP Data Base from 2004 to 2011).
S1	■Africa: Natural resource reserves increase 2.4% per year (twice as high as the rest of the world). ■Rest of the world: (Same as BL) Natural resource reserves increase 1.2% per year.
S2	■Africa: Remains in the present state (no change). ■Rest of the world: (Same as BL) Natural resource reserves increase 1.2% per year.

Table 3-2(6) Scenario Configuration (Technology Innovation)

10. Technological Innovation (1st Year Study Results) All scenarios: (1) Productivity of horticulture, livestock farming, and fisheries, as well as storage/transport technologies, continue to improve and become more sophisticated. (2) Super-large container ships (40,000 TEU class) will not emerge (They will stay at the current 20,000 TEU level due to navigation restrictions in the Suez Canal and the Straits of Malacca).	
Rate of Technological Innovation in Transport (ATS, ATD) Settings	
BL	■Global: Increases 0.76% per year (set based on the global average productivity rate increase in the transport sector in the GTAP Data Base from 2004 to 2011).
S1	■Africa: Increases 3.38% per year (set based on the African average productivity rate increase in the transport sector in the GTAP Data Base from 2004 to 2011). ■Rest of the world: (Same as BL) Increases 0.76% per year.
S2	■Africa: Remains in the present state (no change) due to lack of technical innovation. ■Rest of the world: (Same as BL) Increases 0.76% per year.

3. Analysis Result

The results of the GTAP Model Analysis are as outlined below:

- The simulations show the highest rates of change for Africa and the world in Scenario "S2", followed by Scenarios "BL" and "S1". Particularly, in South Asia, a region with active trade with Africa, exports increase substantially despite a decrease in exports to Africa due to the impact of burgeoning intraregional free trade there, and imports also increase substantially. The resulting expansion of globalization and regional integration under Africa Economic Corridor Development, the AfCFTA, and other economic cooperation framework only benefit Africa, but also radiate outward to other regions of the world. However, this is likely the result of intensified competition in international trade between South Asian exports and goods produced in Africa.
- There are significant differences in the rates of change of countries, regions, and industrial sectors in Africa. Additionally, Scenarios "BL" and "S2" show higher rates of increase than Scenario "S1". This is likely due to the expansion of Africa Economic Corridor Development and the AfCFTA, and indicative of inequality within Africa due to alternative goods brought about by changes to terms of trade between regions and industrial sectors.

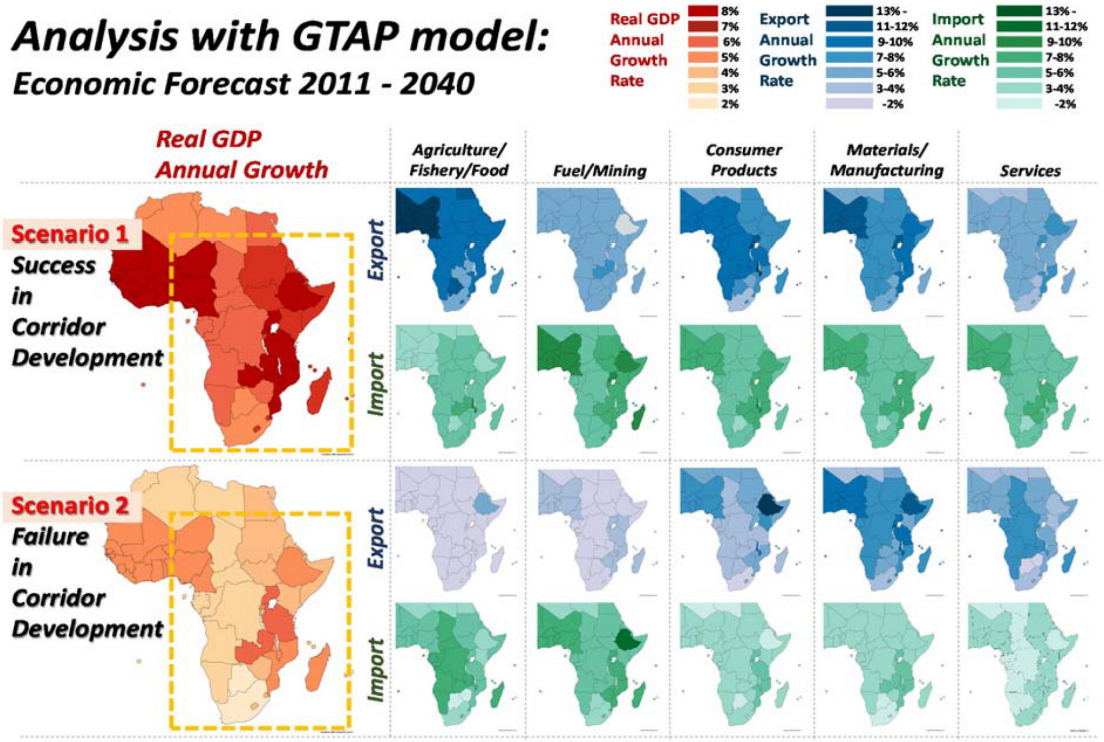


Figure 3-2 Change of Trade Value by Industries (GTAP Model Analysis)

Ch.4. Intermodal Global Logistics Model Analysis

1. Objective of Logistics Model Analysis

To identify infrastructure development issues in the region and gain implications for strategies, the intermodal global logistics model developed by University of Tokyo Associate Professor Shibasaki and others ("the Logistics Model") is applied to the Indo-Pacific, with special focus on East Coast of Africa. The current situation and the future freight transport were simulated and analyzed based on actual maritime and land transport networks within the region with the Logistics Model.

2. Target Areas for Analysis

The target of this analysis is the Indo-Pacific, with a particular focus on land transport in East Africa. The analysis involves simulating and projecting the flow of freight in freight transport networks within the hinterland of each port in the region. Additionally, a global maritime container transport model is applied to analyze the flow of freight in container freight transport networks between ports around the world.

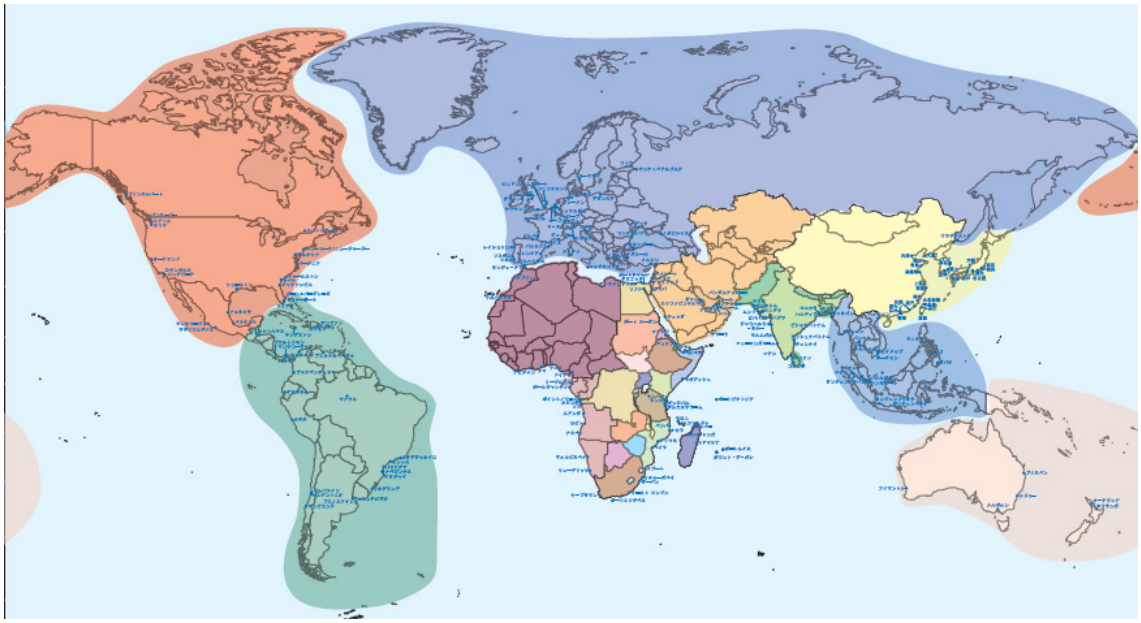


Figure 4-1 Ports Incorporated into the Global Logistics Model

3. Analysis Result: Case of Successful Economic Corridor Development

According to the calculation result of the logistics model for the economic corridor development, the development of economic corridors and OSBP are expected to deliver an 18% reduction in the average unit price of land transport in East African countries. The changes of average transportation cost by region are as shown in

The average unit price of land transport in coastal countries 1 with their own ports declined 12%, while the average unit price of land transport in landlocked countries 2 that rely on border crossings to access ports declined 18%; landlocked countries enjoyed a roughly 50% greater reduction in the unit price of transport than coastal countries.

However, the average unit price of land transport may increase because gaps between the planned transport capacity and future freight demand of some roads in coastal countries will result in congestion due to the concentration of freight.

If these roads are upgraded to ensure sufficient transport capacity in the future, further reductions in the unit price of transport can be expected.

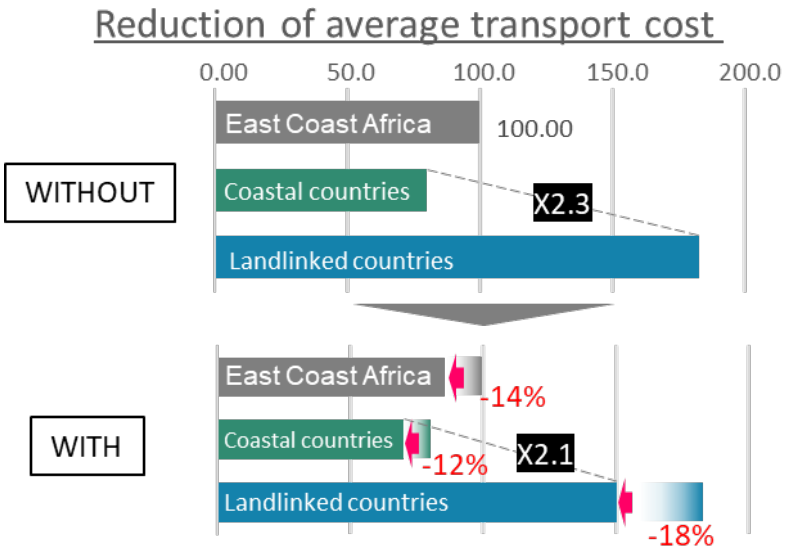


Figure 4-2 Comparison of the Average Unit Price of Land Transport in Coastal Countries and Landlocked Countries

1 Coastal countries: Egypt, Sudan, Eritrea, Djibouti, Somalia, Kenya, Tanzania, Mozambique, South Africa

2 Landlocked countries: Ethiopia, South Sudan, Uganda, Rwanda, Burundi, Democratic Republic of the Congo, Zambia, Malawi, Zimbabwe, Botswana, Eswatini, Lesotho

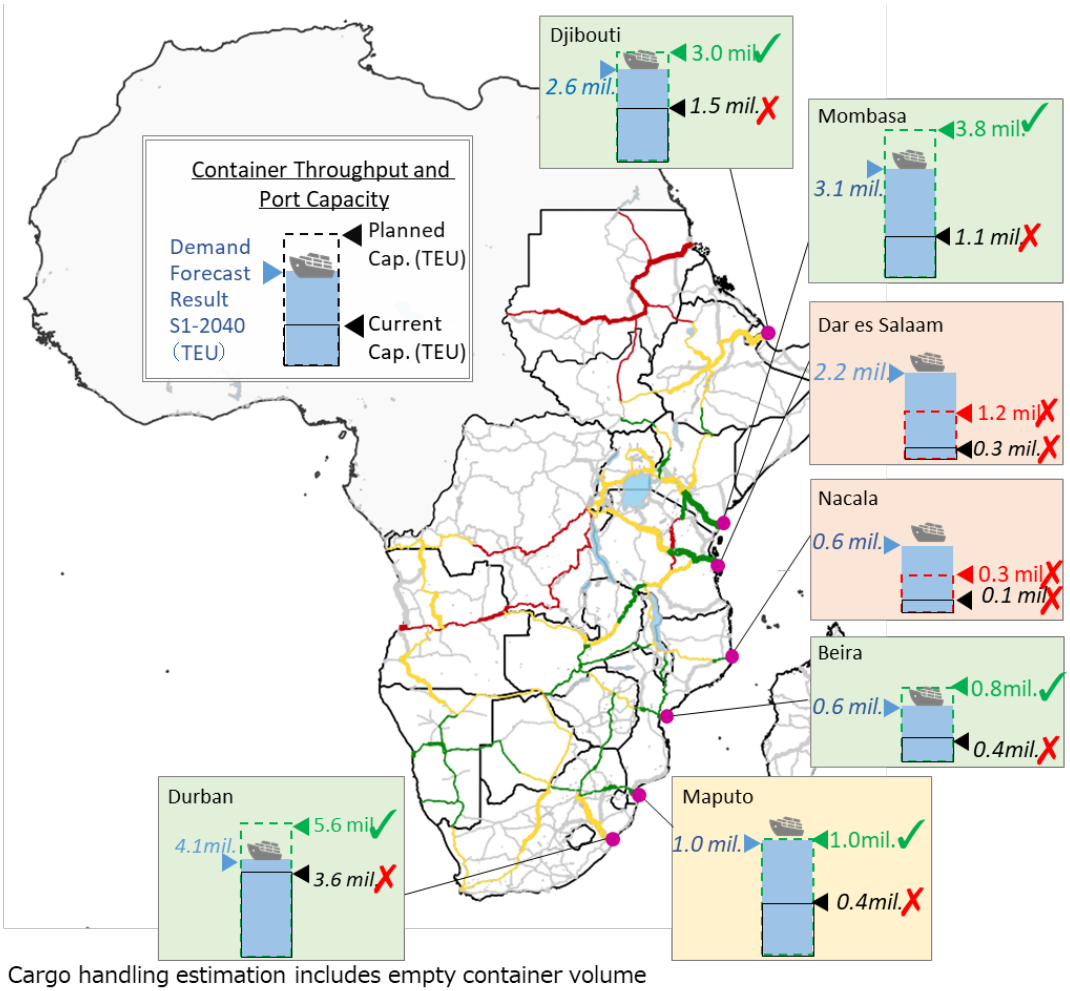
Ch.5. Logistics Strategy in the Indo-Pacific Region

Bottlenecks in logistics infrastructure such as ports and roads (economic corridors) were identified based on the results of the logistics model simulations explained in the previous sections.

1. Ports

The comparison of projected future freight demand against the current and planned capacity of the ports are as shown in Figure 5-1.

The result of the analysis implies that Dar es Salaam and Nacala should be given high priority for development, as they will most likely face capacity shortages.



* Cargo handling estimation includes empty container volume

Figure 5-1 Projections of Port Freight Handling Demand, against Current and Planned Port Handling Capacity

2. Roads

Figure 5-2 shows the present conditions of the freight road network based on PIDA report, and freight flow forecasts based on the simulation result.

North-South Corridor has the largest freight flow, followed by Northern Corridor and Central Corridor.

Growth in freight flow is expected especially in the road sections connecting ports and large cities, for which steady development needs to be ensured. Here, attention needs to be paid to railroad development, as it could affect the freight transport capacity.

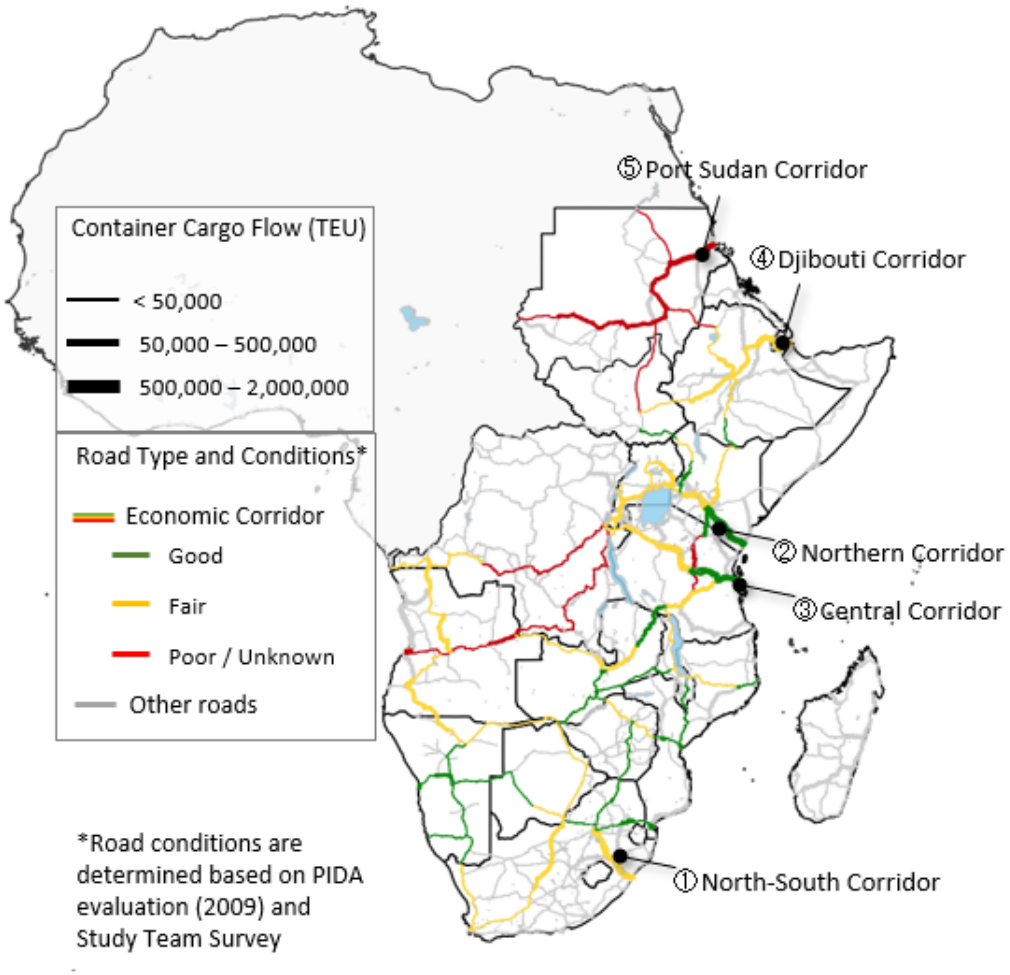


Figure 5-2 Current State of Freight Transport Road Networks and Freight Flow Forecast

3. Findings and Recommendations for Logistics Infrastructure Strategy

Based on the findings of the analysis, the future challenges for logistics infrastructure development, and recommendations for JICA's approach and opportunities for logistics sector are outlined.

3-1 Challenges for Logistics Infrastructure Indicated from the Study

3-1-1 Facilitation of Integrated Development of Economic Corridors and OSBPs for Sustainable Growth

The analysis results of the logistics model suggest that physical measure of developing economic corridor while providing institutional measure of developing OSBPs to improve custom procedures would contribute to reducing the average land freight transport cost for coastal countries and inland countries by 12% and18% respectively. Thus, it was implied that the impact on trade cost reduction would be higher in inland countries.

In order to further facilitate growth of the inland countries, it is important to take wholistic approach, that is, to promote development and improvement of port facilities in coastal countries, while at the same time enhance connectivity through economic corridor development and OSBP facilitation.

3-1-2 Formulation of Ports Development Strategy with regards to Hinterland Connectivity

The analysis of ports with high economic benefits from international import/ export of maritime container freight in the East African region indicated that the development of economic corridors and trade facilitation by OSBP can diversify the port selections. In particular, the major ports such as Mombasa, Dar es Salaam, Beira, Durban also transport freights to several inland countries and plays an important role in the economic development of these regions.

In order to formulate a port development strategy in the future, it is important to consider the changes in the transport network in the hinterland and also the freight transport demand of inland regions and countries that result from the development of economic corridors and the facilitation of OSBP.

3-1-3 Facilitation of proportionate infrastructure development with regards to the future growth of freight demand

The integrated analysis of freight flow by transport route in the eastern African region and the road condition as of 2009 indicated by PIDA showed that it is imperative to have develop and maintain the road conditions to a sufficient level,

especially for the roads with poor conditions and huge freight transport demand.

In addition, the results of freight transportation demand forecasts in the eastern African region and network allocations indicated that there were ports with sufficient planned capacities for future demands and ports with insufficient capacities (such as Dar es Salaam and Nacala). The infrastructures that should be developed with priority were identified.

In order to achieve sustainable economic growth in the eastern African region, it is important to fully consider the freight demand in the hinterland, as well as to develop ports in the surrounding area with considerations into the development plans of transport infrastructure in the hinterland.

3-2 Recommendations for JICA's Approach and Opportunity

In view of the findings of the previous section, the strategy for logistics infrastructure projects (JICA's approach and opportunity) consists of the following:

① Promote the infrastructure development and institutional improvement for ports and inland logistics facilities

(Specific Examples)
Development of transportation infrastructures (roads, railways, etc.) and One Stop Border Post (OSBP) in economic corridors, development of Special Economic Zones and inland Free Trade Zones, facilitation of customs clearance operations, etc.

② Formulate port strategies considering hinterland connectivity

(Specific Examples)
Formulation of a national / regional level port development master plan and development plans and individual port development plans based on freight demand and connectivity in the hinterland and other neighboring countries.

③ Consider measures to improve cargo handling efficiency and expansion for ports where capacity gap is expected

Main Report

0. Introduction

1 Overview of the Study

1-1 Background of the Study

The Indo-Pacific region, the target territory of this project study (hereinafter, the "Study"), is a collective term that encompasses the fast-growing Asia region and the emerging African region with huge potential for economic growth. At the 2016 Tokyo International Conference on African Development (TICAD VI), the Japanese Government announced its Free and Open Indo-Pacific (FOIP) Strategy, which drew attention to Indo-Pacific as a region that can achieve high growth as a connected whole by promoting free trade and infrastructure investment to enhance economic connectivity.

To facilitate stable economic growth of each country within the region, it is essential to develop the basic logistics infrastructure, such as ports, harbors, roads, and railways. However, since separate efforts of individual countries can only generate limited effects, partnerships and concerted efforts of neighboring countries and regions, in addition to infrastructure development by individual states, are needed to develop cross-border corridors, etc. to further expand and accelerate the growth of the whole region. To this effect, formulation of an effective logistics strategy from a global and long-term perspective is urgently called for.

However, studies thus far have only projected future demands or analyzed the feasibility of individual projects for developing logistics infrastructure facilities or corridors. Accordingly, no consistent data is available to determine the outlook of global economy and trade volume or the various effects of infrastructure development on a regional scale.

Against this backdrop, JICA, prior to this Study, conducted a project study in 2017 (hereinafter, the "1st Year Study") to analyze various factors that could affect the international logistics strategy for the Indo-Pacific region, including India and the Sub-Saharan Africa where long-term future growth is expected due to population bonus. The 1st Year Study adopted the scenario planning method to create two scenarios representing a broad range of situations that take into account the high uncertainty of modern society.

1-2 Objectives of the Study

This Study attempts to quantitatively project the trade trends in the Indo-Pacific region in 2040 by envisioning the future of global logistics in the region taking a holistic approach to propose a group of transport infrastructure projects that are consistent throughout the region.

1-3 Procedures of the Study

Due to the dynamic changes in socio-economic and industrial structures, accompanied by the recent technological innovation, providing a prediction for remote future is an extremely difficult task with great uncertainty. Under these circumstances, JICA has adopted scenario approach in project scheme conceptualization. Thus, the following two kinds of future scenarios have been elaborated in cooperation with seven experts and JICA representatives: Scenario 1 in which a desirable future scenario is indicated (Recognized as an desirable scenario and hereinafter referred to as S1); and Scenario 2 in which an undesirable, yet possible scenario is indicated (hereinafter referred to as S2).

Next, in order to forecast the future trade trend, Global Trade Analysis Project (GTAP) is used as a general applied equilibrium model for global trade to predict future trade values. The future scenarios are incorporated to the GTAP model, reflecting the variables as much as possible, ranging from infrastructure investment plans to trade and international economic policies, including future trends of international politics and economy, FTA (free trade agreement) and EPA (economic partnership agreement). Future estimation is made on trade values or GDP in the Indo-Pacific region. In this case, the future scenario for 2040 is produced with appropriate prediction flexibility, considering future Chinese and Indian trends as key players in the region or corridor development performance status, including the Northern Corridor tackled by JICA in Africa. Subsequently, cargo volume for year 2030 and 2040 are aggregated based on OD table. The global intermodal logistics model, developed by Associate Professor Ryuichi Shibasaki (The University of Tokyo) et al. is then used to analyze the logistics flow on the actual transportation network consisting of maritime shipping lines and the hinterland transport network (inland water transportation, road and railway). Through this analysis, the priority project group or its requirements regarding logistic infrastructure and institutional measures (such as Cross-border and customs procedures) that minimize the total cost for general transportation and enhance the robustness would be determined.

In addition, the grand design for global logistics in Indo-Pacific region is proposed, with a special focus on fostering growth in Africa.

1-4 Scope of the Study

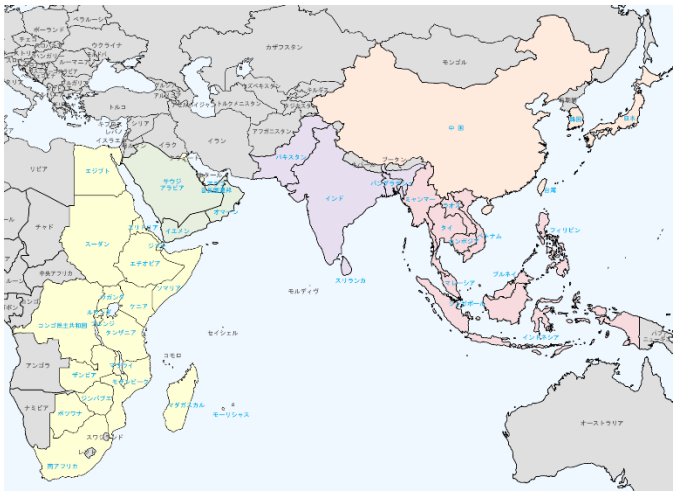
The purpose of this Study is to accomplish the following two tasks based on the 1st Year Study with 2030 being the target year and looking further ahead to 2040:

- Quantitatively analyze the logistics bottlenecks in the Indo-Pacific region and formulate a logistics infrastructure strategy for the region after qualitatively comparing and analyzing the global trade trends in two future scenarios (S1 and S2).
- Provide recommendations regarding the future orientation and possibilities of JICA's assistance (draft).

The intended four outputs of this Study is shown in Table 0-2.

Table 0-1: Intended outputs of this Study

Output 1: Quantitative comparative analysis of global trade trend using the GTAP model (S1 and S2, three time-horizons)
• GDP growth rate and trade value projections of each country within the Indo-Pacific region (by scenario and by industry, 3 time-horizons (2020, 2025, 2030)) ➢ S1: African corridor development "realizes" under a loose trade bloc. ➢ S2: African corridor development "fails" under a loose trade bloc.
Output 2: Estimation of OD freight flow by product type (S1, 2030)
• Conversion of trade value into freight flow for each industry, estimation of ocean OD freight flow (6 items): ➢ Ocean container freight (① containers) ➢ Bulk freight (② crude oil, ③ LNG, ④ iron ore, ⑤ coal) ➢ RoRo freight (⑥ finished motor vehicles)
Output 3: Future freight trend analysis based on intermodal international logistics model (S1, 2030)
• Comparative analysis of transport service levels and freight flows of various routes between origins and destinations: ➢ Build/use an intermodal international logistics model for the Indo-Pacific region.
Output 4: Identification of problems in logistics infrastructure, recommendations for JICA's aid orientation, etc. (S1, 2030)
• Identification and quantitative analysis of bottlenecks in the intermodal international logistics networks • Understanding the challenges to logistics infrastructure development in the Indo-Pacific region, formulation of a logistics infrastructure strategy • Recommendations for the orientation and possibilities of JICA's assistance (draft).



East Africa coastal/inland countries (18 countries)	Egypt, Sudan, Eritrea, Ethiopia, Djibouti, Somalia, Kenya, Uganda, Rwanda, Burundi, DR Congo, Tanzania, Mozambique, Malawi, Zambia, Zimbabwe, Botswana, South Africa, Madagascar, Mauritius
West Asia (4 countries)	Saudi Arabia, Yemen, Oman, UAE
South Asia (4 countries)	Pakistan, India, Sri Lanka, Bangladesh
Southeast Asia (10 countries)	Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Brunei, Singapore, Indonesia, Philippines
East Asia (4 countries)	Japan, China, South Korea, Taiwan

Figure 0-1: Location map of target countries of this Study (Indo-Pacific region)

2 Study Procedure

This section describes the procedure for conducting this Study.

2-1 Methodology

In this study, several scenarios are first set, based on the prediction by the year 2040. The global trade trend is then analyzed with GTAP (Global Trade Analysis Project), which is a general applied equilibrium model. The model comprehensively incorporates economic structures or trade conditions of the 40 target country/region in the Indo-Pacific Region, and elsewhere around the world.

The results gained by GTAP model is subsequently inputted into the intermodal global logistics model, and the future logistics infrastructure is analyzed chiefly for nations along the eastern coast of Africa and landlocked nations.

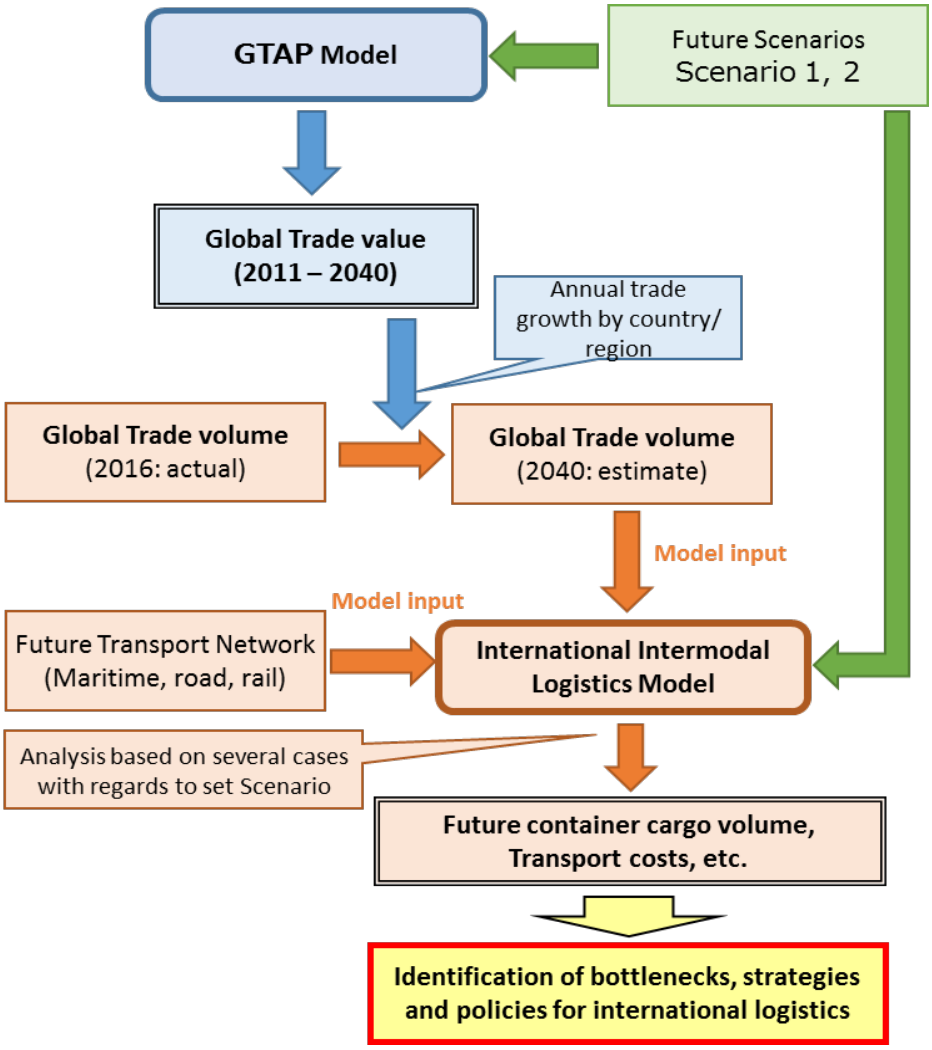


Figure 0-2: Study Procedure

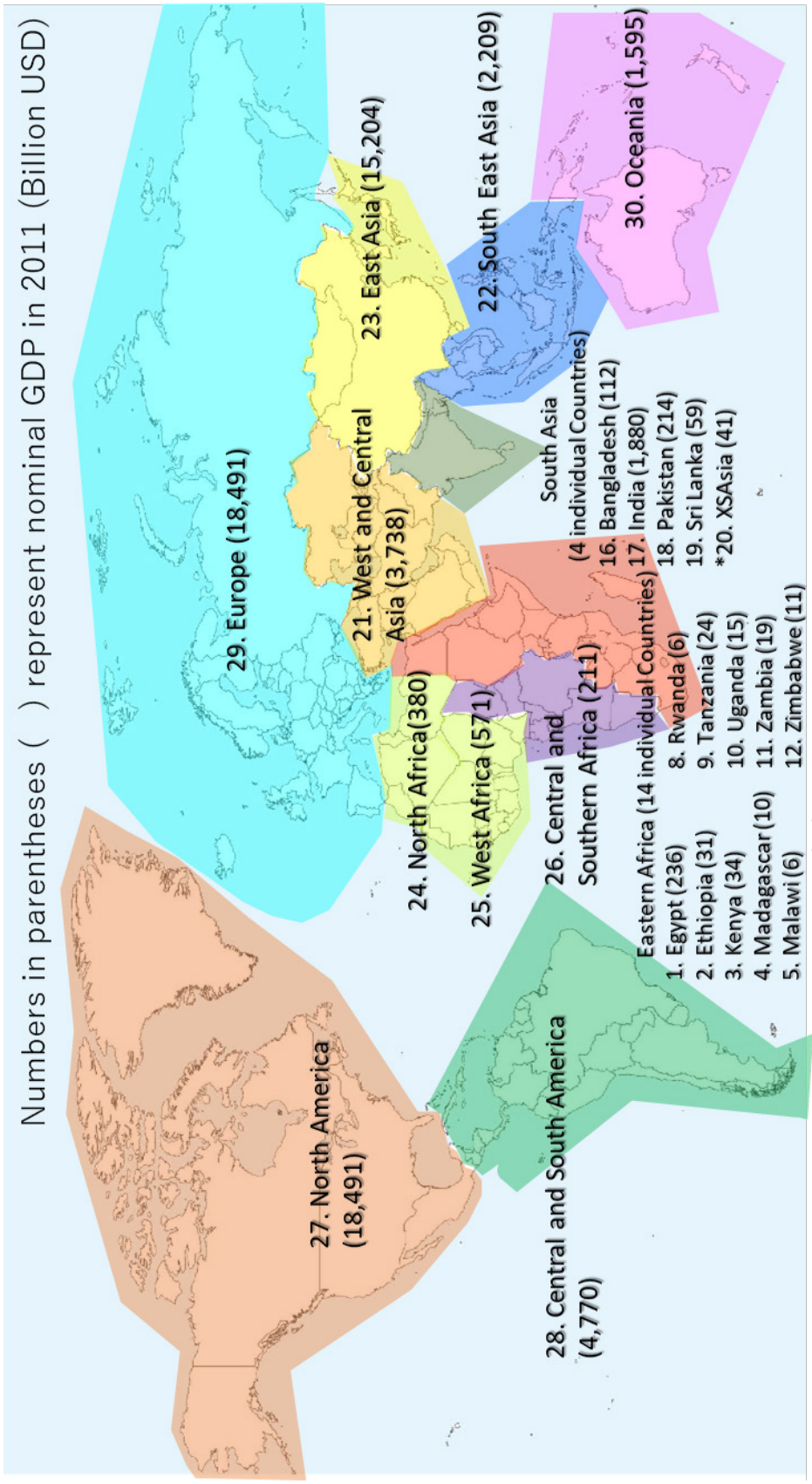


Figure 0-3: Target countries and regions for GTAP Model

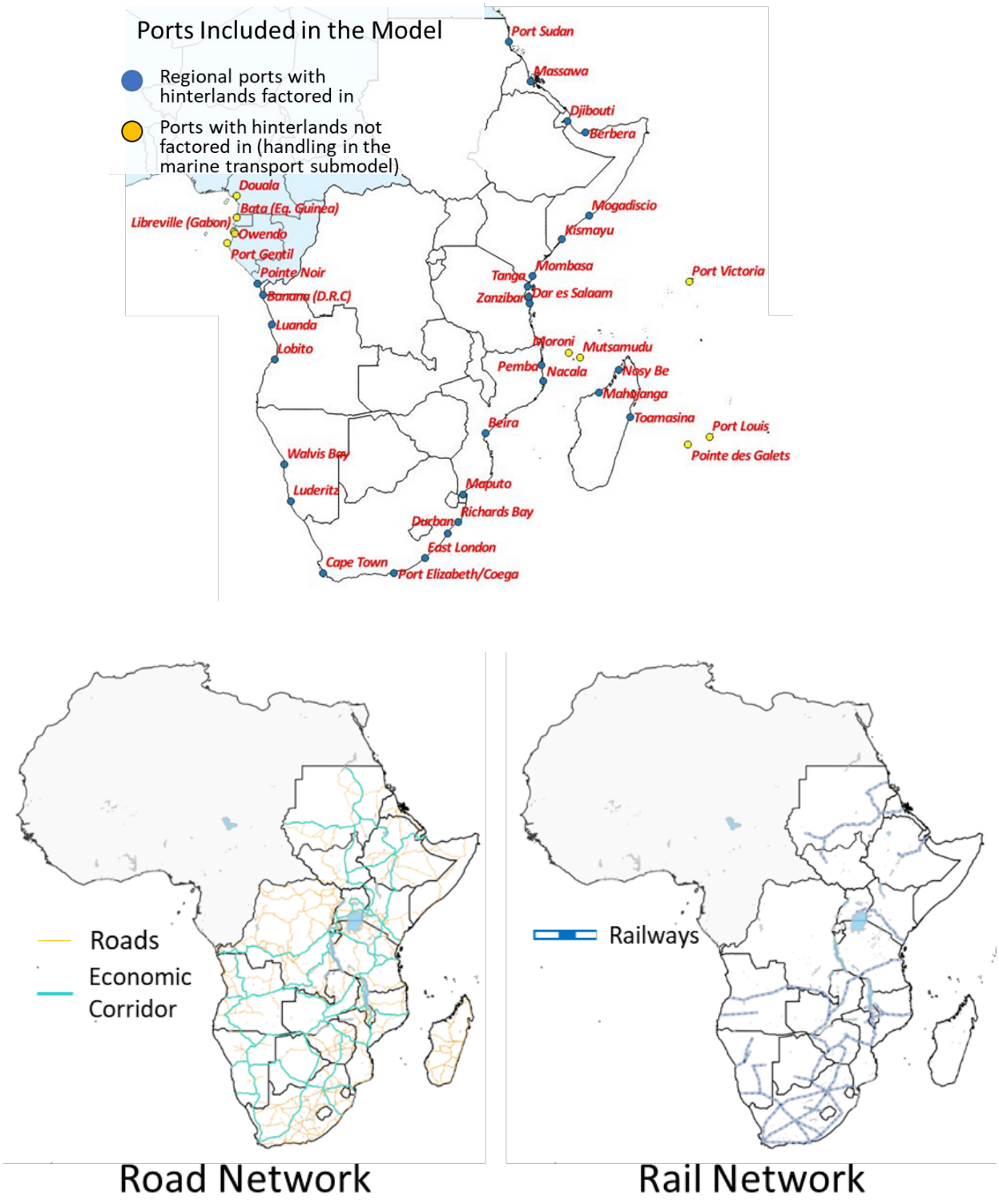


Figure 0-4: Target countries and regions for Intermodal Global Logistics Model

2-2 Structure of the Report and Components

The report is structured with components outlined below.

(1) Review of 1st Year Study

The 1st Year Study was reviewed in prior to this Study.

(2) Logistics Infrastructure Development Trends in Indo-Pacific Region

- Collect and sort out information on initiatives and masterplans related to logistics infrastructure based mainly on JICA's past projects and study reports.
- In gathering information, pay special attention to African corridor development, as its success or failure was found by the 1st Year Study to be a key to the realization of quality growth in the Indo-Pacific region.

(3) GTAP Model Analysis

1) Establishing Initial Conditions

- In performing a GTAP model analysis, define the initial parameters, namely, countries/regions, industries, and analysis periods/time-horizons, to focus on global logistics in the Indo-Pacific region.
- In addition, sort out the characteristics of the current GTAP model data (industrial and import/export compositions as of 2011).

2) Scenario Configuration

- Based on the future scenarios presented by the 1st Year Study, create the following scenarios:
  - ✧ Base scenario
  - ✧ Scenario-1 (African corridor development succeeds.)
  - ✧ Scenario-2 (African corridor development fails.)
- Since the future scenarios produced by the 1st Year Study contain data that are too conceptual to be used in the GTAP model, reexamine such data closely to set more appropriate values.

3) Future Scenario Estimations

- Based on the initial parameters and scenarios defined above, simulate future scenarios using the GTAP model.

(4) Intermodal Global Logistical Model Analysis

1) Interview Surveys

- Field survey and interviews were conducted to gather information relevant to the intermodal international model analysis.
- The schedule and content of the field survey is as follows.

Dates	Country	Overview
February 25-28	Ethiopia	Interviews with six individual companies
November 25-26	Egypt	Presentation at PIDA Week 2019
November 27-29	Tanzania	Workshop held at the JICA Tanzania Office Interviews with six individual companies Dar es Salaam Port site visit
December 2-3	Malawi	Interviews with six individual companies
December 5-6	South Africa	Interviews with six individual companies

Figure 0-5: Countries visited for Field Survey

Survey at Ethiopia (Feb. 25 al 8, 2020)

Interviewed organization	Organization types
Ethiopian Freight Forwarders & Shipping Agents	Forwarders association
Ethiopian Shipping & Logistics Service Enterprise (ES&LSE)	Private trade company
Ethiopian Maritime Affairs Authority	Ethiopian maritime authority (in charge of maritime containers)
Ethiopian Customs Commission	Customs (Cross border freight management)
Kality Dry Port	Private dry port
Mekelle Dry Port	Private dry port
Tanzania Revenue Authority (TRA)	Forwarders association


Road between Ethiopia and Eritrea①


Road between Ethiopia and Eritrea②

Survey at Egypt (Nov. 25 – 26, 2020)

Date	Organization
25th Nov (Mon)	PIDA Week 2019 meetings and preparations
26th Nov (Tue)	PIDA Week : Presentation of the Study

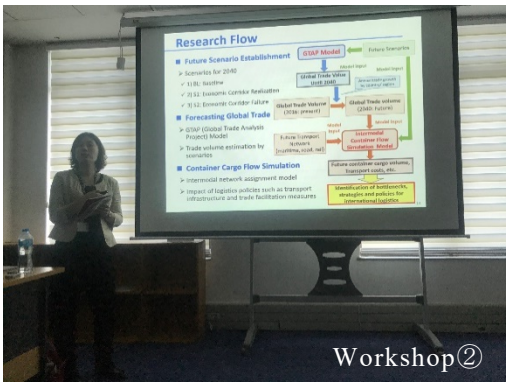
Presentation Session


Greetings exchanges

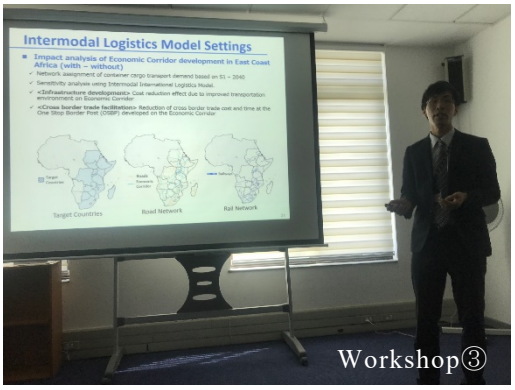
Survey at Tanzania (Nov. 27 – 29)

Date	Organization
27th Nov (Wed)	World Food Programme, Tanzania Office
28th Nov (Thu)	Workshop at JICA Tanzania Office Tanzania Freight Forwarders Association (TAFFA) Tanzania Railways Corporation (TRC)
29th Nov (Fri)	Tanzania Trade Development Authority (TanTrade) Tanzania International Container Terminal Service (TICTS) Tanzania Revenue Authority (TRA)


Workshop①



Workshop②



Workshop③


Dar es Salaam Port Site Visit①


Dar es Salaam Port Site Visit②


Dar es Salaam Port Site Visit③

Survey at Malawi (Dec. 2 – 3)

Date	Organization
2nd Dec. (Mon)	World Food Programme, Malawi Office Food and Agriculture Organization of the United Nations (FAO), Malawi Office JICA Malawi Office
3rd Dec. (Tue)	Malawi Ministry of Transport and Public Works Ministry of Finance, Economic Planning and Development Ministry of Industry, Trade and Tourism（MITT） Malawi Shipping Corporation


Lilongwe Road


Chipoka Port①

Chipoka Port②


Chipoka Port③

Chipoka Port④

Survey at South Africa (Dec. 5-6)

Date	Organization
5th Dec. (Thu)	JOGMEC South Africa Office JETRO Johannesburg Office and other organizations including private companies
6th Dec. (Fri)	Transnet SOC Ltd. and other organizations including private companies

Transnet SOC Ltd

Meeting at Transnet SOC Ltd

2) Establishing Initial Conditions

- Create initial datasets needed to construct an intermodal international freight model (hereinafter, the "Logistics Model") developed by Dr. Shibasaki, Associate Professor at Tokyo University, and used in this Study.
- Specifically, prepare the following data to enter into the model:
  - Target ports and freight flows
  - Hinterland freight network
  - Port freight demand
  - Inter-regional freight demand
  - Shipping routes
  - Port charges and time data
  - Import/export time data at borders and ports

3) Present State Simulation Model Calculations

- Check the model's reproducibility of the present status based on the initial datasets prepared above.
- Evaluate the reproducibility based on the actual freight flows, etc. of target ports.

4) OD Freight Volume Projections

- Estimate future OD freight flows based on the actual OD freight flows between two countries, which provide basis for determining the port freight demand in the initial datasets, and the GTAP model projections.
- Estimate OD freight flows for container freight, bulk freight (coal, crude oil, LNG, and iron ore), and RoRo freight (finished motor vehicles).
- Decide on the specific calculation method, which can be either one of the following, by consulting with the members of the Study Group:
  - Estimate future OD freight flows by multiplying GTAP projections with each original unit (i.e., container equivalent unit, etc.) of the actual OD data.
  - Estimate future OD freight flows by multiplying the actual OD data with the growth rate of trade value projected by the GTAP model.

5) Projection Model Calculations and Model-Based Policy Analysis

- Simulate future projections by setting the freight network capacity and other datasets for each scenario dependent on the fate of corridor development.
- Quantitatively evaluate the future projections of the effects of corridor development, etc. in terms of freight cost reduction, impact on port hinterland, and infrastructure supply-demand gap.

(5) Logistics Strategy in the Indo-Pacific Region

1) Identifying Bottlenecks in Logistics Infrastructure

- Based on the results of the above future simulation (quantitative evaluation of the effects of corridor development), identify bottlenecks in the logistics infrastructure and prioritize them from a mid- to long-term perspective.

2) Formulation of Logistics Infrastructure Strategy (recommendations for JICA's aid orientation and possibilities)

- In view of the identified bottlenecks and other findings of this analysis, formulate a logistics infrastructure strategy in the Indo-Pacific region and make recommendations for JICA regarding the future orientation and possibilities of its cooperation.

3) Remaining Tasks and Challenges

- Sort out remaining tasks and challenges based on the results of these analyses.

1. Outline of the Outputs of the 1st Year Study

1-1 Background and objectives

Since the 2000s, the international economy has undergone dramatic changes including the advancement of globalization, and emergence of new economic powers such as China and India. It is projected that the gravity center of global economy would continue its shift towards the Indo-Pacific region.

This calls for the necessity for formulation of a long-term logistics strategy for the Indo-Pacific region, including corridor development in East African coastal countries, West Asia, South Asia, and other regions that comprise the Indo-Pacific.

It also requires projection of future scenarios which considers uncertainties in a broad range of variables that can affect global economy and trade.

To address these needs, this Study attempts to quantitatively project the trade trends in the Indo-Pacific region for 2030 and beyond, envisioning the future of global logistics in the region from a wholistic approach to propose a group of potential transport infrastructure projects for the region that are consistent to the projection.

The 1st Year Study adopted the scenario-planning method, one of the techniques to examine multiple possibilities of future developments, to analyze various factors that could affect international logistics infrastructure in the Indo-Pacific region. Two scenarios that represent a broad range of possible situations were thus developed.

1-2 Outputs of the 1st Year Study

Outlined below are the outputs of the 1st Year Study.

1-2-1 Output-1

After reviewing different scenario analysis methods, an appropriate method (exemplary scenario analysis) was selected for analyzing global-trade-related scenarios looking into 2050.

- It was decided to use the exemplary scenario, as Japan will likely be able to demonstrate its controlling influence in the Indo-Pacific region by building collaborative relations with newly-emerging aid donors.
  - Through workshops and other opportunities, 11 major factors that would affect world trade in 2050 were determined: ①technological innovation, ② industrial location and structure, ③ population, ④ resource and energy, ⑤ climate change, ⑥ foodstuff, ⑦ consumer behavior, ⑧ international politics, ⑨trade system, ⑩war and conflict, and ⑪economic growth.

- Selected three factors, whose future developments are particularly difficult to predict: ①consumer behavior, ②technological innovation, and ③trade system.

1-2-2 Output-2

Assumptions of scenarios were defined.

- Quantitative analysis of trade projections and logistics simulations were decided to be performed for year 2030. Meanwhile the future scenario planning would be conducted up until year 2050, in order to envision the future world from a longer-term perspective.
- International cooperation system centered on the United Nations will repeatedly undergo changes but the overall framework would be maintained. No large-scale wars between nations will occur.
- As geo-economic approaches gain momentum, loose trade blocs based on Mega-FTAs will emerge (TPP, TTIP, and RCEP take effect). It is also assumed that China-led investment initiative of One Belt One Road would be implemented.
- For defining the base scenario, future projections of various official agencies and research organizations are referred to (population [UN], GDP [PwC and AfDB], foodstuff [FAO], energy [IEEJ], and climate change [IPCC]).

1-2-3 Output-3

Based on the above factors and assumptions, the following scenarios of future trade were created.

(1) Senario-1: African corridor development realizes under loose trade bloc.

- In this scenario, a coordinated free trade system is established based on the following assumptions: three Mega-FTAs currently under negotiation (TPP, TTI, and RCEP) will take effect; the One Belt One Road will become public goods; and multinational giant corporations will carry out their responsibilities for respecting human rights and protecting the environment. In Africa, intra-regional trade is vitalized due to the ratification of the African Continental Free Trade Agreement (AfCFTA) covering the entire continent, and growth is achieved at a faster pace than the global average due to the development of well-balanced and dispersed multi-polar corridors.

(2) Senario-2: African corridor development fails under loose trade bloc.

- In this scenario, a coordinated free trade system is established under Mega-FTAs, as is the case with Scenario-1. In Africa, however, industry would be developed in a way that intra-regional import/ export would be limited, and AfCFTA does not take place due to conflict of interest among the countries in the region, creating a situation where economic development becomes overly dependent on extra-regional imports and consumption in metropolitan areas.

(3) Assumptions for each scenario

- Provided below are detailed descriptions of the above two scenarios.

Table 1-2-1: Major scenarios presented by the 1st Year Study

Item	Scenario	Description
Population	Common	• Population in 2050 reaches 9.8 billion globally, 1.36 billion in China, 1.66 billion in India, and 800 million in ASEAN.
GDP	Common	• Global GDP grows at an average annual rate of 2.6%. • Global GDP share in 2050: China (20%), India (15%), USA (12%), EU27 (9%)
	S1	• Africa grows at an average annual rate of 6.6 – 5.7% (high case)
	S2	• Africa grows at an average annual rate of 4.0 – 3.6% (low case)
Expansion of free trade	Common	• More Mega-FTAs are created to complement WTO. Horizonal international specialization progresses further in each area. Intra-regional trade becomes relatively dominant (TPP, TTIP, RCEP, etc.)
	S1	• Investment under China's One Belt One Road initiative contributes to the development of India and African countries. • Economic integration within the African continent progresses due to CFTA. • Quality growth is achieved as a result of developing corridors in Africa.
	S2	• Investment under One Belt One Road initiative does not contribute to Africa's quality growth (it only accelerates over dependence on extra-regional imports and consumption in metropolitan areas).

Item	Scenario	Description
		• CFTA is not reached (due to conflict of interest within the African continent).
Global trade	Common	• Global trade increases at a similar pace to GDP (even trade).
	S1	• Trade volume within African region grows faster than GDP due to expanding intra-African trade under CFTA (fast trade).
	S2	• Intra-African trade, as is the case with global trade, increases at a similar pace to GDP (even trade).
Realization of responsible SCs	Common	• Responsible supply chains (SCs) are realized for the most part due to creation of Mega-FTAs, etc.
Widening of disparities	S1	• Quality growth is mostly accomplished worldwide, decreasing disparity in GDP per capita. • Disparity shrinks at a faster pace in Africa, where disparity is greater, than the global average.
	S2	• Africa's external negotiating power is insufficient due to the failure of CFTA. • Disparities among regions and countries widen due to the progress of advanced horizontal international specialization by multinational giants. • Africa's disparity in GDP per capita expands to a moderate level.
Foodstuff	Common	• Food demand per capita of developed and semi-developed countries in 2050 decreases to 90% of that in 2010, whereas that of developing countries in 2050 increases slightly to 102% of the 2010 figure. • In other words, food demand in 2050 increases 1.55 and 2.06 times the 2010 demand worldwide and in developing countries, respectively while food loss gradually decreases in developed countries. • Global food demand is satisfied due to improved productivity (crop yield increases at an annual rate of 1.0% to reach 1.5 times that of 2010 in 2050).
	S1	• Green Revolution successfully takes place in Africa, enabling stable food supply (food self-sufficiency increases while transport infrastructure develops within the region).
	S2	• Green Revolution does not take root in Africa. Extra-

Item	Scenario	Description
		regional imports of food increase (based on MAFF's projection).
Energy	Common	• Global energy consumption in 2050 becomes 1.5 greater than that of 2015. • Energy consumption in developing countries decreases slightly while that in non-OECD countries increases at an annual rate of 1.6% (approx. 1.75 times). Increase is particularly notable in China, India, and ASEAN countries, as well as in Middle East, North Africa, and Sub-Saharan Africa (due to population and economic growth). • 79% of energy demand is satisfied by fossil fuels (30% petroleum, 26% natural gas, and 23% coal) and the remaining 21% by other fuels. There is no depletion of resources. • Production of fossil fuels in 2050 increases to 1.35 times that of 2015 (at an annual rate of 0.9%) for petroleum, 1.76 times (1.6%) for natural gas, and 1.18 times (0.5%) for coal. However, if conversion to electric cars and other ZEVs accelerates, petroleum demand will be about 99% of that in 2015.
Consumer awareness	Common	• While over-consumerism accelerates due to increased income, the "sustainable consumption" concept gradually gains awareness and popularity toward the achievement of SDGs (reaching a halfway point).
Technological innovation	Common	• Productivity of horticulture, livestock farming, and fisheries, as well as storage/transport technologies, continue to improve and become more sophisticated. • Super-large container ships (40,000 TEU class) will not emerge (They will stay at the current 20,000 TEU level due to navigation restrictions in the Suez Canal and the Straits of Malacca).
Climate change risk	Common	• International horizontal specialization progresses under a loose trade bloc. Stable economic growth is achieved while maintaining the supply-demand balance of food and energy. • Climate change risk equivalent to a medium stabilizing scenario (RCP4.5) as a result of certain

Item	Scenario	Description
		mitigation measures is assumed.
Risk of war, conflict, and terrorism	S1	• The risk of war, conflict, and terrorism remains “low” due to formation of a loose trade bloc.
	S2	• While international horizontal specialization progresses based on comparative advantage under a loose trade bloc, corridor development fails. • Multinational giants accumulate wealth by leading the trade market while nations and citizens are deprived of their fair shares, posing a “high risk” for conflict and terrorism.
Impact on global logistics	Common	• Global trade increases at a similar level to GDP (even trade). • Size of large container vessels remains at the current 20,000TEU level. • Two types of ocean freight networks (hub-and-spoke and point-to-point) develop at multiple levels. • Medium to small container ships (4,000TEU – 8,000TEU) are predominant in the Intra-Asia trade. • Advancement of international horizontal specialization heightens the importance of warehouse facilities as storage and inland gateways. • Transshipment services via hub ports in Asia, Sub-Saharan Africa, and Islamic region (Port of Colombo, Port Luis, Port Salalah, and Port Mombasa) are prevalent.

2. Infrastructure Development Trends in the Indo-Pacific Region

2-1 General Directions for Information Collection

- The related development plans and masterplans of logistics infrastructure were reviewed in order to collect information to develop a viable analysis case for Intermodal Global Logistic Model aimed at simulating freight transport.
- The current situation will be represented by identifying the capacity of various existing logistics infrastructures, collecting information on future infrastructure development and investment plans, and envisioning the future freight transport environment.
- As the point of the two scenarios selected in the first-year survey was to examine the success or failure of Africa corridor development, in gathering information, the focus of this study will also be Africa corridor development.
- In addition to the eight corridors that originate from major international ports in eastern Africa (Djibouti Corridor, East Africa Northern Corridor, Central Corridor, Dar es Salaam Corridor, Nacala Corridor, Beira Corridor, Maputo Corridor, North-South Corridor), this study also focuses on three additional corridors that pass through Namibia and Angola to consider transport from inland countries (Lobito Corridor, Trans–Caprivi Corridor, Trans-Kalahari Corridor).

2-1-1 Documents Reviewed

- At present, the review has been conducted mainly the reports of the surveys on JICA's existing projects which are shown in Table 2-1-1 (Part 1 to Part 3). As the purpose of this survey is to gather information on future plans on logistics-related infrastructure development, JICA's past projects and written reports mainly published from 2010 were reviewed to collect information on logistics infrastructure related to planning and master plans.
- Information on regions and logistics infrastructure sectors for which sufficient information could not be obtained through desktop survey was complemented through field survey.

Table 2-1-1: Reviewed Logistics Infrastructure Related Projects, Survey Reports

Related Corridor	Title	Author (s)	Publication Year	No.
Maputo Corridor	Port of Maputo Infrastructure Development Trends	JETRO	September 2015	#01
Northern Corridor	Project for Master Plan on Logistics in Northern Economic Corridor: Final Report	JICA	March 2017	#02

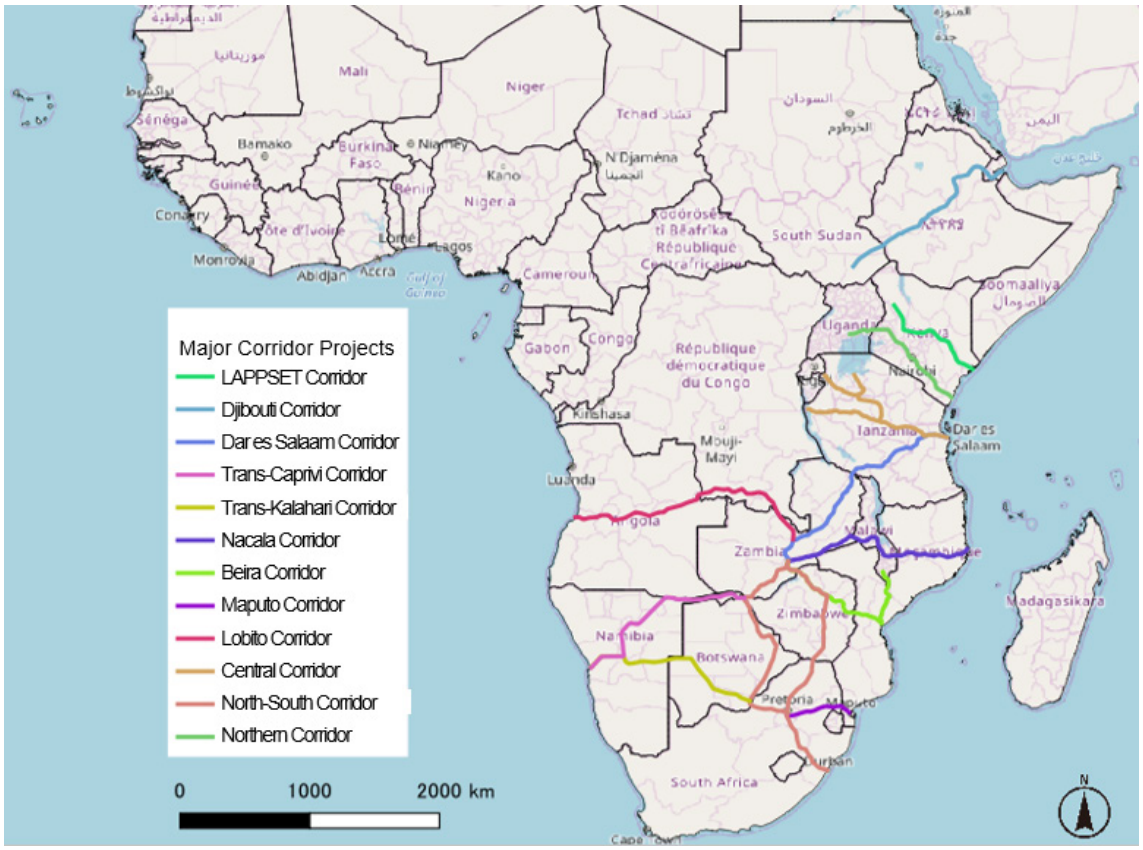
Table 2-1-1: Reviewed Logistics Infrastructure Related Projects, Survey Reports

Related Corridor	Title	Author (s)	Publication Year	No.
Northern Corridor	Formulation of Comprehensive Development Master Plan in the Mombasa Gate City (Kenya)	JICA	March 2018	#03
Northern Corridor	Ngong Road Development Project Phase 2 (Kenya): Preparatory Survey Report	JICA	June 2017	#04
Northern Corridor	Project for supporting the development of a logistics Master Plan in Africa's Northern Economic Corridor: Final Report (Japanese Summary)	JICA	March 2017	#05
Beira Corridor	Port of Beira PPP Project Framework and Investment Plan	JETRO	March 2016	#06
North-South Corridor	Preparatory Survey for Southern Africa Integrated Regional Transport Program: Final Report	JICA	March 2010	#07
North-South Corridor	Investigative Report on Distribution and Logistics in Southern and Eastern Africa	JETRO	May 2014	#08
Nacala Corridor	Preparatory Survey Report on the Project for Construction of Bridges in Cabo Delgado Province in the Republic of Mozambique.	JICA	July 2016	#09
Nacala Corridor	Project for Nacala Corridor Economic Development Strategies in the Republic of Mozambique: Final Report (Summary)	JICA	Apr 2015	#10
Nacala Corridor	Preparatory Survey for Nacala Corridor Road Network Upgrading Project in the Republic of Mozambique: Final Report Summary	JICA	May 2018	#11
Nacala Corridor	Development Support for Economic Development in Nacala Corridor [Technical Assistance Related to Japanese ODA Loan]: Final Report	JICA	March 2018	#12
Nacala Corridor	Development Project for Nacala in the Republic of Mozambique: Ex-Ante Evaluation Paper	JICA	2015	#13
Nacala Corridor	The Project for Supporting the Promotion of Nacala Corridor Development Final Report	JICA	March 2018	#14
Central Corridor Dar es Salaam Corridor Northern Corridor	Project for Revision of Dar es Salaam Urban Transport Master Plan in United Republic of Tanzania	JICA	July 2018	#15
Central Corridor Dar es Salaam Corridor	Comprehensive Master Plan for Transport and Trade System Development in the United Republic of Tanzania: Final Report (English, Volume 3 Master Plan)	JICA	March 2014	#16
Central Corridor	Project for the Improvement of the Port of Bujumbura: Ex-Ante Evaluation Paper	JICA	2014	#17
Dar es Salaam Corridor	Preparatory Survey Report on the Project for Improvement of Transport Capacity in Dar es Salaam in the United Republic of Tanzania (Part 2)	JICA	March 2011	#18

Table 2-1-1: Reviewed Logistics Infrastructure Related Projects, Survey Reports

Related Corridor	Title	Author (s)	Publication Year	No.
Djibouti Corridor	Data Collection Survey Report on Maritime Transport Capacity in the Gulf of Tadjoura, Djibouti	JICA	July 2017	#19
Djibouti Corridor	Data Collection Survey for Djibouti Corridor: Final Report	JICA	January 2018	#20
Djibouti Corridor	Mombasa Port Master Plan Including Dongo Kundu: Final Report	JICA	October 2015	#21
-	Republic of South Africa Report	JETRO	December 2015	#22
-	Additional Preparatory Survey Report on the Project for Rehabilitation of Kigoma Port in the United Republic of Tanzania	JICA	August 2018	#23
-	Launch of the New Suez Canal and the Suez Canal Area Development Project	JETRO Institute of Developing Economies	March 2016	#24
-	Project for Improvement of Namibe Port:2017 Ex-Ante Evaluation Paper	JICA	2017	#25
-	2016 Report on the Results of Gathering Information on Projects Supporting Regional Investment in Africa and Investment Areas Being Promoted in the Democratic Republic of the Congo	JICA	March 2016	#26
-	2017 Overseas Market Trends and Forecasts (Egypt p.41-); Overseas Construction Association of Japan, Inc.	OCAJI	February /March 2017	#27

- Figure 2-1-1 shows the economic corridors which are located in the target countries for the Study. Maputo Corridor, North-South Corridor, Dar es Salaam Corrido, Beira Corridor, Nacala Corridor, Trans-Caprivi Corridor, Trans-Kalahari Corridor, and Lobito Corridor are the major corridors in eastern and southern Africa regions.
- Further, parts of the Nacala Corridor, Djibouti Corridor, and East Africa Northern Corridor were included in the five priority areas for Africa economic corridor development assistance at TICAD V, held in Yokohama in 2013 by the Japanese government.



Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-1-1: Map of Corridor Plan Locations

(1) Djibouti Corridor

- Djibouti Corridor was positioned as one of the five priority areas at TICAD V held in Yokohama in 2013.
- The corridor originates from Port of Djibouti and connects Galafi in Djibouti, Addis Ababa in Ethiopia, Khartoum in Sudan and Juba in South Sudan.
- The route from Port of Djibouti to Ethiopia via Galafi is the primary traffic route of the Djibouti Corridor, and most imports in Ethiopia are transported via this route.
- It is believed that logistic routes could be more widely distributed if roads and railways are developed along separate routes through Dewele and Dire Dawa in Ethiopia.

(2) LAPSSET Corridor

- Originating from Lamu Port in Kenya, LAPSSET Corridor has been developed as a corridor that branches in the northward direction to Ethiopia in Isiolo County Kenya, and the southward direction to Juba in South Sudan.
- It passes through Moyale (Kenya) at the border between Ethiopia and Kenya, and leads to Addis Ababa via Ethiopia's Hawassa city which has been established as a new industrial area of Ethiopia, and Modjo which is near Addis Ababa.
- Roads on the Kenyan side that connect to Ethiopia have already been constructed, and construction is underway on the Ethiopian side, including the development of highways between some sections from the border to Addis Ababa.
- There are high expectations of this corridor as a new logistics route connecting Ethiopia and Kenya.

(3) East Africa Northern Corridor

- Originating from Port of Mombasa in Kenya consists of major roads connecting Nairobi, Kampala in Uganda, Kigali in Rwanda, Bujumbura in Burundi; railway lines from Port of Mombasa to Nairobi, Nakuru, and Kisumu; railway lines connecting Kampala and Port Bell on Lake Victoria; and inland water transport using Lake Victoria at Kisumu and Bell ports.
- Road improvement plans are expected to connect this corridor with LAPSSET and Djibouti corridors.

(4) Central Corridor

- Originating from Port of Dar es Salaam in Tanzania, via Dodoma and Ithaca the Central Corridor connects DRC, Kigali in Rwanda, Kampala in Uganda, and Bujumbura in Burundi.
- Inland lake water transport on Lake Victoria connects Ithaca in Tanzania to Uganda, thereby connecting Port of Mwanza in Tanzania to Port Bell in Uganda.

(5) Dar es Salaam Corridor

- Originating from Port of Dar es Salaam in Tanzania, Dar es Salaam Corridor consists of roads and railways from Tunduma at the border with Zambia, to Lusaka in Zambia. This corridor also connects to the Nacala Corridor and North-South Corridor via Lusaka.

(6) Nacala Corridor

- Originating from the Port of Nacala in Mozambique, this corridor is centered on the arterial road to Lusaka, Zambia through Nampula, Cuamba, and Malawi. It connects to major cities in Mozambique other than Nampula, including Mandimba and Lichinga. The Nacala Corridor Economic Development Strategy (PEDEC-Nacala) targets regional development in four provinces (Nampula, Cabo Delgado, Niassa, Tete) as well as seven counties in northern Zambia.

(7) Beira Corridor

- Beira Corridor extends from Port of Beira in Mozambique to Harare in Zimbabwe. It connects from Harare to the east side of the North-South Corridor.

(8) Maputo Corridor

- Maputo extends from Port of Maputo in Mozambique to Pretoria in South Africa. It connects to the North-South Corridor in Pretoria.

(9) North-South Corridor

- North-South Corridor consists of railways and roads leading from Port of Durban in South Africa to Zambia via Johannesburg and Pretoria. Its western route passes Lobatse and Gaborone in Botswana, and Kazungula in Zambia, while its eastern route passes Beitbridge, Harare and Lusaka in Zimbabwe.

(10) Lobito Corridor

- Lobito Corridor crosses the country from Port of Lobito in Angola and extends to southern DRC as well as northern Zambia.

(11) Trans-Caprivi Corridor

- Originating from Port Walvis Bay in Namibia, the Trans-Caprivi Corridor crosses the country northeast into Botswana and connects to the north section of the North-South Corridor route near the border with Zambia and Zimbabwe.

(12) Trans-Kalahari Corridor

- Originating from Port Walvis Bay in Namibia, the Trans-Kalahari Corridor crosses the country southeast into Botswana and connects to the North-South Corridor.

2-2 Items Assessed in the Review

- Items requiring examination with regards to the logistics infrastructure of each corridor were summarized for each sector, including ports, roads, railways, inland water transport, and dry ports.
- This study also examined and organized the current and future logistics infrastructure related plans of each sector.
- In addition to the major issues, important items assessed for each infrastructure sector are shown in Table 2-2-1.

Table 2-2-1: Focused Infrastructure Sectors and information

Infrastructure Sector	Item Assessed
Port	• Water depth • Number of berths • Berth length • Yard area • Volume of cargo handled • Type of cargo handled
Dry port	• Site area • Volume of cargo handled • Customs clearance time
Road	• Section • Connecting Country/City • Travel time between major cities • Road width • Single/multiple lane • Volume of cargo handled
Railway	• Section • Connecting Country/City • Travel time between major cities • Gauge width • Single/multiple lane • Volume of cargo handled
Inland water transport	• Means of transport • Volume of cargo handled

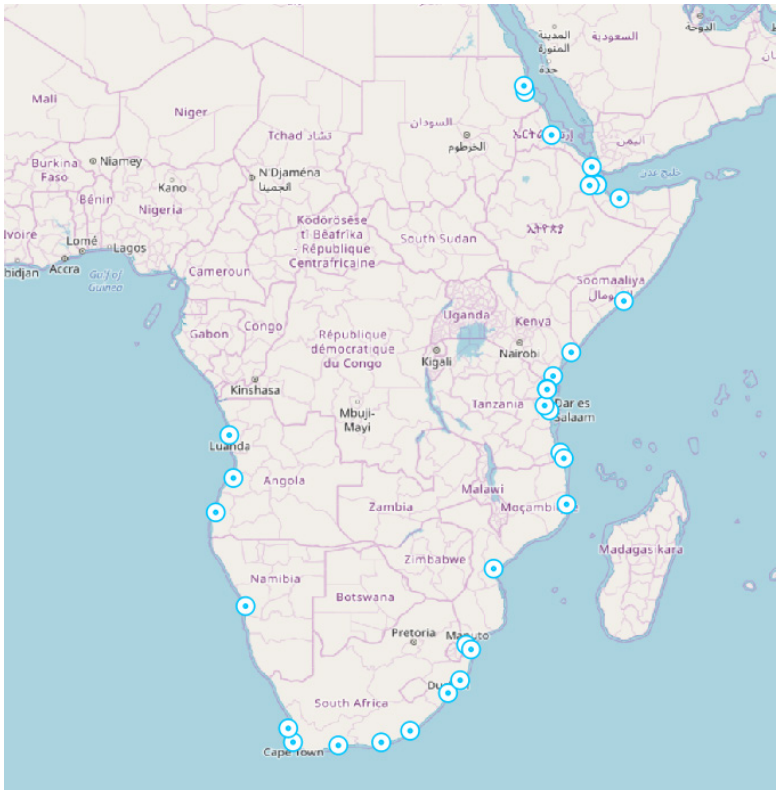
2-3 Information on Logistics Infrastructure Development Trends

- Logistics infrastructure development plans, etc. were referenced from JICA reports.

2-3-1 Logistics Infrastructure Development Plans by Sector

(1) Ports

- For the port sector, development plans for the ports shown in Figure 2-3-1 were reviewed. Table 2-3-1 and Table 2-3-2 shows the current status and development plans of the port sector.



Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-3-1: Location of reviewed ports

Table 2-3-1: Current Status of the Port Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
Djibouti	Port of Djibouti (former port): • Port of Djibouti consists of three main facilities: The former port, Doraleh Container Terminal (DCT), and oil terminal. • The former port handles break bulk, dry bulk, container cargo and RoRo cargo with a maximum draft of 12 m and 15 berths. As the facilities are aging, all functions will be transferred to DMT once Doraleh, the multi-purpose terminal under construction, is completed. • Located on European and Asian routes, Port of Djibouti is a transloading hub that functions as a feeder transport hub to East and South Africa regions. This port handles all cargo to Djibouti and 95% of Ethiopia's cargo. (#20)	2018	Djibouti Corridor
Djibouti	Port of Djibouti (Doraleh Container Terminal): • DCT has a maximum draft of 18 m, berth of 1050 m, 8 Super Post-Panamax quay cranes, and a handling capacity of 12 million TEU. • The container terminal used to be operated through a joint venture between the Djibouti government and DP World. However, it is reported that the Djibouti Government has reclaimed the operation rights from DP World in 2018. (#20)	2018	Djibouti Corridor
Djibouti	Port of Djibouti (Oil Terminal): • The oil terminal consists of two berths.One can accommodate 80,000 DWT Panamax class vessels, with a maximum draft of 18 m and length of 240 m. • The other berth can accommodate 30,000 DWT vessels, with a maximum draft of 10 m and length of 180 m.A total of 31 tanks have been built with a combined capacity of 399,304 m^3. • The terminal is operated by Horizon Djibouti Terminals. (#20)	2018	Djibouti Corridor
Djibouti	Doraleh Multipurpose Port: • Constructed in Phase 1 were (six) berths with a maximum draft of 16 m and length of 1200 m, as well as 12 harbor cranes. The completion ceremony was held in May 2017. (#20)	2018	Djibouti Corridor
Djibouti	New Tadjoura Port: • This port has two quays approximately 455 m in length, 12–15 m in depth, and able to accommodate 65,000 DWT general cargo vessels. The RoRo terminal has a quay that is 190 m in length and 12 m in depth. Phase 1 was completed in June 2017. (#20)	2018	Djibouti Corridor
Djibouti	Port of Ghoubet: • Expected to serve as a salt export port, Port of Ghoubet has a quay 400 m in length and 15 m in depth and can accommodate 100,000 DWT class	2018	Djibouti Corridor

Table 2-3-1: Current Status of the Port Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
	vessels. (#20) • The port's annual handling capacity is 5,000,000 tons and held its opening ceremony in 2017. (#19)		
Djibouti	Damerjog Livestock Port: • This port's quay is 655 m in length and can accommodate up to 5 livestock vessels. Operation start (#20)	2018	Djibouti Corridor
Djibouti	HORIZON Djibouti Terminal: • This terminal has a draft of 20 m, 2 berths, and can accommodate 80,000 DWT class vessels. Oil storage capacity is 370,000 m^3. Cargo handling capacity is 2,000 ton per hour. It operates under a joint investment between a private company and government of Djibouti. Private company: Government ratio is 9:1 (#19)	2018	Djibouti Corridor
Somalia	Port of Berbera: • This is an oil terminal whose quay is 650 m in length. As of 2012, cargo handling volume was 21,538 TEU for containers, 521,300 TEU for break bulk, and 150,425 ton for other bulk cargo. The port is used for import and export of Ethiopia. (#20)	2018	Djibouti Corridor
Kenya	Port of Mombasa: • Of this port's 19 berths, 8 berths (11 to 19) are dedicated as container terminals. These 8 berths are 1,156.7 m in length and 10.5–13.5 m in depth. • As of 2015, container cargo handling volume was 1,076,118 TEU and non-container cargo handling volume was 16,456,00 tons (#20)	2018	Northern Corridor
Sudan	Osman Digna Port: • Located roughly 60 km south of Port Sudan, Osman Digna Port contains 9 berths (4 berths for passenger vessels, RoRo , general cargo combined use; 4 berths for livestock and common cargo; 1 berth for dry bulk, livestock and general cargo. • The quay is 748 m in length with a water depth of 8–12 m. • It has an annual handling capacity of 3 million tons. (#20)	2018	Djibouti Corridor
Sudan	Port Sudan: • Port Sudan consists of four major facilities: North quay, Green terminal, South quay, and the Al-Khair oil terminal. • North quay has 12 berths with a total length of 1866 m and water depth of 8.5–10.7 m. This quay handles mainly general cargo, cooking oil, and molasses with an annual handling capacity of 5 million tons. • Green terminal has 4 berths with a total length	2018	Djibouti Corridor

Table 2-3-1: Current Status of the Port Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
	of 1228 m, water depth of 14.7 m, and can accommodate up to 60,000 DWT class vessels. The terminal handles mainly general cargo, container cargo and bulk cargo with an annual handling capacity of 4 million tons. • South quay is a container terminal with a total length of 1546 m, 6 container berths, 1 grain and general cargo berth (berth 15). It has a depth of 12.6 m to 16 m and an annual handling capacity of 12 million TEU. • Al-Khair Oil Terminal has only one berth with a length of 310 m, water depth of 14.6 m, and can accommodate 50,000 DWT class vessels. Its annual handling capacity is 26 million tons. (#20) • Not only is it the gateway to Sudan, but it also serves as a port for inland countries including South Sudan, Central Africa and Chad. However, it is worth noting that transport to southern Sudan requires over 1000 km of road transport. For this reason, Port of Mombasa in Kenya is often used for transport to South Sudan. (#20)		

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Egypt	New Suez Canal (new): • This new canal was completed in 2015. Due to this, the number of vessels passing through each year is forecast to increase from 17,148 in 2014 to 33,000 in 2023. (#24)	2015 (Completed) → 2023	None
Egypt	Port of Port Said: • SCZone (Suez Canal Regional Development Project) is being implemented in the eastern Port Said back land. • This is Egypt's main port, there are no known future expansion plans (#27)	Unknown	None
Egypt	Port of Alexandria: • Port of Alexandria is the main port in Egypt, and while it has been under construction to expand the port as of 2017, there are no known future expansion plans (#27)	Unknown	None
Egypt	Damietta Port: • Port of Alexandria is the main port in Egypt, and while it has been under construction to expand the port as of 2017, there are no known future expansion plans (#27)	Unknown	None
Egypt	• Port of Dekheila • Port of Alexandria is the main port in Egypt, and	Unknown	None

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	while it has been under construction to expand the port as of 2017, there are no known future expansion plans (#27)		
Egypt	Sokhna Port: • SCZone (Suez Canal Regional Development Project) is planned for the Suez/Ain Sokhna back land, which is expected to increase transport activity. This is Egypt's main port, there are no known future expansion plans (#27)	Unknown	None
Djibouti	Doraleh Multipurpose Port (DMP) (new): • Of the 6 berths completed in Phase 1, two berths will be dedicated to containers, 1 berth to RoRo, and 3 berths to bulk cargo. • The development plan is composed of Phase 1 and Phase 2, however, the scale and timing of the development in Phase 2 are unknown. • This port was built to take over functions of the aging Port of Djibouti facilities, and once completed, all functions of the old port will be transferred to Doraleh Multipurpose Port. Although this new port has fewer berths than the former port, it should have the same handling volume due to its draft depth and the introduction of cargo handling equipment. (#20) • This port has 15 berths, a length of 1,200 m, water depth of 16–18 m, and is capable of handling container cargo, RoRo cargo, general cargo and break bulk cargo. • Annual cargo handling capacity is 220,000 TEUs for container cargo and 8,799,000 tons for general cargo. • Equipment includes two quay cranes, 12 portal cranes, and 2 rail mounted gantry (RMG) cranes. A berth dedicated for the Chinese Navy is also likely to be built. (#19)	Phase 1: Loan provided in 2017 Phase 2: Unknown	Djibouti Corridor
Djibouti	LNG terminal (new): • LNG will be transported from Ethiopia's Ogaden basin via an 803 km pipeline with an annual LNG handling volume of 3 million tons. Completion is scheduled for 2019. (#20)	2019	Djibouti Corridor
Djibouti	Vessel repair and dry dock maintenance (new): • Planned are two floating docks (80,000DWT and 30,000DWT) with a length of 840 m and depth of 20 m. Although operations were planned to start by 2020, funding has not yet been secured. (#20)	2020	Djibouti Corridor
Djibouti	New Tadjoura Port (new): • This port is being developed to export potassium from northern Ethiopia. (#20) • Although Phase 1 completed in June 2017, it is unknown when the port will begin handling	Unknown (2017 or later)	Djibouti Corridor

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	cargo. (#19)		
Somalia	Port of Berbera (expansion): • Now undergoing renovation, this port is scheduled to start operating in 2019. Berth expansion work is now underway. (#20) • Renovation projects underway include a 400 m quay and 250,000 m² yard expansion. (#20) • The Ethiopian government also said that it expects 30% of Djibouti's cargo to shift to Port of Berbera in order to ease congestion at Port of Djibouti. (#20)	2019	Djibouti Corridor
Eritrea	Massawa Port: • No information on development plans could be obtained.	-	None
Eritrea	Port of Assab: • No information on development plans could be obtained.	-	
Kenya	Lamu Port (new): • Lamu port is a deep sea port with 32 berths under construction. • One berth in 2018 and two berths in 2020 were operating. • There are plans for a further 29 berths to be built under concession contract with a private operator. • Transport areas beyond the port are northern Kenya, southern Ethiopia and southern Sudan via the LAPPSET Corridor. • It is under construction 200 m north of Port of Mombasa. • The port is expected to use the LAPSSET corridor to connect to northern Kenya, southern Ethiopia and southern Sudan. (#20)	First berth: 2018 Second berth: 2020 Unknown for 29 berths thereafter	Djibouti Corridor LAPSSET Corridor
Sudan	Port of Osman Digna (new): • A new livestock terminal is being planned 35 km south of the port. Phase1 is being planned with a quay 240 m in length and 12.5 m in depth. Phases 2 and 3 will have quays of 900 m total length (4 berths) and 12.5 m depth. (#20)	Unknown	Djibouti Corridor
Tanzania	Port of Dar es Salaam (expansion): • Expansion of two berths (berths 13 and 14) was planned to start in 2013, but construction had still not started at February 2014 and the construction period is expected to be three years. • There are plans to build a new inland container depot in Kisarawe to expand the container yard. • Berths 13 and 14 will be 750 m in length and able to accommodate 500,000 DWT class vessels. Each of two berths will handle 650,000 TEU for a total annual handling capacity expected to be 1,200,000 TEU.	Unknown (2017 or later)	Central Corridor, Dar es Salaam Corridor

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	• Nevertheless, demand is expected to overtake volume handled by 2020. (#16) • As container cargo volume is forecast to be 2,486,000–4,719,000 TEU by 2028, expansion of the two berths is not expected to meet the projected demand. (#16)		
Tanzania	Mbegani-Bagamoyo Port (new): • This port is planned in separate Phases 1–3. • Phase 1 (2020–2024): Length of 1 km with 4 berths (including 2 for containers and 1 for Ro-Ro); Phase 2 (2024–2028): Length of 1,320 m with 5 berths; Phase 3 (2028–2030): Length of 1,620 m with 7 berths • In 2013, the Chinese and Tanzanian governments signed an agreement on port support (#16)	Phase 1:2024 Phase 2:2028 Phase 3:2030	Central Corridor, Dar es Salaam Corridor
Tanzania	Mwambani Port (new): • Since expanding Port of Tanga is unrealistic due to its surrounding environment (expensive to develop a port with a depth of 12 m or more), there are plans to develop a port in Mwambani Bay, 6 km south of Port of Tanga. • In JICA's FS survey, only a rough selection of suitable sites within Mwambani Bay was carried out.(#16)	Unknown	Tanga Corridor (Tanga→ Arusha→ Lake Victoria)
Tanzania	Mtwara Port (expansion): • Development of Mtwara Port may be expedited by the development of gas fields off the coast of Mtwara. • Though it handles 150,000 tons of cargo, by 2030 it is expected to reach 25,000,000 tons of bulk cargo (cement, coal, iron, etc.) with demand of 41,000 TEU. (#16)	Unknown	Mtwara Corridor (Mtwara →Mbamba Bay (Lake Malawi))
Mozambique	Port of Nacala (expansion): • JICA is implementing the Port of Nacala Development Project. • Based on the JICA's project evaluation, in 2020, target cargo volume is set at 5,071,000 tons/year and container cargo volume is set at 251,000 TEU. (#13) • Phase 2 began in May 2018. Container handling volume is expected to reach 300,000 TEU through Phase 2 of the project. 2012–2016 container handling volume (in order from 2012) has been 65,000 TEU, 82,000 TEU, 97,000 TEU, 79,000 TEU, 71,000 TEU (#14)	Phase 2: 2021 (Scheduled to start in May 2018 with a 3-year construction period)	Nacala Corridor
Tanzania	Mtwara Port (expansion): • Development of Mtwara Port may be expedited by the development of gas fields off the coast of Mtwara. • Though it handles 150,000 tons of cargo, by 2030 it is expected to reach 25,000,000 tons of	Unknown	Mtwara Corridor (Mtwara →Mbamba Bay (Lake

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	bulk cargo (cement, coal, iron, etc.) with demand of 41,000 TEU. (#16)		Malawi))
Mozambique	• Port of Nacala (expansion): JICA is implementing the Port of Nacala Development Project. • Based on the JICA's project evaluation, in 2020, target cargo volume is set at 5,071,000 tons/year and container cargo volume is set at 251,000 TEU. (#13) • Phase 2 began in May 2018. Container handling volume is expected to reach 300,000 TEU through phase 2 of the project. • 2012–2016 container handling volume (in order from 2012) has been 65,000 TEU, 82,000 TEU, 97,000 TEU, 79,000 TEU, 71,000 TEU (#14)	Phase 2:2021 (Scheduled to start in May 2018 with a 3-year construction period)	Nacala Corridor
Mozambique	Port of Palma: • Construction of an LNG plant using natural gas from offshore gas fields was planned by 2018; location of a chemical industry using natural gas was planned by 2020; and public ports to facilitate natural gas-related industries has also been planned. Details on the status of port development are unknown. (#10)	Unknown	Nacala Corridor
Mozambique	Port of Beira (expansion): • Plans include an increase of processing capacity to 750,000 TEU by 2024, and a new container terminal sometime after 2027. There are plans to boost processing capacity for general cargo (Phase 1: 2015 forward; Phase 2: 2019 forward) (#06)	2024 After 2027	Beira Corridor
Mozambique	Port of Maputo (expansion): • Cargo is being shifted from Port of Durban to Port of Maputo, and there are growing needs to expand Port of Maputo. (#07) • By 2033, the capacity will be expanded from 19,300,000 tons at 2014 to 40,000,000 tons by 2033. According to the investment plan to 2020, container handling capacity will be increased from 150,000 TEU at 2014 to 300,000 TEU (#01)	Details unknown (2020, 2033)	Maputo Corridor
Mozambique	Techobanine Port (new): • As an alternative port to Port of Maputo, there are plans to develop a port 70 km south of Port of Durban that will receive cargo switched from Port of Durban. (#07)	Unknown	Maputo Corridor
Republic of South Africa	Port of Durban (expansion/new construction): • The port is planning a short-term expansion project from 2012 to 2019. Medium-Term projects also include a new port scheduled to begin construction between 2019 and 2042. (#08)	Details unknown (2019, 2042)	North-South Corridor
Republic	Port of Cape Town (expansion):	Unknown	None

Table 2-3-2: Port Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
of South Africa	• This is a major port with the second largest container handling volume in South Africa. Although a development plan has been prepared by the National Ports Authority, but there are no specific plans known (#22).		
Republic of South Africa	Port of Port Elizabeth (expansion): • It is the third major port in South Africa in terms of container handling volume. Although a development plan has been prepared by the National Ports Authority, specific plans are unknown (#22)	Unknown	None
Republic of South Africa	Port of East London (expansion): • It is the fourth major port in South Africa in terms of container handling volume. Although a development plan has been prepared by the National Ports Authority, specific details are unknown (#22).	Unknown	None
Republic of South Africa	Port of Richards Bay (expansion): • It is the fifth major port in South Africa in terms of container handling volume. Although a development plan has been prepared by the National Ports Authority, specific plans are unknown (#22)	Unknown	None
Republic of South Africa	Port of Saldanha (expansion): • Development has been planned primarily as a port for handling iron ore. It is expected to provide an alternative port to others; however, specific plans are unknown (#22).	Unknown	None
Namibia	Port of Walvis Bay (expansion): • JICA conducted a preparatory survey in 2010 on container terminal development projects. A new container terminal is expected to be built to increase the capacity to 583,000 TEU by 2026.	Unknown	Trans-Caprivi Corridor / Trans-Kalahari Corridor
Angola	Port of Namibe (expansion): • Under the Port of Namibe improvement plan, work is being carried out with support from Japan. (#25)	Unknown	None
Angola	Port of Lobito (expansion): • There are no known specific future expansion plans	Unknown	Lobito Corridor
Angola	Rwanda Port (expansion): • There are no known specific future expansion plans	Unknown	None

(2) Dry port

- Table 2-3-3 and Table 2-3-4 shows the current status and development plans of dry ports.

Table 2-3-3: Current Status of Dry Ports

Country	Infrastructure Development Plan Details	Status Year	Corridor
Sudan	Kosti Dry Port (Sudan): • Formerly a land transport and inland water transport terminal, this port it is now mainly used as a transshipment terminal for customs clearance and land transport of goods imported from Port Sudan. • The site area is 200 ha with an annual handling capacity of 150,000 TEU. Customs clearance is possible here, after which goods are transported to Central-Western Sudan and South Sudan. (#20)	In operation	Djibouti Corridor
Sudan	Salloum Dry Port (Sudan): • Recently began operation. This port was built to alleviate congestion in Port Sudan. (#20)	In operation	Djibouti Corridor
Ethiopia	Ethiopia: • Existing permanent dry ports are Semera and Modjo. • Existing temporary dry ports are Mekele, Kombolcha, and Dire Dawa. • Comet and Gelan in Kality also have dry ports, which are second only to Modjo Dry Port. (#20)	In operation	Djibouti Corridor

Table 2-3-4: Dry Port Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Ethiopia	Ethiopia: • A project to expand Modjo Dry Port, the largest dry port in Ethiopia, is now underway. • This project will increase site area from 62 to 150 ha, increase the number of customs warehouses from 2 to 6, and secure additional cargo handling equipment. Construction is now underway to connect the port directly to the new railway. (#20)	Details not finalized	Djibouti Corridor
Ethiopia	Ethiopia: • Dry port locations are planned for Bahir Dar, Nekemte, Jimma, Hawassa and Jijiga. (#20)	Details not finalized	Djibouti Corridor
Mozambique	Mozambique: • As a project to establish an integrated transport terminal and rail transport yard in Nacala, this is an integrated terminal composed of three elements: A combined railway and truck terminal, railway yard, and engine shed. It is being established to quickly transfer cargo from	Details unknown	Nacala Corridor

	railroad to truck and vice-versa. • Annual cargo handling volume will be 50,000–60,000 TEU. The planned site is 10 km south of Port of Nacala along the Port of Nacala Access Road. (#12)		
Malawi	Malawi: • In Liwonde and Chipoka, the development of a customs logistics base is being promoted (Malawi Inland Container Customs Logistics Base Project). • This roughly 1.2 ha facility will include a railway yard, bonded warehouse, container transport station, and container storage. (#12)	Details not finalized	Nacala Corridor
Zambia	Zambia: • In Chipata, development of a customs logistics base is being promoted (Chipata Inland Container Customs Logistics Base Project). • This roughly 1.2 ha facility will include a railway yard, bonded warehouse, container transport station, and container storage. (#12)	Details not finalized	Nacala Corridor
Mozambique	Mozambique: • Four truck terminals will be built along N1 and N12 in Namialo, Ribaue and Malema in Nampula city, and Cuamba in Niassa province. These terminals will handle cargo storage, distribute goods to smaller trucks, etc. (#12)	Details not finalized	Nacala Corridor

(3) Road

- Table 2-3-5 and Table 2-3-6 shows the current status and development plans of the road sector.

Table 2-3-5: Current Status of the Road Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
Ethiopia	Ethiopia to Kenya: • To use Lamu and Mombasa ports from southern Ethiopia, road sections between Modjo-Hawassa-Moyale are used as the main access roads to LAPSSET Corridor. (#20)	2018	LAPSSET Corridor
Djibouti Ethiopia	Djibouti to Ethiopia: • The transport route between Ethiopia and Djibouti via Galafi is fully open. Due to this route's flat terrain, it is the primary traffic route of Djibouti Corridor. (#20)	2018	Djibouti Corridor
Ethiopia	Ethiopian Domestic Expressway: • The Addis Ababa–Adama Expressway ("AAE"), which connects Addis Ababa–Dukem–Bishoftu–Modjo–Adama, is now in service. This road is 78 km in length, 6-lane (3-lane per side) expressway. The roadway is 3.75 m wide with a 2 m wide median and 2.5 m of paved road per side. Access is fully limited (as a toll road). • Most container cargo from Port of Djibouti	2018	Djibouti Corridor

Table 2-3-5: Current Status of the Road Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
	clears customs at Modjo Dry Port and is transported to Addis Ababa or the final destination in the vicinity. Therefore, constructing this highway was driven by Addis Ababa to Adama having the highest traffic volume in Ethiopia. (#20)		
Djibouti	Djibouti: • National Highway RN1 is roughly 240 km in length and carries most cargo destined for Ethiopia, making it the most important of the country's four major routes. Due to poor pavement conditions between Dikhil and Galafi, JICA is implementing road maintenance and equipment outfitting projects for emergency repair. (#20)	When the 2018 report was prepared Design stage	Djibouti Corridor
Djibouti	Djibouti: • National Highways RN5 and RN18 are alternative routes to RN1 between Djibouti and Ethiopia, but the pavement conditions are poor. (#20)	When the 2018 report was prepared Pavement incomplete, limited use	Djibouti Corridor
Djibouti	Djibouti: • National Highway RN2 is a 21.4 km road that connects Djibouti and Somalia. (#20)	When the 2018 report was prepared under construction	Djibouti Corridor
Ethiopia Sudan	Ethiopia to Sudan: • The road between Addis Ababa and Metemma (at the border between Ethiopia and Sudan) is expected to be used to access Sudan's Port Sudan from northern Ethiopia as well as promote trade between Ethiopia and Sudan. (#20)	In operation	Djibouti Corridor
Ethiopia South Sudan	Ethiopia to South Sudan: • There is a major road from Ethiopia to Upper Nile state in southern Sudan via Jikawo (Jikawo/Jikou on the southern Sudan side). • In South Sudan's Upper Nile, road construction is problematic due to the flood-frequent Sudd zone and poor soil conditions between this region and Juba (South Sudan), necessitating access from the Ethiopian side. (#20)	In operation	Djibouti Corridor
Sudan	Sudan: • There is a both a "Shorter Route" and "Longer Route" between Khartoum and Port Sudan. The	2018	Djibouti Corridor

Table 2-3-5: Current Status of the Road Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
	Longer Route is more commonly used since vehicles carry empty cargo from Khartoum to Port Sudan. (#20)		
Sudan	Sudan: • The North-South Route between Halfa (Egyptian border)–Khartoum–Galallabat (Ethiopian border) is often used as an international trade route for land transport. (#20)	2018	Djibouti Corridor
Sudan	Sudan to South Sudan: • The route between Khartoum (Sudan) and Renk (border with South Sudan) was once the major route, but has not been utilized as a logistics route in recent years due to poor paving conditions. (#20)	2018	Djibouti Corridor
Sudan	Sudan: • The A5, which connects Khartoum to Al Fashir via route B26, has helped to improve access to western Sudan. (#20)	2018	Djibouti Corridor
South Sudan	South Sudan: • The road between Juba and Nimule leads to the northern corridor, connecting traffic to Port of Mombasa via Uganda and Kenya. (#20)	2018	Djibouti Corridor
Tanzania	Road widening (Gerezani Road–Bandari Road) (2 lanes to 4 lanes): • Project for Improvement of Transport Capacity in Dar es Salaam in the United Republic of Tanzania, Phase 2 (Maximum grant: 104 million yen) • Road widening project of 1.7 km roadway from the intersection of Bandari and Kilwa roads to intersection of Zaregeni and Nyerere roads. This creates a 4-lane 2-way road (2 lanes per direction of 7.5 m width). Both sides have combined vehicle/bicycle lanes each 3.5 m wide (#18)	2011	Dar es Salaam (TAZARA) Corridor
Tanzania	• Mwenge multi-level crossing. Widening of New Bagamoyo Road. (#15)	2011	Dar es Salaam (TAZARA) Corridor

Table 2-3-6: Road Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Ethiopia	Djibouti to Ethiopia: • Once the route through Djibouti-Dewele-Dire Dawa-Halal-Awash-Modjo-Addis Ababa is paved, the paved surface will raise transport speed from 10 km/h to 65 km/h. This is expected to reduce required transport time between Djibouti and Addis Ababa from 31 hours down to 12 hours. Note, however, that details of the project are unknown. (#20)	Details unknown	Djibouti Corridor
Ethiopia	Djibouti to Ethiopia: • Originating from Port of Djibouti, this corridor connects to Dewele and Awash in Ethiopia via National Highway RN5 and RN18 on the Djibouti side. Although Ethiopia side roads (Awash-Dire Dawa-Dewele) are unpaved now, paving has been budgeted until FY2019/2020 in the Ethiopian Road Sector Development Program (RSDP V). (#20)	Construction is budgeted to FY2019/2020	Djibouti Corridor
Djibouti	Djibouti to Ethiopia: • National Highway RN11, which connects Port of Tadjoura to the Djibouti-Ethiopia border (Balho), is currently under construction. (#20)	Under construction when the 2018 Report was prepared	Djibouti Corridor
Djibouti	Ethiopia to Djibouti: • The road between Galafi and Balho, which connects from Ethiopia to Djibouti's National Highway RN11, the route leading to Tadjoura Port, is currently undergoing road improvements. (#20)	Under repair when the 2018 Report was prepared	Djibouti Corridor
Djibouti	Djibouti Domestic Expressway: • A highway between Port of Djibouti and RN18 has been planned but not yet budgeted. (#20)	Not budgeted when the 2018 Report was prepared	Djibouti Corridor
Ethiopia	Somalia to Ethiopia: • The road between Dire Dawa and Togechane, which connects Ethiopia to Port of Berbera in Somalia, is currently under construction. (#20)	Under construction when the 2018 Report was prepared	Djibouti Corridor
Ethiopia	Ethiopian Domestic Expressway: • Expressway between Adama and Awash is currently under construction. (#20)	Under construction when the 2018 Report was prepared	Djibouti Corridor

Table 2-3-6: Road Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Ethiopia	Ethiopian Domestic Expressway: • Expressway between Awash and Dire Dawa has been planned, but there are no solid funding prospects. (#20)	No solid funding prospects when the 2018 Report was prepared	Djibouti Corridor
Ethiopia	Ethiopian Domestic Expressway: • Expressway between Modjo and Hawassa is currently under construction. Logistics demand in Hawassa is expected to increase due to development of a new industrial park, and the expressway is expected to improve transport capacity. (#20)	Under construction when the 2018 Report was prepared	Djibouti Corridor
South Sudan	• South Sudan: As an alternative route for international trade, a road is being developed between Juba and Nadapal. It is planned to connect to the LAPSSET corridor which leads to Lamu Port. (#20)	Under construction when the 2018 Report was prepared	Djibouti Corridor LAPSSET Corridor
Tanzania	• A road improvement plan connecting Kibamba IC to the Outer Ring Road (R=20–30 km) extending from Bunju has been approved. • A Middle Ring Road (R =10–15 km) plan is under consideration. A road improvement plan connecting Bay Link and Baymouth Link roads has already been approved. (#15)	Unknown	Dar es Salaam (TAZARA) Corridor
Mozambique	Mozambique: • World Bank is planning to build an access road to Nacala–Nacala a Velha. (#12)	Scheduled for construction when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • World Bank plans to construct an access road from Nacala to Angónia District in Tete Province. (#12)	Scheduled for construction when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • Road reconstruction was recommended between Nampula and Nametil, which began in 2017 through a loan from Export-Import Bank. (#12)	Reconstruction began in 2017	Nacala Corridor
Mozambique	Mozambique: • A Port of Nacala Access Road Project is being promoted.	FS was underway when the	Nacala Corridor

Table 2-3-6: Road Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	• This is a 13.5 km road north of N12 to Port of Nacala, including 0.7 km of bridges. Though it will initially be a 2-lane road, it will be expanded to 4 lanes in the future. (#12)	2018 Report was prepared	
Mozambique	Mozambique: • The Port of Nacala Access Road connects from the Port of Nacala extension to N12 bound for Nampula at the intersection of R702. • It provides direct access to the port without passing through Nacala's city center. A multimodal terminal (railway yard) is also planned along the route. It has two lanes per side and is 13.5 km in length. (#11)	Unknown	Nacala Corridor
Mozambique	Mozambique: • A Nampula/Southern road bypass project in Nampula City is being promoted. • This is a 32.5 km bypass road that would run through the southern part of Nampula City, bypassing N13 traffic from the west and N1 traffic from the east of Nampula City. • Initially, the road will be 16 m wide as well as part of a future proposed ring road. (#12)	FS was underway when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • Of the road sections of N1 which runs from Port of Nacala to Nampula city center, the Nampula South Bypass bypasses the city on the south side just before N1 enters the city. • It crosses R686 and N104, then crosses N1 which runs south from Nampula city, and joins N13 without passing through the city center. It has two lanes per side and is 32.5 km in length. (#11)	FS was underway when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • A Cuamba Bypass Road Development Project is being promoted in Cuamba City. • This is a 2-lane road with a length of around 11 km, including a 50 m bridge. At around 5 km east of Cuamba City, the road branches off from Route N13 extending northwest, merges with N360, and bypasses inflowing traffic from N13 into Cuamba City. (#12)	FS was underway when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • The Cuamba Bypass is a road that bypasses the north side of Cuamba without passing through the inner city where the rail route from Malawi and Nacala Corridor intersect. It crosses N360 and connects to both ends of N13. • The route allows road traffic to avoid crossing the railway tracks. This road has one lane per side and is 11 km in length. (#11)	FS was underway when the 2018 Report was prepared	Nacala Corridor
Mozambique	Mozambique: • This corridor improves access to Tanzania from Mozambique's coastal city of Pemba or Palma by	Being implemented when	Nacala Corridor

Table 2-3-6: Road Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	rebuilding two bridges between Mueda and Negomane in eastern Cabo Delgado. (#12)	the 2018 Report was prepared	
Mozambique	Mozambique: • The Messalo I, Messalo III and Mapuede Bridges on N380 will be replaced through grant aid with a target completion date of 2022. • Current passage between Macomia and Oasse is limited for fully-loaded large trucks, taking around 300 minutes due to detouring away from Macomia to the coast. By rebuilding the bridges, trucks can travel on N380 and reduce travel time by 80 minutes. (#09)	Aimed to be rebuilt by 2022	Nacala Corridor
Mozambique	Mozambique: • The development of 12 expressways and 27 trunk roads is planned in the Urban Transport Master Plan formulated by National Roads Administration (ANE) in March 2014. See the appendix for details. (#09)	Was preparing for implementation to 2020 when the 2016 Report was prepared	Nacala Corridor
Kenya	• Southern bypass construction project including Kipevu Link. • This provides an alternative route for cargo from the container terminal to Nairobi. (#03)	Unknown	Northern Corridor
Kenya	• New container terminal development project. An additional handling volume of 70,000 TEU will be newly added to Port of Mombasa, which now has a handling volume of 1 million TEU. However, these mainly focus on container cargo rather than bulk cargo. (#03)	Unknown	Northern Corridor
Kenya	• Standard Gauge Railway Improvement Project. This provides an alternative route for cargo from the container terminal to Nairobi. (#03)	Unknown	Northern Corridor
Kenya	• Project to widen the existing 2-lane road to a 4-lane road for Ngong Road on sections between Nairobi's city center and west area (Dagoretti Corner intersection to Kilimani Intersection). • The target area, Ngong Road, is Nairobi city's most congested area, and this project is expected to significantly reduce traffic congestion. (#04)	2019	Northern Corridor
Kenya	• Development of a SEZ (South Economic Zone) in the southern Africa and Dongo Kundu area port development (JICA) (#03)	Not implemented	Northern Corridor
Kenya	• Mombasa Gate Bridge Construction Project (JICA) (#03)	Not implemented	Northern Corridor

Table 2-3-6: Road Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Kenya	• Development plan for the Second Nyali Bridge/Development plan for a northern bypass (World Bank) (#03)	Not implemented	Northern Corridor
Kenya	• Road widening plan for National Highway A109 (European Investment Bank) (#03)	Not implemented	Northern Corridor

(4) Railway

- Table 2-3-7 and Table 2-3-8 shows the current status and development plans of the railway sector.

Table 2-3-7: Current Status of the Railway Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
Djibouti Ethiopia	Rail transport between Djibouti and Ethiopia: • Ethio-Djibouti Railway between Port of Djibouti and Addis Ababa is no longer in use. Total length is 784 km with 1000 mm narrow gauge. (PCKK Note: Current existence of the track is unknown) (#20)	Route began operation in 1917 Currently unusable due to lack of maintenance	Djibouti Corridor
Djibouti Ethiopia	Rail transport between Djibouti and Ethiopia: • Port of Djibouti -Dire Dawa-Awash-Adama-Modjo-Addis Ababa- Sebeta. The route is single track between Port of Djibouti and Adama (641 km), and double track between Adama and Sebeta (115 km). The route is 756 km in length, 1435 mm gauge track, electrified railway, with a maximum speed of 120 km/h. (#20)	Started operation in 2017	Djibouti Corridor
Sudan South Sudan	Sudan to South Sudan: • Total length 4180 km, 1067 mm gauge track, single track. Diesel railway. Maximum speed is 40 km/h (actual operation speed is 35 km/h or less). • Some routes such as Hayya- Singa- Ad Damazin are not in operation. Operation rate is 44% (only 44% of all trailer vehicles can operate) (#20)	In operation Some sections not usable due to dilapidation	Djibouti Corridor
Mozambique	Tete to Port of Nacala: • Improvement project completed. • Coal transport has begun through joint operation between CDN (Mozambique operator) and CEAR (Malawi operator). (#12)	In operation	Nacala Corridor
Tanzania	TRC (2 lines): • 31.7 km	In operation	Dar es Salaam

Table 2-3-7: Current Status of the Railway Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
		(2017)	(TAZARA) Corridor
Tanzania	Tanzania Rail Limited (TRL) (freight) : • Total length of 2,724 km with 7 routes (#15)	In operation (2017)	Dar es Salaam (TAZARA) Corridor
Tanzania	Dar es Salaam to Zambia TAZARA Railway: • 1,860 km (#15)	In operation (2017)	Dar es Salaam (TAZARA) Corridor
Tanzania	Tanzania Rail Limited (TRL) (freight) : • Total length of 2,724 km with 7 routes (#15)	In operation (2017)	Dar es Salaam (TAZARA) Corridor
Tanzania	TAZARA Railway : • Dar es Salaam- Kidatu -Mbeya-Tunduma-Zambia-Kapiri Mposhi: Length 1,860 km (#15)	In operation (2017)	Dar es Salaam (TAZARA) Corridor
Kenya	Standard Gage Railway (SGR) Rail route (Mombasa to Nairobi): • Aims to close the market share gap between railway and road transport by providing world-class rail service along the Northern Corridor. (#02)	Started operation in 2017	Northern Corridor
Kenya	Meter Gage Railway (MGR)a Rail route (Mombasa to Kampala): • Aims to improve services for shippers, shift transport from trucks to rail, and provide a competitive option to SGR. (#02)	2017–2019	Northern Corridor

Table 2-3-8: Railway Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
Sudan	Rail transport within Sudan: • Between Khartoum and Port Sudan. In 2007, a project to upgrade from 1,000 mm MGR to 1,435 mm SGR was ordered by the Sudan Railway Corporation to a Chinese company. (#20)	Unknown	Djibouti Corridor
Ethiopia	Rail transport between Djibouti and Ethiopia: • Railway service between Djibouti, Dewele and Addis Ababa is scheduled to begin in 2017. (#20)	2017	Djibouti Corridor
Ethiopia	Ethiopia: • A north-south route between Awash and Mekele (643 km length, single track, electrified railway) is now under construction. (Ref5)	Under construction when the 2018 Report was prepared	Djibouti Corridor
Ethiopia	Ethiopia: • The route between Modjo-Hawassa-Konso-	Constructions funds	LAPPSET Corridor

Table 2-3-8: Railway Sector Development Plans

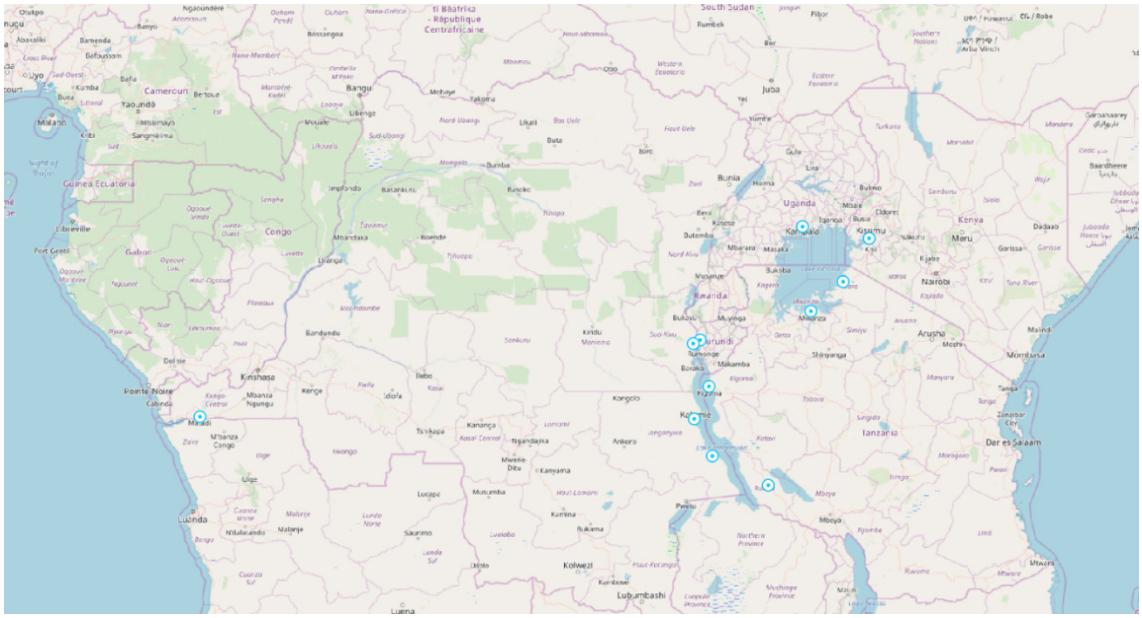
Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	Moyale provides access to Port of Lam. There are plans to connect to the Kenya railway network as part of LAPPSET Corridor. Length is 976 km. (#20)	have not been secured yet	
Ethiopia	Ethiopia to Djibouti: • Between Weldiya/Hara Gebeya-Asaita (Djibouti border)-Port of Tadjoura. Corridor is 218 km on the Ethiopian side and 100 km on the Djibouti side. (#20)	Constructions funds have not been secured yet	Djibouti Corridor
Ethiopia	Ethiopia to Sudan: • Railway route is a 1435 mm gauge, partly single/partly double track, diesel railway. In the future, it will be connected with neighboring African countries as well as Arab countries. • In order of priority, routes are: Khartoum-Port Sudan; Hayya-Kassala-El Gadarif- Sennar-Ad Damazin. (#20)	Construction has begun by a Chinese company (2018)	Djibouti Corridor
Ethiopia	• Between Ethiopia and Sudan: The prime minister and president of both countries have agreed to connect Ethiopia and Port Sudan by rail. (#20)	* Reference info	Djibouti Corridor
Mozambique	Nakaya to Mchinji: • There are plans to extend the corridor from Nakaya to Mchinji (border between Malawi and Zambia). This will provide a rail transport network from Port of Nacala to the Zambian border. (#12)	Started in January 2018 Expected to complete within two years	Nacala Corridor
Mozambique	Mozambique: • This 43 km in length double-track railway bypass north of Nampula City will transport coal, general cargo and container rail from Moatize. (#12)	Unknown	Nacala Corridor
Tanzania	• Tanzania Rail Limited (TRL) routes will be 4 lines, 101.4 km in length. Sections are unknown. (#15)	2040	Dar es Salaam (TAZARA) Corridor
Tanzania	• Existing line TRC Pugu and Ubungo lines will be improved over 32 km with double-track electrification etc. by 2025. • This will ensure a schedule speed of 35 to 45 km/h and provide one-way transport capacity of 20,000 to 60,000 people/h. (#15)	2025	Dar es Salaam (TAZARA) Corridor
Tanzania	• Three newly built TRC rail lines covering 85 km. • Includes Tegeta Line (Tegeta-Aga Khan district), 21.7 km; Morogoro Line (Mbezi-Ubungo), 11.5 km; Loop Line (Ubungo-Mwenge), 4.5 km; partial subway extension, 27 km; urban center coverage over 20 km. (#15)	2030	Dar es Salaam (TAZARA) Corridor
Tanzania	• Existing lines (Pugu Line, Ubungo Line) will be connected to the new line Tegeta Line (Aga Khan-	2040	Dar es Salaam

Table 2-3-8: Railway Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	Central Station), 4.5 km; Morogoro Line (Tegeta-Bunju), 13 km; and Loop Line (Mbezi-Kibaha), 14.5 km. • This will construct a railway network covering in an almost 30 km radius of the city. (#15)		(TAZARA) Corridor
Tanzania	• Bagamoyo Line (Tegeta Line) 1,435 mm SGR double track, Morogoro Line extension (#15)	2040	Dar es Salaam (TAZARA) Corridor
Tanzania	• One new TRC line, a 15 km Kilwa line, will be built after 2040 • Including the above, this will create 101.4 km of service with 4 lines (#15)	After 2040	Dar es Salaam (TAZARA) Corridor
Tanzania	TRC (Tanzania Railway Corporation)/Tanzania Rail Limited (TRL) (2 lines): • Extends existing 31.7 km to 101.4 km and upgrades to 4 lines. 15 km added to Kilwa Line. (#15)	2040	Dar es Salaam (TAZARA) Corridor
Kenya	Standard Gage Railway (SGR) Railway (between Mombasa and Nairobi): • Design is underway for rail routes up to Naivasha in Kenya and between Kampala-Tororo in Uganda. There are also other sections that have completed their FS and are being implemented. This is a massive project that will take many years to complete and realize the SGR vision. (#02)	Started operation in 2017	Northern Corridor

(5) Inland water transport

- Regarding inland water transport, a review of the development plan was conducted for ports located on Lake Victoria and Lake Tanganyika, as shown in Figure 2-3-2. Table 2-3-10 and Table 2-3-10 the current status and development plans of inland water transport sector.



Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-3-2: Location of reviewed ports (inland water)

Table 2-3-9: Current Status of the Inland Water Transport Sector

Country	Infrastructure Development Plan Details	Status Year	Corridor
Tanzania	The Victoria Lake water transport rail ferry is not currently operating (#15)	2018	Central Corridor/Northern Corridor

Table 2-3-10: Inland Water Transport Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
South Sudan Sudan	Inland water transport between southern Sudan and Sudan: There are seven river ports on Nile River. Inland water transport between Juba and Kosti exists, but is not currently being used. Goods bound for Port Sudan were being transloaded at Salloum Dry Port beside Kosti River Port. The UN conducted a feasibility study on the White Nile River in southern Sudan in 2017. With the support of the AfDB, the southern Sudan government has	Unknown	None

Table 2-3-10: Inland Water Transport Sector Development Plans

Country	Infrastructure Development Plan Details	Target Grant Year	Corridor
	developed a 10-year IWT Master Plan (2018–2020). (#20)		
Tanzania	Mwanza South Port (expansion): Formerly, Tanzania-Based company MSCL (Marine Services Co., Ltd.) operated a freight car ferry between Mwanza South Port and Port Bell Port in Uganda and has been engaged in railway-linked lake transport. This is an important transport route for Uganda that connects Dar es Salaam and Kampala. Mwanza South Port (expansion): According to the Ports Master Plan of Tanzania Ports Authority (TPA), the rail route between Dar es Salaam and Mwanza South Port is scheduled to start operation in 2015. Also, the expansion of a container terminal at Mwanza South Port is planned for 2018 completion. Cargo volume between Mwanza and Port Bell is expected to be 2,494 TEU in 2015 and 23,350 TEU in 2030. (#16)	Unknown (After 2018)	Central Corridor
Tanzania	Port of Musoma (new): If a railway between Arusha and Musoma is developed (currently not constructed), this port will be planned to transport cargo from railway to Uganda. JICA's Master Plan, this is positioned as a long-term plan (until 2030). JICA's feasibility study proposed the development of a port near the railway station that is capable of handling transport for 60 TEU-class vessels. (#16)	Unknown (Aimed at 2030)	Central Corridor
Tanzania	Port of Kigoma (expansion): With rail transport of cargo between Dar es Salaam and Kigoma scheduled to begin in 2015, this expansion was planned to address the anticipated increase in cargo volume. This expansion is planned to be able to handle the cargo of 30 freight trains (at 60 TEU per train). JICA's Master Plan, this was planned for implementation as a short-term plan (until 2017). Handling volume at Port of Kigoma is forecast to reach 5,745 TEU in 2015 and 26,211 TEU in 2030. Kigoma and Kasanga ports are expected to play an integral role in freight transport to inland countries such as Rwanda and Burundi. (#16)	Unknown (2017)	Central Corridor

2-4 Information Collection on Streamlining Cross-Border and Customs Procedures

- In addition to the logistics infrastructure, factors impacting logistics in the region include efficiency and barriers in cross-border crossings and customs procedures.
- Therefore, separately from logistics infrastructure, information was gathered on freight transport border crossing points between countries in order to understand trends in improving the efficiency of border procedures between countries.

2-4-1 Understanding Freight Transport Border-Crossing Points between Countries

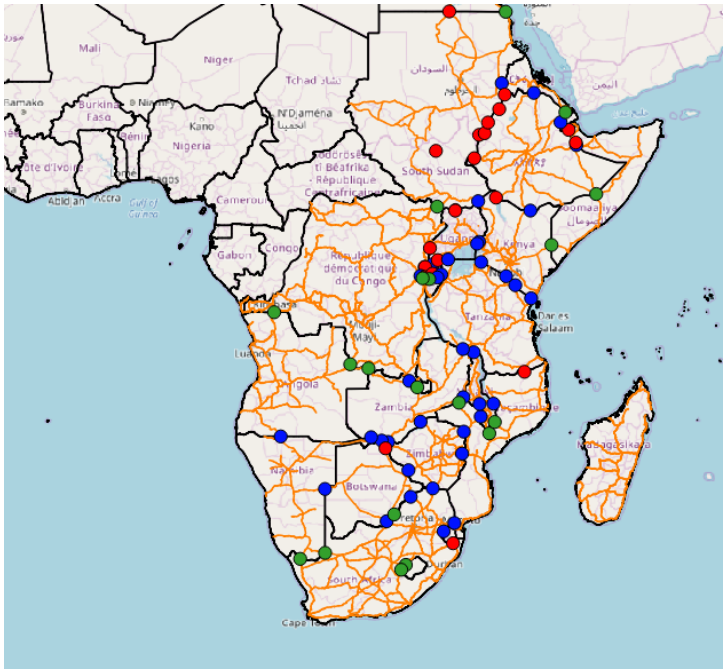
- In order to confirm the two points below when implementing an Intermodal Global Logistics Model, information on border crossing points between countries was collected and organized.
- Are there any border-crossing points that have not been considered in the model despite the large volume of cargo passing through?
- Is freight being transported at points where the road handled in the model crosses the border?
- Table 2-4-1 summarizes known border-crossing points between the countries. Countries that do not share a border are grayed out. Yellow-Shaded cells represent cases where no border-crossing points could be confirmed, or where additional research is needed.

Table 2-4-1: Number of Border Crossing Points between Countries

	Egypt	Sudan	South Sudan	Eritrea	Ethiopia	Djibouti	Somalia	Kenya	Uganda	DR Congo	Rwanda	Burundi	Tanzania	Malawi	Zambia	Zimbabwe	Mozambique	Botswana	South Africa	Swaziland	Angola	Namibia
Egypt																						
Sudan	1																					
South Sudan		1																				
Eritrea		1																				
Ethiopia		5	1	1																		
Djibouti				0	2																	
Somalia					2	0																
Kenya			1		2		0															
Uganda			2					2														
DR Congo			0						1													
Rwanda									2	2												
Burundi										1	3											
Tanzania								4	1	0	1	1										
Malawi													1									
Zambia										1			1	1								
Zimbabwe															2							
Mozambique													1	3	0	2						
Botswana															1	2						
South Africa																1	1	2				
Swaziland																	0		2			
Angola										0					0							
Namibia															1	0		1	0		1	

Source: Prepared by the Study Team

- Here, by comparing road networks considered in the Intermodal Global Logistics Model against the border-crossing points reviewed, we checked whether there were any border-crossing points that were not considered in the model.
- In Figure 2-4-1, the red points denote the cross border points that are not incorporated in the logistics model due to the limitation of available and valid GIS data.
- Also in Figure 2-4-1, the green points indicate where the road network crosses a border in the current logistics model. However, the existence or nonexistence of cargo passing through such points is not clearly known at this point.
- Data collection of the freight volume of these cross border points would be an issue for the future in understanding the global trade between the African countries and in improvement of the accuracy of the model.

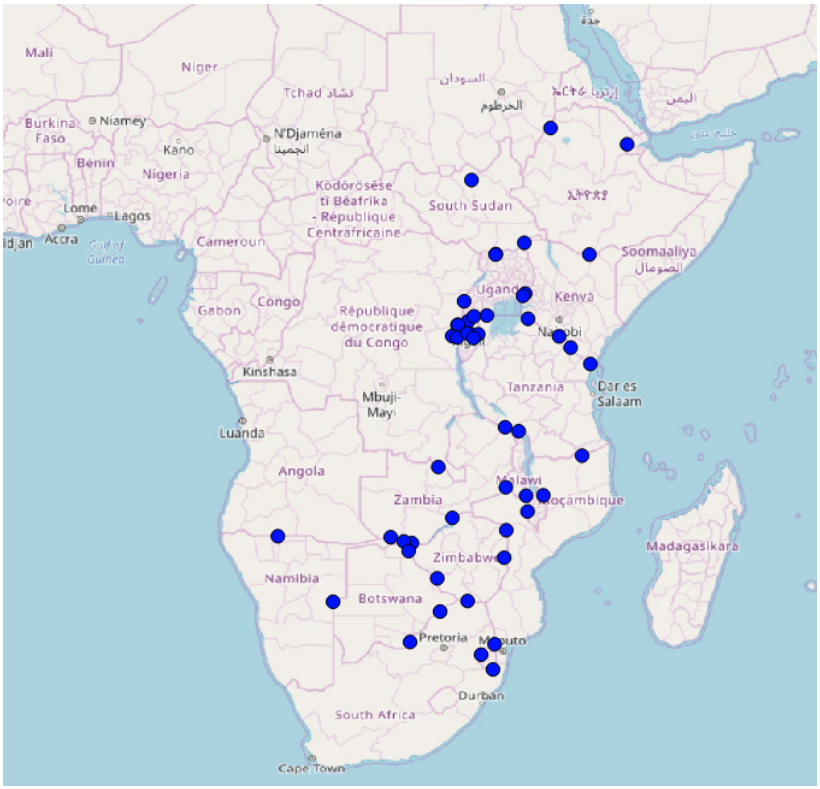


Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-4-1: Relationship between Road Networks and Border-Crossing Points Considered in the Current Intermodal Logistics Model

2-4-2 Understanding Border Crossing Points Where OSBP or Other Efforts to Streamline Custom Procedures are to be Implemented

- In African countries, procedures concerning customs clearance and immunization etc. required at border crossings are not carried out separately when entering/leaving to or from the two neighboring countries. Rather, OSBP (One Stop Border Post) is implemented in order to improve customs clearance efficiency.
- In the Intermodal Logistics Model, ways to improve the efficiency of OSBP will be considered for crossing points where OSBP is planned, such as by adjusting the number of crossing days.
- Figure 2-1-1 shows the cross border points in which OSBPs are to be developed.



Source: Prepared by the Study Team (Background map: Open Street Map)

Figure 2-4-2: Location of Border-Crossing points planned for OSBP

3. GTAP Model Analysis

3-1 Overview of GTAP Model Analysis

- The analysis is conducted for the purpose of quantitatively simulating and projecting the effects of economic strategies devised to illustrate an image of global logistics in the Indo-Pacific in year 2040, based on the scenario that covers long-term future until 2050.
- Analysis using GTAP model—multi-country, multi-region applied general equilibrium models—makes it possible to grasp the spillover effects of policies and changes in economic indicators through complex international trade.

3-1-1 GTAP Overview

- The Global Trade Analysis Project (GTAP) is headed by the Center for Global Trade Analysis at Purdue University in the USA, and was launched in 1992 by Thomas W. Hertel and others.
- The GTAP Model is applied general equilibrium models that use the GTAP Data Base (explained later) to perform analysis. They were developed by the GTAP, and are publicly available on the GTAP website. With the free version of GEMPACK (the software that comprises the GTAP Model programs) and the free version of the GTAP Data Base, anyone can use the GTAP Model to analyze policy effects for up to three regions and three sectors.
- Along with the GTAP Model, the GTAP develops the GTAP Data Base for use in analysis using the GTAP Model. The GTAP Data Base is updated approximately once every four years; the latest version, GTAP10 (base year: 2014) was released in 2019. As with the GTAP Model, to enable all researchers and policy analysts to use the GTAP Data Base, a free version is available for up to three regions and three sectors, and a standard model is commercially available.
- GTAP researchers and general users are constantly improving the GTAP Model, while also developing derived models and additional databases that correspond to model structures (static, dynamic, semi-dynamic, etc.) and targets of analysis (trade, waste materials, global warming).

3-1-2 GTAP Model Overview

(1) Overview

- As explained previously, the GTAP Model is applied general equilibrium (computable general equilibrium) models developed by the GTAP at Purdue University in the USA.
- Applied general equilibrium models are the foundation of general equilibrium theory in microeconomics, and are preconditions for analyzing the total optimization of economic units (households, governments, investors, and manufacturers).
- Applied general equilibrium models have gained popularity in policy analysis in recent years because they enable more detailed analysis than econometric models and other models due to characteristics such as their economic foundation and attribution of economic spillover effects to each unit under total optimization.
- Specifically, the ability to gain a quantitative understanding of the effects and impact of introducing policies (scenarios) to the different industries that comprise the models has led to their frequent application in industrial policy, trade policy, and environmental policy. Additionally, the vast improvement of computing power in recent years has led to the development of spatial computable general equilibrium models that analyze trade between multiple countries and regions as the GTAP Model does. Moreover, applied general equilibrium models fulfill a role in integrated assessment models that comprehensively analyze and project the long-term impacts of global warming across multiple aspects.
- It is worth noting that basic applied general equilibrium models create simulations by using flow data from specific points in time (or periods of time) from input-output tables, social accounting matrices, and other inputs to estimate coefficients of systems of equations that comprise the model (a process called “calibration”), and then adding coefficients (shocks) of tax rates and the like. In other words, time-series data is not needed to establish basic economic models, making them relatively simple to establish in developing countries as well as advanced countries with well-established socioeconomic data.
- However, the impact of temporary yet substantial changes in economic circumstances, such as the collapse of Lehman Brothers, on the models should be considered; the decision of which database to use as the baseline data (in terms of the factors such as the base year and creator of the database) should be made carefully.

(2) GTAP Model Structure

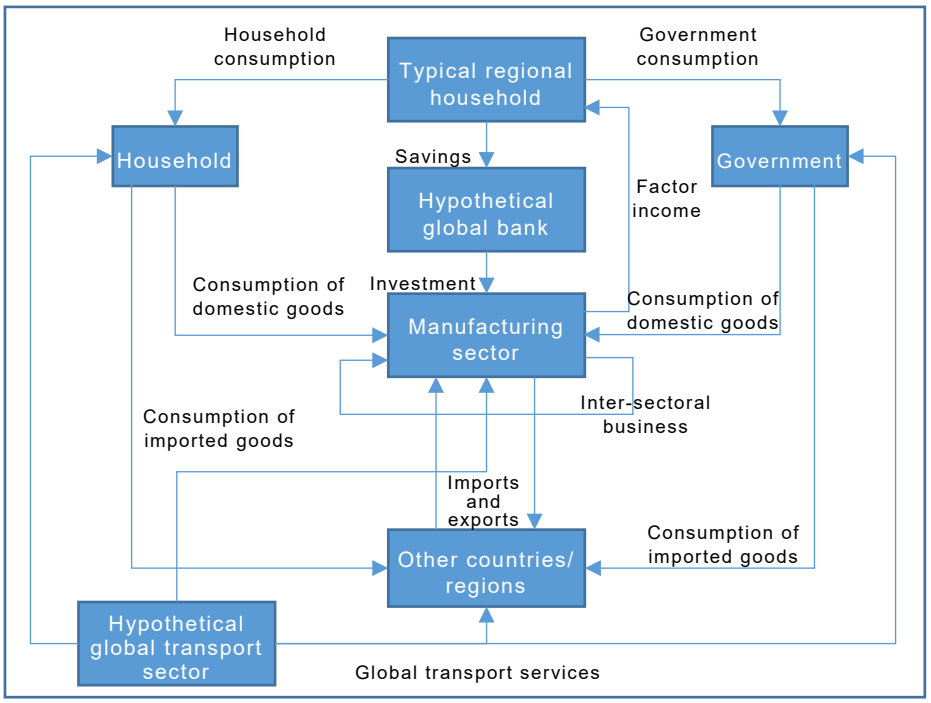


Figure 3-1-1 GTAP Model Structure

- The GTAP has typical regional households for each country and region, and divides tax revenue and factor income (land, skilled/unskilled labor, capital, natural resources) under utility maximization into household consumption, government consumption, and savings.
- Households and governments consume both domestic goods and imported goods, and either can be substituted for the other. Additionally, in the manufacturing sector, an Armington structure, which envisions substitutions between domestic and imported goods and between different domestic goods, is assumed.
- The hypothetical global bank that stores the savings of typical regional households uses the savings as an investment resource to invest in the manufacturing sector.
- The GTAP Model contains a hypothetical global transport sector that provides global transport services to the manufacturing sector—the importers and exporters who pay the cost of those services.
- Note that this global transport is the only form of circulation in the GTAP Model; the basic model does not factor in transport costs within countries or regions.
- Additionally, the model assumes the input of only the labor, capital, and other factors of manufacturing available in a given country or region; the basic model does not factor in variations such as the outflow and inflow of laborers to and from other countries.

- Attempts are underway to mitigate these conditions in derived models released by the GTAP and proprietary models developed from the GTAP Model.

3-1-3 GTAP Data Base Overview

- As explained previously, the GTAP develops the GTAP Data Base to serve as the baseline data for the GTAP Model. The Data Base and the Model are made available to general researchers and policy analysts.
- The Data Base has been updated 10 times since the release of GTAP1 in 1993; recently, a new version has been released every three to four years.
- The base year of the Data Base used in this study, GTAP9, is 2011 (GTAP9 also includes baseline data from 2004 and 2007). GTAP10 was released in July 2019 (after the Study commenced), and contains baseline data from 2014.
- The GTAP Data Base is a collection of data about the economic activity of economic units (households, governments, investors, and manufacturers) throughout the world. It is worth noting that the data is subdivided into detailed data for individual countries, regions, and industrial sectors (goods), and includes economic transactions between each. This Data Base enables the analysis of economic transactions between countries, regions, and industrial sectors within the framework of applied general equilibrium models.
- The GTAP9 Data Base used for the Study contains data for each of 57 industrial sectors (goods) for manufacturing, consumption, imports and exports, and more for each of 140 countries and regions throughout the world.
- No other database covers the entire world so comprehensively, and contains as much information for individual countries, regions, and industrial sectors (goods).
- The Study used baseline data from 2011, the base year of GTAP9, the latest database when the Study commenced (March 2019).
- It is worth noting that, by the GTAP9 base year of 2011, the global economy had nearly reached a steady state after a certain level of recovery from the global financial crisis instigated by the collapse of Lehman Brothers in 2008, which caused a temporary contraction in worldwide economic activity.

Table 3-1-1: Changes in the GTAP Data Base

Version	GTAP 6	GTAP 7	GTAP 8	GTAP 9	GTAP10
Base year	2001	2004	2004, 2007	2004, 2007 ,2011	2004, 2007, 2011, 2014
Number of countries/regions	87	113	129	140	141
Industrial sectors	57	57	57	57	57
Release date	May 2005	December 2008	March 2012	May 2015	Mid-2019

Table 3-1-2: Classification of Countries and Regions in GTAP9

No.	Code	Description	No.	Code	Description
1	AUS	Australia	71	NLD	Netherlands
2	NZL	New Zealand	72	POL	Poland
3	XOC	Rest of Oceania	73	PRT	Portugal
4	CHN	China	74	SVK	Slovakia
5	HKG	Hong Kong, Special Administrative Region of China	75	SVN	Slovenia
6	JPN	Japan	76	ESP	Spain
7	KOR	Korea, Republic of	77	SWE	Sweden
8	MNG	Mongolia	78	GBR	United Kingdom
9	TWN	Taiwan	79	CHE	Switzerland
10	XEA	Rest of East Asia	80	NOR	Norway
11	BRN	Brunei Darussalam	81	XEF	Rest of European Free Trade Association
12	KHM	Cambodia	82	ALB	Albania
13	IDN	Indonesia	83	BGR	Bulgaria
14	LAO	Lao PDR	84	BLR	Belarus
15	MYS	Malaysia	85	HRV	Croatia
16	PHL	Philippines	86	ROU	Romania
17	SGP	Singapore	87	RUS	Russian Federation
18	THA	Thailand	88	UKR	Ukraine
19	VNM	Viet Nam	89	XEE	Rest of Eastern Europe
20	XSE	Rest of Southeast Asia	90	XER	Rest of Europe
21	BGD	Bangladesh	91	KAZ	Kazakhstan
22	IND	India	92	KGZ	Kyrgyzstan
24	PAK	Pakistan	93	XSU	Rest of Former Soviet Union
25	LKA	Sri Lanka	94	ARM	Armenia
23	NPL	Nepal	95	AZE	Azerbaijan
26	XSA	Rest of South Asia	96	GEO	Georgia
27	CAN	Canada	97	BHR	Bahrain
28	USA	United States of America	98	IRN	Iran, Islamic Republic of
29	MEX	Mexico	99	ISR	Israel
30	XNA	Rest of North America	100	JOR	Jordan
31	ARG	Argentina	101	KWT	Kuwait
32	BOL	Bolivia	102	OMN	Oman
33	BRA	Brazil	103	QAT	Qatar
34	CHL	Chile	104	SAU	Saudi Arabia
35	COL	Colombia	105	TUR	Turkey
36	ECU	Ecuador	106	ARE	United Arab Emirates
37	PRY	Paraguay	107	XWS	Rest of Western Asia
38	PER	Peru	108	EGY	Egypt
39	URY	Uruguay	109	MAR	Morocco
40	VEN	Venezuela	110	TUN	Tunisia
41	XSM	Rest of South America	111	XNF	Rest of North Africa
42	CRI	Costa Rica	112	BEN	Benin
43	GTM	Guatemala	113	BFA	Burkina Faso
44	HND	Honduras	114	CMR	Cameroon
45	NIC	Nicaragua	115	CIV	Côte d'Ivoire
46	PAN	Panama	116	GHA	Ghana
47	SLV	El Salvador	117	GIN	Guinea
48	XCA	Rest of Central America	118	NGA	Nigeria
49	DOM	Dominican Republic P	119	SEN	Senegal
50	JAM	Jamaica	120	TGO	Togo
51	PRI	Puerto Rico	121	XWF	Rest of Western Africa
52	TTO	Trinidad and Tobago P	122	XCF	Rest of Central Africa
53	XCB	Rest of Caribbean	123	XAC	Rest of South Central Africa
54	AUT	Austria	124	ETH	Ethiopia
55	BEL	Belgium	125	KEN	Kenya
56	CYP	Cyprus	126	MDG	Madagascar
57	CZE	Czech Republic	127	MWI	Malawi
58	DNK	Denmark	128	MUS	Mauritius
59	EST	Estonia	129	MOZ	Mozambique
60	FIN	Finland	130	RWA	Rwanda
61	FRA	France	131	TZA	Tanzania

62	DEU	Germany	132	UGA	Uganda
63	GRC	Greece	133	ZMB	Zambia
64	HUN	Hungary	134	ZWE	Zimbabwe
65	IRL	Ireland	135	XEC	Rest of Eastern Africa
66	ITA	Italy	136	BWA	Botswana
67	LVA	Latvia	137	NAM	Namibia
68	LTU	Lithuania	138	ZAF	South Africa
69	LUX	Luxembourg	139	XSC	Rest of South African Customs Union
70	MLT	Malta	140	ROW	Rest of the World

Table 3-1-3: Classification of Industrial Sectors (Goods) in GTAP9

GTAP 9 CODE					
No.	Code	Description (Detailed Sector Breakdown)	No.	Code	Description (Detailed Sector Breakdown)
1	PDR	Paddy rice	29	LEA	Leather products
2	WHT	Wheat	30	LUM	Wood products
3	GRO	Cereal grains nec	31	PPP	Paper products, publishing
4	V_F	Vegetables, fruit, nuts	32	P_C	Petroleum, coal products
5	OSD	Oil seeds	33	CRP	Chemical, rubber, plastic products
6	C_B	Sugar cane, sugar beet	34	NMM	Mineral products nec
7	PFB	Plant-based fibers	35	I_S	Ferrous metals
8	OCR	Crops nec	36	NFM	Metals nec
9	CTL	Bovine cattle, sheep and goats, horses	37	FMP	Metal products
10	OAP	Animal products nec	38	MVH	Motor vehicles and parts
11	RMK	Raw milk	39	OTN	Transport equipment nec
12	WOL	Wool, silk-worm cocoons	40	ELE	Electronic equipment
13	FRS	Forestry	41	OME	Machinery and equipment nec
14	FSH	Fishing	42	OMF	Manufactures nec
15	COA	Coal	43	ELY	Electricity
16	OIL	Oil	44	GDT	Gas manufacture, distribution
17	GAS	Gas	45	WTR	Water
18	OMN	Minerals nec	46	CNS	Construction
19	CMT	Bovine meat products	47	TRD	Trade
20	OMT	Meat products nec	48	OTP	Transport nec
21	VOL	Vegetable oils and fats	49	WTP	Water transport
22	MIL	Dairy products	50	ATP	Air transport
23	PCR	Processed rice	51	CMN	Communication
24	SGR	Sugar	52	OFI	Financial services nec
25	OFD	Food products nec	53	ISR	Insurance
26	B_T	Beverages and tobacco products	54	OBS	Business services nec
27	TEX	Textiles	55	ROS	Recreational and other services
28	WAP	Wearing apparel	56	OSG	Public Administration, Defense, Education, Health
			57	DWE	Dwellings

3-1-4 Treatment of Logistics Infrastructure, etc. in the GTAP Data Base and GTAP Model

- The GTAP Data Base shows the flow of goods and services throughout the world at specific points in time (or periods of time), and the economic transaction data therein was established based on assumed states of infrastructure development in the base year; however, the state of infrastructure development is stock data, and is not factored into the framework of the GTAP Model.
- Additionally, changes that occur during scenario analysis—that is, changes in imports, exports, consumption, and other factors—are implicitly assumed to have occurred in societies that develop the logistics infrastructure needed to realize the changes during the given period.
- It is worth noting that the GTAP Model assigns coefficients for the rate of technical progress in transport for imports and exports. The default coefficients are zero, but any value can be assigned for calculations, enabling the use of the coefficients to analyze scenarios that account for future states of logistics infrastructure development.

3-1-5 Benefits and Challenges of GTAP Analysis

- The GTAP Model has a structure with the most unprecedented, detailed classification in term of regions/countries and industries/goods among generally applied equilibrium models, focusing on the economic activities (production, consumption and investment) in the entire world and industry.
- As calculations can be made in the detail classification of region and industry (goods), this Study can obtain calculation results, by region/country/industry (goods), on export and import values (to be evaluated at the 2011 price level) to be analyzed as output in the GTAP Model under this Study.
- This enables more detailed analysis, as to how economic and political shocks will bring spillover effects to regions/nations or industries.
- In terms of exports and imports especially targeted in this Study, the model will clarify what kind of transactions for goods would increase or decrease through the introduction of policies in the region or the country in a quantitative way.
- On the other hand, as mentioned later, the generally applied equilibrium model, like the GTAP Model, can set up coefficients and others in the model, based on the flow data for one time point (period), depending upon the economic structure for the one time point. In developing countries and others, in which defects for time-series data are pointed out, it is relatively easy to establish the model. Meanwhile, it is difficult to evaluate the reliability for model coefficients and to simulate a change in the economic structure in the model, which can be indicated as a challenge for the generally applied equilibrium model as a whole.
- Although these challenges could be seen, as it is judged in this Study that the model's advantage is hugely beneficial as described earlier, the GTAP Model has been adopted as an analysis model.

3-1-6 Framework of GTAP Model Analysis for the Study

- For the Study, the GTAP Model is used to create simulations based on multiple long-term scenarios for 2050. Then, trends in simulation results from individual scenarios and between scenarios are comparatively analyzed.
- The basic model of the GTAP Model is a static model based on a specific point in time (or period of time such as one year); generally, dynamic models (Dynamic GTAP) or recursive dynamic model (GTAP-RD) are used for projections.
- However, as explained later, in calculations for the Study, exogenous application to fix the GDP growth rates solved endogenously with the basic GTAP Model as preconditions for each scenario, and the discontinuous setting of the timing of tariff rate reductions and various rate increases in line with scenarios is envisioned, and it is best to have simpler modeling and analytical methods for these calculations.

- The calculation method for the Study is a quasi-dynamic method in which five-year rates of change of GDP, population, and other factor input are assumed for each scenario, and exogenously applied to the static model—the GTAP's basic model—and calculated, and the calculation results are used as basic data for sequential and repeated calculations for subsequent periods. This method makes it possible to fully understand how each variable will change in the future of each scenario, even while using the static GTAP Model.
- In a true semi-dynamic model, each period is linked to the following period based on the assumption that investments in one period equal an increase in capital in the following period; however, it must be mentioned that for this Study, these changes in investments (capital) are introduced from outside when making the calculations for each period.
- The following flow of model development and analysis shall be implemented.

Table 3-1-4 Model Building and Analysis Flow

(1) Establish the GTAP Model and Data Base	(a) Set the region and industry classifications for the model (b) Align the Data Base region and industry classifications with those of the model (c) Set the estimation period
(2) Configure the scenarios	(a) Configure the baseline scenario (b) Configure alternative scenarios for comparison with the baseline scenario
(3) Gather and consolidate information about the changes of exogenous variables	(a) Gather and consolidate rates of change for factor abundance and the like to be applied to the GTAP Model as exogenous variables in order to make projections for both the baseline scenario and alternative scenarios (projections of international agencies, etc.) (b) Use past statistical data and the like to estimate future values (c) For the Study, GDP is also exogenously fixed (set other variables as endogenous variables) (d) Set rates of change in roughly five-year intervals (2011 to 2016 to 2020 to 2025 to 2030 to 2035 to 2040)
(4) Project the baseline	(a) Apply the shocks set for the baseline scenario to the GTAP Model to compute equilibrium, and use the calculation results as the base data for the following period. (b) Repeat (a) for the set number of periods.
(5) Make projections based	(a) Apply the shocks set for the alternative scenarios to the GTAP Model to compute equilibrium, and use the calculation

on alternative scenarios	results as the base data for the following period. (b) Repeat (a) for the set number of periods.
(6) Analyze the projections	(a) Analyze the projected values for the baseline and alternative scenarios (changes during the projection period, etc.) (b) Perform comparative analysis on differences between the baseline projections and the alternative scenario projections, etc.

3-2 Establishing Initial Conditions

3-2-1 Country/Region Classifications

- The 140 countries and regions of the GTAP9 Data Base are consolidated into the 31 countries and regions in the GTAP Model used for the Study.
- The Study focuses on global logistics in the Indo-Pacific; therefore, countries in East Africa and South Asia that border the Indian Ocean are the targets of the analysis, and are treated as individual countries.
- Countries in other regions are consolidated into regional units, with each treated as a hypothetical country.

Table 3-2-1: GTAP Model Country/Region Classifications for the Study

	GTAP Region Name	Overview	Countries/Regions Included
1	Egypt	Egypt	Egypt
2	Ethiopia	Ethiopia	Ethiopia
3	Kenya	Kenya	Kenya
4	Madagascar	Madagascar	Madagascar
5	Malawi	Malawi	Malawi
6	Mauritius	Mauritius	Mauritius
7	Mozambique	Mozambique	Mozambique
8	Rwanda	Rwanda	Rwanda
9	Tanzania	Tanzania	Tanzania
10	Uganda	Uganda	Uganda
11	Zambia	Zambia	Zambia
12	Zimbabwe	Zimbabwe	Zimbabwe
13	South Africa	South Africa	South Africa
14	Botswana	Botswana	Botswana
15	XEAfrica	Rest of East	Sudan, Eritrea, Djibouti, Somalia, Burundi,

	GTAP Region Name	Overview	Countries/Regions Included
		Africa	Rest of East Africa
16	Bangladesh	Bangladesh	Bangladesh
17	India	India	India
18	Pakistan	Pakistan	Pakistan
19	Sri Lanka	Sri Lanka	Sri Lanka
20	XSAsia	Rest of South Asia	Nepal, Rest of South Asia
21	WCAsia	West and Central Asia	Saudi Arabia, Oman, United Arab Emirates, Armenia, Azerbaijan, Georgia, Bahrain, Iran, Israel, Jordan, Kuwait, Qatar, Turkey, Rest of Western Asia
22	SEAsia	Southeast Asia	Myanmar, Thailand, Lao PDR, Cambodia, Viet Nam, Malaysia, Brunei Darussalam, Singapore, Indonesia, Philippines, Rest of Southeast Asia
23	E. Asia	East Asia	Japan, China, Hong Kong, Macao, Korea, Taiwan, Rest of East Asia
24	NAfrica	North Africa	Morocco, Tunisia, Rest of North Africa
25	WAfrica	West Africa	Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, Rest of Western Africa
26	SCAfrica	South Central Africa	Angola, Namibia, Rest of Central Africa, South Central Africa, Rest of South African Customs Union, Democratic Republic of the Congo
27	NAmerica	North America	Canada, United States, Mexico, Rest of North America
28	CSAmerica	Central and South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Rest of Caribbean
29	Europe	Europe	Austria, Belgium, Cyprus, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland,

	GTAP Region Name	Overview	Countries/Regions Included
			Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Switzerland, Norway, Rest of European Free Trade Association, Albania, Bulgaria, Belarus, Croatia, Romania, Russian Federation, Ukraine, Rest of Eastern Europe, Rest of Europe
30	Oceania	Oceania	Australia, New Zealand, Rest of Oceania
31	ROWorld	Rest of the World	Rest of World

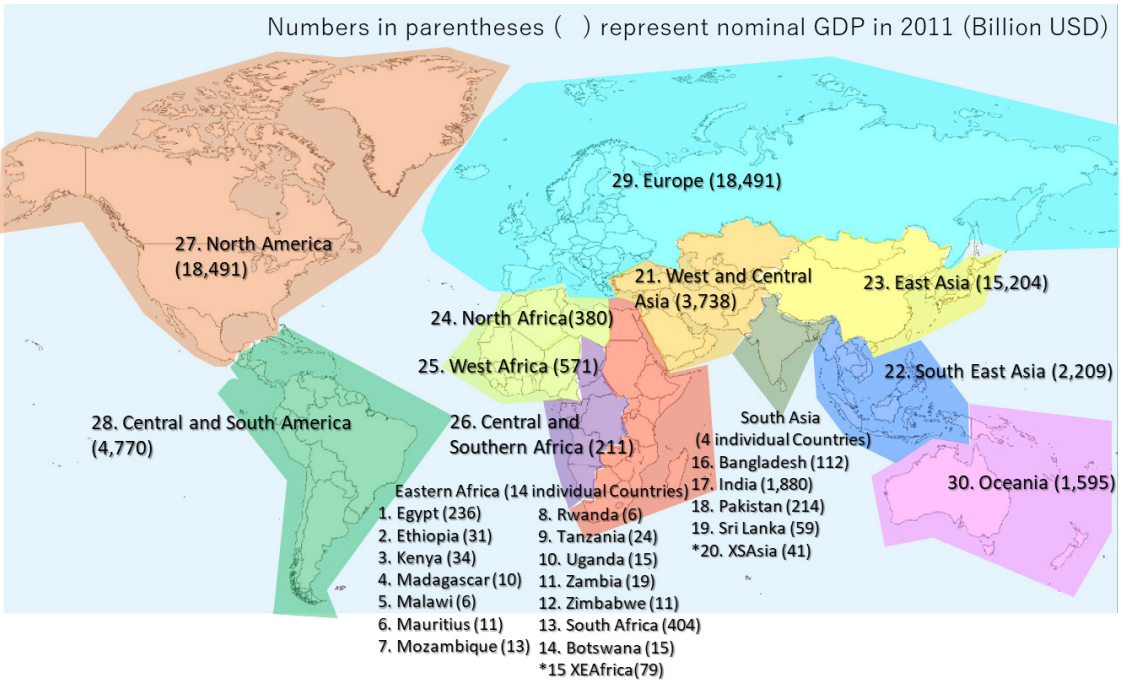


Figure 3-2-1: Image of GTAP Model Country/Region Classification for the Study

3-2-2 Industry Classifications

- The GTAP9 Data Base used for the Study contains 57 different industrial sectors (goods) that are aggregated into the following 10 industrial sectors for the GTAP Model for the Study.

Table 3-2-2 Industrial Sectors (goods)

Aggregated sectors	Original sectors code
1. Agriculture (agriculture, forestry, and fisheries)	PDR, WHT, GRO, V_F, OSD, C_B, PFB, OCR, CTL, OAP, RMK, WOL, FRS, FSH
2. Coal	COA
3. Oil (crude oil)	OIL
4. Gas (LNG)	GAS
5. Minerals (mining)	OMN
6. Consumption goods (consumer goods)	CMT, OMT, VOL, MIL, PCR, SGR, OFD, B_T, TEX, WAP, LEA, LUM, OMF
7. Industrial materials (industrial input goods)	PPP, P_C, CRP, NMM, I_S, NFM, FMP
8. Motor vehicles (automobiles)	MVH
9. Processing/Assemblings (industrial machinery/assembly)	OTN, ELE, OME
10. Services (other services)	ELY, GDT, WTR, CNS, TRD, OTP, WTP, ATP, CMN, OFI, ISR, OBS, ROS, OSG, DWE

- Based on the assumption that logistics model analysis is conducted on bulk cargo, primary resource industries that involve a lot of bulk cargo are subdivided to the highest degree. Conversely, given that the main purpose of the Study is to gain a full understanding of trends in international trade, non-tradable goods are aggregated into the "10. Services" sector.

3-2-3 Present Conditions in the GTAP Data Base (2011)

(1) Industrial Structure (Production Value Ratios)

- Present conditions in the GTAP Data Base are comparisons of the final production values in each industrial sector in each country (Variable name in the GTAP Model: QO).

Figure 3-2-2: Industrial Structure

- In African countries, agriculture, mining, and other primary industries account for a high percentage.
- Kenya has the highest percentage of manufacturing for consumption goods (Hous) of the African countries.
- Botswana has an extremely high percentage of mining (Mine) compared to the other African countries.
- Mauritius, Zambia, South Africa, and other countries have extremely high percentages of non-manufacturing (Othe); in other African countries and regions, service industries are expanding substantially as they are in the other countries and regions of the world.

(2) Export Structure (Export Value Ratios)

Figure 3-2-3 Export Structure

(3) Import Structure (Import Value Ratios)

Figure 3-2-4 Import Structure

3-2-4 Analysis Period and Point of Time

- The base year is 2011—the base year of GTAP9—and the analysis year are set at 2016, 2020, 2025, 2030, 2035, and 2040.
- The base year of the logistics model is 2016; setting 2016 as an analysis section aligns the results of the calculations, which are used as input data for the logistics model, with the assumptions of the logistics model.

3-3 Scenario Configuration

3-3-1 Overview of Scenario Analysis

- In the GTAP Model, scenario-based shocks are applied to the exogenous variables, and the impacts on endogenous variables are analyzed with and without the shocks.
- In the Study, the future scenario resulting from 1st Year Study is the basis for setting the baseline scenario (see "BL" of the example scenarios on Table 3-3-1) and two long-term scenarios: the "Africa Economic Corridor Development Success Scenario" (see "S1" of the example scenarios on Table 3-3-1) and the "Africa Economic Corridor Development Failure Scenario" (see "S2" of the example scenarios on Table 3-3-1).
- It is worth noting that the results of 1st Year Study contain parts that are conceptual, and parts that do not fully consider the calculation possibilities of the GTAP Model. Therefore, in this research, the details of each scenario—specifically, the settings in the GTAP Model—are defined.
- Outlines of each scenario are as follows.

(1) Baseline Scenario (Scenario BL)

- A so-called Business As Usual (BAU) scenario that envisions the continuation of normal economic activities at the present moment.
- Additionally, to accommodate various issues such as climate change response, policies that forecast interim expenses and effects are adopted.

(2) Africa Economic Corridor Development Success Scenario (Scenario S1)

- Africa Economic Corridor Development—the development of transportation infrastructure and other infrastructure along the corridors, and the mitigation of barriers to trade such as tariffs—propelled by JICA and other multilateral aid agencies streamlines the movement of people, goods, and money, and delivers economic benefits that radiate outward from the corridors to surrounding areas.
- Policy dialogues focused on the countries and regions along the corridors progress in parallel with corridor development, and African countries cooperate with efforts to stimulate not only economic activity but also make progress on development issues in energy, the environment, demographics, education, health and sanitation, and other areas, further enhancing the economic benefits, innovation, and other positive effects envisioned in Scenario BL.

(3) Africa Economic Corridor Development Failure Scenario (Scenario S2)

- The "failure" of Africa Economic Corridor Development describes a state in which the development of transportation infrastructure and other infrastructure planned under the corridor development is delayed or suspended, coordination between African countries and regions has stalled, and barriers to trade such as customs duties have not been mitigated. In this state, the movement of people, goods, and money has not changed from the present state, or has become even more inefficient, rendering it impossible to achieve the economic benefits expected under Scenario BL and Scenario S1.
- In contrast to Scenario S1, policy dialogues between countries and regions along the corridors fail to progress because each country and region is concerned only with the benefits to themselves, preventing cooperative relationships from forming between them and resulting in insufficient progress on development issues in energy, the environment, demographics, education, health and sanitation, and other areas, stunting the economic benefits, technological innovation, and other positive effects envisioned in Scenario BL.

Table 3-3-1: Main Scenarios in 1st Year Study (1st Year Study)

Item	Scenario	Description
Population	BL(same in S1, S2)	• Population in 2050 reaches 9.8 billion globally, 1.36 billion in China, 1.66 billion in India, and 800 million in ASEAN.
GDP	BL	• Global GDP grows at an average annual rate of 2.6%.Global • GDP share in 2050: China (20%), India (15%), USA (12%), EU27 (9%)
	S1	• Africa grows at an average annual rate of 6.6 – 5.7% (high case)
	S2	• Africa grows at an average annual rate of 4.0 – 3.6% (low case)
Expansion of free trade	BL	• More Mega-FTAs are created to complement WTO. Horizonal international specialization progresses further in each area. Intra-regional trade becomes relatively dominant (TPP, TTIP, RCEP, etc.)
	S1	• Investment under China's One Belt One Road initiative contributes to the development of India and African countries. • Economic integration within the African continent progresses due to CFTA. • Quality growth is achieved as a result of developing corridors in Africa.

	S2	• Investment under One Belt One Road initiative does not contribute to Africa's quality growth (it only accelerates over dependence on extra-regional imports and consumption in metropolitan areas). • CFTA is not reached (due to conflict of interest within the African continent). •
Global trade	BL	• Global trade increases at a similar pace to GDP (even trade).
	S1	• Trade volume within African region grows faster than GDP due to expanding intra-African trade under CFTA (fast trade).
	S2	• Intra-African trade, as is the case with global trade, increases at a similar pace to GDP (even trade).
Realization of responsible SCs	BL(same in S1, S2)	• Responsible supply chains (SCs) are realized for the most part due to creation of Mega-FTAs, etc.
Widening of disparities	S1(No assumption inBL)	• Quality growth is mostly accomplished worldwide, decreasing disparity in GDP per capita. • Disparity shrinks at a faster pace in Africa, where disparity is greater, than the global average.
	S2(No assumption inBL)	• Africa's external negotiating power is insufficient due to the failure of CFTA. • Disparities among regions and countries widen due to the progress of advanced horizontal international specialization by multinational giants. • Africa's disparity in GDP per capita expands to a moderate level.
Foodstuff	BL	• Food demand per capita of developed and semi-developed countries in 2050 decreases to 90% of that in 2010, whereas that of developing countries in 2050 increases slightly to 102% of the 2010 figure. • In other words, food demand in 2050 increases 1.55 and 2.06 times the 2010 demand worldwide and in developing countries, respectively while food loss gradually decreases in developed countries. • Global food demand is satisfied due to improved productivity (crop yield increases at an annual rate of 1.0% to reach 1.5 times that of 2010 in 2050).

	S1	• Green Revolution successfully takes place in Africa, enabling stable food supply (food self-sufficiency increases while transport infrastructure develops within the region).
	S2	• Green Revolution does not take root in Africa. Extra-regional imports of food increase (based on MAFF's projection).
Energy	BL(same in S1, S2)	• Global energy consumption in 2050 becomes 1.5 greater than that of 2015. • Energy consumption in developing countries decreases slightly while that in non-OECD countries increases at an annual rate of 1.6% (approx. 1.75 times). Increase is particularly notable in China, India, and ASEAN countries, as well as in Middle East, North Africa, and Sub-Saharan Africa (due to population and economic growth). • 79% of energy demand is satisfied by fossil fuels (30% petroleum, 26% natural gas, and 23% coal) and the remaining 21% by other fuels. There is no depletion of resources. • Production of fossil fuels in 2050 increases to 1.35 times that of 2015 (at an annual rate of 0.9%) for petroleum, 1.76 times (1.6%) for natural gas, and 1.18 times (0.5%) for coal. However, if conversion to electric cars and other ZEVs accelerates, petroleum demand will be about 99% of that in 2015.
Consumer awareness	BL(same in S1, S2)	• While over-consumerism accelerates due to increased income, the "sustainable consumption" concept gradually gains awareness and popularity toward the achievement of SDGs (reaching a halfway point).
Technological innovation	BL(same in S1, S2)	• Productivity of horticulture, livestock farming, and fisheries, as well as storage/transport technologies, continue to improve and become more sophisticated. • Super-large container ships (40,000 TEU class) will not emerge (They will stay at the current 20,000 TEU level due to navigation restrictions in the Suez Canal and the Straits of Malacca).
Climate change risk	BL(same in S1, S2)	• International horizontal specialization progresses under a loose trade bloc. Stable economic growth is achieved while maintaining the supply-demand balance of food and energy.

		• Climate change risk equivalent to a medium stabilizing scenario (RCP4.5) as a result of certain mitigation measures is assumed.
Risk of war, conflict, and terrorism	S1(No assumption inBL)	• The risk of war, conflict, and terrorism remains “low” due to formation of a loose trade bloc.
	S2(No assumption inBL)	• While international horizontal specialization progresses based on comparative advantage under a loose trade bloc, corridor development fails. • Multinational giants accumulate wealth by leading the trade market while nations and citizens are deprived of their fair shares, posing a “high risk” for conflict and terrorism.
Impact on global logistics	BL(same in S1, S2)	• Global trade increases at a similar level to GDP (even trade). • Size of large container vessels remains at the current 20,000TEU level. • Two types of ocean freight networks (hub-and-spoke and point-to-point) develop at multiple levels. • Medium to small container ships (4,000TEU – 8,000TEU) are predominant in the Intra-Asia trade. • Advancement of international horizontal specialization heightens the importance of warehouse facilities as storage and inland gateways. • Transshipment services via hub ports in Asia, Sub-Saharan Africa, and Islamic region (Port of Colombo, Port Luis, Port Salalah, and Port Mombasa) are prevalent.Transshipment services through hub ports in Asia, sub-Saharan Africa, and Muslim-majority countries (the Port of Colombo, Port Louis, the Port of Salalah, the Port of Mombasa) is mainstream.

3-3-2 Scenario Configuration

- The following are detailed explanations of the settings and other parameters of each scenario in the GTAP Model for each of the items on Table 3-3-1.
- It is worth noting that the population and real GDP (growth rate) settings for Scenario BL are projections based on SSP2, the Shared Socioeconomic Pathway (SSP) scenario with the most BAU-like projections over the medium term.

- SSP is an abbreviation of Shared Socioeconomic Pathways.
- SSP were developed for the purpose of analyzing the impact of socioeconomic factors (GDP, demographics, land use, urbanization, technological progress, etc.) to add to Representative Concentration Pathways (RCPs), which are scenarios for the impact of greenhouse gases in terms of natural sciences, for making long-term projections of the impact of climate change.
- A research team comprised of researchers from IIASA, OECD, NCAR, NIES, and other institutions was involved in the development of SSP. Since 2016, IIASA has made GDP, demographic transitions, and other information quantified by international agencies and research institutions based on the SSP scenarios available as an SSP Database on its website.
- SSP were used with RCPs in the IPCC Fifth Assessment Report, and were also used in the Coupled Model Intercomparison Project Version 6 (CMIP6), a new climate change monitoring project for the Sixth Assessment Report.
- SSP set out five "narratives" (called "scenarios" here for convenience) about future socioeconomic trends in terms of two aspects: mitigating and adapting to climate change.

Table 3-3-2 Narratives of SSP

	Main Content
SSP1: Sustainability (Low challenges to mitigation and adaptation)	• The world shifts gradually toward a more sustainable path of growth. • More comprehensive growth • Practices are improved throughout the world, educational and health investments accelerate demographic transitions, and emphasis shifts from economic growth to human well-being. • Inequality is reduced both across and within countries. • Personal consumption is oriented toward low-resource and low-energy intensity.
SSP2: Middle of the Road (Middle challenges to mitigation and adaptation)	• The world follows a path of growth that does not deviate substantially from historical patterns. • Development and income growth proceeds unevenly, with some countries enjoying relatively good growth and others falling short of expectations. • International and national institutions work toward achieving sustainable development goals, but their progress is slow. • Environmental systems deteriorate, although there are some improvements. Overall, energy efficiency increases. • Global population growth slows, and begins to

	decline in the second half of the 21st century. • Income inequality persists or improves slowly, and challenges to reducing social and environmental vulnerability remain.
SSP3: Regional Rivalry - A Rocky Road (High challenges to mitigation and adaptation)	• Resurgent nationalism concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic issues or only the most pressing regional issues. • Countries ignore broad-based development, instead focusing on energy and food security within their borders and regions. • Investments in education and technological progress decline. • Economic development slows. • Personal consumption is material intensive. • Income inequality persists or worsens. • Population growth declines in developed countries, and increases in developing countries. • A low international priority for addressing environmental concerns leads to major environmental deterioration in some regions.
SSP4: Inequality - A Road Divided (Low challenges to mitigation, high challenges to adaptation)	• Unequal investments in human capital, coupled with increasing inequality of economic opportunity and political power, lead to increasing inequality and stratification both across and within countries. • Inequality gradually widens between internationally connected societies that compete mainly in knowledge-intensive, capital-intensive sectors of the global economy, and isolated, lower-income, poorly educated societies that function in labor-intensive, low-tech economies. • Social cohesion degrades, and conflict and unrest become increasingly common. Technology develops further in economies and industries that embrace advanced technology. • The globally connected energy sector diversifies, with active investment in both low-carbon energy sources and carbon-intensive resources like coal. • Environmental policies focus on domestic issues in middle-income and high-income countries.
SSP5: Fossil-fueled Development - Taking the Highway (High challenges to mitigation, low challenges to adaptation)	• The world places faith in competitive markets, innovation, and participatory societies to produce rapid technological innovation and human capital development as the path to sustainable growth. • Global markets are increasingly integrated. • Investment in education and health is strong, and systems are designed to enhance human and social capital.

	• As social and economic development progresses, abundant petroleum resources are exploited and resource-intensive, energy-intensive lifestyles are adopted throughout the world. • The global economy expands rapidly, yet the global population peaks and begins to decline during the 21st century. • Environmental problems are solved on the local level. • The world places faith in the ability to efficiently manage social and ecological systems, including by geo-engineering if necessary.

Source: The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change.

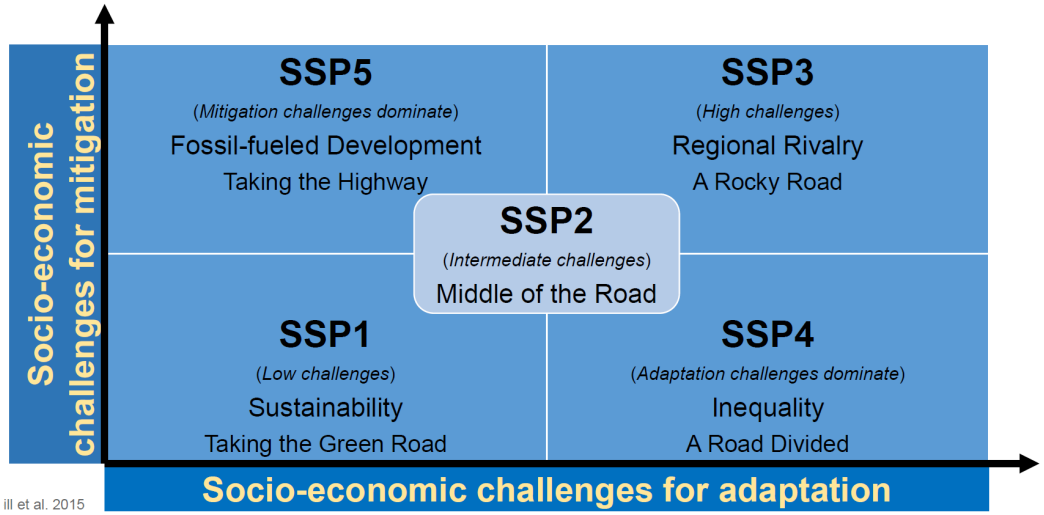


Figure 3-3-1 Relationship between the Scenarios of SSP

Source: The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change.

- The vertical and horizontal axes show the difficulty of challenges for mitigation and challenges for adaptation, respectively, with the difficulty increasing the farther from the origin. A challenge is regarded as difficult if it has a high social cost for mitigating or adapting to it to limit the environmental impacts of climate change; SSP1 challenges have the lowest social cost for limiting environmental impacts, while SSP3 challenges have the highest.
- The Center for Global Trade Analysis at Purdue University in the USA—the developers of GTAP—releases numerous reports about SSP on its project website, as well as examples of the use of the SSP Database in GTAP dynamic models and other applied general equilibrium models.
- Henry Jacobs (2016) “Climate change and Canada in 2030: A computable general equilibrium analysis”(GTAP Resource #4927) uses the GDP and demographic information quantified in SSP2 to analyze the impacts of climate change in those

cases. Additionally, Victor Nechifor (2018) “Global economic and food security impacts of demand-driven water scarcity” (GTAP Resource #5510) use SSP2 as the basis for their analysis of the global impacts of water shortages.

- Accordingly, SSP is used not only by the UNFCCC and IPCC, but also in future impact analysis in many areas, which shows that high liability. Especially, the middle-of-the-road scenario SSP2 is used in particularly high-profile cases.
- For the Study as well, SSP2 is assigned as the baseline for the GTAP analysis against a background of aforementioned high liability and many application cases.
- The following sections describe individual configurations for respective elements in the GTAP Model. Based on the objectives with a main focus on the African region in this Study, the configuration is divided into the African and the non-African regions.

(1) Population

- BL: In all over the world, the population increases amid moderate social changes patterned after the present state → Use demographic transitions from SSP2
- S1: In accordance with economic corridor development and spread of AfCFTA, African countries coordinate in the health sector to reduce infant mortality and extend lifespans. However, population growth wanes due to greater access to secondary education and family planning →
  - ■Africa - Use annual growth rate 0.33% higher than that of SSP2, which means 10% higher population growth rate than that of SSP2 in 2040.
  - ■Rest of the world - Use same growth rate with SSP2
- S2: Due to the failure in economic corridor development and spread of AfCFTA, African countries fail to coordinate in health and education, and the infant mortality increases→
  - ■Africa - Use annual growth rate 0.33% lower than that of SSP2, which means 10% lower population growth rate than that of SSP2 in 2040.
  - ■Rest of the world - Use same growth rate with SSP2

(2) GDP

- BL: Envisions economic growth amid moderate social changes patterned after the present state →
  - ■Global - Use GDP transitions from SSP2.
- S1: Owing to increased economic activities by economic corridor development and promotion of free trading in Africa, GDP growth rate in Africa achieves higher than that of SSP2 →
  - ■Africa - Use annual growth rate 1.5% higher than that of SSP2; the 1.5%

comes from the difference between 5.1%, the avereage annual GDP growth rate from 2010 to 2040 among African countries in SSP2 and 6.6%, the maximum rate of assumption in 1st Year Study.

■Rest of the world - Use GDP transitions from SSP2.

- S2: Due to spread of protectionism in African countries by failure of economic corridor development and promotion of free trading in Africa, GDP growth rate in Africa become lower than that of SSP2 →

  ■Africa - Use annual growth rate 1.5% higher than that of SSP2; the 1.5% comes from the difference between 5.1%, the avereage annual GDP growth rate from 2010 to 2040 among African countries in SSP2 and 3.6%, the minimum rate of assumption in 1st Year Study.

  ■Rest of the world - Use GDP transitions from SSP2.

- In GTAP calculations, GDP is fixed, and the rate of technological innovation (GTAP variable name: Afereg) is calculated as an endogenous variable (this can be interpreted as the rate of technological innovation required to achieve a fixed target for GDP).

(3) Labor input (Skilled, Unskilled)

- The GTAP Model does not cover labor transfer among regions/countries. Therefore, it seems natural that the labor input in a region/country increase/decrease at the same rate of population growth late. However, labor transfer among regions/countries is one of elements to be consider in actual society, so it should be solved to improve the GTAP model.
- In the GTAP Model, labor is composed of Skilled and Unskilled, and Skilled-Unskilled ratio can be changed. However, significant change in Skilled-Unskilled ratio could become a major shock to the calculation; one trial calculation shown that the change could give a distortion to calculation results of the GTAP Model because the GTAP Model cannot accommodate rapid industrial structure as mentioned above. Therefore, the Skilled – Unskilled ration in all scenarios are common to be unchanged from 2011 to 2040 in the GTAP Model.

(4) Capital input

- In general, economic flow, increase of capital investment triggers GDP growth and increase of the capital in next fiscal term. Hence GDP growth rate and growth rate of capital input have high correlation →

  Common in BL/S1/S2: Assumed to fluctuate at the same rate as GDP growth

(5) Resource input

- BL/S1/S2: Like capital input, there is a strong correlation between fluctuations in resource input and the GDP growth rate; therefore, the resource input growth rate is set to the GDP growth rate

(6) FTAs and EPAs

1) Present State of FTAs and EPAs

- Regarding the bilateral and multilateral lowering of tariff rates under free trade agreements (FTAs) and economic partnership agreements (EPAs), information from the WTO (Regional Trade Agreements Information System (RTA-IS)) and JETRO's "Contracting Member Status with WTO and Others" were used to consolidate the status of free trade treaties and the like.
- The following tables show the main FTAs and EPAs involving Africa and India that were in effect, agreed to, or under negotiation as of March 2019.

Table 3-3-3: Negotiation Status of FTAs and EPAs (Africa)

Abbreviation	Official Name	Signatories	Negotiation Stage	Timing of Establishment
CEMAC	Communauté Économique et Monétaire de l'Afrique Centrale (Economic and Monetary Community of Central Africa)	Cameroon, Chad, Central African Republic, Equatorial Guinea, Gabon, Republic of the Congo	Under negotiation	-
COMESA	Common Market for Eastern and Southern Africa	Egypt, Djibouti, Sudan, Kenya, Burundi, Rwanda, Madagascar, Malawi, Mauritius, Zambia, Zimbabwe, Comoros, Libya, Seychelles, Uganda, Democratic Republic of the Congo	Under negotiation (CU)*	-
SACU	Southern African Customs Union	Botswana, Lesotho, Namibia, South Africa, Eswatini (formerly Swaziland)	In effect (CUs) Under negotiation (FTAs)	1910 (established)
SADC	Southern African Development Community	Tanzania, Zambia, Botswana, Mozambique, Angola, Zimbabwe, Lesotho, Swaziland, Malawi, Namibia, South Africa, Mauritius, Democratic Republic of the Congo, Madagascar, Seychelles, Comoros	In effect (FTAs)	1992 (established)
AfCFTA	African Continental Free Trade Area	Signed by 52 African countries (all but Eritrea, Nigeria, and Benin), and ratified by 24 (Ghana, Kenya, Rwanda, Niger, Chad, Republic of the Congo, Djibouti, Guinea, Eswatini (Swaziland), Mali, Mauritania, Namibia, South Africa, Uganda, Côte d'Ivoire, Senegal, Togo, Egypt, Ethiopia, The Gambia, Sierra Leone, Western Sahara, Zimbabwe, Burkina Faso))	In effect	2019
GSTP	Global System of Trade Preferences among Developing Countries	Algeria, Argentina, Bangladesh, Benin, Bolivia, Brazil, Cameroon, Chile, Colombia, Cuba, Ecuador, Egypt, Ghana, Guinea, Guyana, India, Indonesia, Iran, Iraq, Democratic People's Republic of North Korea, South Korea, Libya, Malaysia, Mexico, Morocco, Mozambique, Myanmar, Nicaragua, Nigeria, Pakistan, Peru, Philippines, Singapore, Sri Lanka, Sudan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Venezuela (República Bolivariana de Venezuela), Vietnam, Zimbabwe	In effect	1998

Comprehensive Economic Cooperation Agreements (CECAs), Comprehensive Economic Partnership Agreements (CEPAs), Customs Unions (CUs), Deep and Comprehensive Free Trade Areas (DCFTAs), Economic Integration Agreements (EIAs), Economic Partnership Agreements (EPAs), Free Trade Agreements (FTAs), Partial Scope Agreements (PSAs)

*Classified as "under negotiation" because parties have agreed to establish the customs union, but the agreement has not yet been executed

Table 3-3-4 Negotiation Status of FTAs and EPAs (Asia)

Abbreviation	Official Name	Signatories	Negotiation Stage	Timing of Establishment
PAFTA	Pan Arab Free Trade Area	Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Palestine, Tunisia, United Arab Emirates, Yemen	In effect	1998
CU (1999)	Customs Union	Burundi, Comoros, Democratic Republic of the Congo, Djibouti, Egypt, Eritrea, Eswatini, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, Uganda, Zambia, Zimbabwe	In effect	1999
Agardir	Agardir Agreement	Egypt, Tunisia, Morocco, Jordan	In effect	2007
RCEP	Regional Comprehensive Economic Partnership	Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, Cambodia, China, Japan, South Korea, India, Australia, New Zealand	Under negotiation	-
ASEAN	Association of East Asian Nations	Brunei, Myanmar, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Vietnam, Thailand	In effect (FTAs) Under negotiation (CECAs)	1967 (established)
PTN	Protocol relating to Trade Negotiations among Developing Countries	Bangladesh, Brazil, Chile, Egypt, Israel, Mexico, Pakistan, Paraguay, Peru, Philippines, South Korea, Romania, Tunisia, Turkey, Uruguay, Yugoslavia	In effect	1973
APTA	Asia Pacific Trade Agreement	Bangladesh, China, India, South Korea, Laos, Sri Lanka	In effect	1976
SAFTA	South Asian Association for Regional Cooperation	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka	In effect	2006
ECO	Economic Cooperation Organization	Afghanistan, Azerbaijan, Iran, Uzbekistan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Turkey, Pakistan	In effect (PSA)	1992
GCC	Gulf Cooperation Council	United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, Kuwait	In effect (CU) Under negotiation (FTA)	2003

Comprehensive Economic Cooperation Agreements (CECAs), Comprehensive Economic Partnership Agreements (CEPAs), Customs Unions (CUs), Deep and Comprehensive Free Trade Areas (DCFTAs), Economic Integration Agreements (EIAs), Economic Partnership Agreements (EPAs), Free Trade Agreements (FTAs), Partial Scope Agreements (PSAs)

Table 3-3-5 Negotiation Status of FTAs and EPAs (Other Regions)

Abbreviation	Official Name	Signatories	Negotiation Stage	Timing of Establishment
Alianza del Pacífico	Alianza del Pacífico (Pacific Alliance)	Colombia, Mexico, Peru, Chile	Under negotiation	2011 (established)
MERCOSUR	Mercado Común del Sur (Southern Common Market)	Argentina, Brazil, Paraguay, Uruguay	In effect (CUs) Under negotiation (FTAs)	2016
SPARTECA	South Pacific Regional Trade and Economic Co-operation Agreement	Australia, New Zealand, Cook Islands, Fiji, Kiribati, Marshall Islands, Micronesia, Nauru, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu	In effect	1981
ANZCERTA	Australia New Zealand Closer Economic Agreement	Australia, New Zealand	In effect	1983
TPP	Trans-Pacific Partnership	Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, Vietnam	In effect	2018
EC	European Communities	Belgium, Italy, Denmark, Luxembourg, France, Netherlands, West Germany, Portugal, Greece, Spain, Ireland, UK	—	1967 (established)
EU	European Union	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, UK (Ireland, Scotland, Wales, North Ireland)	In effect (FTAs) Under negotiation (DCFTAs)	1993 (established)
EEA	Europe Economic Area	EU member nations + Liechtenstein, Iceland, Norway	In effect (EIA)	1994

Comprehensive Economic Cooperation Agreements (CECAs), Comprehensive Economic Partnership Agreements (CEPAs), Customs Unions (CUs), Deep and Comprehensive Free Trade Areas (DCFTAs), Economic Integration Agreements (EIAs), Economic Partnership Agreements (EPAs), Free Trade Agreements (FTAs), Partial Scope Agreements (PSAs)

- These lists of countries and regions can be expressed as follows.

Table 3-3-6: Negotiation Status of FTAs and EPAs in Africa and India

	Country/Region	1 Egypt	2 Ethiopia	3 Kenya	4 Madagas	5 Malawi	6 Mauritius	7 Mozambic	8 Rwanda	9 Tanzania	10 Uganda	11 Zambia	12 Zimbabwe	13 SouthAfri	14 Botswana	15 XEAfrica	16 Banglade	17 India	18 Pakistan	19 SriLanka	20 XSAsia	21 WCAsia	22 SEAsia	23 EAsia	24 NAfrica	25 WAfrica	26 SCAfrica	27 NAmerica	28 CSAmeric	29 Europe	30 Oceania	31 Restofth e
1	Egypt	0	5	5	5	5	4	4	5	5	5	5	5	4	4	1	1	0	1	3	0	2	1	1	5	5	5	0	0	3	0	0
2	Ethiopia	5	0	5	5	5	4	4	5	5	5	5	5	4	4	5	0	0	0	0	0	0	0	0	4	4	5	0	0	0	0	0
3	Kenya	5	5	0	5	5	5	4	5	1	5	5	5	4	4	5	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
4	Madagascar	5	5	5	0	5	5	1	5	1	5	5	2	1	4	5	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
5	Malawi	5	5	5	5	0	5	1	5	1	5	5	5	1	1	5	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
6	Mauritius	4	4	5	5	5	0	1	5	1	1	5	5	1	4	4	0	0	1	0	0	1	1	0	4	4	1	0	0	0	0	0
7	Mozambique	4	4	4	1	1	1	0	4	1	4	1	1	1	1	4	0	0	0	0	0	0	0	1	5	4	1	0	0	0	0	0
8	Rwanda	5	5	5	5	5	5	4	0	1	5	5	5	4	4	5	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
9	Tanzania	5	5	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1	1	5	0	1	0	0	0
10	Uganda	5	5	5	5	5	1	4	5	1	0	5	5	4	4	5	0	0	0	0	0	0	0	0	5	5	1	0	0	0	0	0
11	Zambia	5	5	5	5	5	5	1	5	1	5	0	5	1	1	5	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
12	Zimbabwe	5	5	5	2	5	5	1	5	1	5	5	0	1	1	5	1	0	0	1	0	0	1	1	5	5	5	0	1	0	0	0
13	SouthAfrica	4	4	4	1	1	1	1	4	1	4	1	1	0	1	4	0	3	0	0	0	0	0	0	4	4	1	1	1	1	0	0
14	Botswana	4	4	4	4	1	4	1	4	1	4	1	1	1	0	4	0	0	0	0	0	0	0	0	4	4	1	0	1	1	0	0
15	XEAfrica	1	5	5	5	5	4	4	5	1	5	5	5	4	4	4	1	0	0	1	0	1	1	1	1	1	5	0	1	0	0	0
16	Bangladesh	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	3	1	1	0	1	1	1	1	0	1	1	0	0	0
17	India	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	3	0	1	3	3	3	0	0	3	3	1	3	3	0
18	Pakistan	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	3	0	1	0	3	3	1	3	0	0	1	0	0	0	0
19	SriLanka	3	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1		1	0	1	0	1	1	1	1	0	0	1	0	0	0
20	XSAsia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1		1	0	0	0	0	0	0	0	0	0	0	0	0
21	WCAsia	2	0	0	0	0	1	0	0	0	0	0	0	0	0	1		3	3		0	3	3	3	1		3	3	3	1	0	0
22	SEAsia	1	0	0	0	0	1	0	0	1	0	0	1	0	0	1	1	3	3	1	0	3	2	3	1	1	0	3	3	3	0	0
23	EAsia	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	1	3	1	1	0	3	3	3	1	3	0	3	3	3	3	0
24	NAfrica	5	4	5	5	5	4	5	5	1	5	5	5	4	4	1	1	0	3	1	0	1	1	1	1	1	4	3	1	3	0	0
25	WAfrica	5	4	5	5	5	4	4	5	1	5	5	5	4	4	1	1	0	0	1	0	0	1	3	1	2	4	0	0	1	0	0
26	SCAfrica	5	5	5	5	5	1	1	5	5	1	5	5	1	1	5	0	3	0	0	0	3	0	0	4	4	1	0	1	1	0	0
27	NAmerica	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	1	0	0	3	3	3	3	0	0	1	3	3	3	0
28	CSAmerica	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	1	0	3	3	3	1	0	1	3	1	3	3	0
29	Europe	3	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	0		0	1	3	3	3	1	1	3	3	1	3	0
30	Oceania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	3	3	3	1	0
31	Restofthe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Prepared based on information from the WTO (Regional Trade Agreements Information System (RTA-IS)) and JETRO's "Contracting Member Status with WTO and Others"

- Table 3-3-6 shows the negotiation status of pairs of countries and regions, with one on the horizontal axis and the other on the vertical axis. The number shown in each cell corresponds to the status of negotiations between the two countries, and details for each are as follows.

1	There exist FTAs, EPAs, or other comprehensive tariff agreements originally put into effect by 2016 (Effective Stage)
2	There exist FTAs, EPAs, or other comprehensive tariff agreements originally put into effect or signed by March 2019 (Signing Stage)
3	There exist agreements under negotiation as of March 2019 (other than negotiations between African countries listed as "under negotiation" in JETRO's "Contracting Member Status with WTO and Others") (Negotiation Stage)
4	There exist agreements under negotiation as of March 2019 (only negotiations between African countries listed as "under negotiation" in JETRO's "Contracting Member Status with WTO and Others") (Negotiation Stage)
5	Negotiations for The African Continental Free Trade Area (AfCFTA) are underway (the establishment agreement was put into effect in May 2019, and the goal is to begin executing the agreement in July 2020) (Negotiation Stage)

2) Introduction to the GTAP Model and Scenario Configuration

- Given the negotiation statuses shown on the table, it is envisioned that tariffs levied on trade between pairs of countries or regions will be phased out; therefore, the following values for tariffs are assigned for GTAP Model calculations.

■Effective Stage (Negotiation Status 1 from the table):

FTAs, EPAs, or other comprehensive tariff agreements originally put into effect by 2016:

Tariff rates gradually reduced to zero in three stages starting in 2011

- 2011 to 2016: 25% reduction
- 2016 to 2020: 33% reduction
- 2020 to 2025: 50% reduction
- 2025 and later: 100% reduction (no tariff between the two countries)

■Signing Stage (Negotiation Status 2 from the table):

FTAs, EPAs, or other comprehensive tariff agreements signed or put into effect by March 2019:

Tariff rates gradually reduced to zero in three stages starting in 2016

- 2016 to 2020: 25% reduction
- 2020 to 2025: 33% reduction
- 2025 to 2030: 50% reduction
- 2030 and later: 100% reduction (no tariff between the two countries)

■Negotiation Stage (Negotiation Status 3/4/5 from the table):

Agreements under negotiation as of March 2019 (listed as “under negotiation” in JETRO’s “Contracting Member Status with WTO and Others”):

Tariff rates gradually reduced to zero in three stages starting in 2020

- 2020 to 2025: 25% reduction
- 2025 to 2030: 33% reduction
- 2030 to 2035: 50% reduction
- 2035 and later: 100% reduction (no tariff between the two countries)

- The envisioned tariff rates for each scenario (BL, S1, and S2) are as follows.

■BL:

- Effective Stage and Signing Stage FTAs/EPAs are applied in stages as described previously. For Negotiation Stage FTAs/EPAs, tariffs are phased out between countries with Negotiation Status 3 or 4 on the table above.

■S1:

- The success of Africa Economic Corridor Development should enhance economic group interrelations between African countries and increase their willingness to participate in the AfCFTA; the AfCFTA system is executed with the participation of all African countries. Therefore, tariffs are phased out between all countries with Negotiation Status 3, 4, or 5 on the table above.

■S2:

- The failure of Africa Economic Corridor Development weakens economic relations between African countries, inciting protectionism that intensifies.
- The AfCFTA also fails to expand, and bilateral agreements under discussion outside of the AfCFTA also fail to come to fruition.
- Therefore, in Scenario S2, tariffs are only abolished between countries with Negotiation Status 3 on the table above.
- During these considerations, coefficients were set based on FTAs and EPAs put into effect, signed, or under negotiation as of March 2019; however, as discussed in 1st Year Study “Grand Design for Global Logistics in the Indo-Pacific,” advanced international horizontal specialization is expected to continue progressing based on comparative advantages, driving the development of intraregional trade over interregional trade.
- Specifically, in Africa, the establishment of the AfCFTA and other factors promoting the economic integration of the entire continent (the establishment and introduction of free trade areas, customs unions, common markets, a single currency, etc.) are expected to progress, further driving the corridor development promoted by JICA.
- Therefore, scenario settings should reflect the future progression of intraregional trade on a deeper level.

(7) Scenario Summary

- The following table summarizes the scenario settings described previously.

1. Population (1st Year Study results) All scenarios: Population in 2050 reaches 9.8 billion globally, 1.36 billion in China, 1.66 billion in India, and 800 million in ASEAN	
Population Settings	
BL	■Global: SSP2 population growth rate
S1	■Africa: SSP2 population growth rate plus an additional 0.33% per year (envisioning a population 10% greater than the SSP2 population in 2040) ■Rest of the world: (Same as BL) SSP2 population growth rate
S2	■Africa: SSP2 population growth rate minus 0.33% per year (envisioning a population 10% less than the SSP2 population in 2040) ■Rest of the world: (Same as BL) SSP2 population growth rate
Labor Settings	
BL S1 S2	■Global: (Same as BL) The overall workforce fluctuates at the same rate as the population. The ratio of skilled to unskilled workers remains in the present state until 2040.

2. GDP (1st Year Study results) All scenarios: Global GDP grows at an average annual rate of 2.6% All scenarios: Global GDP share in 2050: China (20%), India (15%), USA (12%), EU27 (9%) S1: Africa grows at an average annual rate of 6.6 – 5.7% (high case) S2: Africa grows at an average annual rate of 4.0 – 3.6% (low case)	
GDP/Rate of Technological Innovation Settings	
BL	■Global: Rate of technological innovation for total factor productivity (Afereg) to achieve SSP2 GDP growth rate
S1	■Africa: GDP growth rate set to the BL GDP growth rate for African countries plus 1.5% (the difference of 1.5%/year between the SSP2 GDP growth rate of 5.1%/year for 2010-2040 and the maximum envisioned growth rate of 6.6%/year from 1st Year Study). ■Rest of the world: (Same as BL) SSP2 GDP growth rate.

S2	■Africa: GDP growth rate set to the BL GDP growth rate for African countries minus 1.5% (the difference of 1.5%/year between the SSP2 GDP growth rate of 5.1%/year for 2010-2040 and the minimum envisioned growth rate of 3.6%/year from 1st Year Study). ■Rest of the world: (Same as BL) SSP2 GDP growth rate.

3. Expansion of Free Trade (1st Year Study results) All scenarios: (1) More Mega-FTAs are created to complement WTO. Horizonal international specialization progresses further in each area. Intra-regional trade becomes relatively dominant (TPP, TTIP, RCEP, etc.) S1: (1) Investment under China's One Belt One Road initiative contributes to the development of India and African countries, (2) Economic integration within the African continent progresses due to CFTA, and (3) Quality growth is achieved as a result of developing corridors in Africa S2: (1) Investment under One Belt One Road initiative does not contribute to Africa's quality growth (it only accelerates over dependence on extra-regional imports and consumption in metropolitan areas), and (2) CFTA is not reached (due to conflict of interest within the African continent)
Tariff Rate Settings

BL	■Global: FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA
S1	■Africa: (Same as BL) The development of economic corridors in Africa enhances opportunities for free trade, and FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA ■Africa: In addition to the above, all tariffs between African countries that have not yet discussed FTAs/EPAs are phased out starting in 2020. (Envisioning the transcontinental reach of the Africa Continental Free Trade Area (AfCFTA) put into effect in May 2019) (2020 to 2025 (Stage 1): 25% reduction: 2025 to 2030 (Stage 2): 33% reduction, 2030 to 2035 (Stage

	3): 50% reduction, 2035 to 2040 (Stage 4): 100% reduction) ■Rest of the world: (Same as BL) The development of economic corridors in Africa enhances opportunities for free trade, and FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA
S2	■Africa:Stalemates, suspensions, and other problems with negotiations for FTAs/EPAs planned/discussed as of 2019 cause tariff rates to remain at the present level in and after 2020 to 2025 (Stage 3). ■Rest of the world: (Same as BL) FTAs/EPAs planned/discussed as of 2019 are established. Tariffs between signatories are phased out in four stages. (Stage 1: 25% reduction, Stage 2: 33% reduction, Stage 3: 50% reduction, Stage 4: 100% reduction) *The timing of tariff rate reduction stages depends on the FTA/EPA

7. Foodstuff (1st Year Study results) All scenarios: (1) Food demand per capita of developed and semi-developed countries in 2050 decreases to 90% of that in 2010, whereas that of developing countries in 2050 increases slightly to 102% of the 2010 figure.(2) In other words, food demand in 2050 increases 1.55 and 2.06 times the 2010 demand worldwide and in developing countries, respectively while food loss gradually decreases in developed countries.(3) Global food demand is satisfied due to improved productivity (crop yield increases at an annual rate of 1.0% to reach 1.5 times that of 2010 in 2050). S1: (1)Green Revolution successfully takes place in Africa, enabling stable food supply (food self-sufficiency increases while transport infrastructure develops within the region). S2: (1) Green Revolution does not take root in Africa. Extra-regional imports of food increase (based on MAFF's projection).
Agricultural and Fisheries Factor Productivity Settings

BL	■Global: Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor

	productivity (land, skilled labor, unskilled labor, capital, resources).
S1	■Africa: Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 3.04% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources) (set based on the average productivity rate increase between factors in Africa in the GTAP Data Base from 2004 to 2011). ■Rest of the world: (Same as BL) Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources).
S2	■Africa: Remains in the present state (no change). ■Rest of the world: (Same as BL) Agricultural and fisheries (Agri) factor productivity (Afeall) increases at an annual rate 1% higher than total factor productivity (land, skilled labor, unskilled labor, capital, resources).

8. Energy (1st Year Study results)

All scenarios:

(1) Global energy consumption in 2050 becomes 1.5 greater than that of 2015.

(2)Energy consumption in developing countries decreases slightly while that in non-OECD countries increases at an annual rate of 1.6% (approx. 1.75 times). Increase is particularly notable in China, India, and ASEAN countries, as well as in Middle East, North Africa, and Sub-Saharan Africa (due to population and economic growth).

(3) 79% of energy demand is satisfied by fossil fuels (30% petroleum, 26% natural gas, and 23% coal) and the remaining 21% by other fuels. There is no depletion of resources.

(4) Production of fossil fuels in 2050 increases to 1.35 times that of 2015 (at an annual rate of 0.9%) for petroleum, 1.76 times (1.6%) for natural gas, and 1.18 times (0.5%) for coal. However, if conversion to electric cars and other ZEVs accelerates, petroleum demand will be about 99% of that in 2015.

Natural Resource Reserve Settings	
BL	■Global: Natural resource reserves increase 1.2% per year (set based

	on the annual average rate of increase in the GTAP Data Base from 2004 to 2011).
S1	■Africa: Natural resource reserves increase 2.4% per year (twice as high as the rest of the world). ■Rest of the world: (Same as BL) Natural resource reserves increase 1.2% per year.
S2	■Africa: Remains in the present state (no change). ■Rest of the world: (Same as BL) Natural resource reserves increase 1.2% per year.

10. Technological Innovation (1st Year Study Results)
All scenarios:
(1) Productivity of horticulture, livestock farming, and fisheries, as well as storage/transport technologies, continue to improve and become more sophisticated.
(2) Super-large container ships (40,000 TEU class) will not emerge (They will stay at the current 20,000 TEU level due to navigation restrictions in the Suez Canal and the Straits of Malacca).

Rate of Technological Innovation in Transport (ATS, ATD) Settings	
BL	■Global: Increases 0.76% per year (set based on the global average productivity rate increase in the transport sector in the GTAP Data Base from 2004 to 2011).
S1	■Africa: Increases 3.38% per year (set based on the African average productivity rate increase in the transport sector in the GTAP Data Base from 2004 to 2011). ■Rest of the world: (Same as BL) Increases 0.76% per year.
S2	■Africa: Remains in the present state (no change) due to lack of technical innovation. ■Rest of the world: (Same as BL) Increases 0.76% per year.

- The following scenarios are outside the scope of GTAP Model analysis.

4. Global trade (1st Year Study results)
All scenarios: Global trade increases at a similar pace to GDP (even trade).
S1: Trade volume within African region grows faster than GDP due to expanding intra-African trade under CFTA (fast trade).
S2: Intra-African trade, as is the case with global trade, increases at a similar pace to GDP (even trade).

Reasoning: The trade volume is outside the scope because it is solved as an endogenous variable
5. Realization of responsible SCs (1st Year Study Results) All scenarios: Responsible supply chains (SCs) are realized for the most part due to creation of Mega-FTAs, etc.
Reasoning: This scenario setting is outside the scope because it is qualitative and thus difficult to express in GTAP Model
6 Widening of disparities (1st Year Study Results) S1: (1) Quality growth is mostly accomplished worldwide, decreasing disparity in GDP per capita.Ÿ (2) Disparity shrinks at a faster pace in Africa, where disparity is greater, than the global average. S2: (1) Africa's external negotiating power is insufficient due to the failure of CFTA.Ÿ (2) Disparities among regions and countries widen due to the progress of advanced horizontal international specialization by multinational giants. Ÿ (3) Africa's disparity in GDP per capita expands to a moderate level.
Reasoning: This setting is outside the scope because GDP is exogenous in the scenario
9. Consumer awareness (1st Year Study Results) All scenarios: While over-consumerism accelerates due to increased income, the "sustainable consumption" concept gradually gains awareness and popularity toward the achievement of SDGs (reaching a halfway point).
Reasoning: Consumption is outside the scope because it is solved as an endogenous variable
11. Climate Change Risk (1st Year Study Results) All scenarios: (1) International horizontal specialization progresses under a loose trade bloc. Stable economic growth is achieved while maintaining the supply-demand balance of food and energy. (2) Climate change risk equivalent to a medium stabilizing scenario (RCP4.5) as a result of certain mitigation measures is assumed.
Reasoning: This setting is outside the scope because the use of SSP2 population and GDP as in Scenario BL is the same as using moderate climate change mitigation and adaptation measures Reference: RCP scenarios are not factored into the OECD's SSP GDP projections, but SSP2 assumes the adoption of moderate environmental policies. Additionally, the IIASA's SSP GDP projections, which do factor in RCP, do not show any major differences in RCP scenario GDP projections

through 2040.
12. Risk of War, Conflict, and Terrorism (1st Year Study Results) S1: The risk of war, conflict, and terrorism remains “low” due to formation of a loose trade bloc. S2: (1) While international horizontal specialization progresses based on comparative advantage under a loose trade bloc, corridor development fails. Ÿ (2) Multinational giants accumulate wealth by leading the trade market while nations and citizens are deprived of their fair shares, posing a “high risk” for conflict and terrorism.
Reasoning: This scenario setting is outside the scope because it is qualitative and thus difficult to express in GTAP Model
13. Impact on Global Logistics (1st Year Study Results) All scenarios: (1) Global trade increases at a similar level to GDP (even trade). (2) Size of large container vessels remains at the current 20,000TEU level. (3) Two types of ocean freight networks (hub-and-spoke and point-to-point) develop at multiple levels. (4)Medium to small container ships (4,000TEU – 8,000TEU) are predominant in the Intra-Asia trade. Advancement of international horizontal specialization heightens the importance of warehouse facilities as storage and inland gateways. (5) Transshipment services via hub ports in Asia, Sub-Saharan Africa, and Islamic region (Port of Colombo, Port Luis, Port Salalah, and Port Mombasa) are prevalent.
Reasoning: The trade volume is outside the scope because it is solved as an endogenous variable. However, some of the technological innovation described previously is reflected in the Rate of Technological Innovation in Transport (ATS, ATD) Settings.

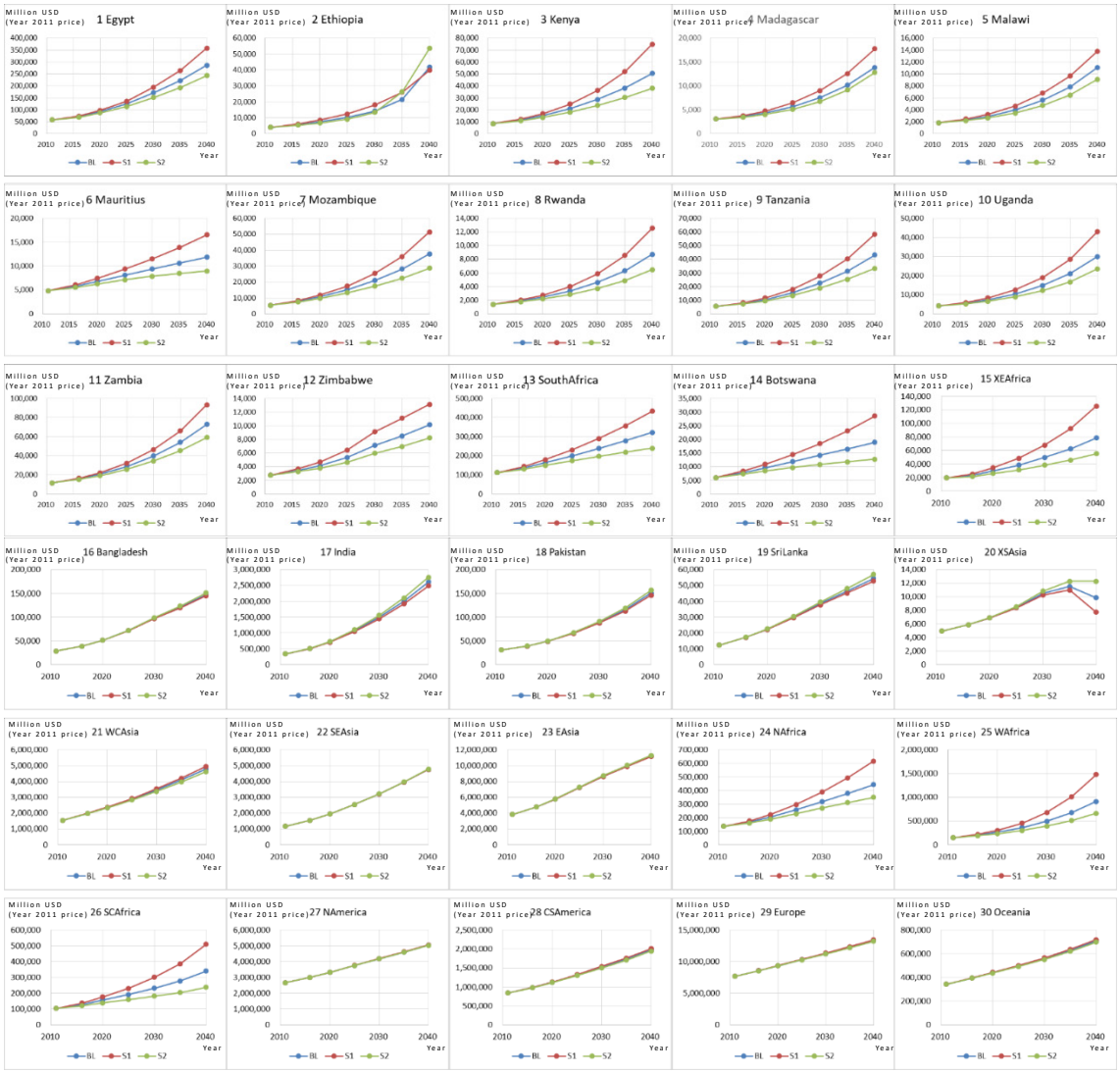
3-4 Future Scenario Estimations

3-4-1 Simulation Results

(1) Exports

1) Totals for All Industries

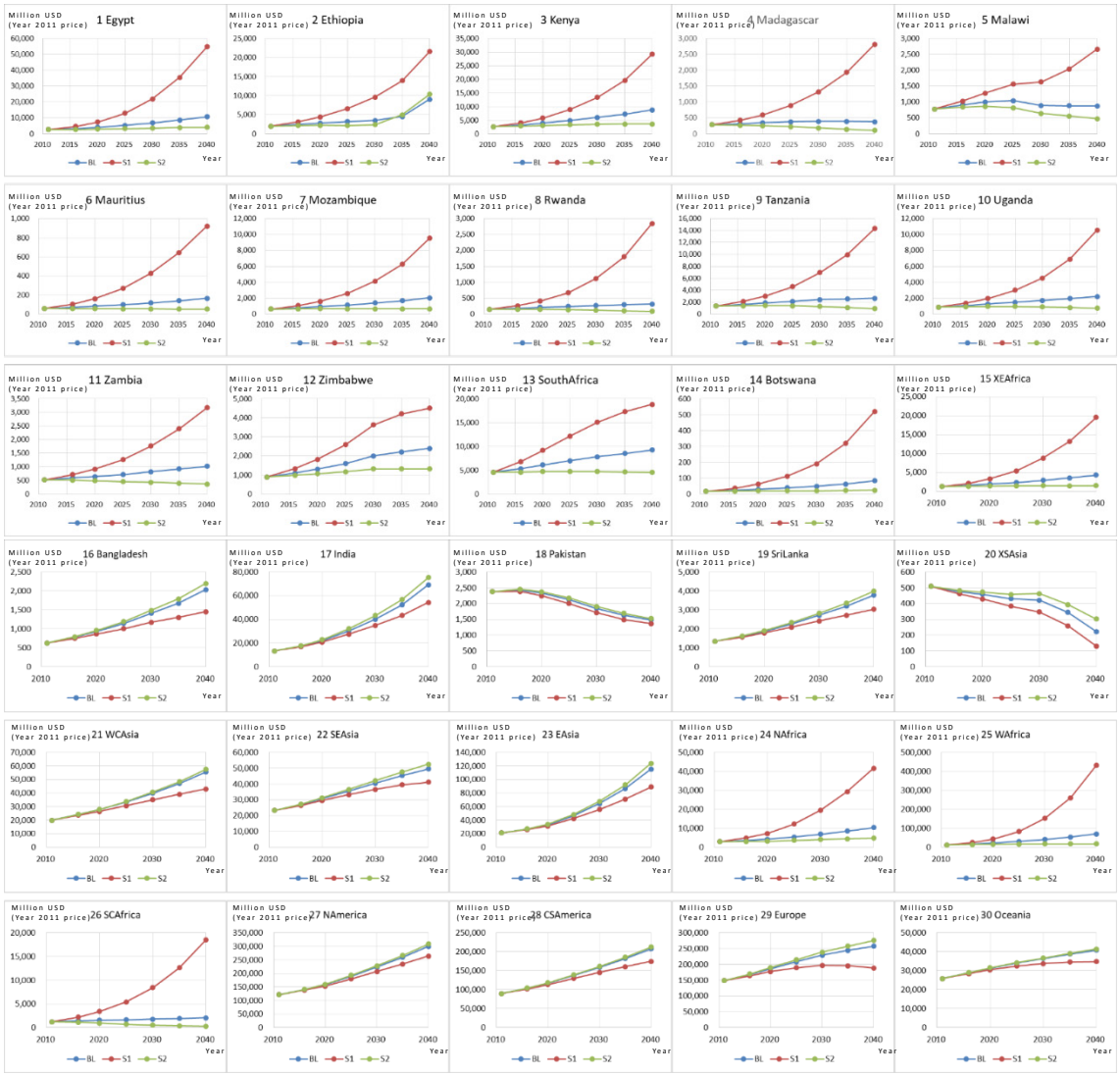
Unit: Million USD (Year 2011 price)



- Some figures, with only green lines for the results of S2, show that respective chart lines are overlapped due to small differences in calculation results between BL, S1 and S2.

2) Agriculture

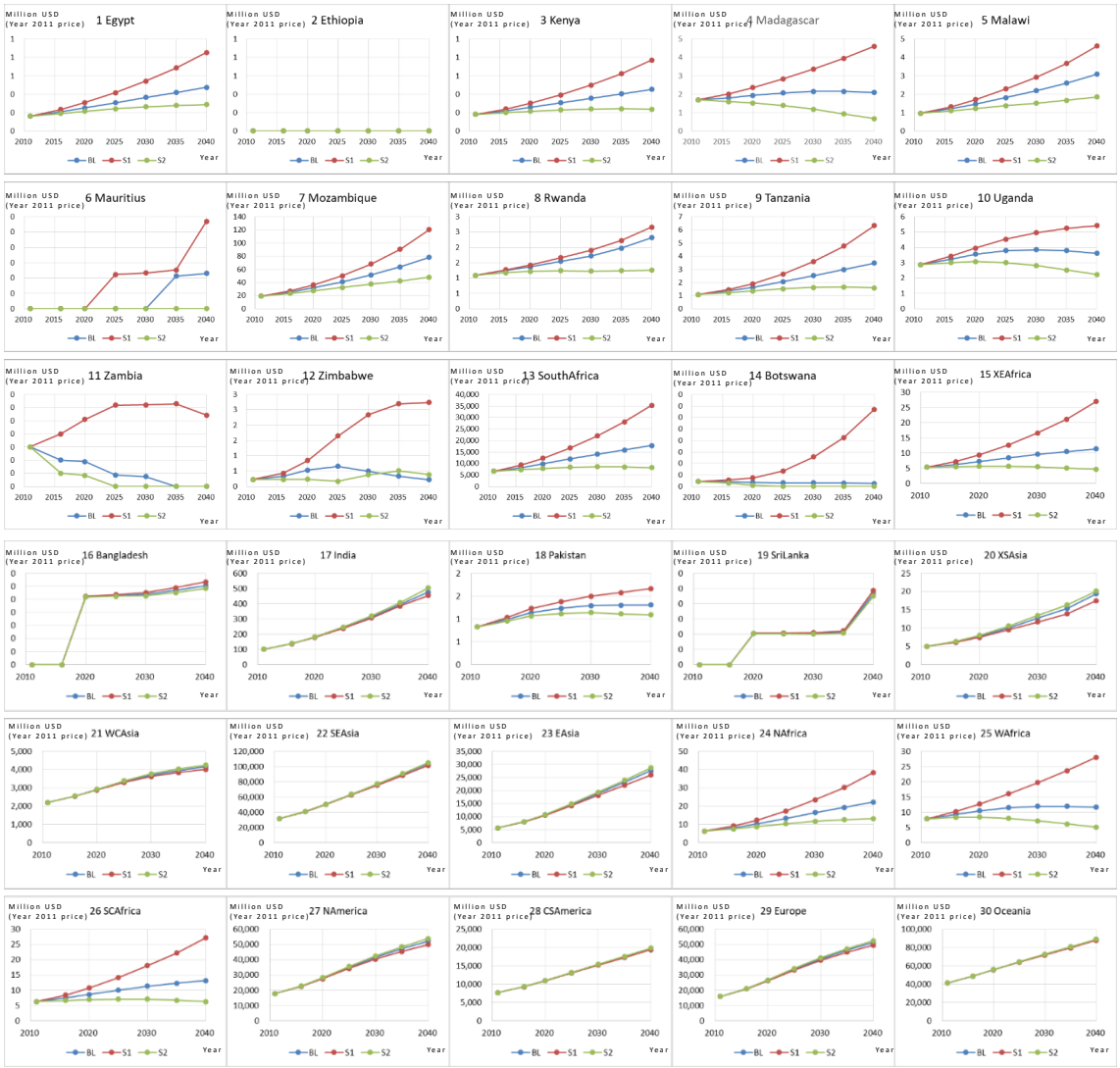
Unit: Million USD (Year 2011 price)



- Some figures, with only green lines for the results of S2, show that respective chart lines are overlapped due to small differences in calculation results between BL, S1 and S2.

3) Coal

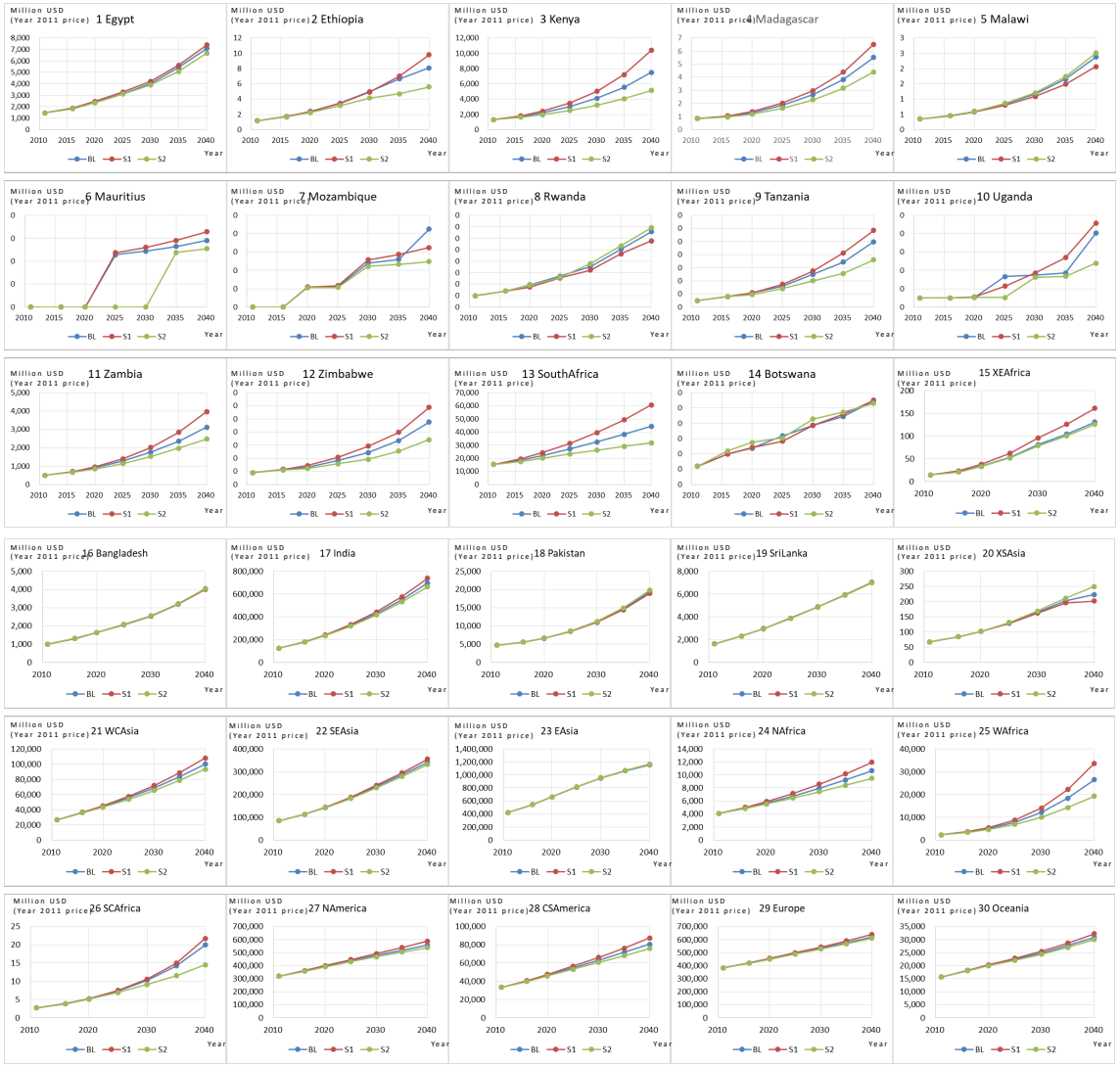
Unit: Million USD (Year 2011 price)



- Some figures, with only green lines for the results of S2, show that respective chart lines are overlapped due to small differences in calculation results between BL, S1 and S2.
- As for some figures where maximum values are extremely small, if the default value is just about nil, the phenomenon happens unavoidably in the GTAP model and therefore the small values are not subject to consideration.

4) Oil

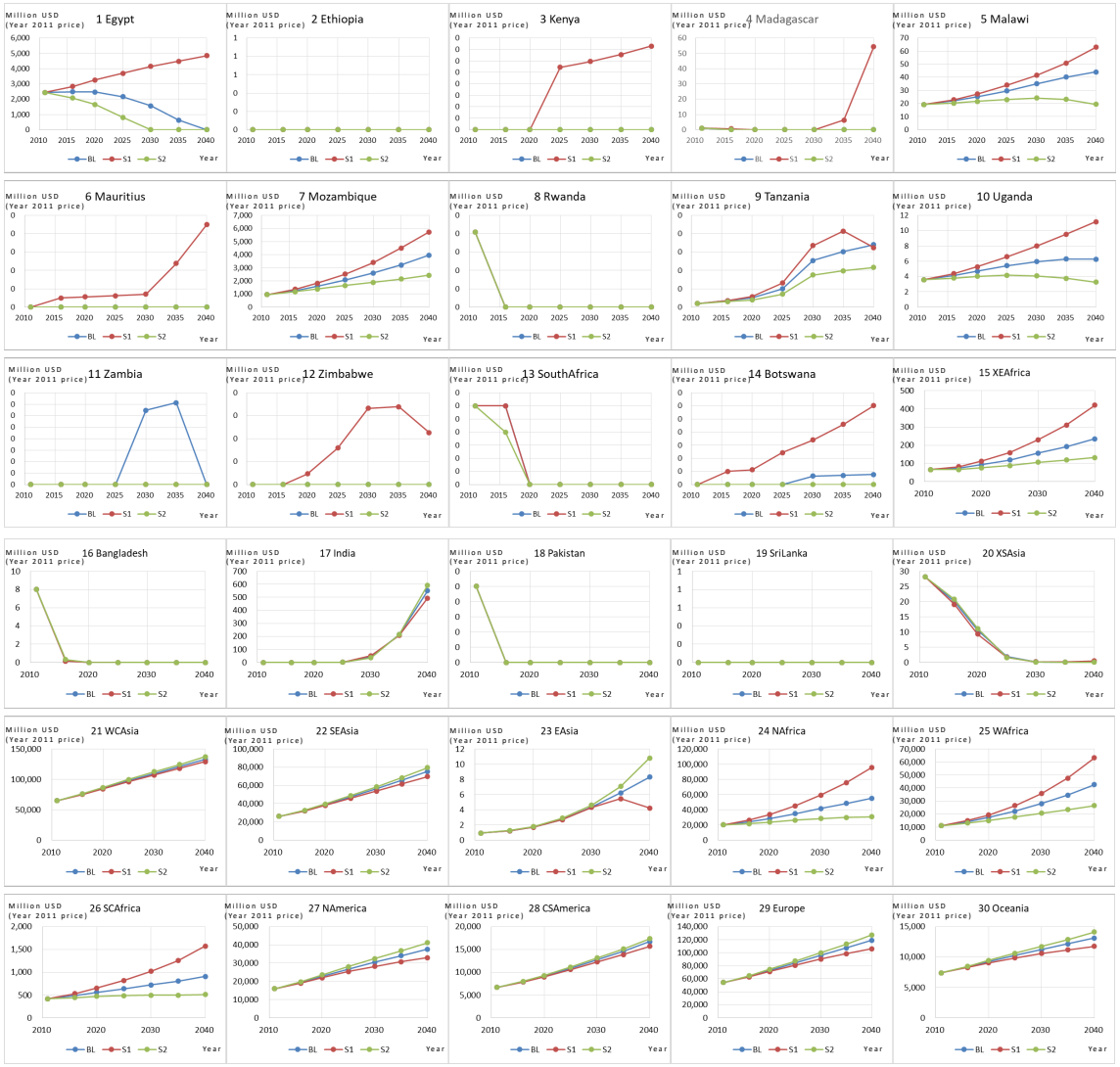
Unit: Million USD (Year 2011 price)



- Some figures, with only green lines for the results of S2, show that respective chart lines are overlapped due to small differences in calculation results between BL, S1 and S2.
- As for some figures where maximum values are extremely small, if the default value is just about nil, the phenomenon happens unavoidably in the GTAP model and therefore the small values are not subject to consideration.

5) LNG

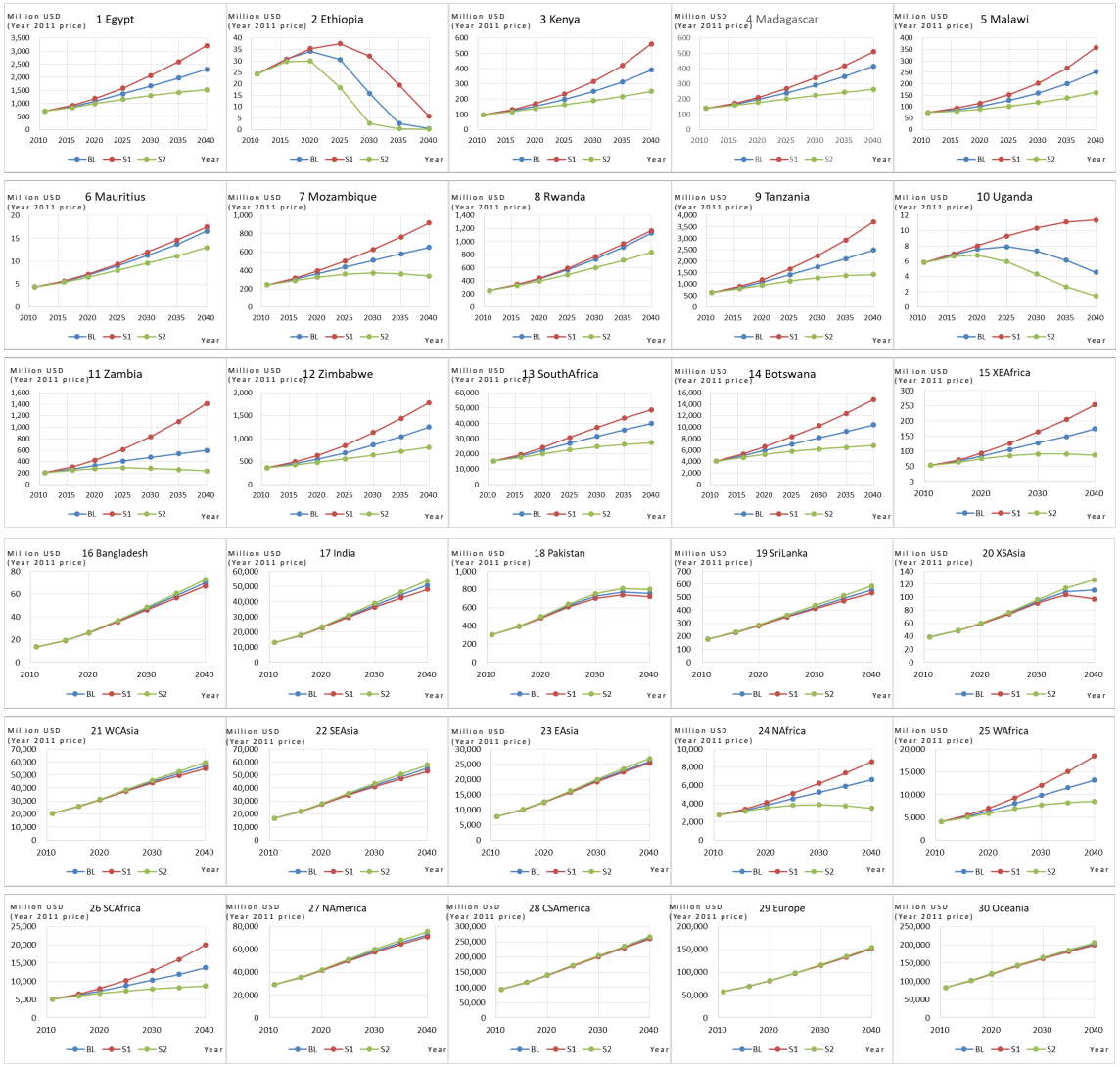
Unit: Million USD (Year 2011 price)



- Some figures, with only green lines for the results of S2, show that respective chart lines are overlapped due to small differences in calculation results between BL, S1 and S2.
- As for some figures where maximum values are extremely small, if the default value is just about nil, the phenomenon happens unavoidably in the GTAP model and therefore the small values are not subject to consideration.

6) Minerals

Unit: Million USD (Year 2011 price)



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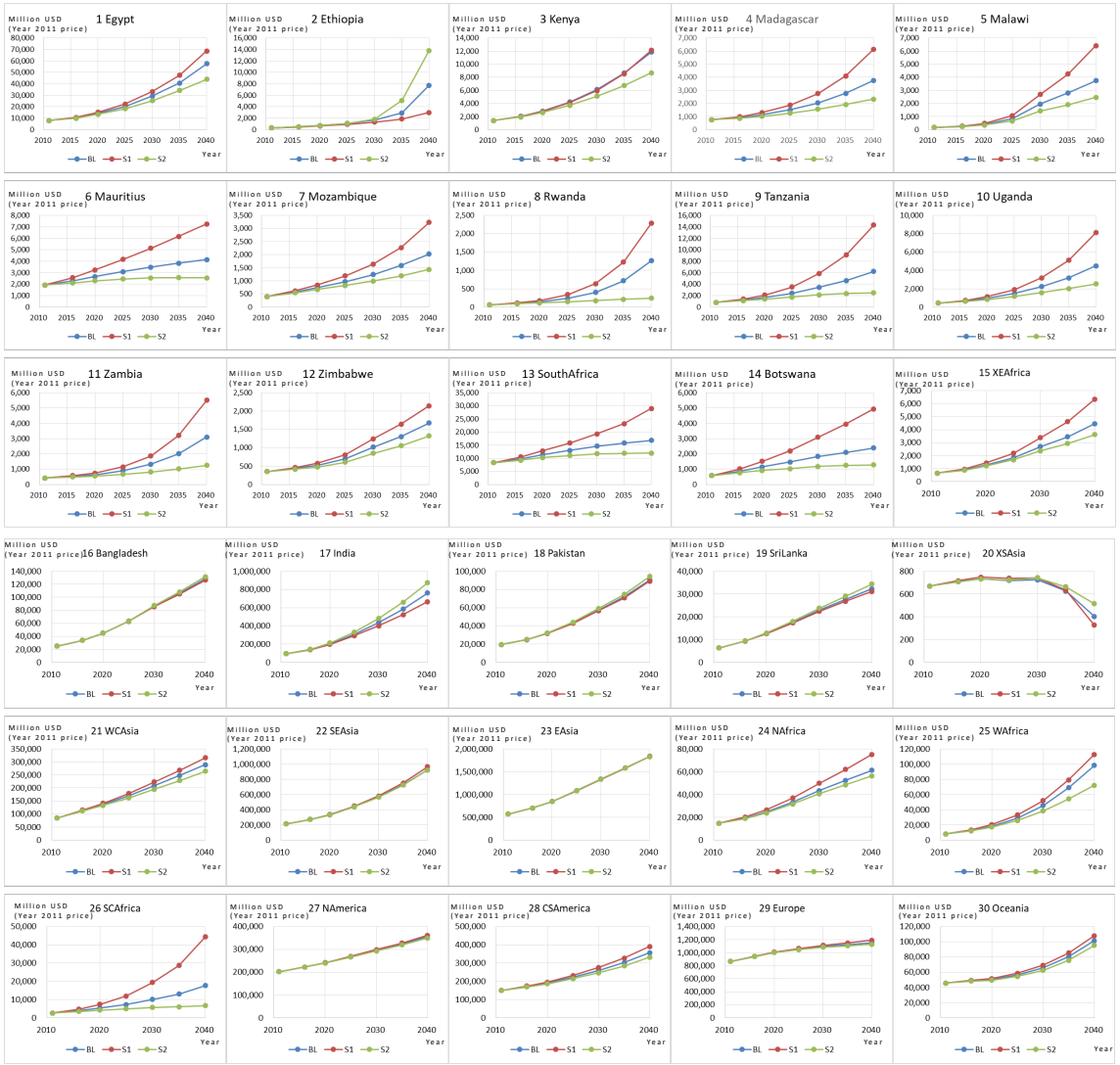
7) Consumption Goods

Unit: Million USD (Year 2011 price)



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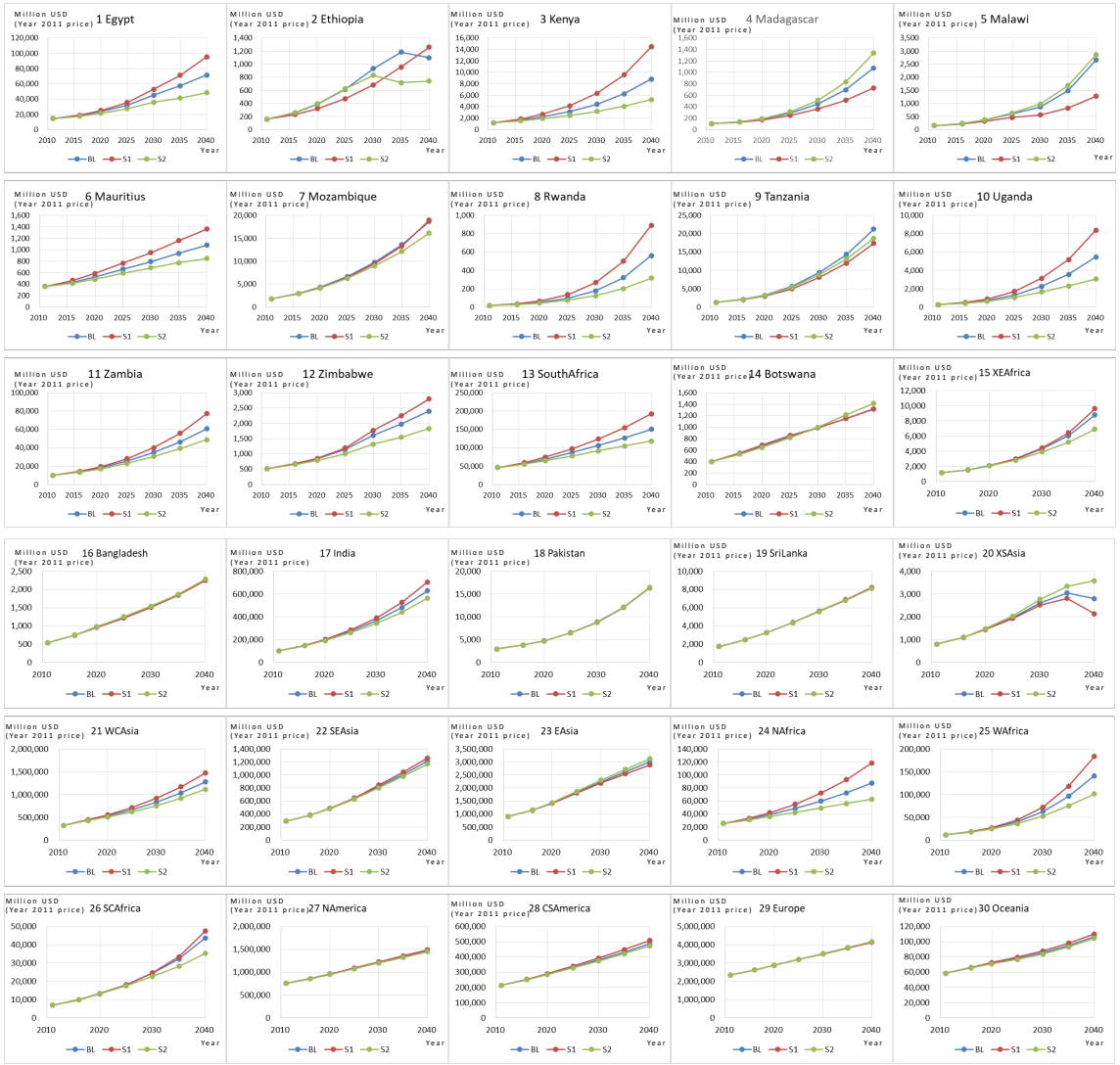
8) Industrial Materials

Unit: Million USD (Year 2011 price)



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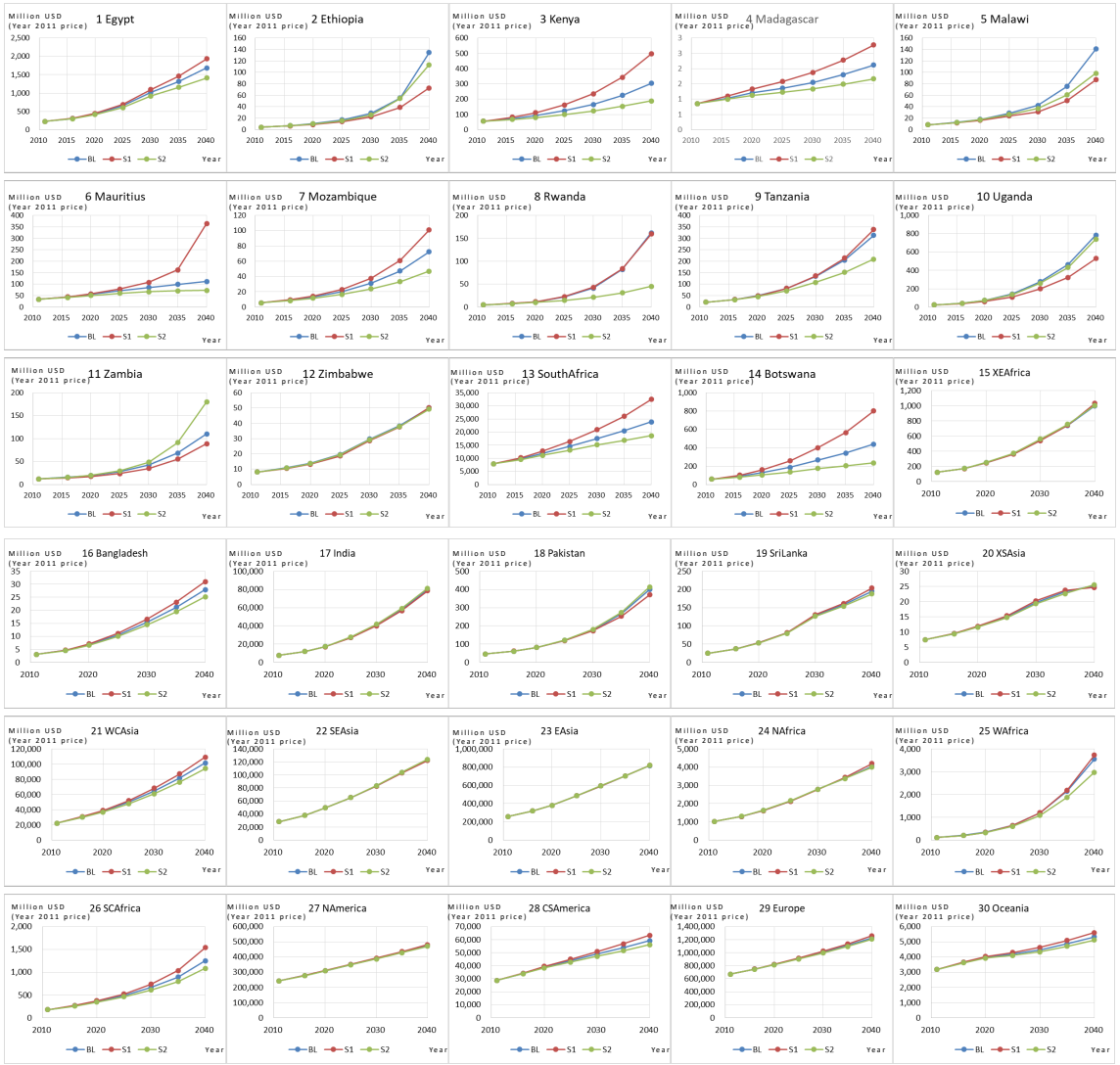
9) Motor Vehicles

Unit: Million USD (Year 2011 price)



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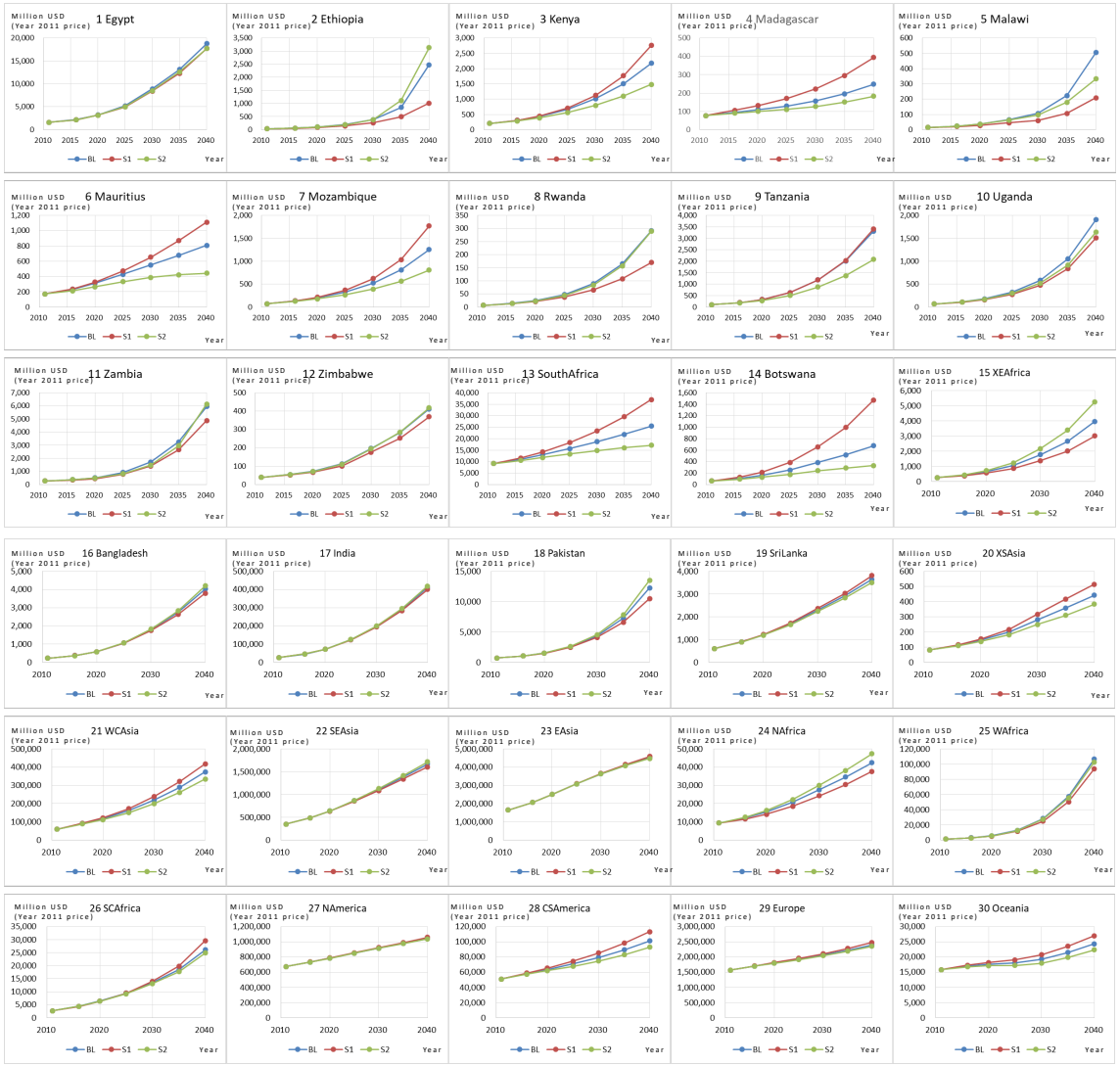
10) Processing/Assemblings

Unit: Million USD (Year 2011 price)



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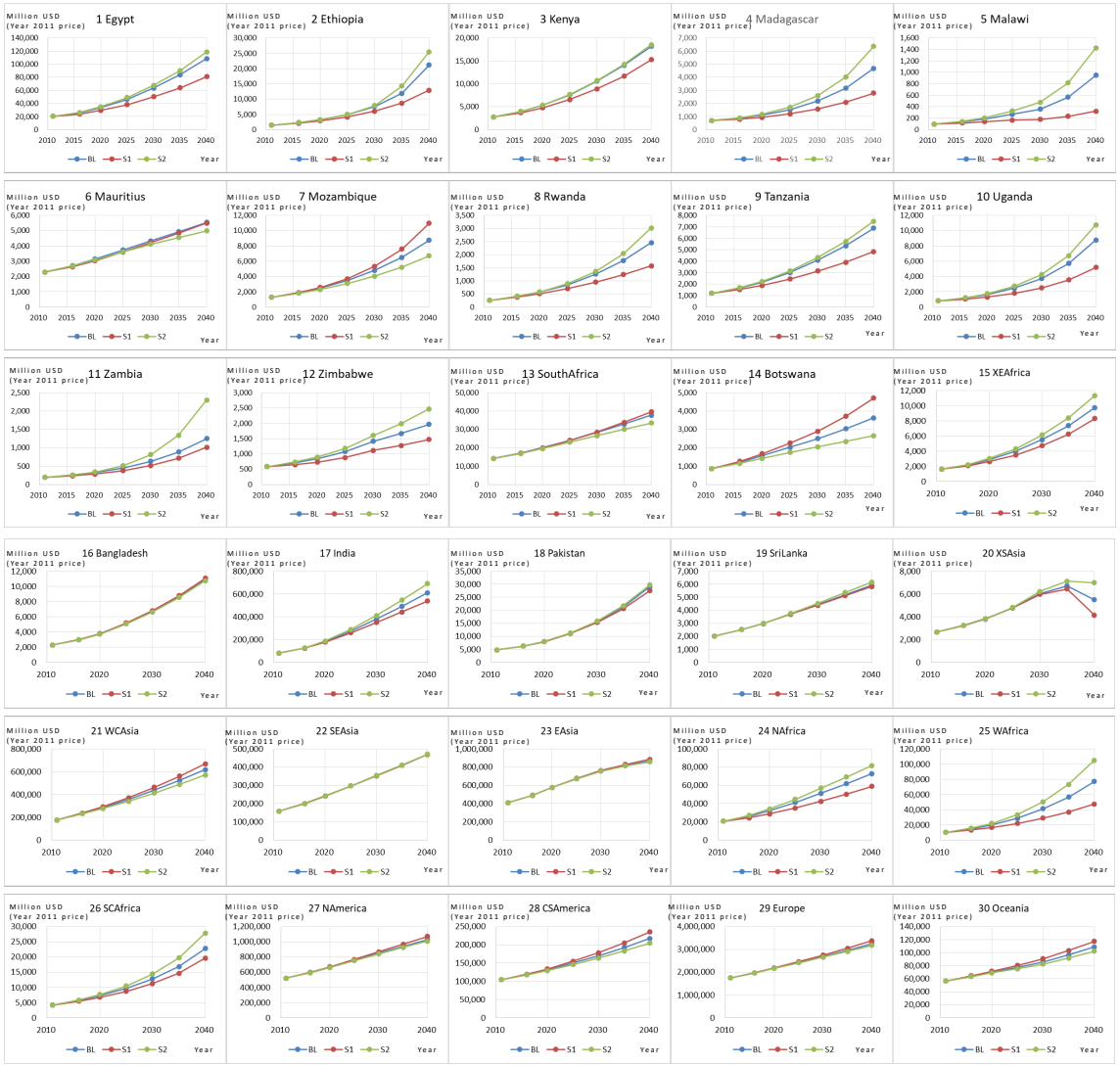
11) Services

Unit: Million USD (Year 2011 price)



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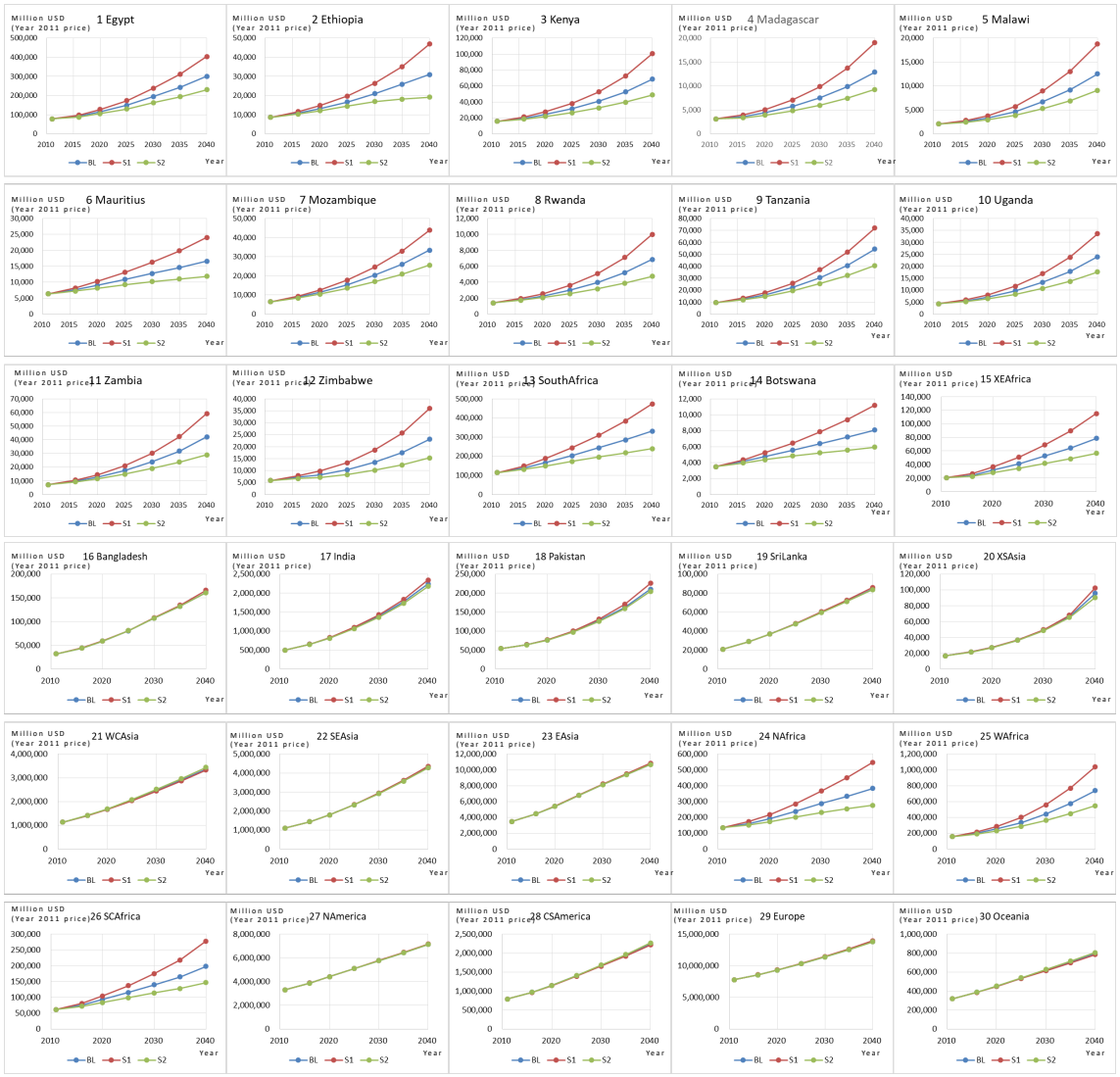
(2) Imports

1) Totals for All Industries

Unit: Million USD (Year 2011 price)



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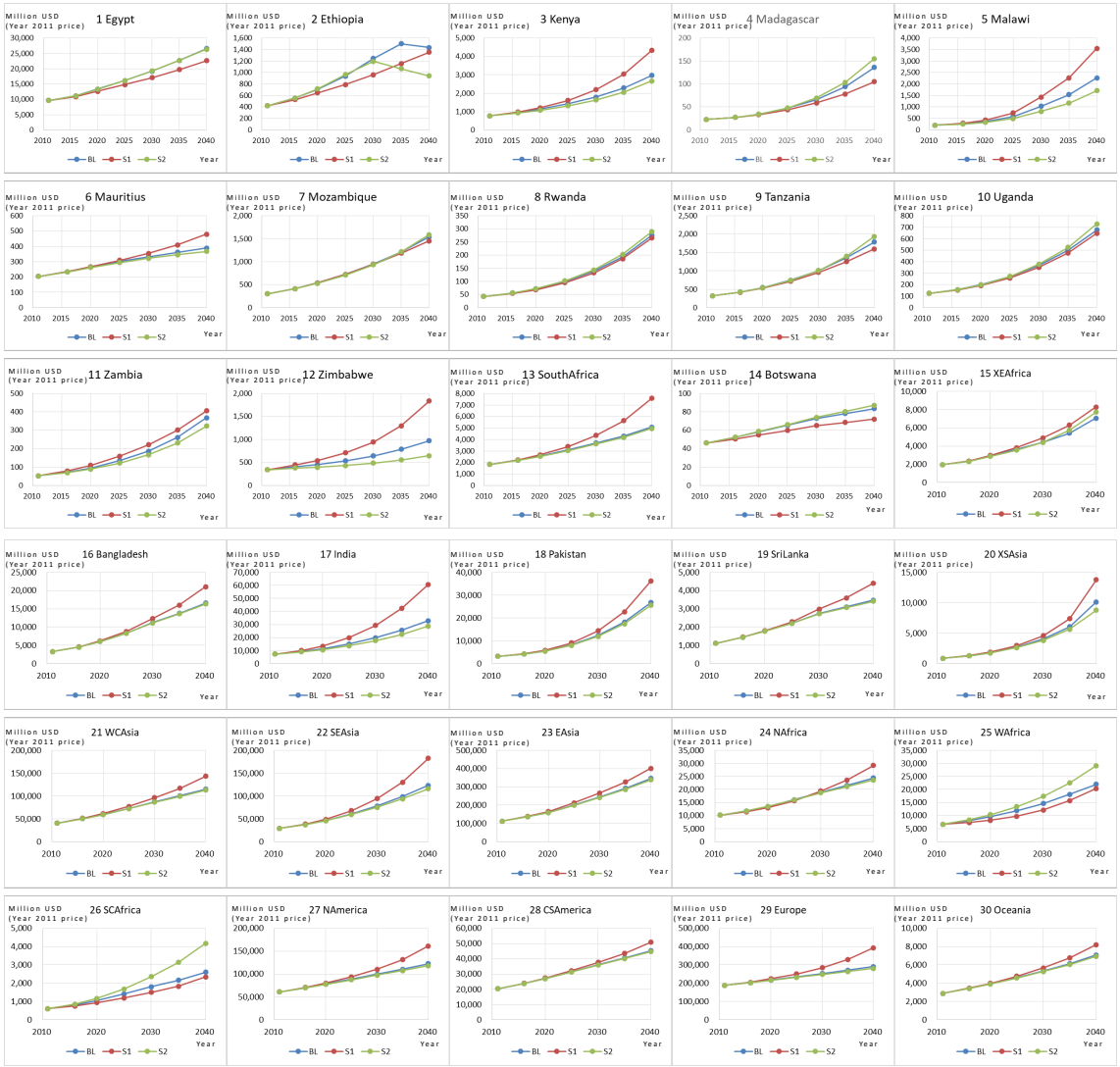
2) Agriculture

Unit: Million USD (Year 2011 price)



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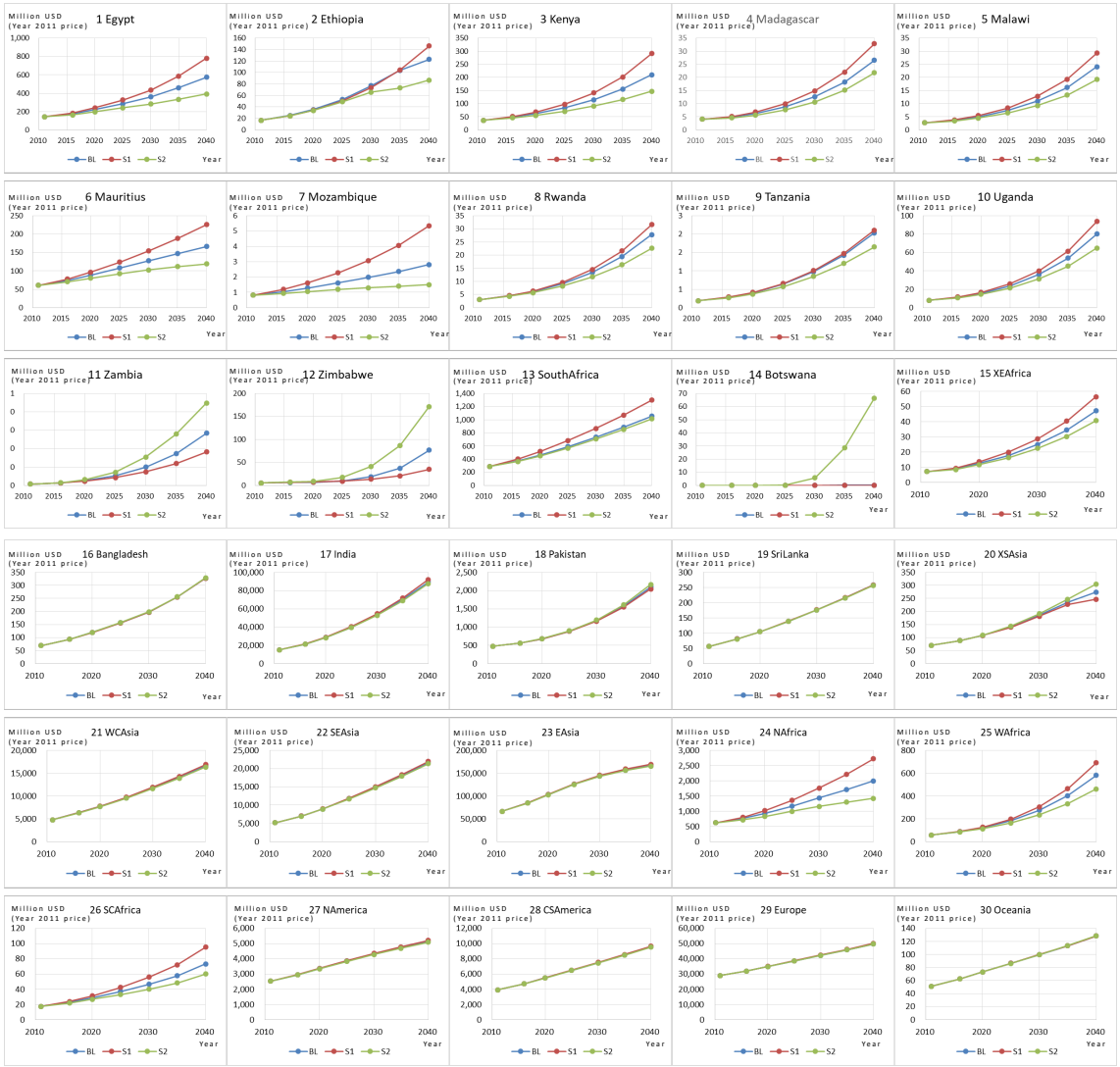
3) Coal

Unit: Million USD (Year 2011 price)



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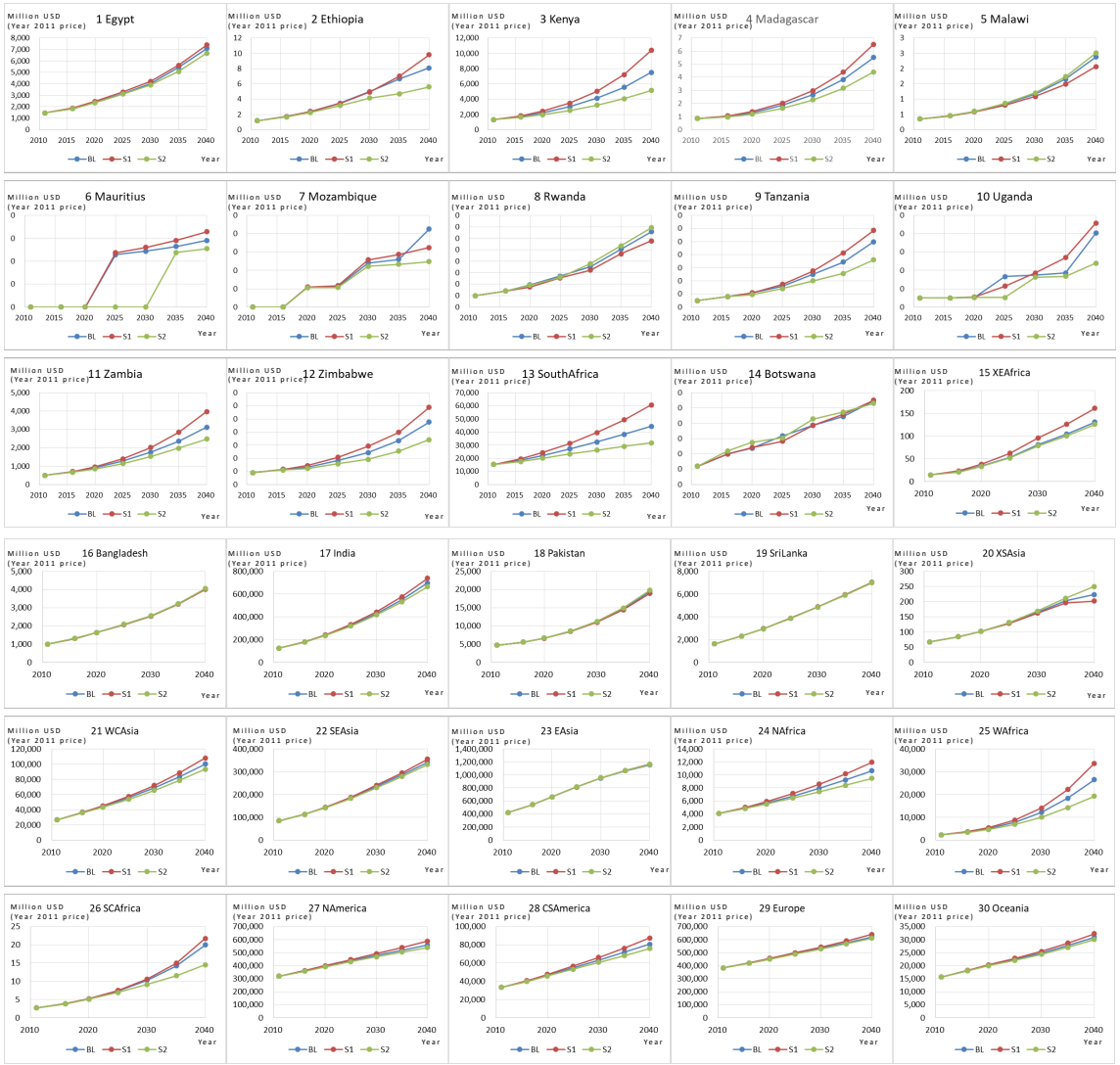
4) Oil

Unit: Million USD (Year 2011 price)



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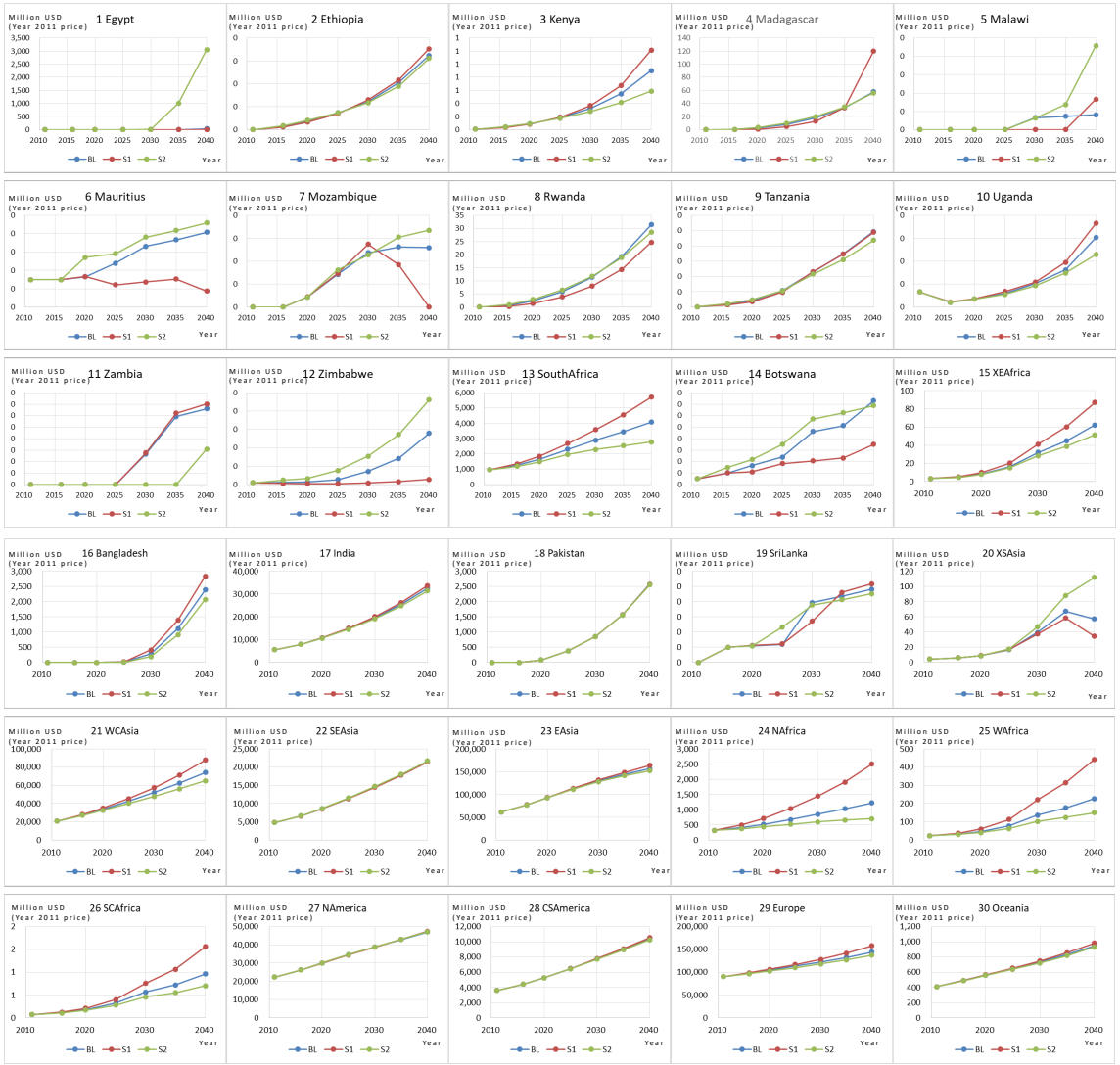
5) LNG

Unit: Million USD (Year 2011 price)



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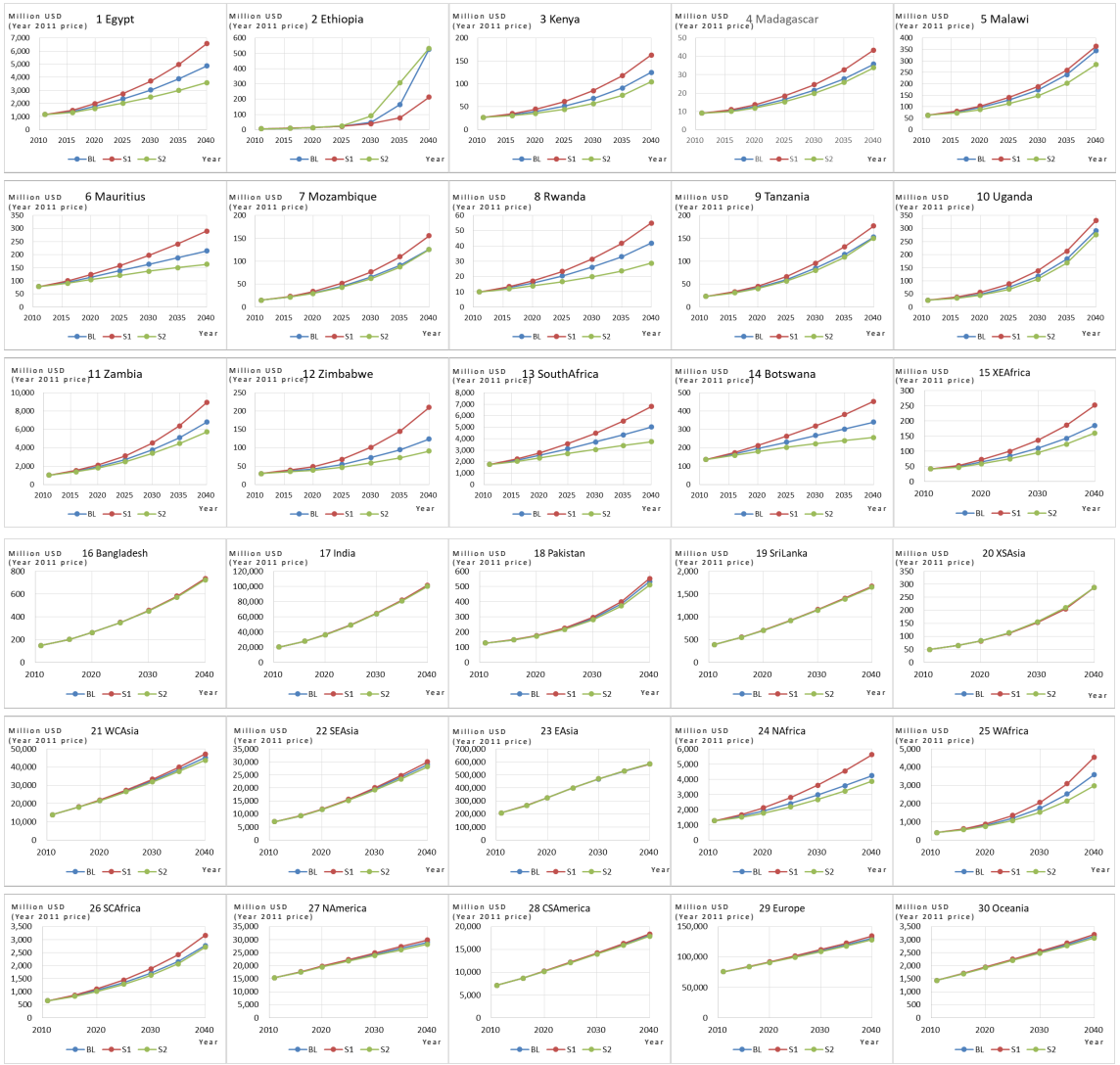
6) Minerals

Unit: Million USD (Year 2011 price)



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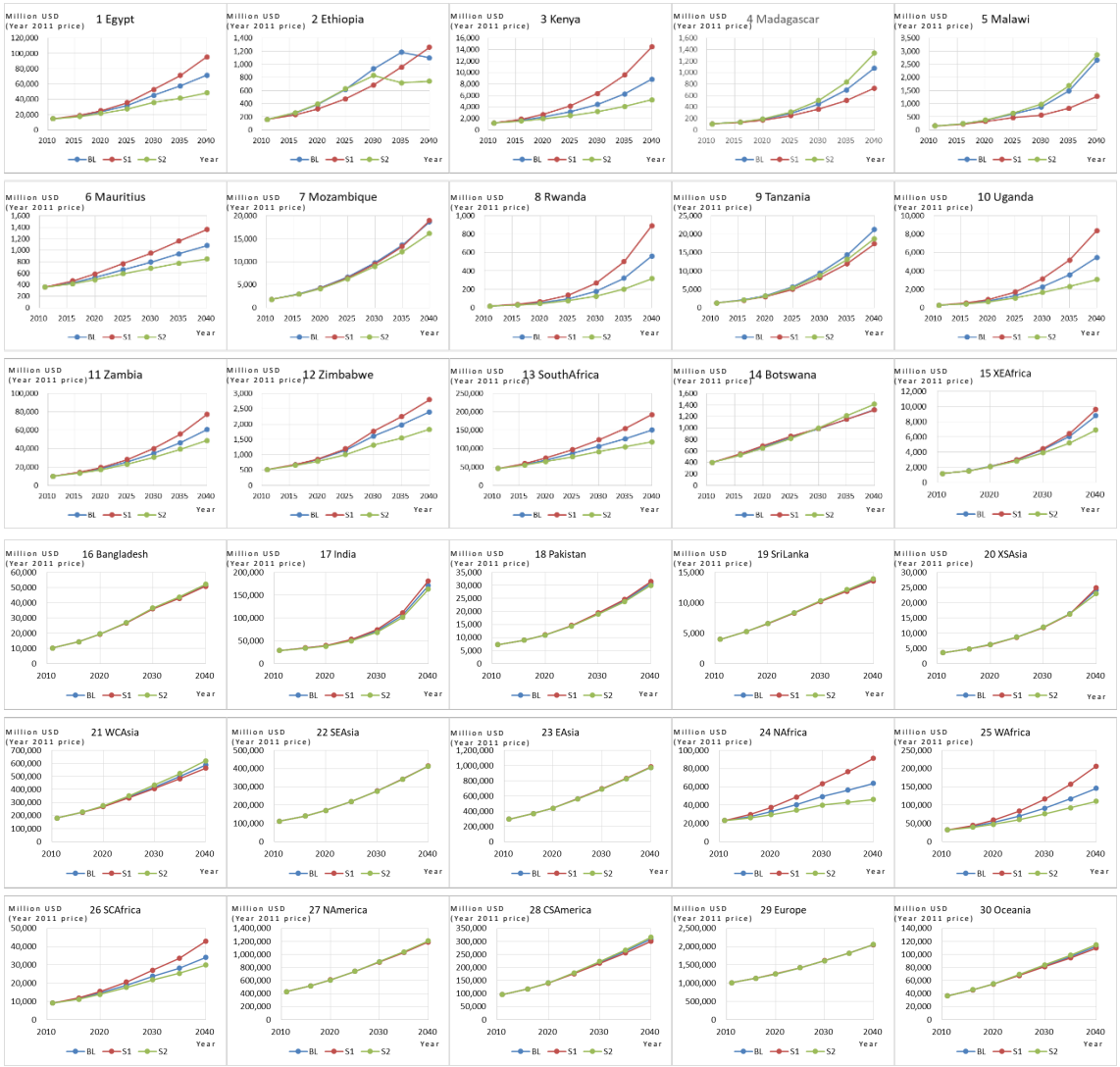
7) Consumption Goods

Unit: Million USD (Year 2011 price)



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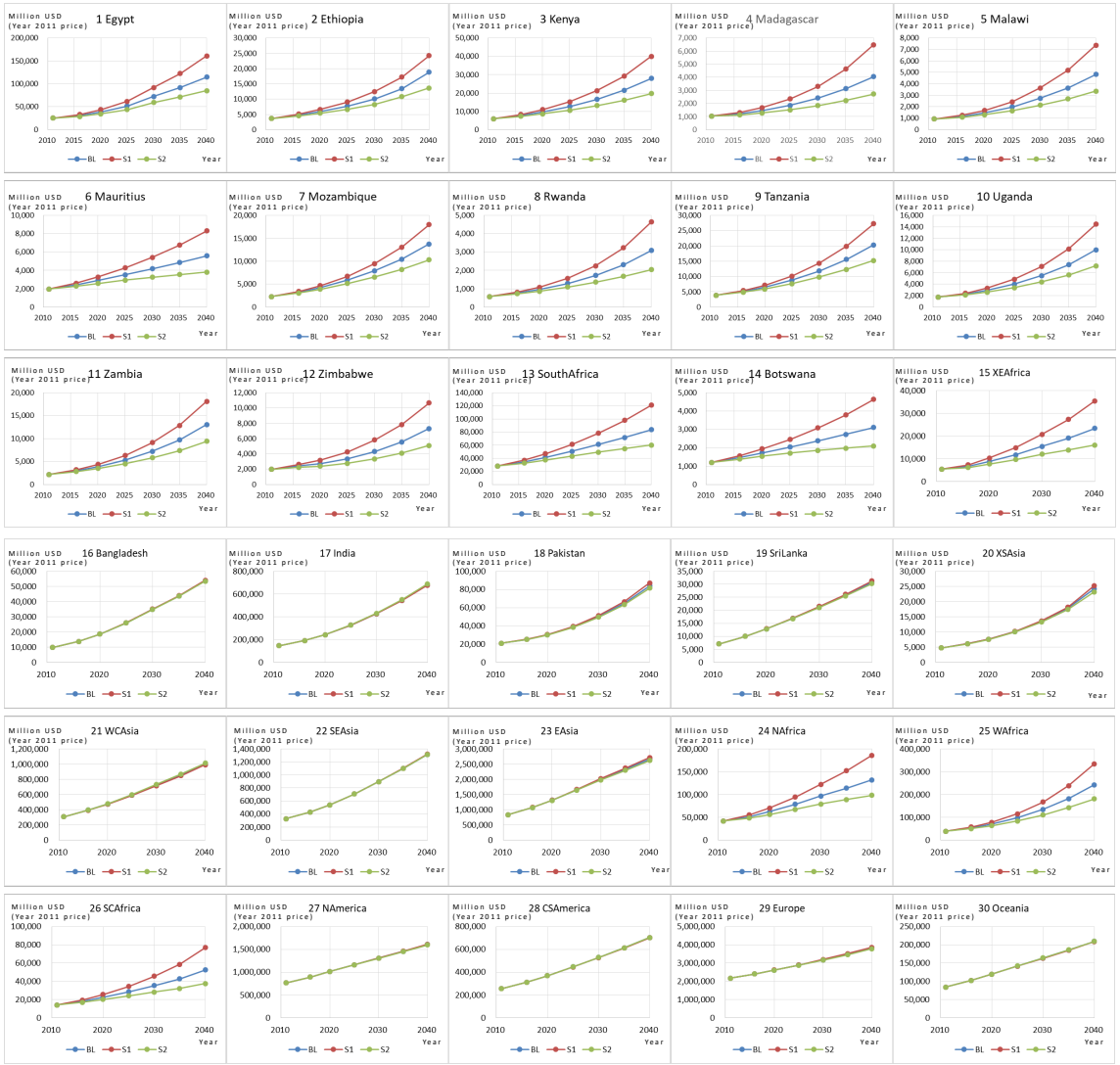
8) Industrial Materials

Unit: Million USD (Year 2011 price)



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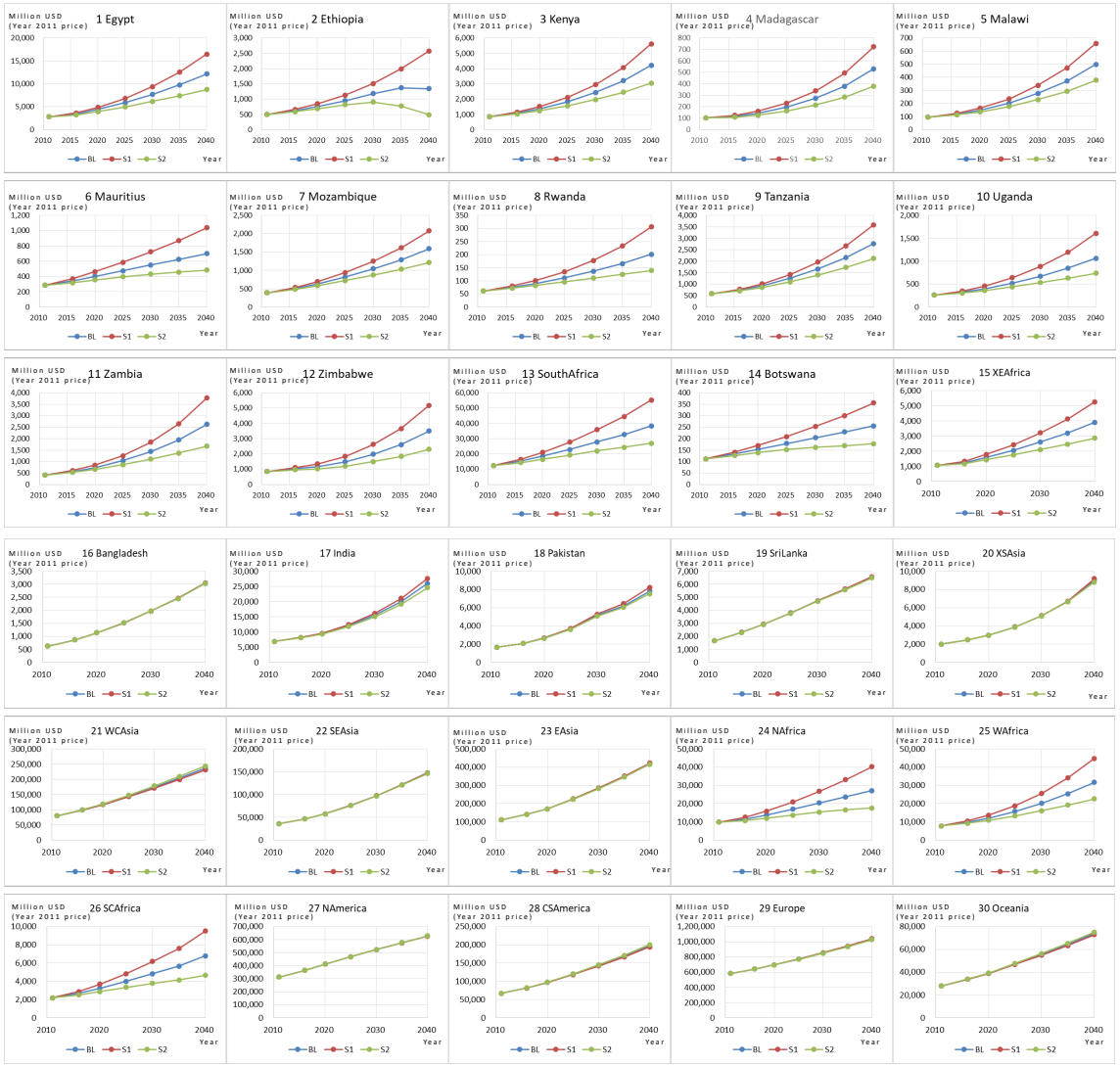
9) Motor Vehicles

Unit: Million USD (Year 2011 price)



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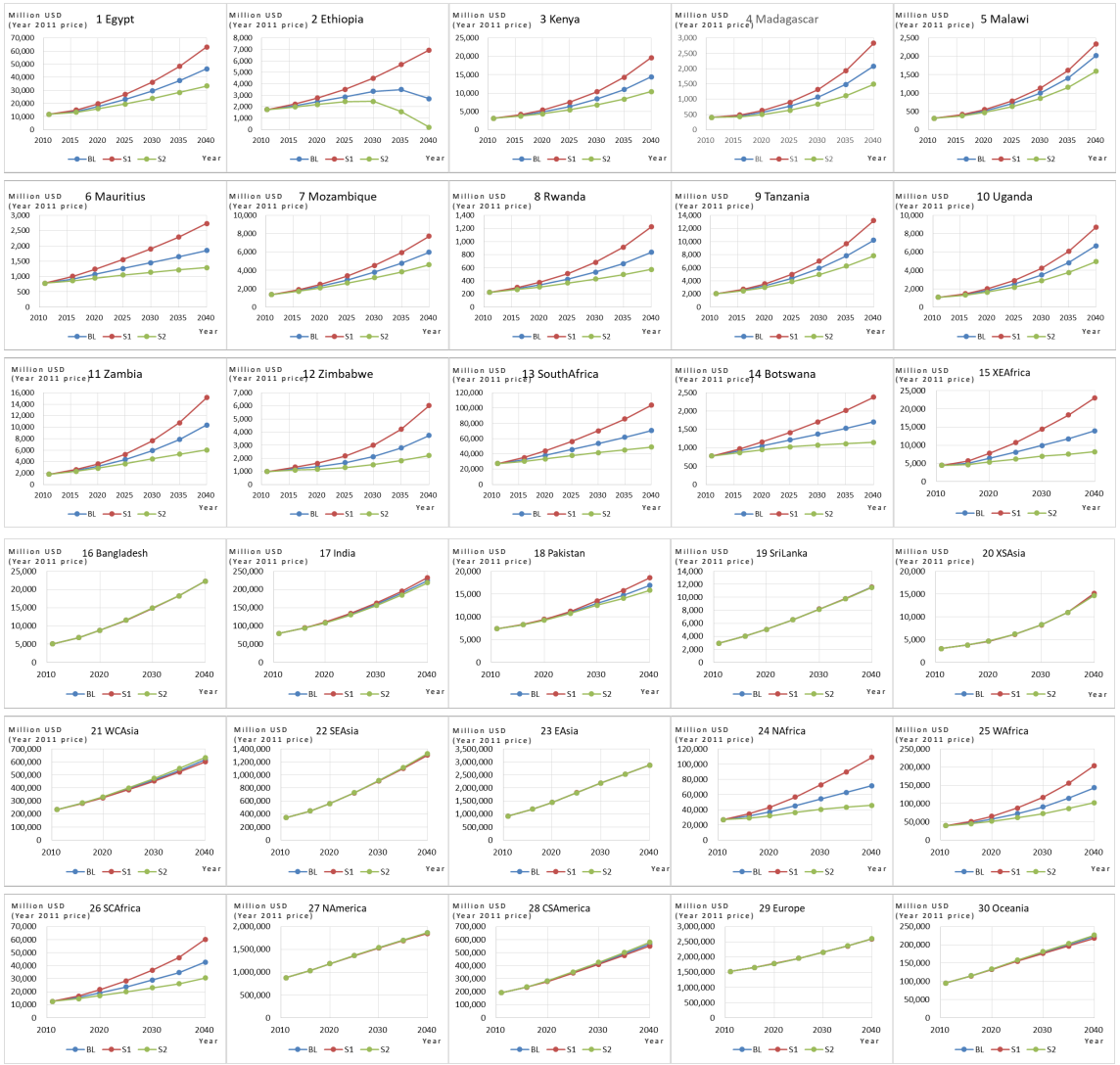
10) Processing/Assemblings

Unit: Million USD (Year 2011 price)



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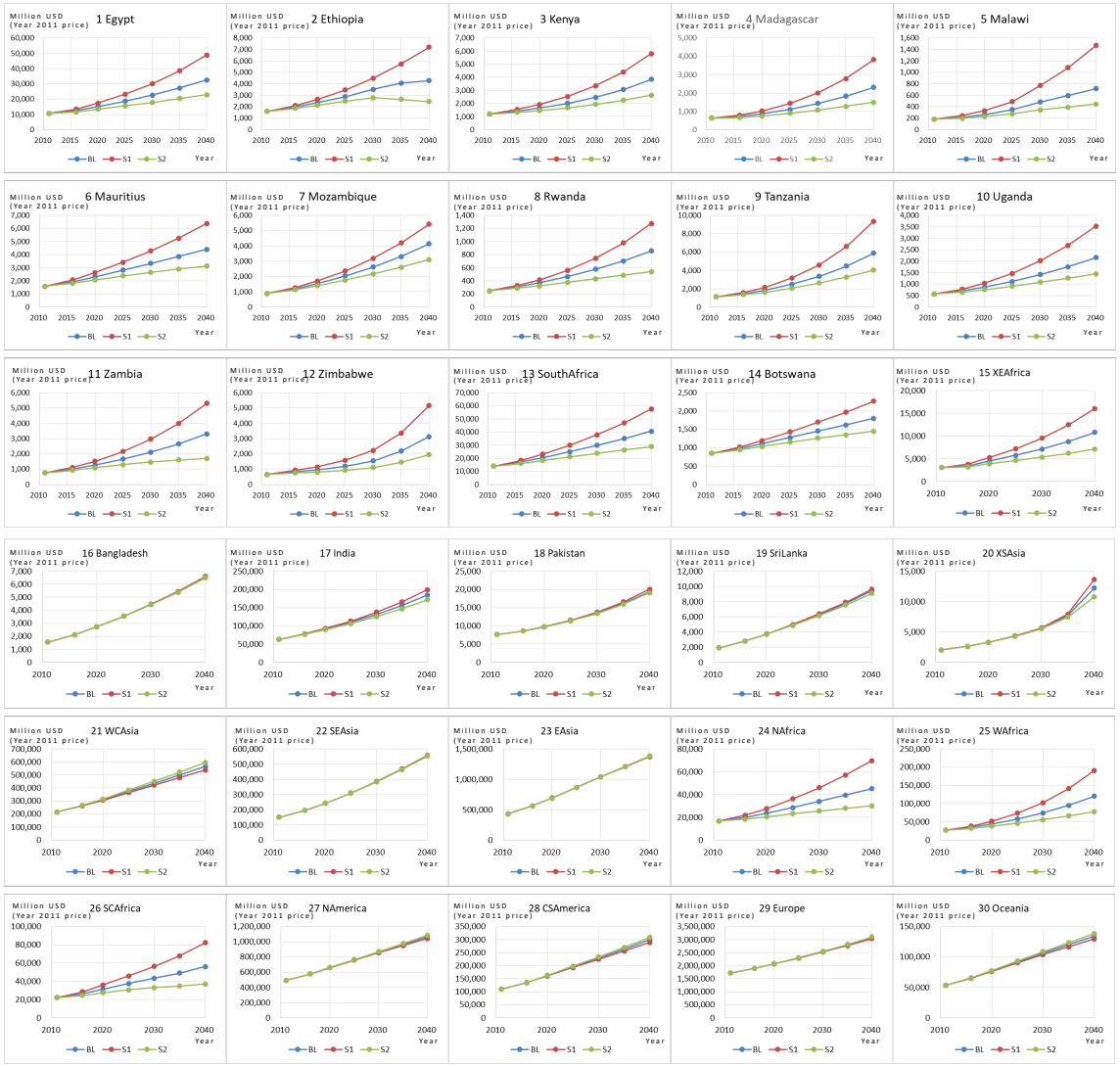
11) Services

Unit: Million USD (Year 2011 price)



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3-4-2 Discussion

- The simulations show the highest rates of change for Africa and the world in Scenario S2, followed by Scenarios BL and S1. Particularly, in South Asia, a region with active trade with Africa, exports increase substantially despite a decrease in exports to Africa due to the impact of burgeoning intraregional free trade there, and imports also increase substantially. The resulting expansion of globalization and regional integration under Africa Economic Corridor Development, the AfCFTA, and other economic cooperation framework only benefit Africa, but also radiate outward to other regions of the world. However, this is likely the result of intensified competition in international trade between South Asian exports and goods produced in Africa.
- There are significant differences in the rates of change of countries, regions, and industrial sectors in Africa. Additionally, Scenarios BL and S2 show higher rates of increase than Scenario S1. This is likely due to the expansion of Africa Economic Corridor Development and the AfCFTA, and indicative of inequality within Africa due to alternative goods brought about by changes to terms of trade between regions and industrial sectors.
- The GTAP Model projections are used in the Intermodal Global Logistics Model described in the next chapter to simulate the present state (2016) and analyze projections (2040) of global maritime transport and land transport by road and rail along the east coast and southern part of Africa to simulate in quantitative terms the expansion of supply-demand gaps in logistics infrastructure in landlocked (land-linked) countries in Africa and other effects of reducing the cost of transport to landlocked (land-linked) countries. This application of GTAP Model projections demonstrates the robustness of the GTAP Model, and thus wider use of the models is expected in the future.

4. Intermodal Global Logistics Model Analysis

4-1 Interview Surveys

4-1-1 Survey Overview

- From February 25th to February 28th, 2019, JICA representatives visited Ethiopia to collect data such as the status and statistics of the logistics infrastructure around Ethiopia for calibration of the Intermodal Global Logistics Model.
- From November 27 to December 6, 2019, the study team visited Tanzania, Malawi, and South Africa to conduct interviews mainly of government-related organizations, Japanese corporations, and port operators in those three countries.
- The matters confirmed in the interviews are as follows.
  - Verification of current projections
  - Extraction of issues in the upcoming effort to improve the precision of the intermodal global logistics model
- The table below shows the schedule of the interview surveys.
- Details about the interview results in each country are shown in Table 4-1-1.
- The results of individual interviews are attached as reference materials.

Table 4-1-1: Schedule of Interview Surveys

Dates	Country	Overview
February 25 - 28	Ethiopia	Interviews with six individual companies
November 27-29	Tanzania	Workshop held at the JICA Tanzania Office Interviews with six individual companies
December 2-3	Malawi	Interviews with six individual companies
December 5-6	South Africa	Interviews with six individual companies

4-1-2 Survey Results

(1) Ethiopia

1) Overview of Interview Surveys

- In Ethiopia, the JICA representatives conducted individual interviews with Ethiopian ministries and agencies (maritime authority, customs), forwarders association, private trading companies, and private dry ports.
- The agencies visited are as follows;

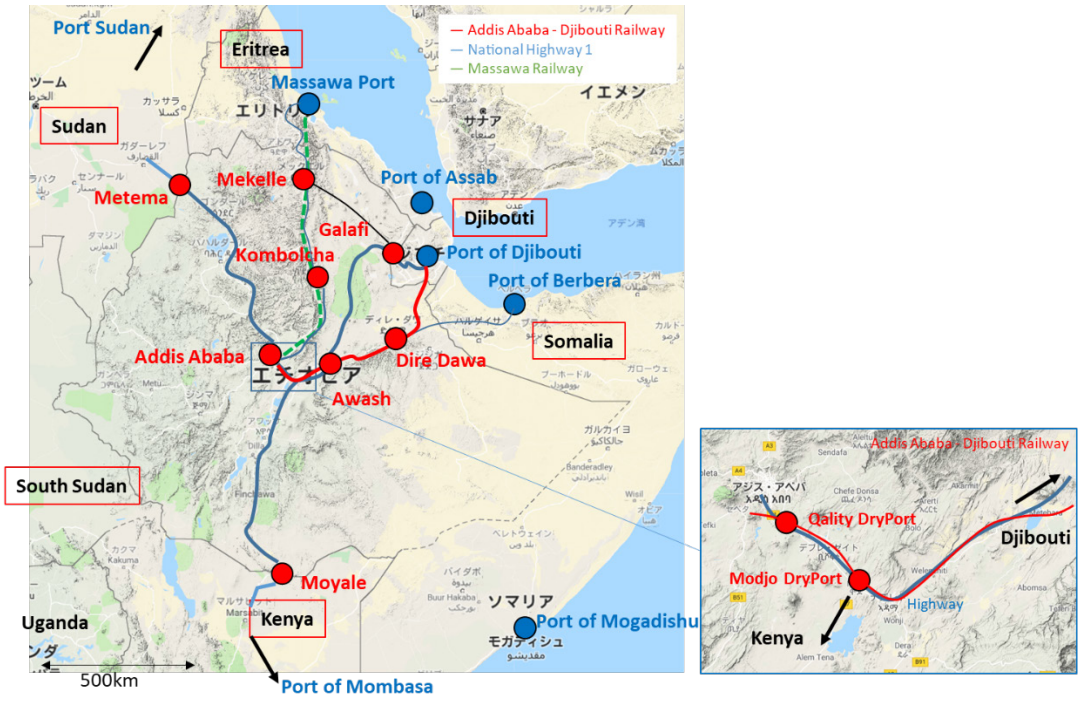
Table 4-1-2: Schedule of Interview Surveys (Ethiopia)

Agency	Agency Structure
Ethiopian Freight Forwarders & Shipping Agents	Forwarders association
Ethiopian Shipping & Logistics Service Enterprise (ES&LSE)	Private trade company
Ethiopian Maritime Affairs Authority	Ethiopian maritime authority (in charge of maritime containers)
Ethiopian Customs Commission	Customs (Cross border freight management)
Kality Dry Port	Private dry port
Mekelle Dry Port	Private dry port

2) Overview of Interview Survey Results

① Regarding Logistics Infrastructure in Ethiopia

- Freights to/ from Ethiopia are mostly transported via the Port of Djibouti with the main route being National Highway 1. While ports used for Ethiopian freights include Port Sudan (Sudan); Massawa Port and Port of Assab (Eritrea); Port of Djibouti (Djibouti); Port of Berbera and Port of Mogadishu (Somalia); and Port of Mombasa (Kenya), Port of Djibouti currently accounts for 95% of imports and exports.
- The Addis Ababa - Djibouti Railway is being built with China's support.
- It is reported that the Italian Government is currently considering provision of support for the construction of Massawa Railway, and thus is unclear whether the railway will be built. If the railway is built, the convenience of Port of Massawa will be improved and the logistics trends may change.



Source: Materials prepared by JICA

Figure 4-1-1: Main Logistics Infrastructures in Ethiopia

② Regarding Logistics Infrastructure connecting Eritrea

- At the time of the interview survey, the border between Ethiopia and Eritrea is open. However, according to the interviews, it is currently not used as a main route for Ethiopian cargo.
- The field survey was conducted along the above-mentioned route to as far as around the Ethiopian border, and the team found that the route is not yet suitable as a shipping route for marine containers, as the route includes a 400km mountain road between Mekelle Dry Port to Massawa Port beyond the 800 km from Addis Ababa (Ethiopia) to Mekelle Dry Port (Ethiopia). However, it is noteworthy that the route also consists of paved road sections that are wide enough for trucks to pass each other.
- With regards to access to/ from Somali side, further research on the transportation routes would be necessary, since it was not possible to identify any major arterial roads between Addis Ababa and Somali ports such as Berbera and Mogadishu.

(Approximately 800 km from Addis Ababa)

Source: Materials prepared by JICA

Figure 4-1-2: Road connecting Ethiopia and Ethiopia (Mekelle)

(2) Tanzania

1) Overview of Interview Surveys

- In Tanzania, 15 relevant organizations, including ministry agencies and multilateral development agencies, were interviewed at a workshop and exchange of opinions at the JICA Tanzania Office, and port observations were conducted and port operators were interviewed at the Port of Dar es Salaam.
- The table below shows the schedule of surveys.

Table 4-1-3: Schedule of Interview Surveys (Tanzania)

Date	Destination	Relevant Team
Wednesday, November 27	World Food Programme, Tanzania Office	GTAP/Logistics
Thursday, November 28	Workshop held at the JICA Tanzania Office	GTAP/Logistics
	Tanzania Freight Forwarders Association (TAFFA)	GTAP/Logistics
	Tanzania Railways Corporation (TRC)	GTAP/Logistics
Friday, November 29	Tanzania Trade Development Authority (TanTrade)	GTAP/Logistics
	Tanzania International Container Terminal Service (TICTS)※	Logistics
	Tanzania Revenue Authority (TRA)	GTAP

2) Overview of Interview Survey Results

① Regarding GTAP

Item	Main Interview Results
Agriculture	◆ For people engaged in small-scale agriculture, productivity is low, and losses are high due to insufficient crop storage technology and facilities. Incomplete cold chains for crop transport are also an issue. ✧ Irrigation and other forms of industrialization are needed to improve productivity, and crop storage technology improvement is needed to reduce losses. Additionally, cold chains must be improved to transport crops, the raw materials for the developing food processing industry.
Industrial structure	• The industrialization of the key industry of agriculture is progressing, and energy is devoted to developing a food

Item	Main Interview Results
	processing industry.
Tariff barriers	• Tanzania is a member of the EAC and the SADC, and is a community of the ECOWAS and other organizations. It is expected that these communities will be aggregated into a single organization in the future.

② Regarding Logistics

Item	Main Interview Results
Rail transport	• Transport demand is high, but transport capacity is low due to the deterioration of existing infrastructure. ✧ Regular service is nonexistent. 20-car trains operate in response to demand. ✧ Railways carry less than 1% of the national cargo load.
OSBP facilities	• The transition to a single-window system has shortened the wait time for crossing borders. ✧ Crossing borders previously took 7 to 10 days; now, it takes roughly three days. ✧ This has led to reductions in personnel expenses and trailer truck opportunity cost.
Inland waterway transport	• A project to rehabilitate the railway from Dar es Salaam to the Lake Victoria port of Mwanza is progressing (loans provided by the World Bank). ✧ Once complete, the development of a lake transport route between Mwanza, Tanzania, and Kampala, Uganda, is expected.
Port and harbor infrastructure	• Present capacity is insufficient, and operation is inefficient due to the deterioration of machinery ✧ Despite design capacity of roughly 400,000 TEU per year, the port handled more than 500,000 TEU per year as of 2018. ✧ Some cargo ships have to wait more than 10 days to enter the Port of Dar es Salaam due to congestion. ✧ The use of old machinery limits port operation to roughly half the efficiency of other ports operated by Hutchison.
Development plans	• Development projects are underway to resolve insufficient capacity. ✧ Three multipurpose berths will be converted into

Item	Main Interview Results
	dedicated container berths, and the entire seawall will be expanded toward the ocean to create sufficient depth and yard space. ✧ A white paper has been prepared on the development of a new port in Bagamoyo, but the Tanzanian government's policy is to continue considerations.

(3) Malawi

1) Overview of Interview Surveys

- In Malawi, government agency employees responsible for trade, international agencies involved in agriculture, and others were interviewed individually about GTAP, and port observations were conducted and government agency employees responsible for logistics were interviewed about logistics at Chipoka Port.
- The table below shows the schedule of surveys.

Table 4-1-4: Schedule of Interview Surveys (Malawi)

Date	Destination	Relevant Team
Monday, December 2	World Food Programme, Malawi Office	GTAP/Logistics
	Food and Agriculture Organization of the United Nations (FAO), Malawi Office	GTAP
	JICA Malawi Office	Logistics
Tuesday, December 3	Malawi Ministry of Transport and Public Works	Logistics
	Ministry of Finance, Economic Planning and Development	GTAP
	Ministry of Industry, Trade and Tourism (MITT)	GTAP
	Malawi Shipping Corporation	Logistics

2) Overview of Interview Survey Results

① Regarding GTAP

Item	Main Interview Results
Agriculture	• Maize exports are prohibited as a domestic anti-starvation measure, but low productivity is a factor in the low production quantity. Additionally, there is a lack of export

Item	Main Interview Results
	commodities; the country's agricultural product competitiveness is weak. Losses are high due to insufficient crop storage technology and incomplete cold chains. ✧ Cold chain development is vital toward expanding the export of mangoes and other products in good condition.
Industrial structure	• Like Tanzania, policies drive the industrialization of the key industry of agriculture, but major structural reform is not expected.
Tariff barriers	• The expectation that an FTA will go into effect by 2025 is not necessarily unrealistic; it could be achieved. FTAs are advantageous for countries with goods to export; however, for net-importing countries like Malawi that do not have many goods to export, FTAs bring the risk of removing barriers that protect domestic industries against exports.

② Regarding Logistics

Item	Main Interview Results
International freight transport	• Presently, much international freight goes through Mozambique and South Africa; little passes through Tanzania.
Rail transport	• Many railways have deteriorated, limiting transport capacity.
Inland waterway transport	• The national master plan aims to develop rail transport to and from the hub of Chipoka Port, and transport routes over Lake Malawi. ✧ The transport network is weak in the mountainous northern part of Malawi; transport routes over Lake Malawi should be effective. Additionally, the development of a corridor linking to Mtwara Port in Tanzania could lead to the development of transport routes over Lake Malawi. ✧ Furthermore, facilities at Chipoka Port require upgrading because they are small-scale, and the water is shallow.

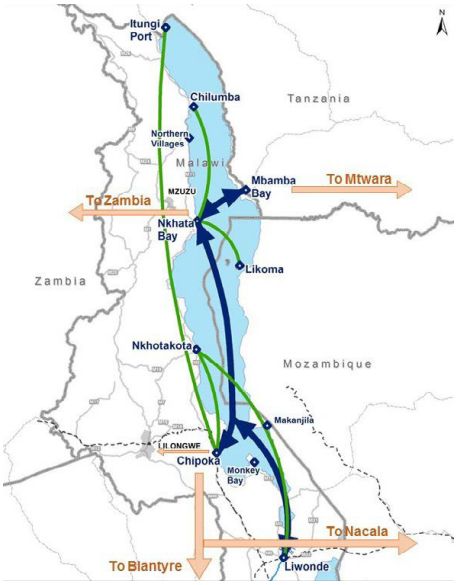


Figure 4-1-3: Chipoka Port

(4) South Africa

1) Overview of Interview Surveys

- In Malawi, government agency employees responsible for trade, international agencies involved in agriculture, and others were interviewed individually about GTAP, and port observations were conducted and government agency employees responsible for logistics were interviewed about logistics at Chipoka Port.
- The table below shows the schedule of surveys.

Table 4-1-5: Schedule of Interview Surveys (South Africa)

Date	Destination	Relevant Team
Monday, December 2	World Food Programme, Malawi Office	GTAP/Logistics
	Food and Agriculture Organization of the United Nations (FAO), Malawi Office	GTAP
	JICA Malawi Office	Logistics
Tuesday, December 3	Malawi Ministry of Transport and Public Works	Logistics
	Ministry of Finance, Economic Planning and Development	GTAP
	Ministry of Industry, Trade and Tourism (MITT)	GTAP
	Malawi Shipping Corporation	Logistics

2) Overview of Interview Survey Results

① Regarding GTAP

Item	Main Interview Results
Agriculture	• Packaging in which tobacco leaves produced in Malawi are taken to South Africa is an example of an established supply chain. However, even with demand for imports, without exports from the hinterlands, the cost of transport only flows in one direction, and the issues of processing and transporting those agricultural products to ports remain unresolved.
Industrial structure	• There are movements toward specialization in Africa through efforts such as shifting bases to African countries with low personnel costs, but issues with logistics limit the transition to retail and service industries. Additionally, efforts to develop industries in other African countries by attracting South African companies are limited to some ETZ.
Tariff barriers	• The AfCFTA went into effect in May 2019, but the issues of the extent and target goods of tariff reductions will not be resolved until the next phase. Another issue is how to open markets to South Africa, Nigeria, and the other top beneficiaries of abolished tariffs and the like.

② Regarding Logistics

Item	Main Interview Results
Rail transport	• Transnet is establishing development plans based on 30-year projections of transport demand (the company has detailed databases on the implementation status of development, maintenance, etc.). ✧ The company has its own economic models to project intensive freight volumes generated by each of the 200-plus local municipalities of South Africa, and models to assign the freight to railway lines. ✧ The company is also developing demand projection models and assignment models for the part of Africa south of and including Kenya.
Road transport	• Transnet is developing a network assignment model for economic corridors (similar to this study).

Item	Main Interview Results
	✧ The company has branch offices in Kenya, and is expanding into other parts of Africa outside South Africa. ✧ The company is interested in JICA's analysis in this study, and has expressed its desire to coordinate on matters such as demand projection methods.

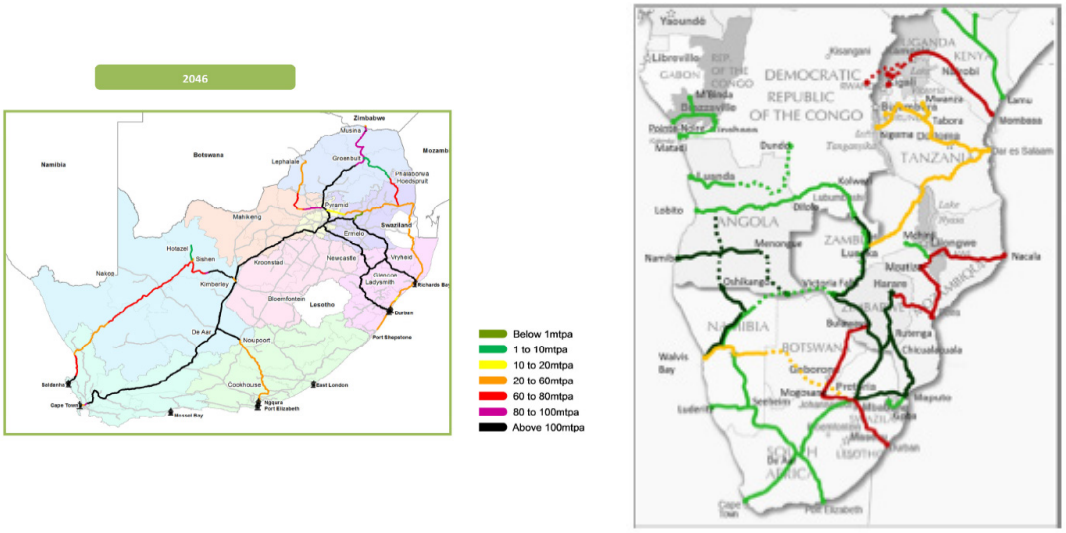


Figure 4-1-4: Freight Transport Demand (Left: Railway Network (2046), Right: Corridor (2044))

4-1-3 Summary

- The following table summarizes the relevance of the projections resulting from this study and future issues based on the interview results described previously.

Table 4-1-6: Main Interview Results and Relevance to the Project

Country	Interview Summary	Verification of Projections/Future Issues	
Tanzania	OSBP facilities reduce border-crossing time from 7-10 days to roughly 3 days	The present model assumes the facilities achieve a 50% reduction of border-crossing time; thus, the present model is relevant.	Verification
	Existing facility capacity at the Port of Dar es Salaam is insufficient; plans exist to expand functions and add new facilities	Confirm that the present model simulates the insufficiency of facility capacity	Verification
	Obtain statistical data for the Port of Dar es Salaam (TICT)	Utilize as a model reproducibility confirmation indicator	Verification
	A white paper has been prepared on the development of a new port in Bagamoyo, but the Tanzanian government's policy is to continue considerations	Reflect in the model in line with future conditions	Issue
	A project to rehabilitate the railway from the Port of Dar es Salaam to the Lake Victoria port of Mwanza is progressing Once complete, the development of a lake transport route between Mwanza, Tanzania, and Kampala, Uganda, is expected	Future issue: Adding to the inland railway/waterway transport network	Issue

Malawi	Efforts are being made to develop rail transport to and from the hub of Chipoka Port, and transport routes over Lake Malawi Specifically, the development of a corridor linking to Mtwara Port in Tanzania could lead to the development of the routes Chipoka Port requires repairs to deteriorated facilities	Future issue: Adding to the inland railway/waterway transport network	Issue
South Africa	Transnet is developing a network assignment model for economic corridors	Confirm that high-volume freight transport networks and the like essentially match in the results of Transnet model calculations and the current simulation	Verification

4-2 Objective and Procedure of Analysis

4-2-1 Objective of Logistics Model Analysis

- In this study, the intermodal global logistics model developed by University of Tokyo Associate Professor Shibasaki and others ("the Logistics Model") is applied to the Indo-Pacific, which includes the East Coast of Africa, to simulate the present state and analyze the future state of freight transport on actual marine and land transport networks within the region. This is done to identify infrastructure development issues in the region and gain implications for strategies therein.

4-2-2 Procedure and Flow of Analysis under the Logistics Model

- The analysis is conducted using the Logistics Model, which comprises two models—a simulation model for the present state, and a projection model for the future state.
- First, in the course of developing the simulation model, data on the present state of freight transport demand, freight transport networks, and the like is used to confirm the reproducibility under different parameter settings.
- After developing a simulation model that guaranteed sufficient reproducibility, future freight transport demand based on GTAP Model projections is input into

the Logistics Model to assign future freight transport demand. When doing so, simulation model settings are generally used as parameters for the projection model, but in this case, freight transport networks, their capacity, friction at borders, and other variables were reset based on future plans published by governmental agencies, and the scenarios from this study.

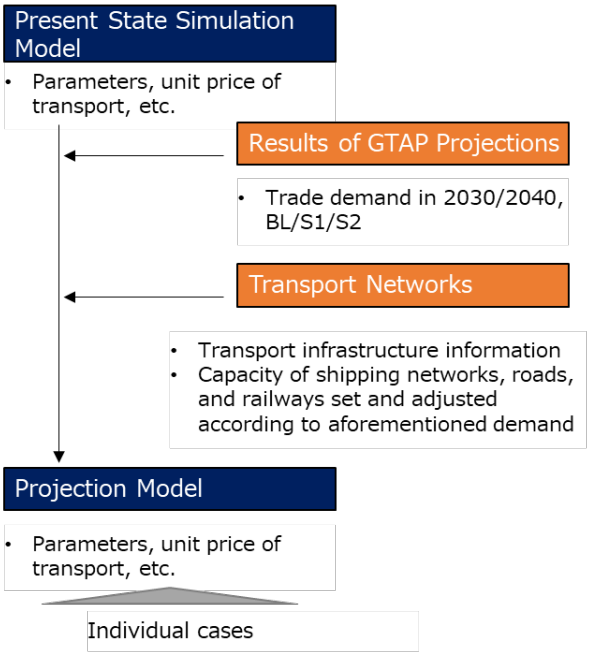


Figure 4-2-1: Flow of Consideration

4-2-3 Structure of the Logistics Model

- The intermodal global logistics model used in this study comprises three assignment models: two assignment models based on actual networks for (1) marine container freight transport between ports and (2) land freight transport within each port's hinterland (collectively, the low-level problems), and one assignment model based on the integration of the two actual networks into a hypothetical intermodal network (the high-level problem).

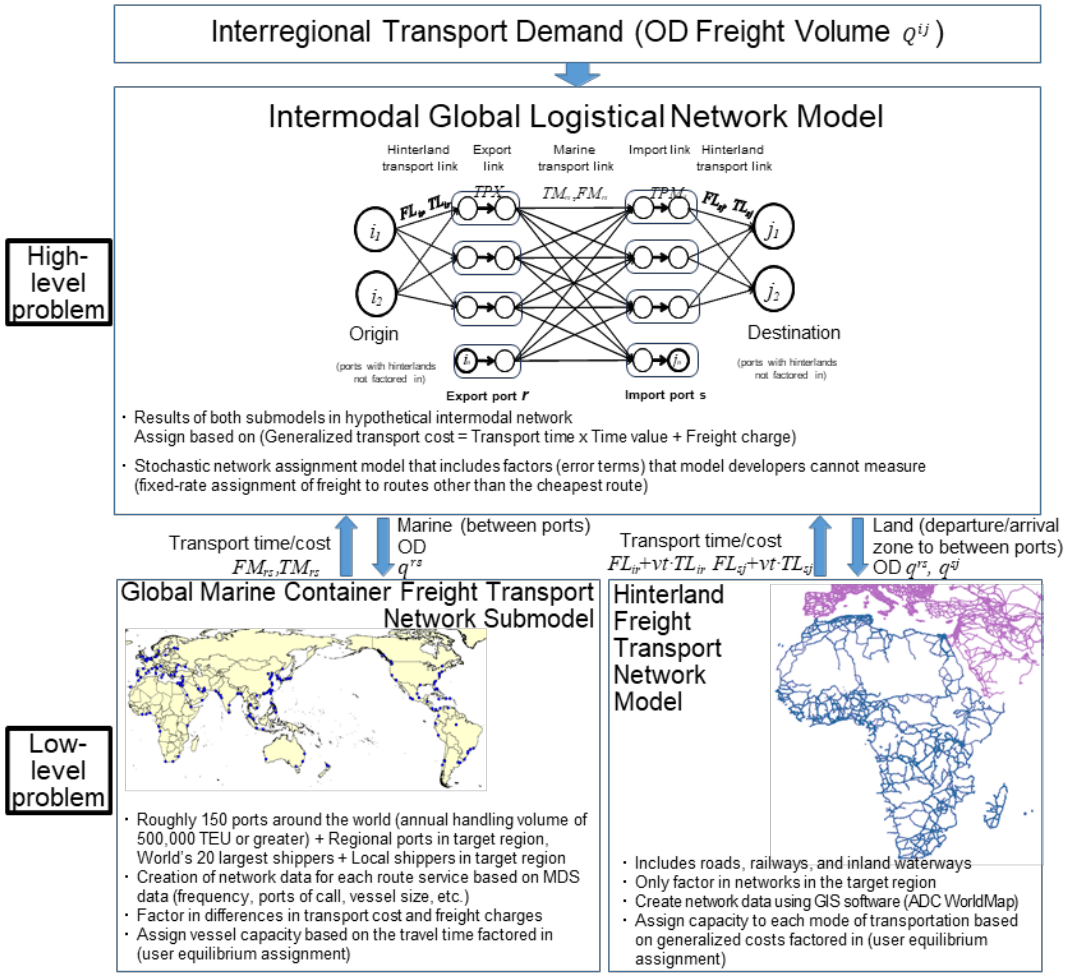


Figure 4-2-2: Structure of the Intermodal Global Logistics Model

- In the intermodal network (the upper-level problem), a stochastic assignment model directs a fixed quantity of freight along secondary and tertiary routes between all hypothetical OD links; in the marine container freight transport network model and the port hinterland transport network submodel (the lower-level problems), a user equilibrium assignment model factors in the capacities of ships, roads, railways, and other modes of transport in the actual networks. The freight volume and the transportation cost are serially calculated through the upper and lower level model.
- Details about the structures and calculations of the models are available in reference materials such as "Intermodal Global Logistics Model Structure for South Asia, and Policy Analysis" (Ryuichi Shibasaki, Tomoya Kawasaki), a research report by the National Institute for Land and Infrastructure Management that contains examples of analysis using the models.

4-2-4 Target Areas for Analysis

- The target of this analysis is the Indo-Pacific, with a particular focus on land transport in East Africa. The analysis involves simulating and projecting the flow of freight in freight transport networks within the hinterland of each port in the region. Additionally, a global maritime container transport model is used to analyze the flow of freight in container freight transport networks between ports around the world.

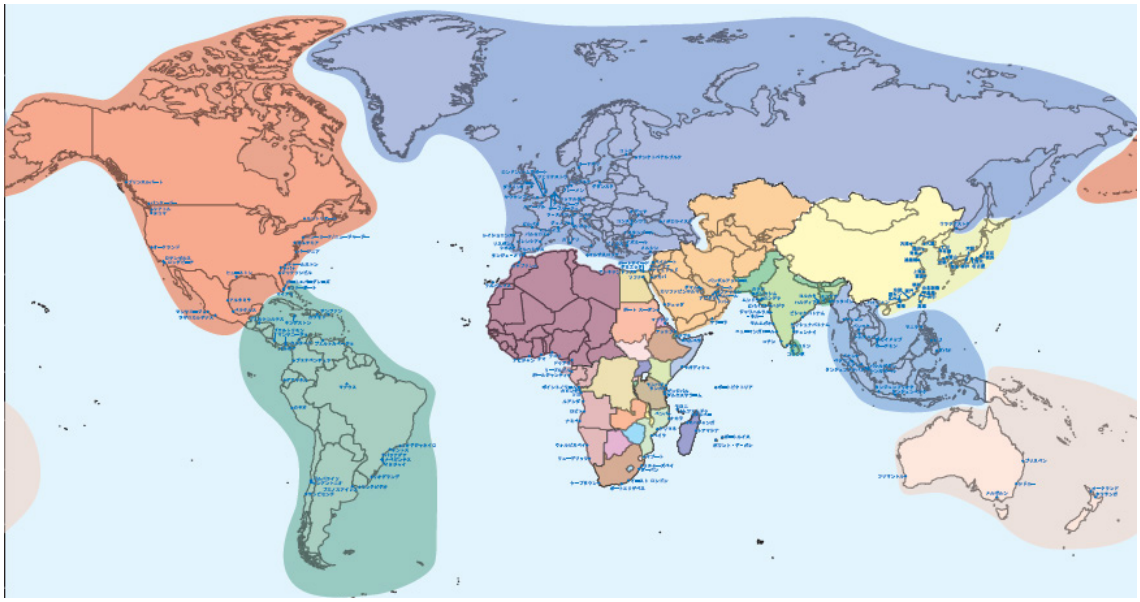


Figure 4-2-3: Ports in the Global Marine Container Transport Model (Blue)

- The countries shown in Table 4-2-1 were set as the area that factors in the port hinterland transport network in the Logistics Model in order to fully understand the dynamics of the movement of land freight transport in East African countries.
- Note that Namibia, Angola, on the west coast of Africa were added to the transport network as countries outside East Africa to factor in transport from landlocked countries. Although the transport networks of Angola and Namibia are factored into the model, land freight originating from those two countries is not factored in; for convenience, freight from the two countries is allocated to the freight volumes of the respective port nodes based on marine transport demand tables (marine transport OD tables). This is to focus on simulating the logistics situation on the East Africa regions.

Table 4-2-1: East African Countries Included in the Logistics Model

Target Country	Remarks		Target Country	Remarks
Angola	Land freight transport originating from Angola is excluded from model calculations		Mozambique	
Botswana			Namibia	Land freight transport originating from Namibia is excluded from model calculations
Burundi			Rwanda	
DR. Congo			Somalia	
Djibouti			South Africa	
Eritrea			South Sudan	
Ethiopia			Sudan	
Kenya			Eswatini	
Lesotho			Tanzania	
Madagascar			Uganda	
Malawi			Zambia	
Mauritius	Mauritius is an island country; there is no land transport network setting		Zimbabwe	

- Figure 4-2-4 shows target countries in East Africa included in port hinterland transport networks of the Logistics Model.

Figure 4-2-4: Target Countries of the Logistics Model

4-2-5 Establishing Initial Conditions

(1) Types of Input Data

- Table 4-2-2 shows the data to be prepared as input to the model.

Table 4-2-2: Input Data for the Logistics Model

No.	Data Type	Description	Source
1	Target ports	International ports (around the world), regional ports (East Africa)	CIY, Lloyds List, Drewry, port websites, etc.
2	Port hinterland freight transport networks	Networks of roads, railways, inland waterways, and the like to and from ports with hinterlands factored in	ADC WorldMap data, etc.
3	Freight transport demand between ports	OD tables for container freight transport demand between ports (TEU)	WTS, GTAP calculations, etc.
4	Interregional freight demand	OD tables for container freight transport demand between origins and destinations that include regions included in port hinterlands (TEU)	Trade statistics and statistical information from each country
5	Route data A. Regular route service information B. Data on distance between ports C. Information on routes through Suez/Panama canals	A. Transport service data by service and shipper B. Transport distance between target ports C. Judgment on passing through Panama Canal or Suez Canal for transport between ports	A. MDS data B. Websites for calculating transport distance between ports, etc. C. Websites for calculating transport distance between ports, etc.
6	Port charges/time data	Loading/unloading lead times and charges at target ports	World Bank data, etc.
7	Border/port export/import time data	Data on the cost/time required for export over borders/from ports	World Bank data, etc.

(2) Setting Target Ports

- A total of 218 target ports were set for the Logistics Model: 173 major container ports throughout the world that handle an annual volume of around 500,000 TEU, and 45 regional ports in East Africa, the southern part of Africa, and surrounding waters (including South Asia). Of the target ports, 31 ports in 11 countries (Sudan, Eritrea, Djibouti, Somalia, Kenya, Tanzania, Mozambique, South Africa, Namibia, Angola, and Madagascar) were set as ports that factor in port hinterland transport.

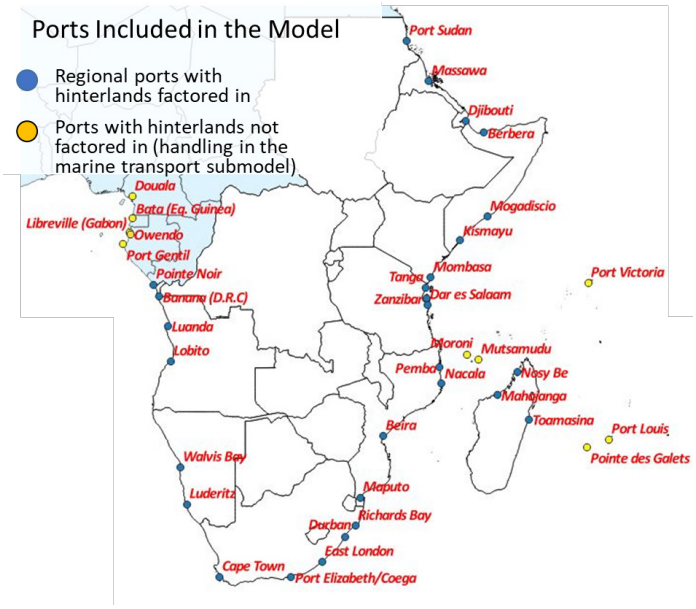


Figure 4-2-5: Target Ports in East Africa and the Southern Part of Africa

(3) Port hinterland freight transport networks

- As shown in Table 4-2-1, 23 countries (Angola, Botswana, Burundi, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Rwanda, Somalia, South Africa, South Sudan, Sudan, Eswatini, Tanzania, Uganda, Zambia, and Zimbabwe) are factored into port hinterland freight transport networks.
- These transport network settings were configured to include a scope sufficient for simulating land transport conditions in East Africa and the southern part of Africa.
- For example, the land transport network of Egypt was not included because the volume of land freight traffic between Sudan and Egypt is considered to be negligibly small as there are limited official data, and there are no major cross border transport infrastructures.

- In contrast, the Democratic Republic of the Congo occupies a broad area in the middle of Africa. While freight in the eastern part of the country likely passes through ports in Tanzania and Kenya, some freight in the western part of the country likely passes through ports in the neighboring Republic of the Congo (namely Pointe-Noire).
- Although this freight is excluded from this analysis due to the limited amount of quantitative information and the low proportion of container freight volume in the entire target region, logistics trends in the Democratic Republic of the Congo and the rest of Central Africa are a topic to be addressed in the future geographical expansion of the Logistics Model.
- As for road and railway networks and the link distances therein, ADC WorldMap data was used to incorporate the road networks and railway lines shown in the figure below into the Logistics Model. The road network was separated into roads and economic corridor networks based on PIDA-PAP (2015) for the analysis described later in this plan.

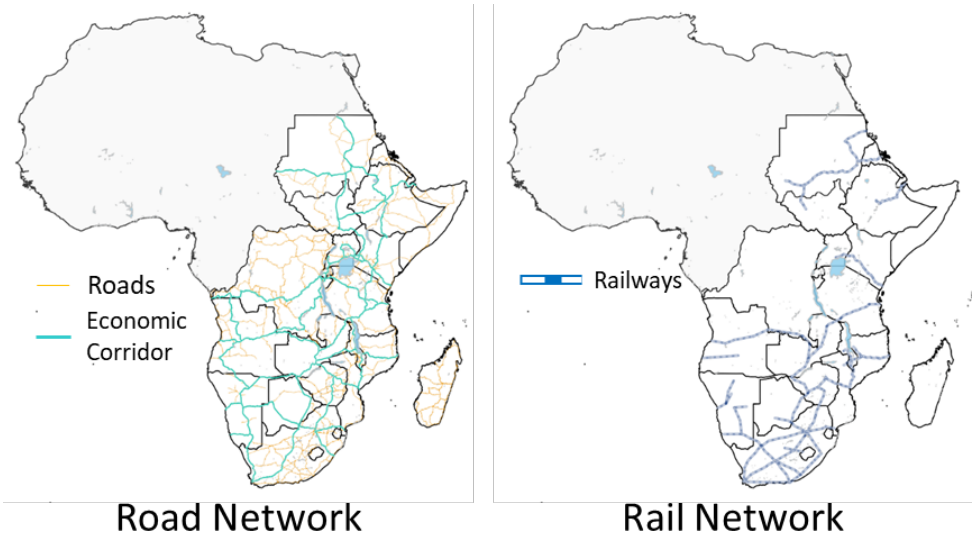


Figure 4-2-6: Port Hinterland Freight Transport Networks in East Africa and the Southern Part of Africa

(4) Creation of OD Tables for Freight Transport Demand Between Ports, and Interregional Freight Transport Demand (Present State Simulation)

- OD tables for present state simulation were created using the method of freight transport demand estimation developed by Ryuichi Shibasaki and others. The following figure shows the flow of OD table creation.
- Note that the regional economic indicators used for creating OD tables for interregional freight transport from OD tables for freight transport demand between ports are as described in the Table 4-5-3.

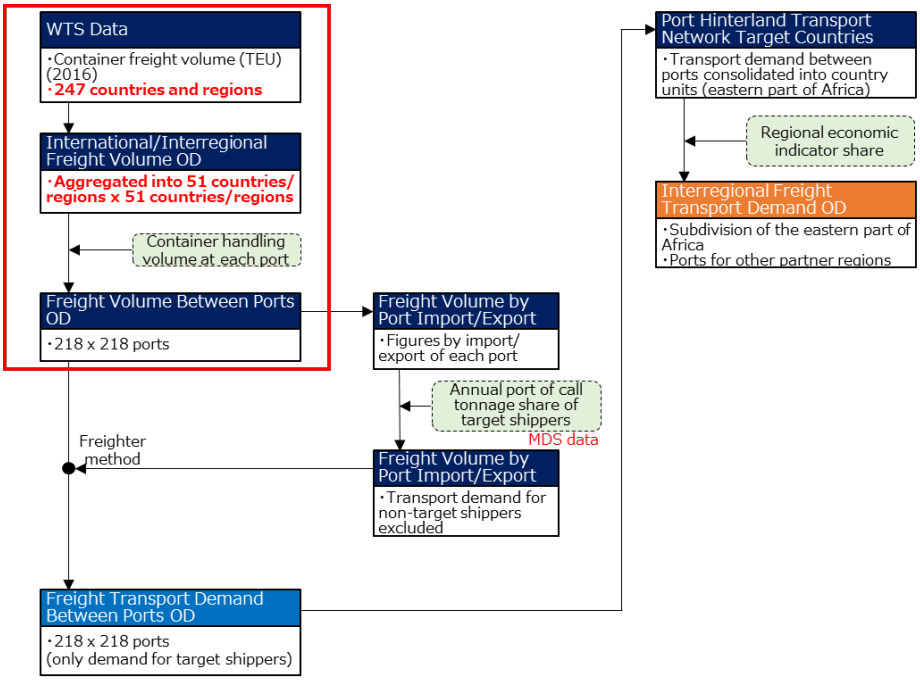


Figure 4-2-7: Flow of Creation of OD Tables for Freight Transport Demand

- The volumes handled by each port in the present state (2016) based on freight transport demand between ports are as shown on the table in Table 4-5-4.
- Additionally, OD tables for freight transport demand between ports were the basis for aggregating freight transport demand into regional units that include landlocked countries, and using population, GRDP, and other socioeconomic statistics to assign transport demand to regional nodes and create interregional transport demand tables (interregional OD tables).
- Note that the total transport demand for each regional node (the total of exports and imports) is as shown in Figure 4-2-8.

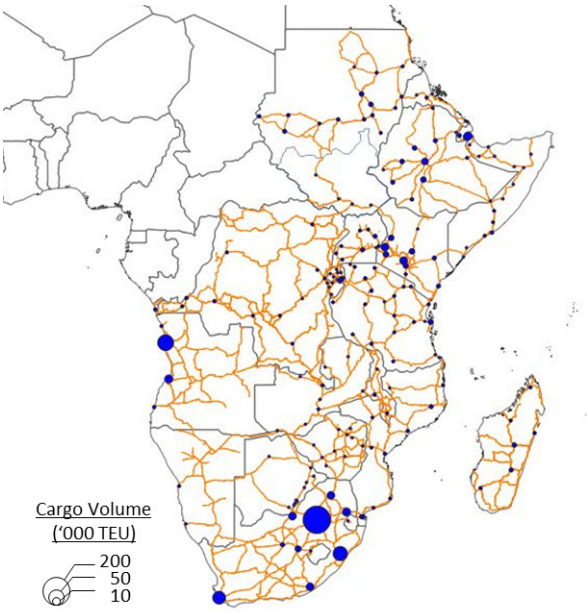


Figure 4-2-8: Transport Demand in Port Hinterlands (Exports and Imports)

(5) Creation of OD Tables for Freight Transport Demand (Projections Using the GTAP Model)

- The following figure shows the procedure for creating OD tables for freight transport demand using projections from the GTAP Model.
- Summary of the volumes handled at each port based on transport demand between ports in 2040 from Scenario S1 is listed in Table 4-5-4.

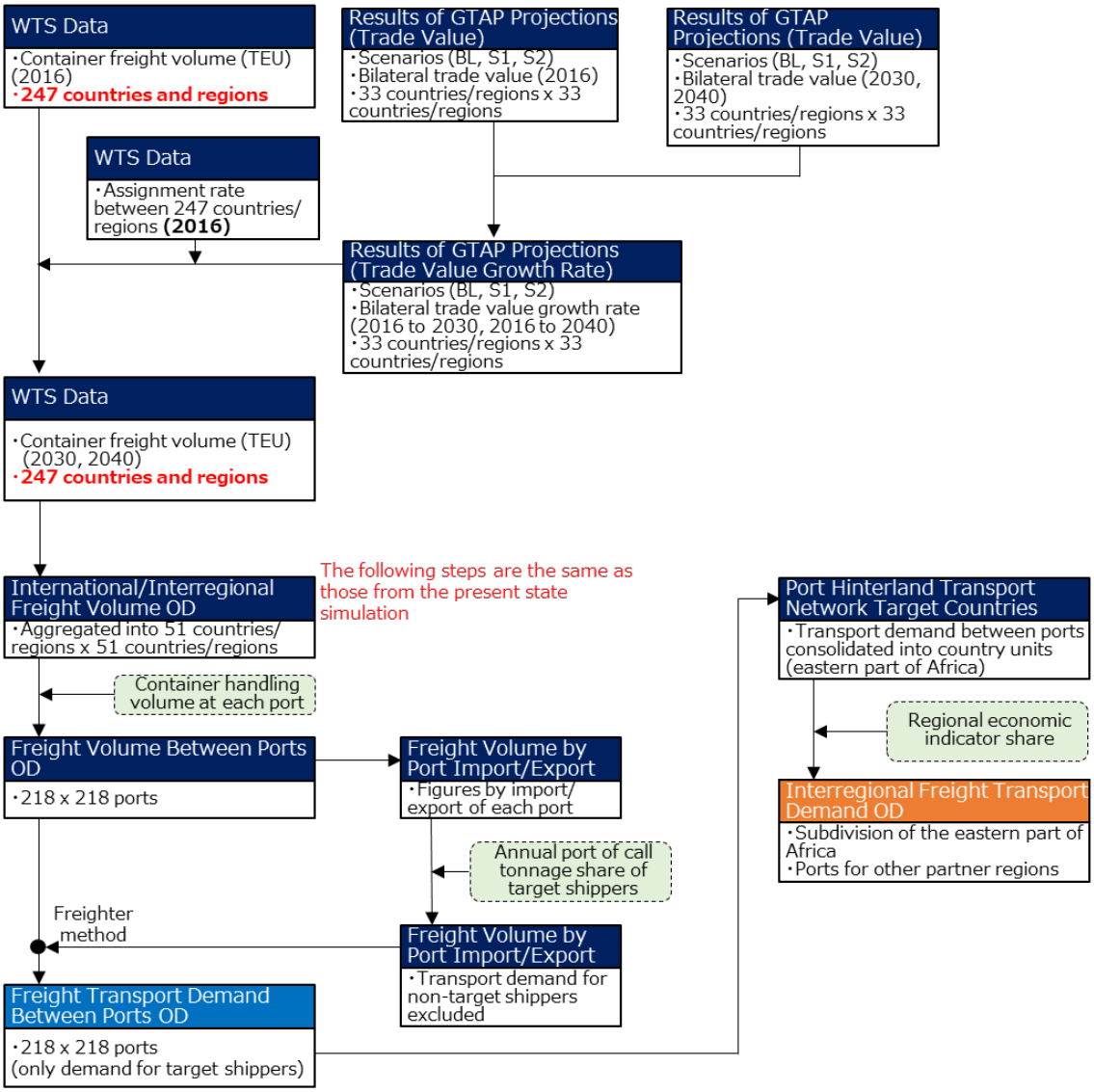
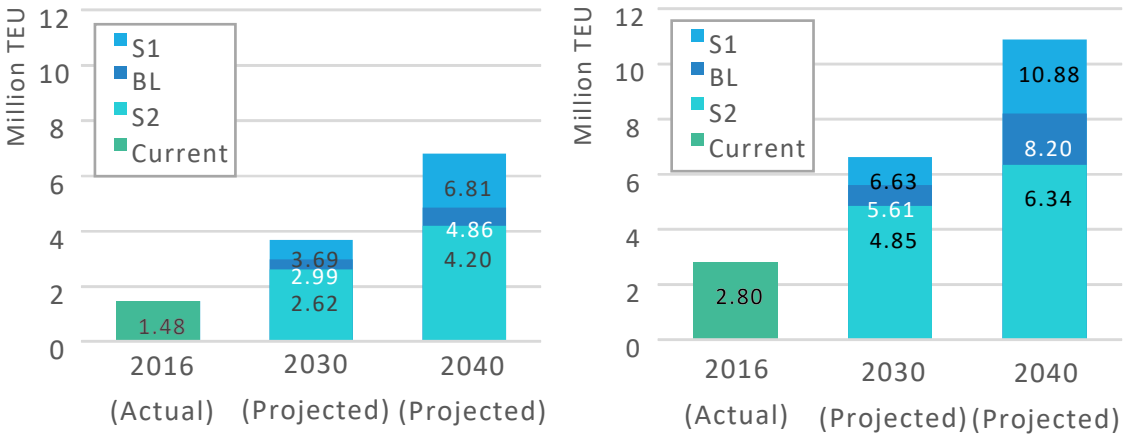


Figure 4-2-9: Flow of Creation of Tables for Freight Transport Demand Using GTAP Model Calculations

- Based on the procedure set out above, interregional freight transport demand was calculated using GTAP Model calculations. The following figure shows projected trends in total trade demand.
- In particular, Scenario S1 projects that exports will increase 460% and imports will increase 390% from 2016 to 2040.



(a) Trends in Regional Export Volume in Each Scenario

(b) Trends in Regional Import Volume in Each Scenario

Figure 4-2-10: Trends in Export and Import Volume in East Africa in Each Scenario

- The following figure summarizes calculations and rates of change in the volume of trade between East Africa and the rest of the world, with a focus on trade volume projections for 2040 in Scenario S1.
- According to the projections, East Asia will be the largest trade partner of East Africa in 2040.
- Additionally, the highest rate of trade volume growth is found in South Asia, where the export and import volume is projected to increase 700% from 2016 to 2040.

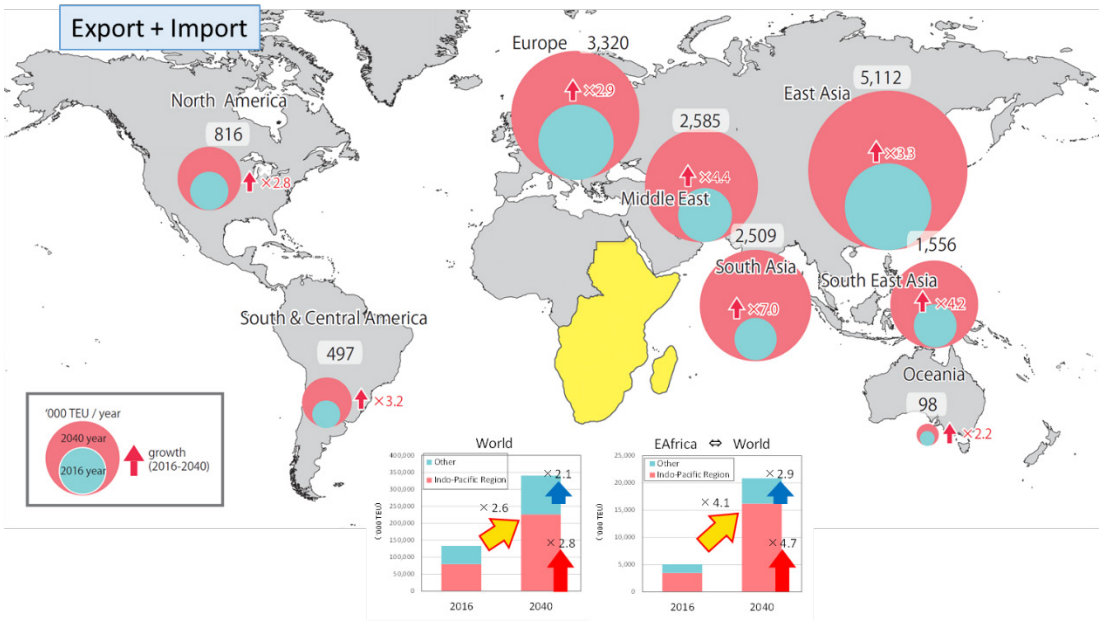


Figure 4-2-11: Changes in Volume of Trade with East Africa Comparison Between 2016 and 2040 (Scenario S1)

(6) Creation of Regular Route Service Information

- Actual container freight data provided by MDS Transmodal Inc. was used as regular route service information for marine freight transport.
- The data includes the name, IMO number, operators, joint operators, slot charters, MDS route classifications, port of call lists (call sequence), annual service frequency, tonnage in TEU and DWT, vessel speed, and more for each container ship.
- The following method was used to consolidate the data for regular route services to the target ports, resulting in data for 891 services as the input for the Logistics Model.

Points to Remember when Creating Data

Necessary input data, such as vessel speed, service frequency, vessel capacity, and port call are derived by the following process.

- ✧ When integrating data for each service, exclude non-target ports.
- ✧ Use values for each service obtained from MDS data for average vessel speed *va* (knots), average capacity *Vcapa* (TEU/ship), and service frequency *freqa* (ships/year) on target routes.
- ✧ In cases when multiple shippers form an alliance or other arrangement to provide target services through joint shipping, or when shippers that do not participate in vessel allocation implement slot charters, the capacity *capa* (TEU/ship) assigned to each shipper is the tonnage *Vcapa* of the target routes divided evenly between the joint shippers based on the assumption that shippers will not combine space after the fact.
- ✧ For slot charters, capacity is divided in the same way, assuming the securing of half the space of joint shippers (half of a shipper's share). For example, if two of the four shippers in a joint shipping agreement implement slot charters, and each of the joint shippers is assigned capacity *capa* of 20% of vessel capacity *Vcapa* (*capa* = 0.2 x *Vcapa*), the capacity of each slot charter shipper is 10% of vessel capacity (*capa* = 0.1 x *Vcapa*).
- ✧ Note that the assumption that shippers will not combine space after the fact is factored into model calculations for convenience because it is more realistic than assuming that each shipper is free to combine space in response to transport demand.

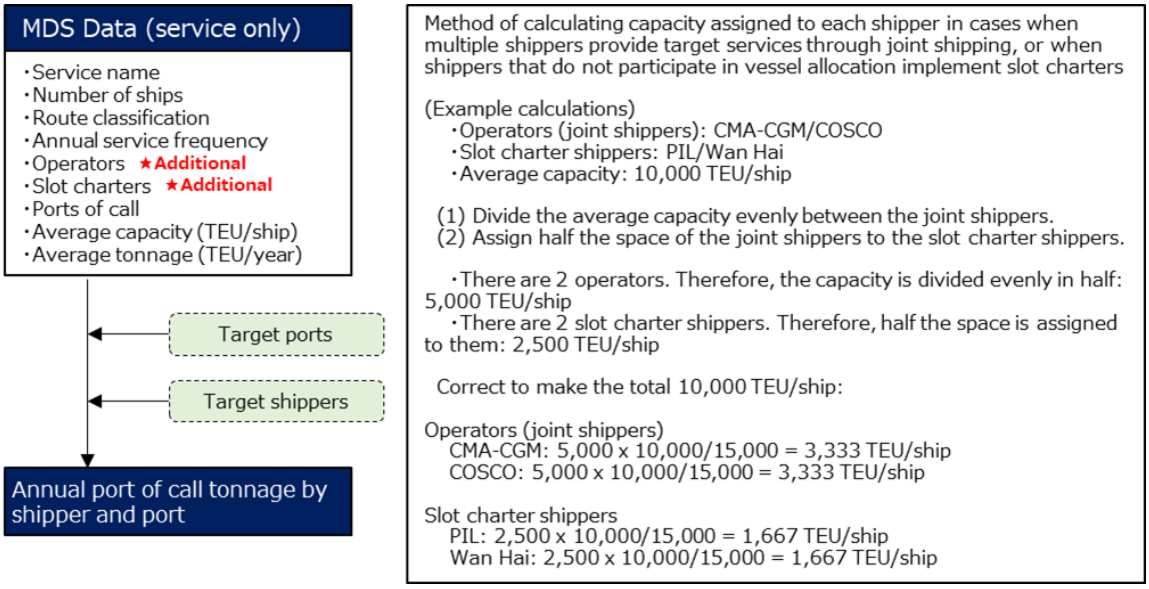


Figure 4-2-12: Flow of Creation of Regular Route Service Information Data

(7) Loading/Unloading Lead Times and Charges at Target Ports

- There are five model input variables for port service standards: port lead time for exports TPXr, port lead time for imports TPMs, transfer time TRa, port charges for export CHXa, and port charges for import CHMa.
- The World Bank's "Doing Business" database shows port loading and unloading times and charges for each country (and each region in some countries) for importing and exporting; thus, these figures are uniformly applied to four of the five variables for ports in the target countries and regions: port lead time and port charges for imports and exports (TPXr, TPMs, CHXa, and CHMa).
- It is worth noting that the database suspended the publication of loading and unloading times and charges for each port in the autumn of 2015. Therefore, the data used by Shibasaki and others[1] was also applied in this analysis.
- Unlike most of the target countries, Somalia, Eritrea, Sudan, South Sudan, the Democratic Republic of the Congo, and Lesotho were not included in similar data; for those countries, average times and charges from surrounding countries were used. Settings are as shown on Table 4-5-5.
- No obtainable data exists for times and charges for loading and unloading in target ports in each country or transfer time TRa set for each port; therefore, times were set in three stages—12 hours, 24 hours, and 48 hours—and assigned to ports in order of estimated efficiency of transshipments based on qualitative information. Note that past research by Shibasaki and others was factored into the settings. Settings are as shown on Table 4-5-4.

1 Shibasaki, Kawasaki (2016) "Intermodal Global Logistics Model Structure for South Asia, and Policy Analysis," NILIM Research Report No. 58

4-3 Present State Simulation Model Calculations

4-3-1 Setting Parameters

- The estimated values Shibasaki and others used to develop the model for South Asia were used for value of time for shipper vt, assignment parameter θ, and congestion functions b1 through b8. Parameter settings are as shown below.

Table 4-3-1: Parameter Settings

Value of Time for Shipper *vt*	Assignment Parameter θ	Parameters Included in Congestion Terms of Link Cost Functions							
		Marine		*Road*		*Railway*		*Inland Waterway*	
		b1	*b2*	*b3*	*b4*	*b5*	*b6*	*b7*	*b8*
0.5	0.05	2.308	1.017	1.0	3.0	2.0	2.0	2.0	2.0

4-3-2 Individual Settings for Capacity and Cost

(1) Speed and Capacity for Roads and Railways

- For road links, trailer truck traveling speed vRo is set to 60, 50, or 40 km/hour and road capacity capRo is set to 5,000,000, 1,000,000, or 100,000 TEU/year based on the road types (Motorway, Primary Route, Important Route) obtained from ADC WorldMap data.
- For railway links, rail speed vRa is set to a uniform rate of 20 km/hour, and container transport capacity per train capRa is set to 60 TEU/train in light of present conditions.
- Additionally, rail transport frequency freqRa is set based on operating information obtained from interviews, websites, and other sources.
- Given that operating conditions are unclear for many railways in East Africa, railways are assigned a frequency of one train per day when it is unclear how many trains are operating.

(2) Freight Charges and Loading and Unloading Time for Land Transport

- Past research and interview surveys were the basis for setting the freight charges (fixed costs, costs proportioned to transport distance) for each mode of land transport as well. For trailer truck freight charges, fixed costs *CFRo* were set to 60.0 USD/TEU, and costs proportioned to transport distance were set to 1.0 USD/km/TEU.
- Note that, for the cost for transport distance on roads, transport distances were

doubled to account for the projected round-trip cost of trailer trucks due to the prevalence of one-way shipments because imports to Africa far outpace exports from Africa; however, the cost of freight into and out of South Africa was reduced 20% (effectively 1.6 times the transport distance) to account for projections of a certain level of two-way shipments. This setting follows the consultation of committee member who has experience of logistics simulation in the southern Africa regions.

- As for railways, given that freight charges only account for the marginal cost, fixed costs CFRa were set to 0, and costs proportioned to transport distance CORa were set to 0.8 USD/km/TEU. Furthermore, loading and unloading time THRa was set to 24 hours. Note that past research by Shibasaki and others was factored into the settings

(3) Border Crossing Cost and Time

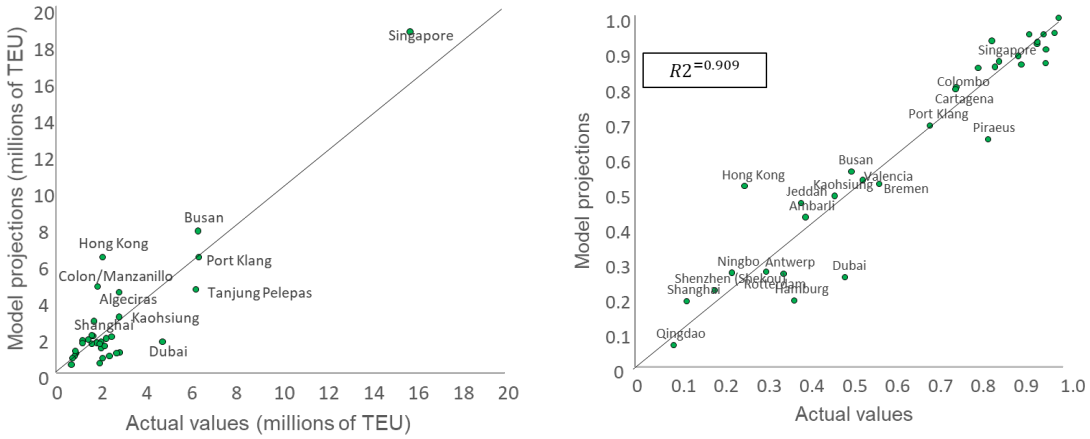
- Similar to port loading and unloading times and charges, the World Bank's "Doing Business" database has data on the additional cost of crossing borders; thus, these figures were used for the cost and time required for document preparation and customs procedures.
- A uniform border-crossing cost factor λa of 0.5 was assigned based on the results of past model calibration, except for pairs of countries with cross-border freight volumes that are exceptionally high (for example, Ethiopia and Djibouti) or low (for example, Somalia and its neighbors) due to political or cultural reasons, traditions, or the like, in which case the border-crossing cost factor was assigned individually.
- The table below shows the individual settings for border-crossing cost factor λa.

Table 4-3-2: Individual Settings for Border-Crossing Cost Factor λa

Exporter	Importer	Setting	Reason
Botswana	South Africa	0.3	Calibration in past research
Zambia	Botswana	0.3	Calibration in past research
Djibouti	Ethiopia	0.2	Ethiopia's dependence on the port of Djibouti
Ethiopia	Djibouti	0.2	Ethiopia's dependence on the port of Djibouti
Somalia	Ethiopia	1.0	Political factors, calibration results
Ethiopia	Somalia	1.0	Political factors, calibration results

4-3-3 Present State Simulation of Marine Transport Submodel

- The reproducibility of the initial (n = 0) calculations of the marine transport submodel with input of the initial value of marine freight transport demand between ports qrs0 is verified through comparison with present values.
- The freight transport demand between ports (volume of exported and imported freight at each port) is given in the marine transport submodel; therefore, the present values and actual values of transshipment freight volumes were compared.
- Here, as with the previous studies, actual values for transshipment freight volumes and percentages from the 34 major hub ports around the world listed in Drewry (annual transshipment volume of 1 million TEU or higher) were compared to model projections (Note that empty containers were excluded from freight volumes).
- In light of the above explanation, the reproducibility of the marine transport submodel is essentially reliable.

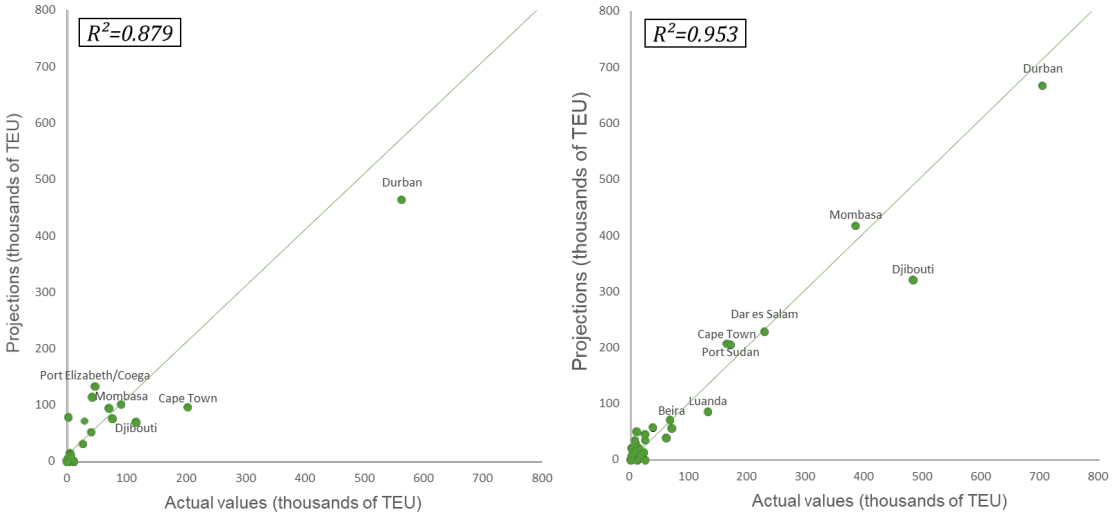


(a) Transshipment Freight Volume (b) Transshipment Percentage

Figure 4-3-1: Present Reproducibility of Marine Transport Submodel
(Transshipment Freight at Major Hub Ports in 2016)

4-3-4 Present State Simulation of the Entire Model

- Regarding the final calculations of the entire model with input of global marine container freight transport demand between regions Q^{ij}, first, the volume of exported and imported container freight handled at each East African port (excluding transshipments and empty containers), which is also a convergence criterion, was compared to the actual values. The figures below show the results.

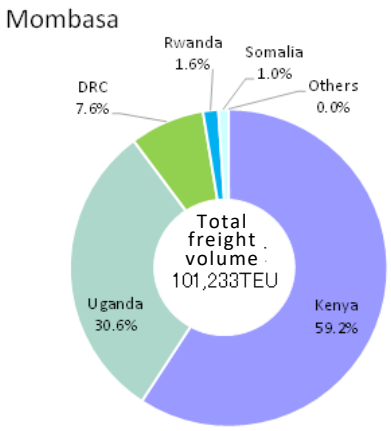
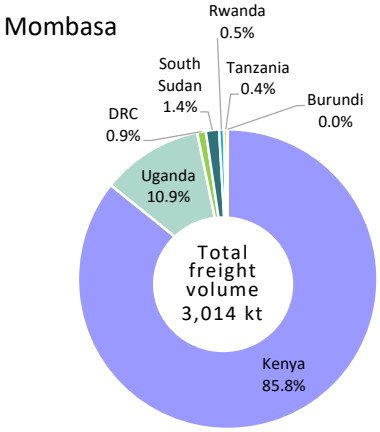
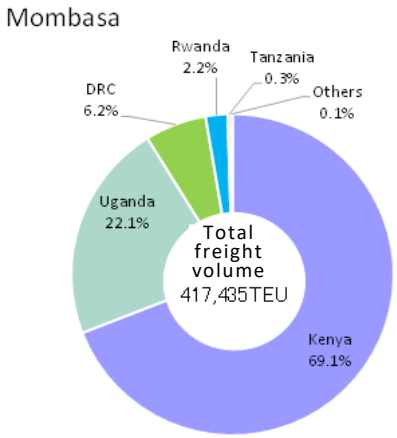
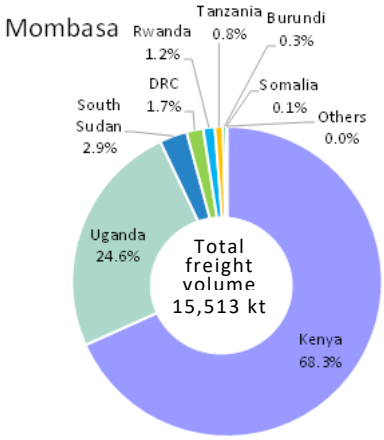


(a) Export Volume at Each Port in the Region

(b) Import Volume at Each Port in the Region

Figure 4-3-2: Present Reproducibility of the Entire Model (Container Freight Volume at East African Ports in 2016)

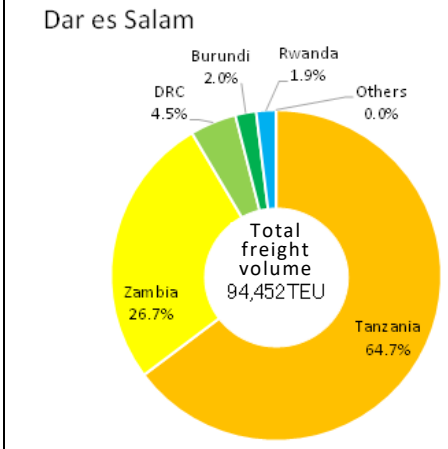
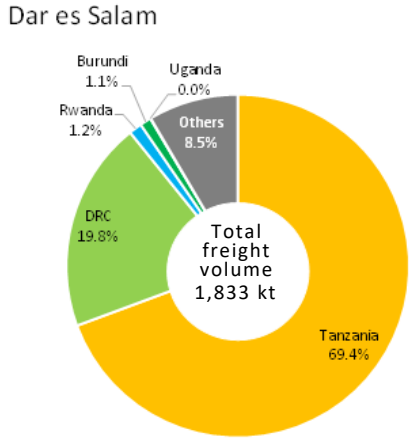
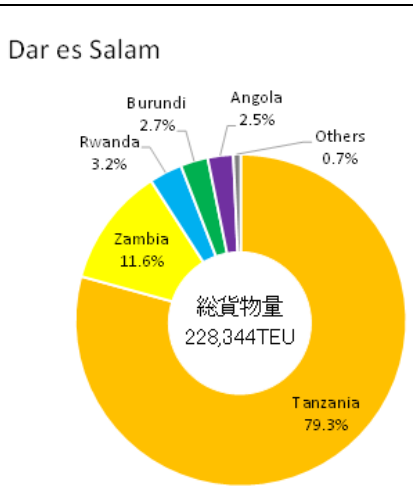
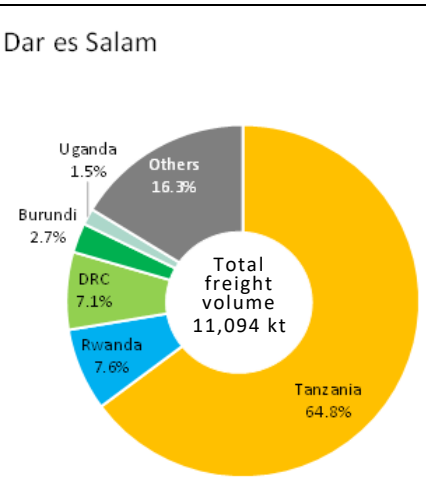
- Both figures show that the model is essentially capable of simulating the volume of exported and imported container freight handled at East African ports.
- To confirm reproducibility, the next step was to compare actual values (port statistics) of hinterland freight handled at each port to model projections.
- Note that the availability of port statistics in East Africa is generally limited. Thus, the comparison was conducted based on hinterland freight handling shares at ports for which statistics were available—the Port of Mombasa in Kenya (2015 statistics) and the Port of Dar es Salaam in Tanzania (2016 statistics).

	Present State Simulation Model Calculations (TEU)	Actual Figures: Port Statistics (t)
Export Share		
Import Share		

Source: Kenya Port Authority

Figure 4-3-3: Shares of Hinterland Freight Handling at the Port of Mombasa

- A simple comparison is not possible because the statistics are weight-based, but it can be confirmed that the model replicates the high volume of freight to and from Uganda and the low percentage of Tanzania freight (Tanzania uses its own ports) at the Port of Mombasa.
- For the Port of Dar es Salaam as well, a simple comparison is not possible because the statistics are weight-based, but it can be said that the model essentially replicates port usage by Rwanda and Djibouti.
- The model's calculations of the volume of freight into and out of the Democratic Republic of the Congo through the Port of Dar es Salaam may be too small. It needs to be noted, however, that more detailed data needs to be acquired to sufficiently evaluate and improve the accuracy of the model.

	Present State Simulation Model Calculations (TEU)	Actual Figures: Port Statistics (t)
Export Share		
Import Share		

Source: Annual Performance Monitoring Report 2017

Figure 4-3-4: Shares of Hinterland Freight Handling at the Port of Dar es Salaam

4-4 OD Freight Volume Projections

- OD freight volumes for container freight, bulk freight (coal, crude oil, LNG, iron ore), and RORO freight (finished motor vehicles) are projected.

4-4-1 Flow of Projection

- Using the following flow, OD freight volumes are projected by multiplying OD freight volumes between pairs of countries based on WTS data (actual figures) by growth rates from the results of GTAP projections.
- Note that another method of projecting OD freight volumes is to multiply the results of GTAP projections by base units from actual OD data (container conversion rates, etc.). However, depending on the way base units are set, the OD table values could simply result in errors.
- In light of the above and discussions at Study Groups, the decision was made to use growth rates from the results of GTAP projections (for details, see documents from the third Study Group).

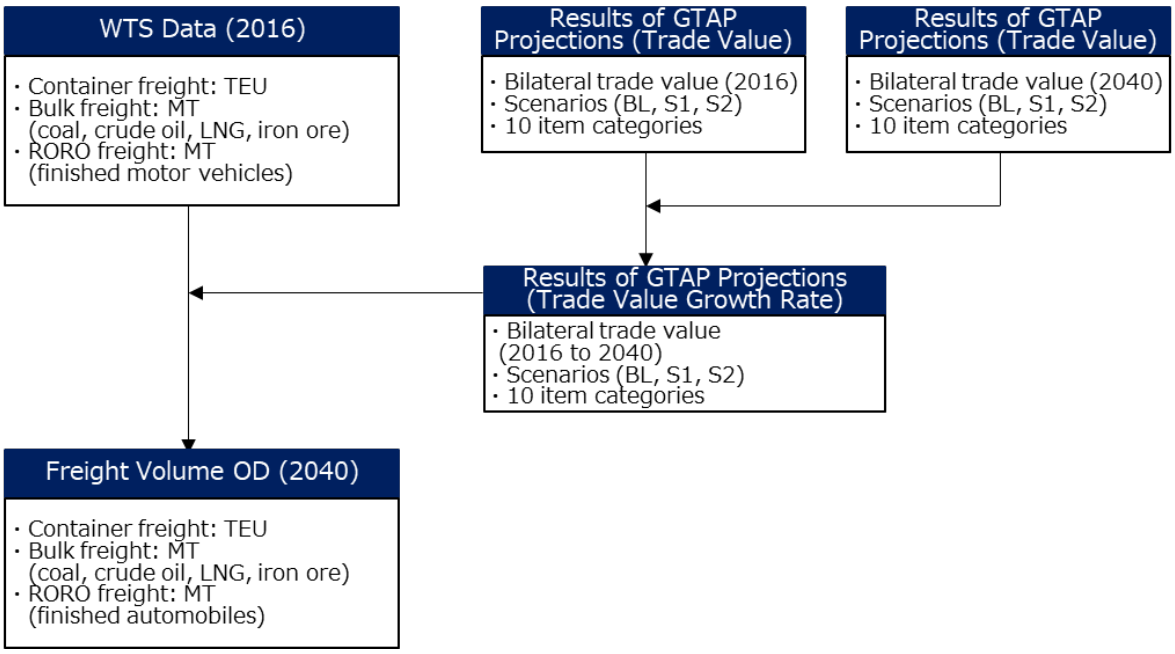


Figure 4-4-1: Flow of OD Freight Volume Projection

4-4-2 Results of OD Freight Volume Projections

- The results of OD freight volume projections are as shown below.
- Note that these projections are based on GTAP trade value growth rates in Scenario S1 (2040).

(1) Container Freight Volume OD

- Table 4-4-1 and Figure 4-4-2 show the results of container freight volume OD projections.

Table 4-4-1: Results of Container Freight Volume OD Projections

Region	Exports (x 10,000 TEU)			Average Annual Growth Rate		Imports (x 10,000 TEU)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	3,811	5,350	12,653	3.5%	3.7%	2,426	3,200	7,798	2.8%	3.8%
02_Southeast Asia	1,094	1,659	5,142	4.3%	4.8%	801	1,658	5,035	7.5%	4.7%
03_South Asia	276	445	2,081	4.9%	6.6%	229	534	1,839	8.8%	5.3%
04_West and Central Asia	419	770	2,248	6.3%	4.6%	649	1,144	2,875	5.8%	3.9%
05_North America	999	1,518	2,978	4.3%	2.8%	2,135	2,440	4,952	1.3%	3.0%
06_Central and South America	760	904	1,791	1.8%	2.9%	558	860	1,962	4.4%	3.5%
07_Europe	1,357	1,859	3,847	3.2%	3.1%	1,649	2,059	4,530	2.2%	3.3%
08_East Africa	168	240	1,141	3.6%	6.7%	239	425	1,709	5.9%	6.0%
09_North Africa	34	45	175	2.8%	5.9%	107	200	658	6.4%	5.1%
10_West Africa	55	94	952	5.5%	10.1%	135	237	1,176	5.8%	6.9%
11_South Central Africa	12	12	64	▲0.5%	7.3%	34	49	148	3.7%	4.7%
12_Oceania	185	261	456	3.5%	2.4%	177	360	764	7.3%	3.2%
13_Rest of the World	83	186	513	8.4%	4.3%	112	176	597	4.7%	5.2%
00_World	9,252	13,340	34,041	3.7%	4.0%	9,252	13,340	34,041	3.7%	4.0%

*Not including intraregional freight in Europe

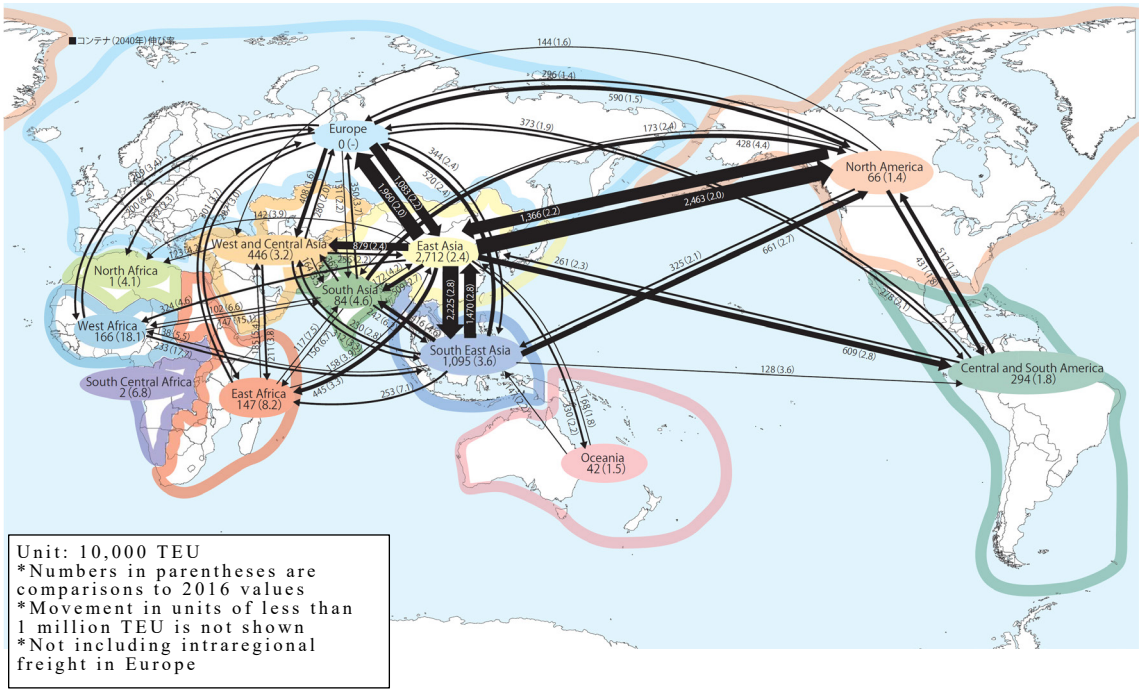


Figure 4-4-2: Results of Container Freight Volume OD Projections

(2) Bulk Freight Volume (Coal)

- Table 4-4-2 and Figure 4-4-3 show the results of bulk freight volume (coal) OD projections.

Table 4-4-2: Results of Bulk Freight Volume (Coal) OD Projections

Region	Exports (millions of MT)			Average Annual Growth Rate		Imports (millions of MT)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	61	8	27	▲18.4%	5.2%	358	550	951	4.4%	2.3%
02_Southeast Asia	190	313	959	5.1%	4.8%	31	82	252	10.2%	4.8%
03_South Asia	0	0	1	▲1.0%	3.5%	50	202	983	15.0%	6.8%
04_West and Central Asia	0	1	1	16.3%	4.2%	16	35	91	7.8%	4.1%
05_North America	27	29	81	1.0%	4.3%	10	5	6	▲6.8%	1.1%
06_Central and South America	39	82	187	7.8%	3.5%	16	30	59	6.5%	2.8%
07_Europe	20	88	273	15.8%	4.8%	142	83	117	▲5.2%	1.4%
08_East Africa	66	79	387	1.7%	6.8%	4	7	27	4.4%	6.0%
09_North Africa	0	0	0	-	5.6%	4	6	22	2.2%	5.8%
10_West Africa	0	0	0	-	-	1	2	14	13.2%	9.1%
11_South Central Africa	0	0	0	▲48.2%	6.0%	0	0	0	26.8%	6.7%
12_Oceania	239	396	601	5.2%	1.8%	2	1	3	▲4.2%	3.2%
13_Rest of the World	1	6	10	22.9%	1.6%	9	0	1	▲31.0%	6.5%
00_World	643	1,002	2,526	4.5%	3.9%	643	1,002	2,526	4.5%	3.9%

*Including both raw coal and ordinary coal
*Not including intraregional freight in Europe

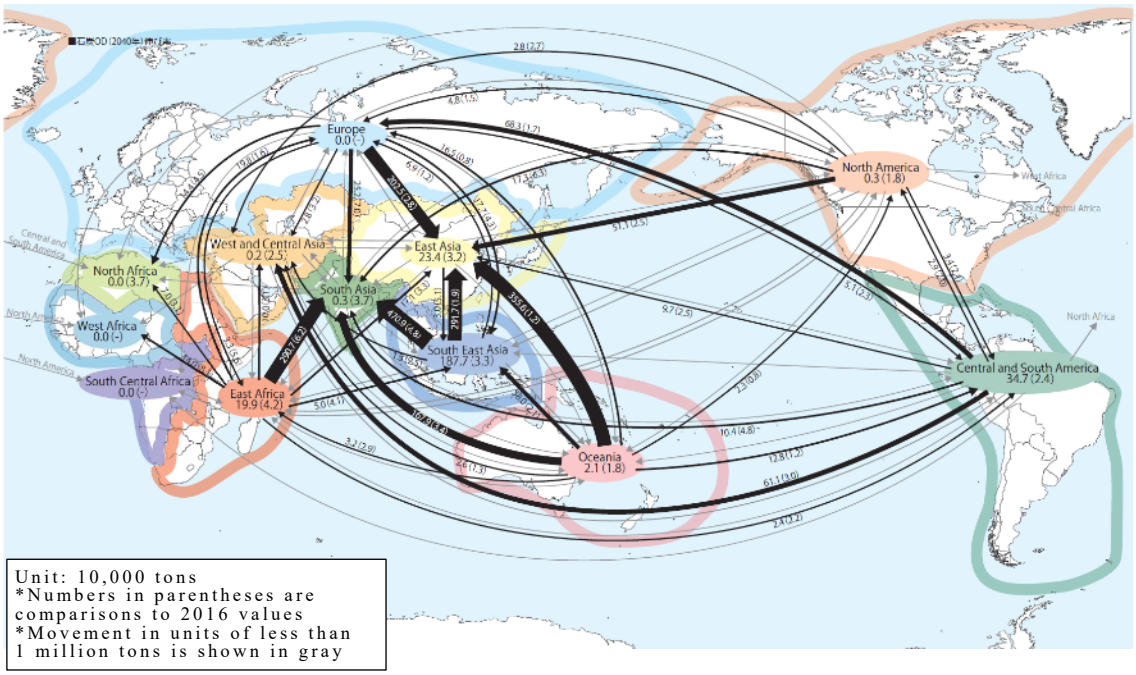


Figure 4-4-3: Results of Bulk Freight Volume (Coal) OD Projections

(3) Bulk Freight Volume (Crude Oil)

- Table 4-4-3 and Figure 4-4-4 show the results of bulk freight volume (crude oil) OD projections.

Table 4-4-3: Results of Bulk Freight Volume (Crude Oil) OD Projections

Region	Exports (millions of MT)			Average Annual Growth Rate		Imports (millions of MT)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	6	3	11	▲6.4%	5.6%	533	804	1,735	4.2%	3.3%
02_Southeast Asia	60	44	95	▲3.0%	3.2%	125	128	428	0.2%	5.2%
03_South Asia	0	0	0	13.7%	▲0.4%	97	185	721	6.7%	5.8%
04_West and Central Asia	775	1,032	1,912	2.9%	2.6%	55	14	52	▲12.5%	5.5%
05_North America	18	28	73	4.4%	4.1%	74	14	26	▲15.5%	2.7%
06_Central and South America	83	159	469	6.7%	4.6%	78	53	103	▲3.7%	2.8%
07_Europe	61	84	261	3.2%	4.8%	283	295	439	0.4%	1.7%
08_East Africa	19	18	50	▲0.7%	4.4%	28	25	95	▲1.2%	5.7%
09_North Africa	110	44	151	▲8.8%	5.3%	5	2	5	▲8.4%	3.6%
10_West Africa	66	78	390	1.7%	6.9%	7	5	48	▲2.2%	9.5%
11_South Central Africa	63	98	337	4.5%	5.3%	0	0	0	12.6%	8.6%
12_Oceania	14	21	43	4.2%	3.1%	26	28	59	1.0%	3.1%
13_Rest of the World	37	12	45	▲10.3%	5.6%	3	66	125	38.4%	2.7%
00_World	1,313	1,621	3,838	2.1%	3.7%	1,313	1,621	3,838	2.1%	3.7%

*Not including intraregional freight in Europe

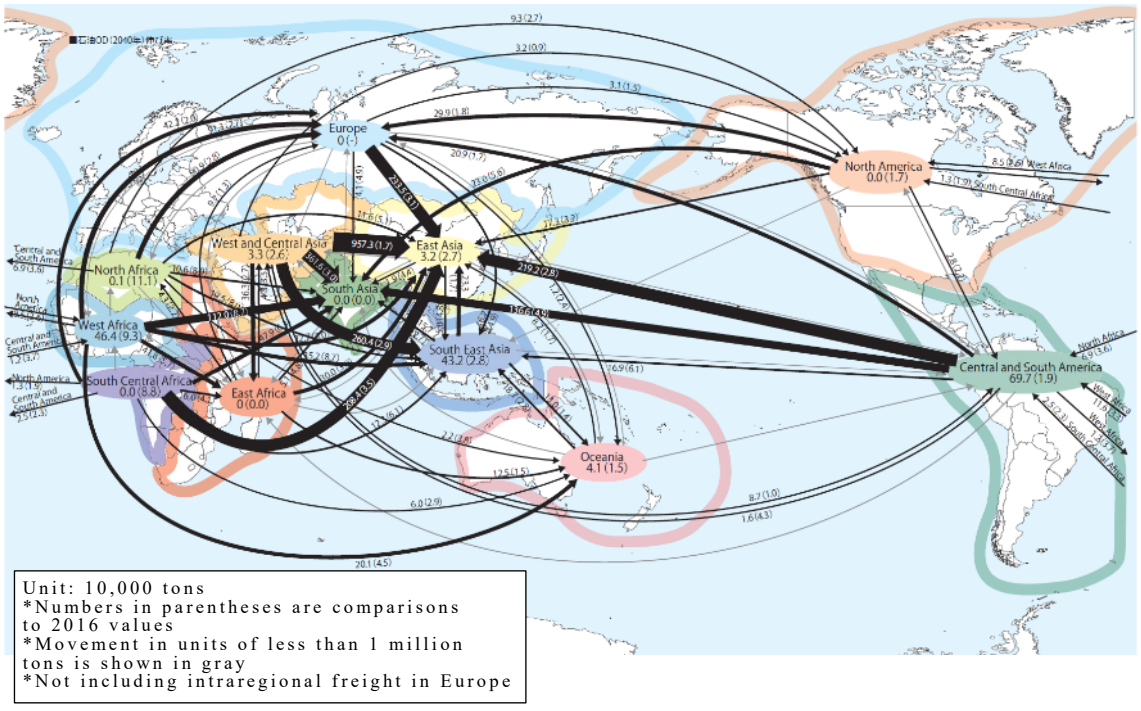


Figure 4-4-4: Results of Bulk Freight Volume (Crude Oil) OD Projections

(4) Bulk Freight Volume (LNG)

- Table 4-4-4 and Figure 4-4-5 show the results of bulk freight volume (LNG) OD projections.

Table 4-4-4: Results of Bulk Freight Volume (LNG) OD Projections

Region	Exports (millions of MT)			Average Annual Growth Rate		Imports (thousands of MT)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	1,063	2,198	7,518	7.5%	5.3%	119,932	184,501	363,420	4.4%	2.9%
02_Southeast Asia	54,300	56,243	114,994	0.4%	3.0%	4,467	18,208	56,904	15.1%	4.9%
03_South Asia	68	18	38	▲12.5%	3.2%	9,391	27,208	111,226	11.2%	6.0%
04_West and Central Asia	82,365	128,345	280,676	4.5%	3.3%	7,969	12,494	40,071	4.6%	5.0%
05_North America	7	13	18	6.1%	1.5%	1,303	1,304	2,012	0.0%	1.8%
06_Central and South America	5,928	9,811	18,390	5.2%	2.7%	3,145	9,886	26,230	12.1%	4.1%
07_Europe	235,753	97,723	188,216	▲8.4%	2.8%	39,854	28,516	46,054	▲3.3%	2.0%
08_East Africa	10,649	1,333	1,348	▲18.8%	0.0%	2,500	4,353	9,227	5.7%	3.2%
09_North Africa	21,780	14,093	59,750	▲4.3%	6.2%	1,461	1,723	5,174	1.7%	4.7%
10_West Africa	8,977	14,563	66,033	5.0%	6.5%	244	645	4,369	10.2%	8.3%
11_South Central Africa	827	2,135	6,314	10.0%	4.6%	6	1	1	▲13.4%	▲2.8%
12_Oceania	16,532	52,335	70,394	12.2%	1.2%	3,462	748	1,553	▲14.2%	3.1%
13_Rest of the World	3,659	2,169	5,842	▲5.1%	4.2%	248,176	91,391	153,291	▲9.5%	2.2%
00_World	441,909	380,978	819,532	▲1.5%	3.2%	441,909	380,978	819,532	▲1.5%	3.2%

*Not including intraregional freight in Europe

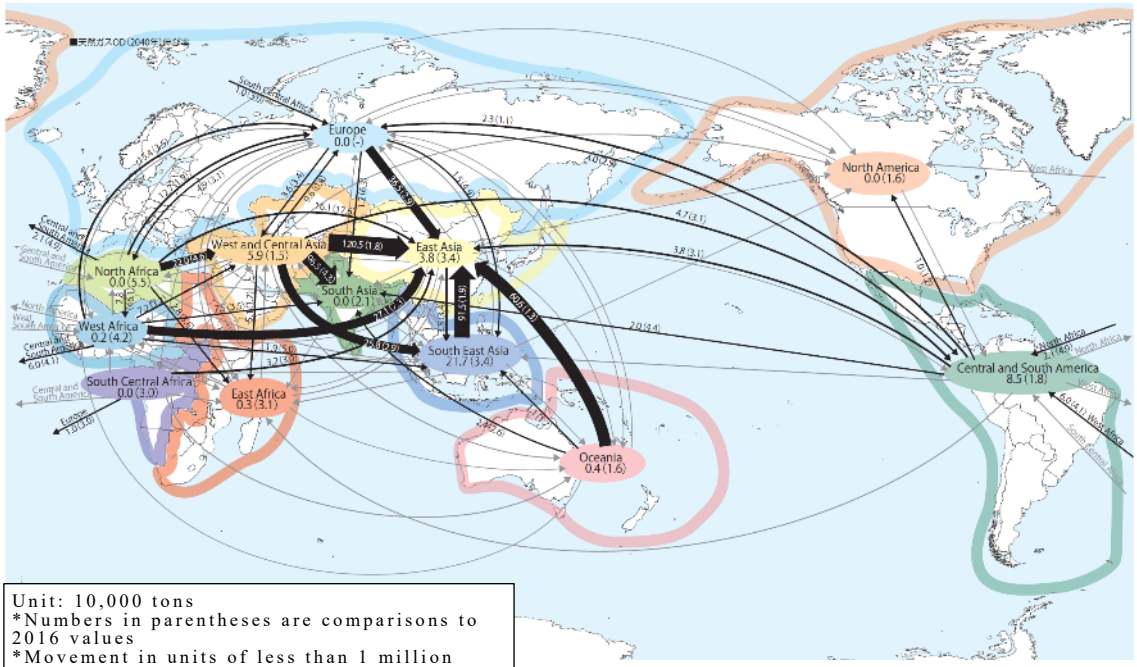


Figure 4-4-5: Results of Bulk Freight Volume (LNG) OD Projections

(5) Bulk Freight Volume (Iron Ore)

- Table 4-4-5 and Figure 4-4-6 show the results of bulk freight volume (iron ore) OD projections.

Table 4-4-5 Results of Bulk Freight Volume (Iron Ore) OD Projections

Region	Exports (millions of MT)			Average Annual Growth Rate		Imports (millions of MT)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	0	0	1	1.9%	4.3%	527	1,361	2,855	9.9%	3.1%
02_Southeast Asia	12	27	60	8.5%	3.4%	9	35	108	14.0%	4.9%
03__South Asia	86	18	48	▲14.5%	4.2%	2	12	55	22.2%	6.7%
04_West and Central Asia	6	20	43	12.6%	3.2%	17	34	89	6.8%	4.1%
05_North America	23	41	79	6.0%	2.8%	5	5	7	▲0.0%	2.0%
06_Central and South America	259	411	940	4.7%	3.5%	8	5	11	▲3.9%	3.1%
07_Europe	13	33	74	9.4%	3.4%	142	103	169	▲3.2%	2.1%
08_East Africa	44	112	300	9.9%	4.2%	7	5	23	▲2.3%	6.4%
09_North Africa	0	0	0	▲8.0%	4.5%	4	1	3	▲13.2%	4.8%
10_West Africa	11	34	116	12.2%	5.2%	0	0	0	▲25.6%	10.5%
11_South Central Africa	3	3	7	0.8%	3.9%	0	0	0	9.3%	7.1%
12_Oceania	262	854	1,643	12.5%	2.8%	6	1	2	▲16.6%	2.4%
13_Rest of the World	8	6	11	▲2.5%	2.4%	2	0	0	▲28.2%	4.1%
00_World	728	1,560	3,323	7.9%	3.2%	728	1,560	3,323	7.9%	3.2%

*Not including intraregional freight in Europe

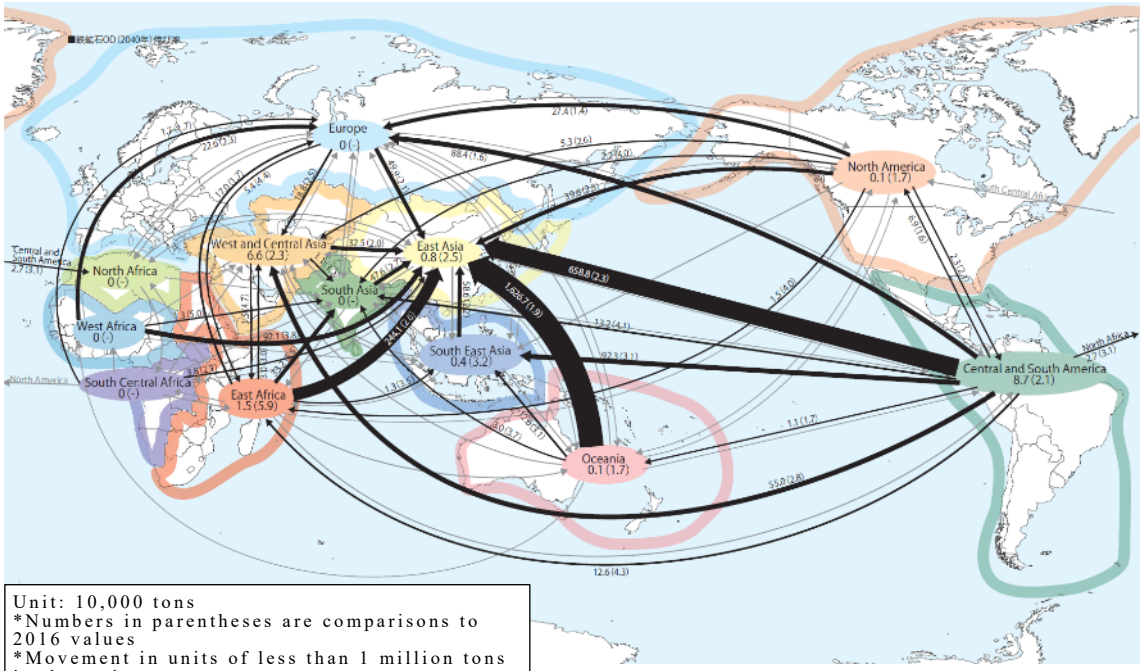


Figure 4-4-6: Results of Bulk Freight Volume (Iron Ore) OD Projections

(6) RORO Freight Volume (Finished Motor Vehicles)

- Table 4-4-6 and Figure 4-4-7 show the results of RORO freight volume (finished motor vehicles) OD projections.

Table 4-4-6: Results of RORO Freight Volume (Finished Motor Vehicles) OD Projections

Region	Exports (thousands of MT)			Average Annual Growth Rate		Imports (thousands of MT)			Average Annual Growth Rate	
	Actual		Projected			Actual		Projected		
	2006	2016	2040 S (1)	06-16	16-40	2006	2016	2040 S (1)	06-16	16-40
01_East Asia	11,300	12,650	31,781	1.1%	3.9%	890	2,839	8,658	12.3%	4.8%
02_Southeast Asia	724	1,873	5,556	10.0%	4.6%	763	1,858	6,032	9.3%	5.0%
03_South Asia	175	642	4,239	13.9%	8.2%	199	350	1,157	5.8%	5.1%
04_West and Central Asia	464	806	3,341	5.7%	6.1%	3,163	4,500	11,331	3.6%	3.9%
05_North America	2,721	3,827	7,933	3.5%	3.1%	7,726	8,925	16,847	1.5%	2.7%
06_Central and South America	1,054	694	1,461	▲4.1%	3.1%	1,829	2,070	5,194	1.2%	3.9%
07_Europe	5,239	7,539	17,226	3.7%	3.5%	3,753	3,690	9,513	▲0.2%	4.0%
08_East Africa	231	599	1,815	10.0%	4.7%	1,153	1,358	5,761	1.7%	6.2%
09_North Africa	7	328	936	47.5%	4.5%	612	658	2,034	0.7%	4.8%
10_West Africa	14	27	329	6.8%	10.9%	657	792	3,480	1.9%	6.4%
11_South Central Africa	4	4	25	▲0.8%	8.1%	213	203	812	▲0.5%	6.0%
12_Oceania	171	234	330	3.2%	1.4%	1,209	2,081	4,351	5.6%	3.1%
13_Rest of the World	107	137	344	2.5%	3.9%	41	36	145	▲1.3%	5.9%
00_World	22,210	29,361	75,316	2.8%	4.0%	22,210	29,361	75,316	2.8%	4.0%

*Not including intraregional freight in Europe

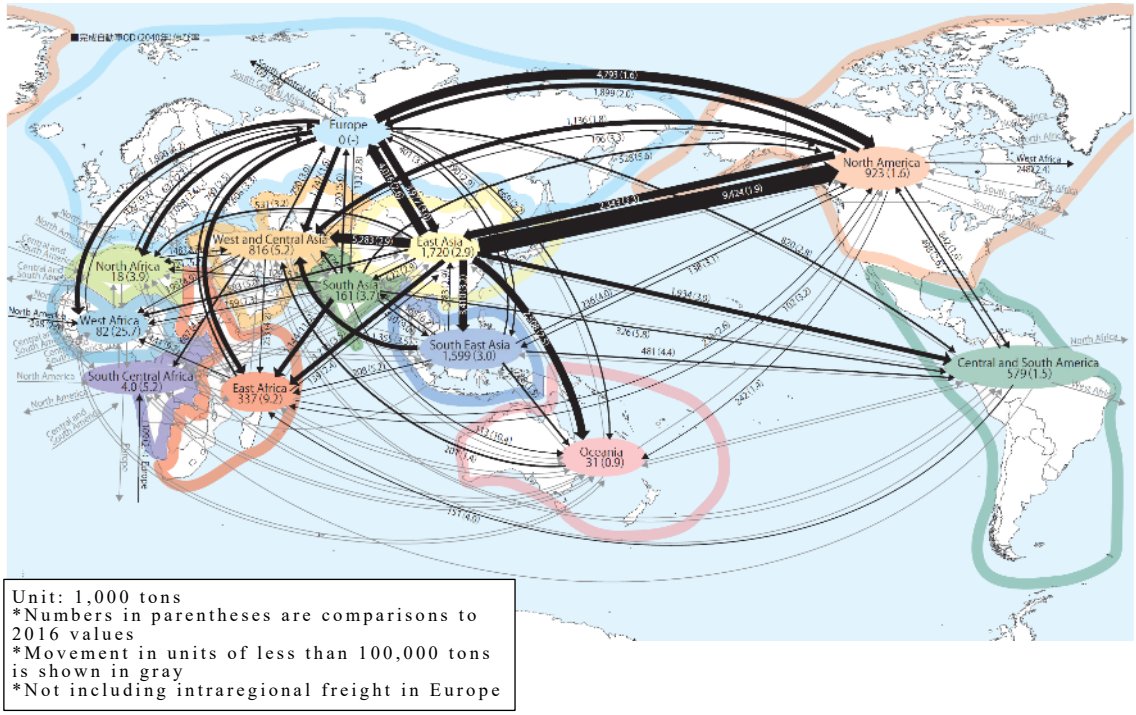


Figure 4-4-7: Results of RORO Freight Volume (Finished Motor Vehicles) OD Projections

4-5 Projection Model Calculations and Model-Based Policy Analysis

4-5-1 Settings for the Projection Model

- In principle, the present state simulation model settings are used as parameters for projection model calculations; however, the input values and parameters for freight transport network capacity and the like were adjusted for the input of future transport demand (three to five times the values from the simulation model).
- Additionally, some variables were set separately for policy simulation (case) analysis. The following is a description of the methodology behind the settings that were changed.

(1) Marine Container Transport Network Capacity

- The tonnage and frequency of ships assigned to each regular route service can be assigned as marine container transport network capacity.
- The capacity of each regular route service was assigned by adding the total volume of freight handled at ports of call for each service to the aggregate growth from the present state (2016) of each service, assuming linear growth due to increases in the volume of freight handled at each of the ports of call.
- Note that this setting assumes an expansion of capacity based on the capacity of present regular route services; it does not envision newly commissioned services that presently do not exist.

(2) Road and Railway Capacity

- Capacity of the road and railway were set according to the increase of transportation demand in the future.
- Road network freight transport capacity settings from the simulation model were tripled uniformly for the projection model, based on the projection on year 2040 in which the trade becomes 2.9 times larger than the current volume..
- In other words, road capacity is set to 15,000,000, 3,000,000, or 300,000 TEU/year based on the road types (Motorway, Primary Route, Important Route) obtained from ADC World Map Data.
- Rail capacity was set to triple the operating frequency of each railway line, similarly to the road network.

4-5-2 Projection Model-Based Impact Analysis for the Case of Successful Economic Corridor Development

(1) Frameworks and Settings for Analysis of the Case of Successful Economic Corridor Development

1) Analysis Framework

- Economic corridor development in East Africa involves efforts on technical aspects such as building and improving logistics infrastructure (ports, roads, and railways), and non-technical aspects such as arrangements for facilitating cross-border trade and promoting transitions to single-window systems in one stop border post (OSBP) procedures.
- Analysis of the case of successful economic corridor development is conducted to quantitatively evaluate the benefits in terms of transport cost reductions, impact on port hinterlands, and infrastructure supply-demand gaps.
- This analysis targeted 2040, with input assigned as freight demand based on Scenario S1 (the successful corridor development scenario).
- In the course of quantifying benefits, two cases were compared: the “Without” case, in which corridor development stalls (infrastructure remains at its current level), and the “With” case, in which corridor development proceeds (specifically, the development set out in PIDA-PAP is achieved).

2) Settings

■ Development of Technical Aspects Associated with Economic Corridor Development

- PIDA-PAP envisions economic corridors that decrease the cost and time required for transport.
- The transport cost proportioned to transport distance was set to decrease 10% along the economic corridors. The basis for this setting is the reduction of traveling expenses due to the development of technical aspects, and the envisioned elimination of one-way shipments and reduction of inventory control costs if circulation increases along the economic corridors.
- Additionally, traveling speed was set to a uniform rate of 60 km/hr along the economic corridors.
- Additionally, to ensure sufficient capacity and prevent excessive congestion, road capacity was set to a uniform rate of 25,000,000 TEU/year on links that comprise the economic corridors.

■ Development of Non-Technical Aspects Associated with Economic Corridor Development

- Given the construction of OSBP and simplification of trade procedures at border crossings on the corridors, the cost and time required for procedures was set to 50% less.
- This 50% reduction of the time required for procedures was determined based on actual time savings at existing OSBP in information gathered from interviews and the like.
- The cost was also reduced based on the reduced opportunity cost associated with time savings (personnel expenses, the cost of trailer truck idling, etc.).

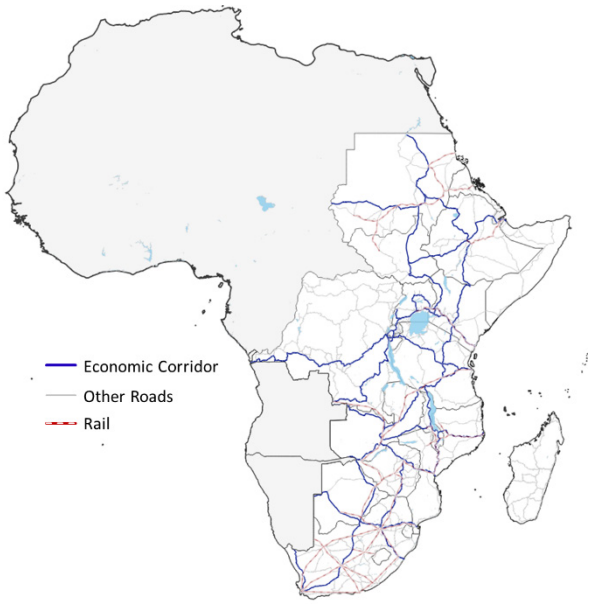


Figure 4-5-1: Freight Transport Networks in the Model (Corridor Network Shown in Blue)

- The table below is a summary of the settings for the case of successful economic corridor development in light of the above.

Table 4-5-1: Settings in the Case of Successful Economic Corridor Development

Input/Setting	Present State Simulation Model	Projection Model	
		Without Economic Corridors	With Economic Corridors
Freight transport demand	2016 (Actual)	2040 Scenario S1 for both	
Marine transport network	2016 (Actual)	Expanded capacity from the present transport network based on projected growth from the present state of freight transport demand	
Road/railway transport networks	Most recent actual figures, statistics, etc.	Expanded capacity (simulation model settings tripled uniformly)	Additionally, on corridors: ◆ 10% reduction in cost proportioned to transport distance ◆ 60 km/hr traveling speed ◆ Additional expansion of capacity
Friction at borders	Most recent actual figures, statistics, etc.	Same settings (most recent actual figures, statistics, etc.)	50% reduction of cost and time required for border-crossing procedures on corridors

(2) Results of Analysis of the Case of Successful Economic Corridor Development: Reduced Freight Transport Costs

1) East Africa

- According to the calculation result of the logistics model for the economic corridor development, the development of economic corridors and OSBP are expected to deliver an 18% reduction in the average unit price of land transport in East African countries. The changes of average transportation cost by region are as shown in Figure 4-5-3.
- The average unit price of land transport in coastal countries 1 with their own ports declined 12%, while the average unit price of land transport in landlocked countries 2 that rely on border crossings to access ports declined 18%; landlocked countries enjoyed a roughly 50% greater reduction in the unit price of transport than coastal countries.
- However, the average unit price of land transport may increase because gaps between the planned transport capacity and future freight demand of some roads in coastal countries will result in congestion due to the concentration of freight.
- If these roads are upgraded to ensure sufficient transport capacity in the future, further reductions in the unit price of transport can be expected.

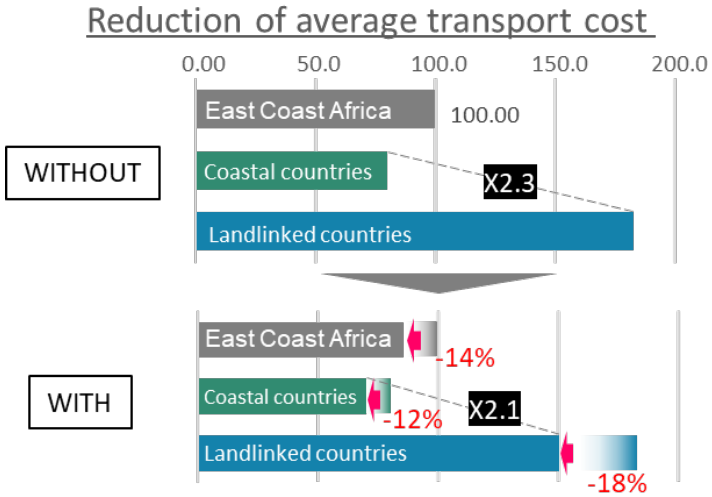


Figure 4-5-2: Comparison of the Average Unit Price of Land Transport in Coastal Countries and Landlocked Countries

1 Coastal countries: Egypt, Sudan, Eritrea, Djibouti, Somalia, Kenya, Tanzania, Mozambique, South Africa

2 Landlocked countries: Ethiopia, South Sudan, Uganda, Rwanda, Burundi, Democratic Republic of the Congo, Zambia, Malawi, Zimbabwe, Botswana, Eswatini, Lesotho

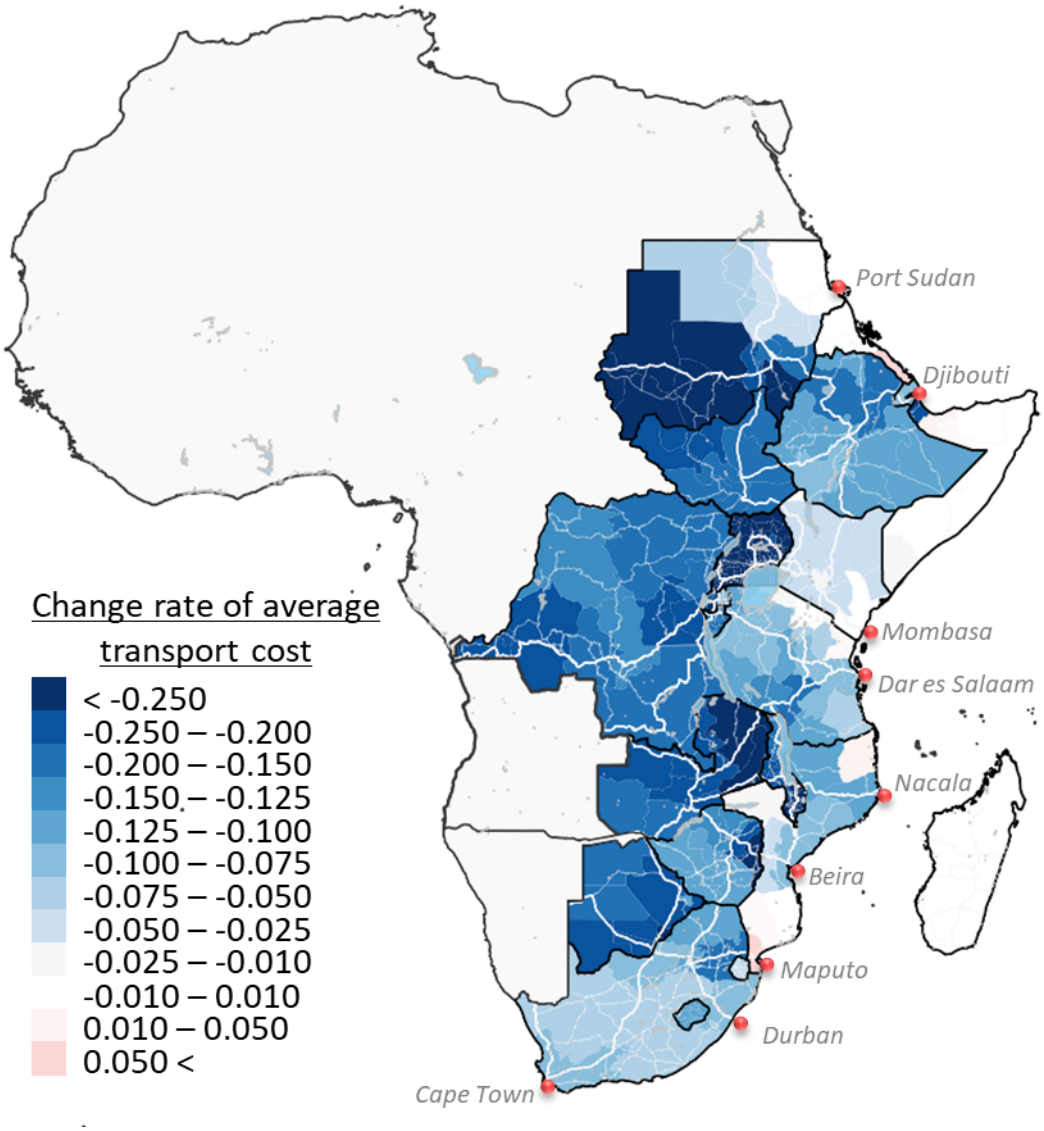


Figure 4-5-3: Changes in the Average Unit Price of Land Transport by Region

2) Impact on Landlocked Countries: The Case of Burundi

- Burundi was considered as an example of the impact of economic corridor development on landlocked countries. Figure 4-5-4 shows changes in the average unit price of freight transport, and changes in port selection in Burundi.
- The model calculated that economic corridor development would produce a 15.7% average reduction in the unit price of land transport for freight in Burundi.
- Economic corridor development would also result in changes in port selection in Burundi. The orange-shaded regions in the figure are those that select the Port of Dar es Salaam in Tanzania most often, and the green-shaded regions are those that select the Port of Mombasa in Kenya most often.
- In the Without case, nearly all of Burundi opts to use the Port of Dar es Salaam; 84.8% of domestic freight in Burundi goes through the Port of Dar es Salaam, compared to 9.6% through the Port of Mombasa.
- In contrast, in the With case, 56.4% of domestic freight and Burundi goes through the Port of Dar es Salaam, compared to 42.1% through the Port of Mombasa.
- This shift is caused by the relatively low transport cost along routes that connect Burundi to the Port of Mombasa.
- As shown in this case, economic corridor development can offer a wider array of routes than are currently available, and can expand port selection, leading to the sustainability of logistics and the securing of redundancy.

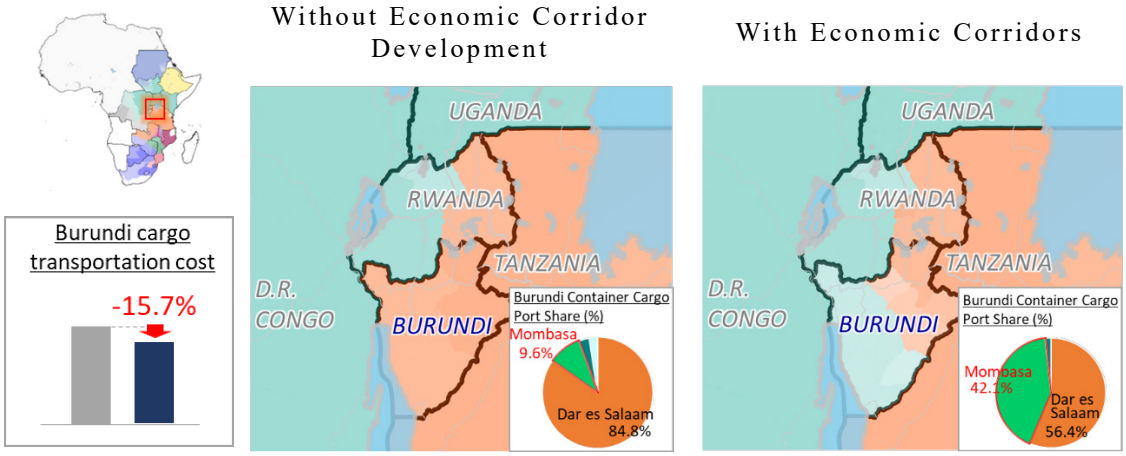


Figure 4-5-4: Changes in the Average Unit Price of Land Transport, and Changes in Port Selection in Burundi

(3) Results of Analysis of the Case of Successful Economic Corridor Development: Impact on Port Hinterlands

- The ports each country and region use for global marine container freight transport are generally selected on the basis of transport cost, transport time, and other factors of economic rationality.
- As in analysis using the Logistics Model, it was confirmed that East African countries tend to use the closest port.

1) East Africa

- The figure below is color-coded to correspond to the ports most often used for freight in the regions of East Africa, and the size of their share (dependency) based on the results of analysis of the case of successful economic corridor development.
- It can be confirmed that eight ports cover nearly all the container freight transport in East Africa: Port Sudan, Djibouti, Mombasa, Dar es Salaam, Nacala, Beira, Maputo, and Durban.
- The benefits of trade facilitation delivered by the development of economic corridors and OSBP were confirmed in the differences in route selection by region. For example, freight from the western part of South Sudan goes through Port Sudan in Sudan, and freight from the rest of the country goes through the Port of Mombasa in Kenya. Freight into and out of the northern part of the landlocked country of the Democratic Republic of the Congo goes through Uganda to the Port of Mombasa in Kenya, and freight into and out of the central part of the country goes through Rwanda and Burundi to the Port of Dar es Salaam.
- The ports of Mombasa, Dar es Salaam, Beira, and Durban transport freight to multiple landlocked countries, fulfilling a major role in the economic development of those regions; therefore, these ports are in particular need of steady improvement to satisfy future demand in landlocked countries.

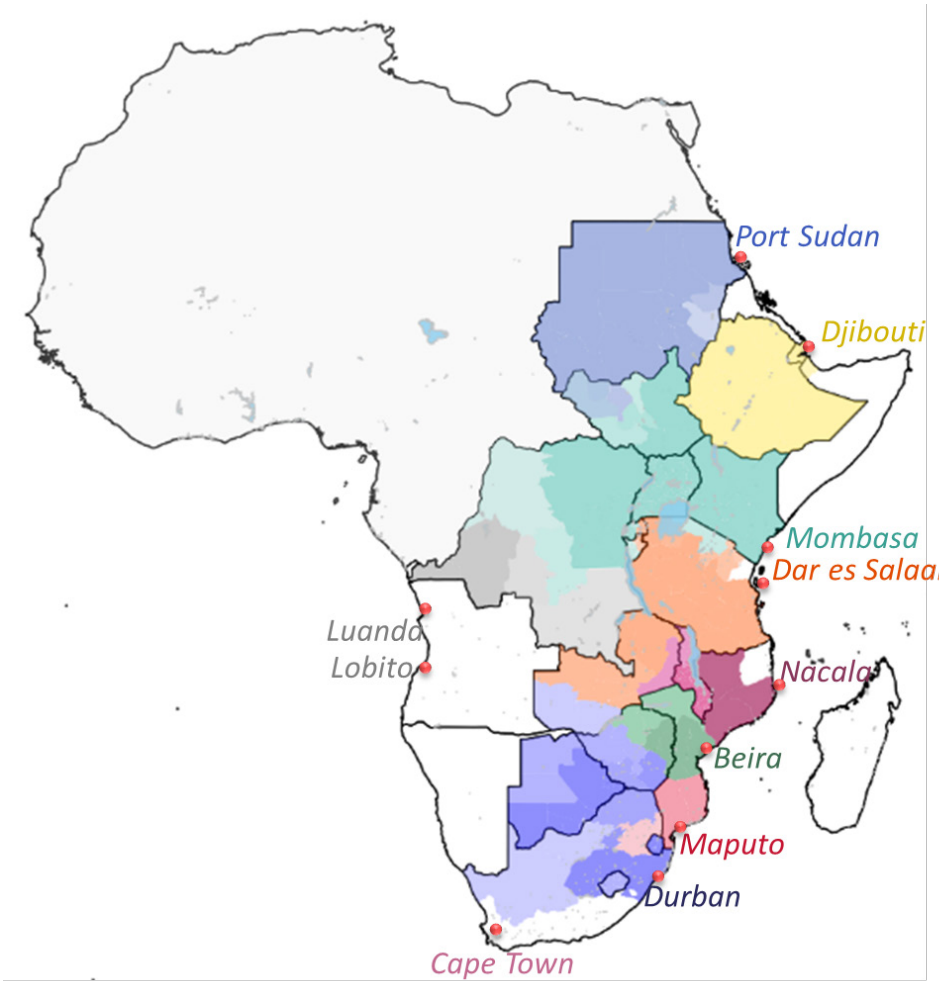


Figure 4-5-5: Most Popular Ports and Dependence by Region

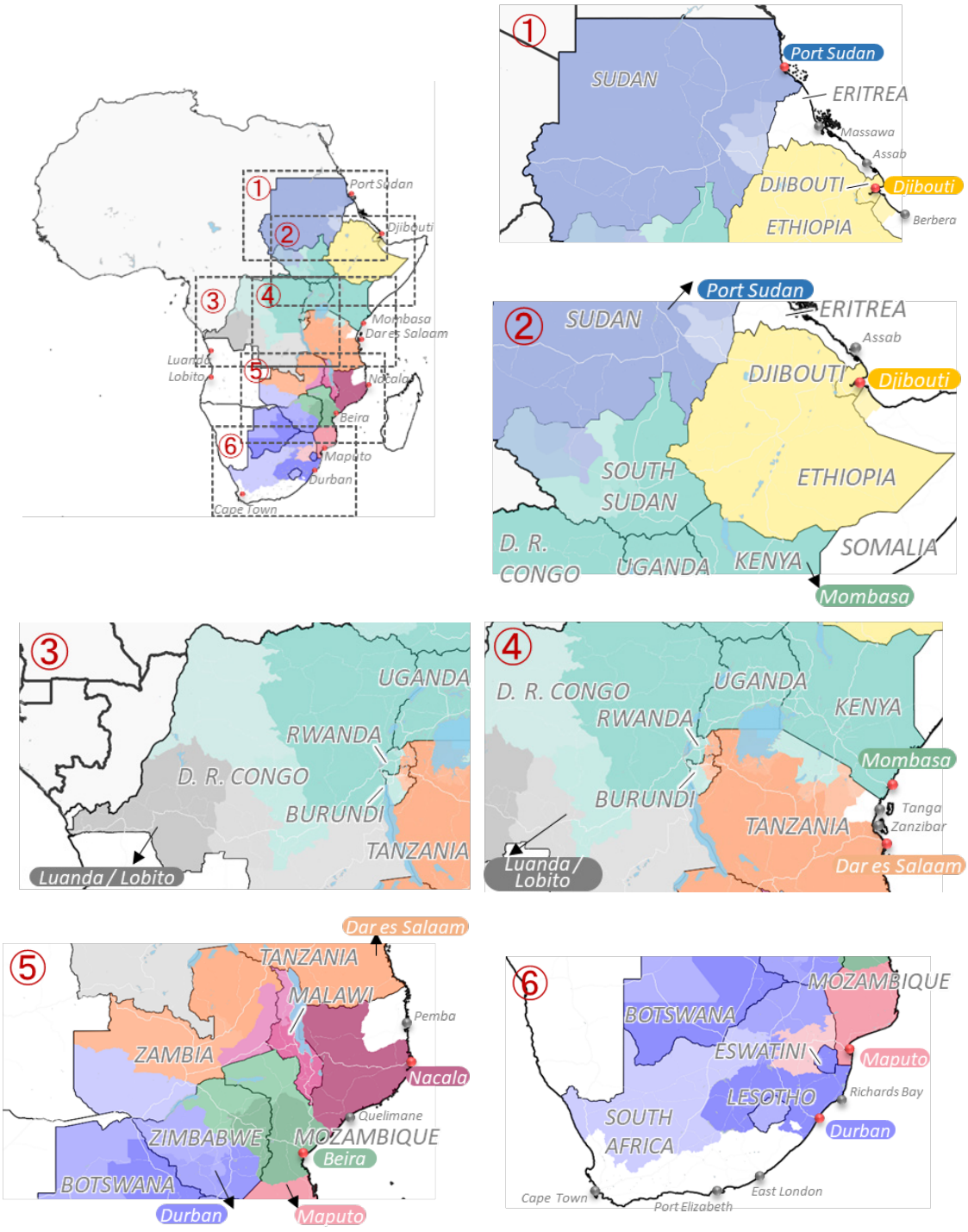


Figure 4-5-6: Most Popular Ports and Dependence by Region (Expanded Views)

2) Hinterlands of Individual Ports and Changes Delivered by Economic Corridor Development

- Figure 4-5-7 is color-coded to correspond to the hinterlands and shares of the eight major container ports in the region.
- Figure 4-5-8 shows the difference in shares in hinterlands of the eight ports in the cases with and without economic corridor development.
- Corridor development expanded shares in red-shaded regions, while shares decreased in blue-shaded regions.

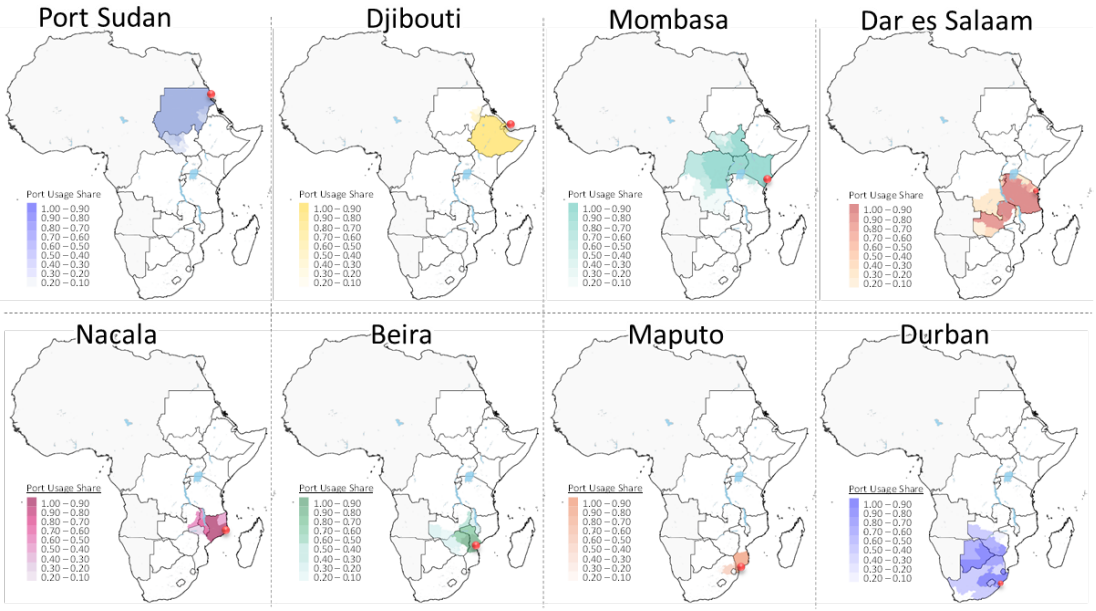


Figure 4-5-7: Hinterlands and Shares of Major East African Ports in the Case of Successful Economic Corridor Development

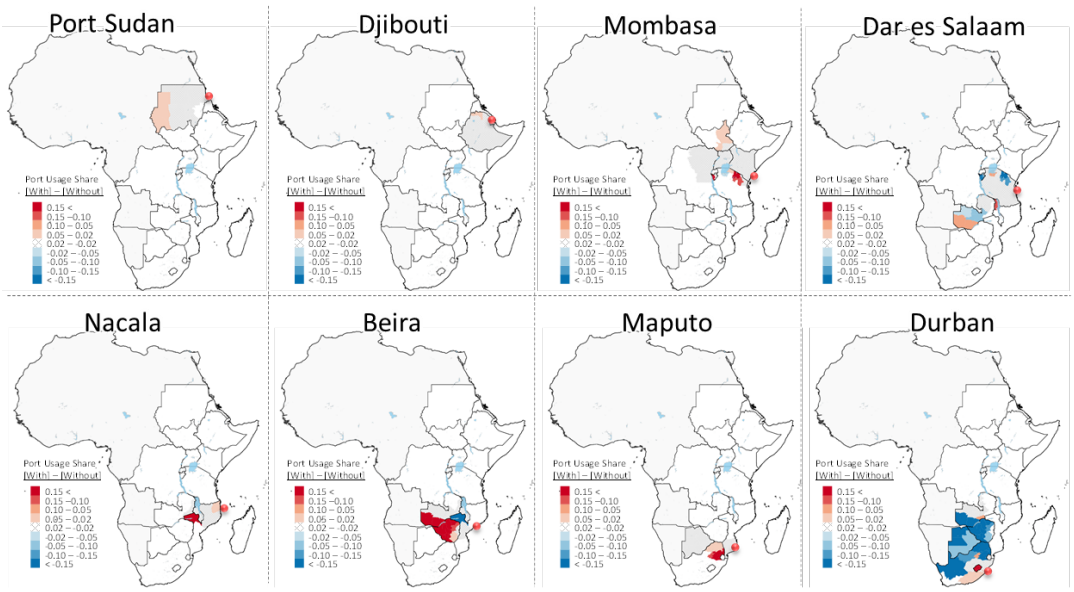
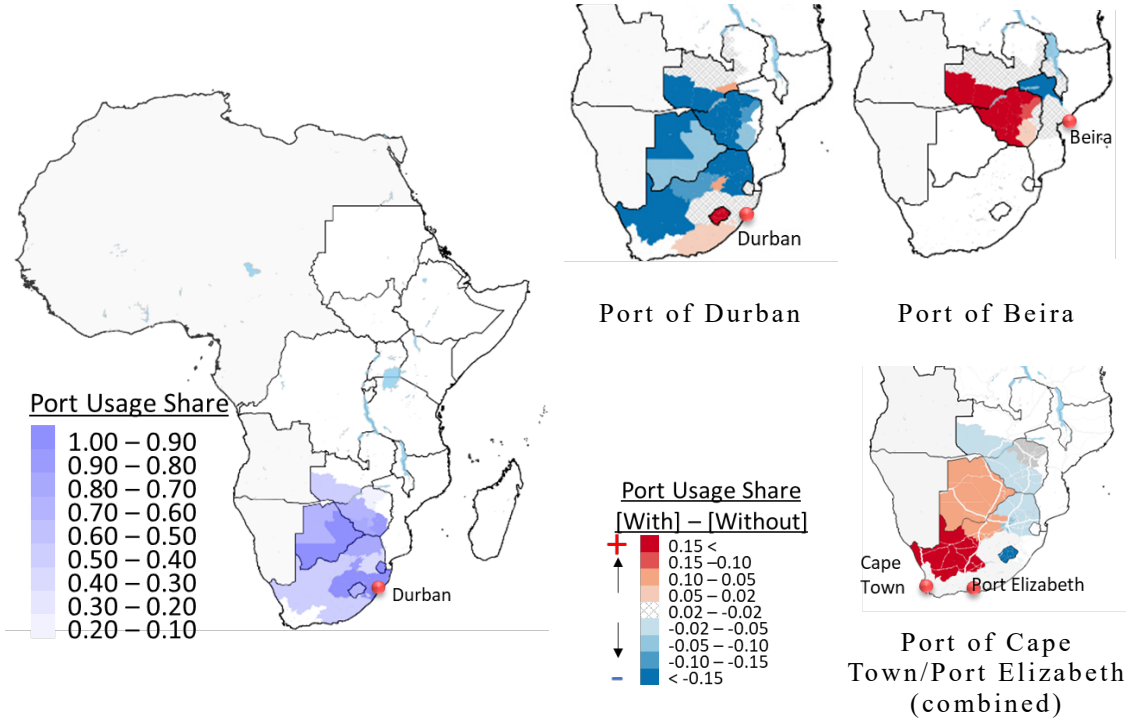


Figure 4-5-8: Changes in Hinterland Shares in the Cases With and Without Economic Corridor Development

- A detailed investigation of the benefits of economic corridor development was conducted for the top four ports in terms of the volume of freight handled—in order from greatest to least, the Port of Durban, the Port of Mombasa, the Port of Dar es Salaam, and the Port of Djibouti.

Changes in the Hinterland of the Port of Durban

- Figure 4-5-9 shows the hinterland of the Port of Durban in the case of successful economic corridor development, and the changes in share in the cases with and without economic corridor development.
- In the With case, the hinterland share decreases. In the Without case, Zimbabwe and the southern part of Zambia use the Port of Beira, and Botswana and the northern part of South Africa use the Port of Cape Town and Port Elizabeth in South Africa.
- However, although the Port of Durban loses a greater share of hinterland than in the Without case, the figure shows that its hinterland is quite vast, and that it already wields considerable influence.



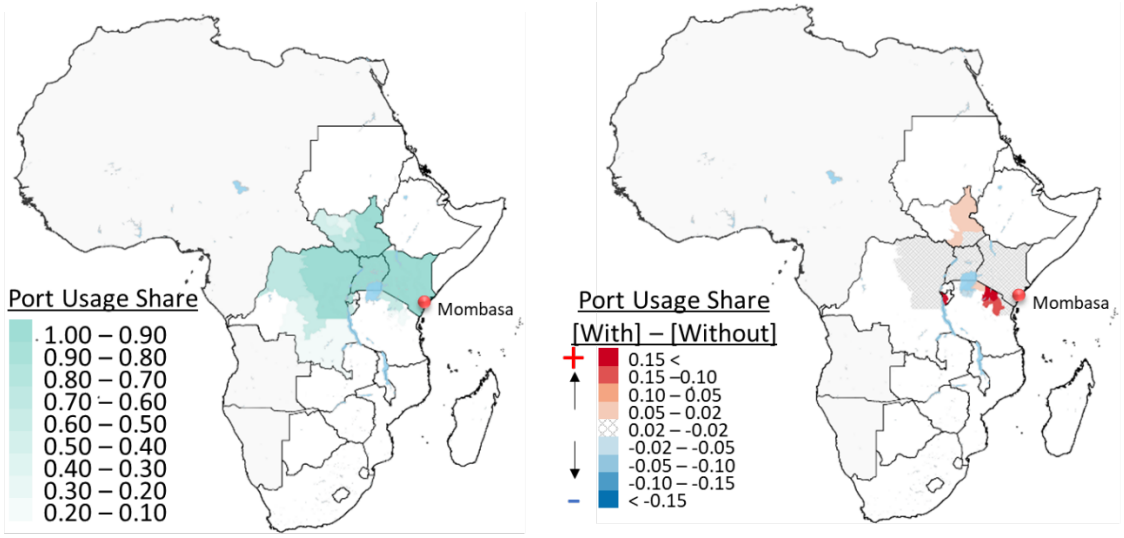
A. Port of Durban Share of Hinterland

B. Changes in Shares of the Port of Durban and Surrounding Ports

Figure 4-5-9: Changes in the Hinterland and Share of the Port of Durban Due to Economic Corridor Development

Changes in the Hinterland of the Port of Mombasa

- Figure 4-5-10 shows the hinterland of the Port of Mombasa in the case of successful economic corridor development, and the changes in share in the cases with and without economic corridor development.
- The With case gives the Port of Mombasa a vast hinterland that includes Uganda, South Sudan, the Democratic Republic of the Congo, and other landlocked countries.
- Additionally, economic corridor development appears to expand the port's hinterland in the eastern part of South Sudan, near the border with Tanzania, and in Burundi.



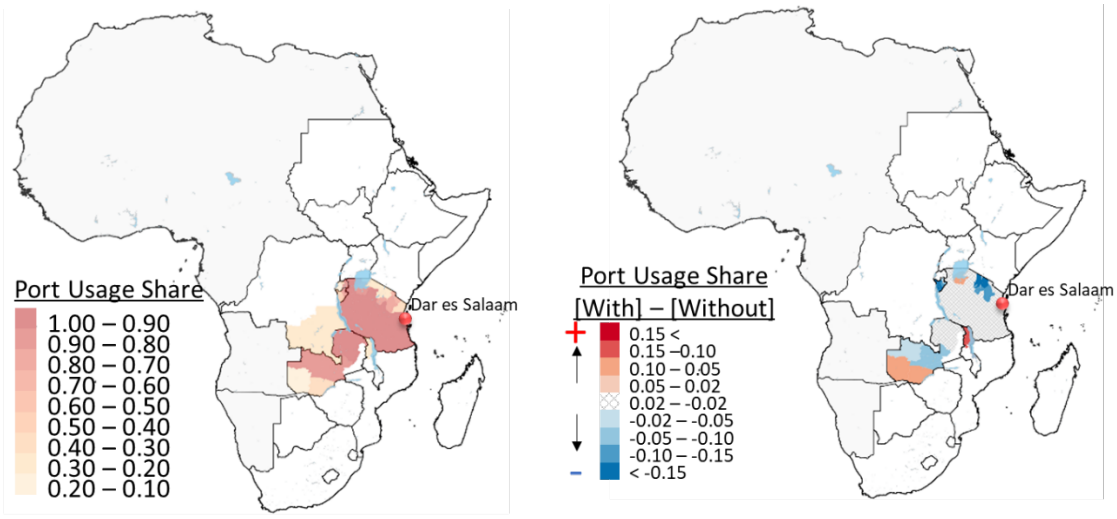
A. Port of Mombasa Share of Hinterland

B. Changes in Shares of the Port of Mombasa and Surrounding Ports

Figure 4-5-10: Changes in the Hinterland and Share of the Port of Mombasa Due to Economic Corridor Development

Changes in the Hinterland of the Port of Dar es Salaam

- Figure 4-5-11 shows the hinterland of the Port of Dar es Salaam in the case of successful economic corridor development, and the changes in share in the cases with and without economic corridor development.
- Like the ports of Durban and Mombasa, the Port of Dar es Salaam is expected to have a vast hinterland.
- The With case expands the port's share to the northern part of Malawi and part of Zambia; however, the port loses some of its share near the border with Kenya and the central part of Zambia.



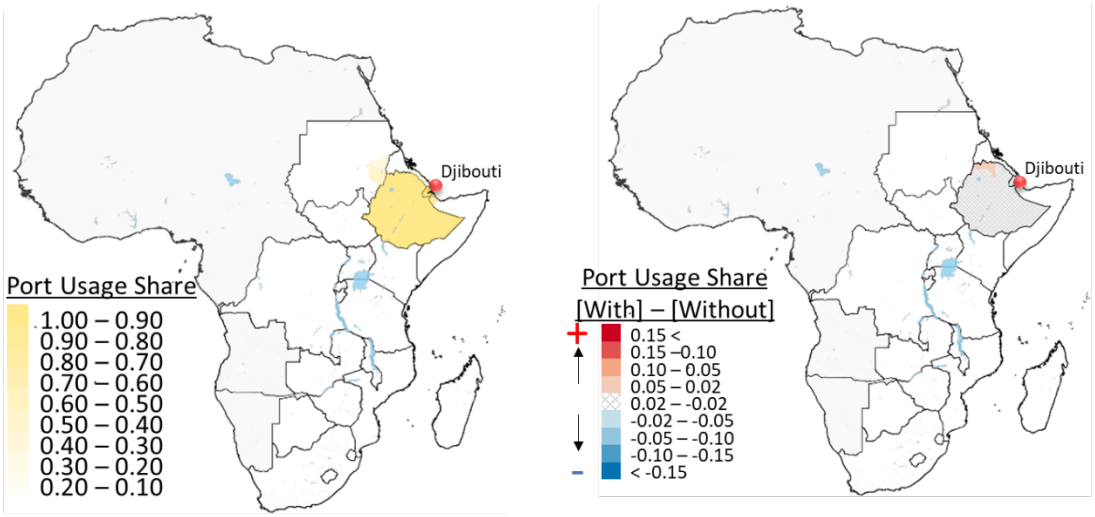
A. Port of Dar es Salaam Share of Hinterland

B. Changes in Shares of the Port of Dar es Salaam and Surrounding Ports

Figure 4-5-11: Changes in the Hinterland and Share of the Port of Dar es Salaam Due to Economic Corridor Development

Changes in the Hinterland of the Port of Djibouti

- Figure 4-5-12 shows the hinterland of the Port of Djibouti in the case of successful economic corridor development, and the changes in share in the cases with and without economic corridor development.
- The hinterland of the Port of Djibouti hardly changes in both the With and Without cases.
- In either case, the port is expected to fulfill its role as the main port of Ethiopia.



A. Port of Djibouti Share of Hinterland

B. Changes in Shares of the Port of Djibouti and Surrounding Ports

Figure 4-5-12: Changes in the Hinterland and Share of the Port of Djibouti Due to Economic Corridor Development

(4) Supply-Demand Gaps in Logistics Infrastructure

- Similar to the investigation explained previously, the Intermodal Global Logistics Model was used to qualitatively analyze the volume of freight circulation for each transport route in each target region in East Africa with freight demand in 2040 as the target based on the scenario of successful economic corridor development (Scenario S1). In addition, analysis that integrated the state of roads in 2009 illustrated by the Programme for Infrastructure Development in Africa (PIDA) was conducted.
- Additionally, future freight volumes and future plans (handling capacity) for some of the ports on the east coast of Africa were compared to confirm the possibility of ports becoming bottlenecks due to projected increases in global marine container freight demand.

1) State of Economic Corridor Transport Network and Comparison of Demand

- In "Infrastructure Outlook 2040" published at the end of 2011, the PIDA pointed out several potential problems that could occur due to supply-demand gaps caused by the inability of improvements to the existing Africa Regional Transport Infrastructure Network (ARTIN Corridor) to keep pace with increases in freight transport demand on the regional and continental level as a result of population growth, economic growth, and other development in Africa in the future.
- Combining the envisioned volume of freight circulation in 2040 with the state of roads in each corridor in 2009 compiled by the PIDA shows that most freight in the immediate hinterlands of the ports of Mombasa and Dar es Salaam will be circulated on roads that are already in good condition; thus, it is envisioned that increased demand will cause no exceptional problems.
- However, on corridors that proceed farther inland, there exist roads that are presently in poor or unknown condition. Also, there exist roads that are in fair (somewhat poor) condition between the Port of Djibouti and Ethiopia, and into the hinterland of the Port of Durban.
- These analysis results suggest the importance of properly improving roads with high freight circulation that are in poor condition.

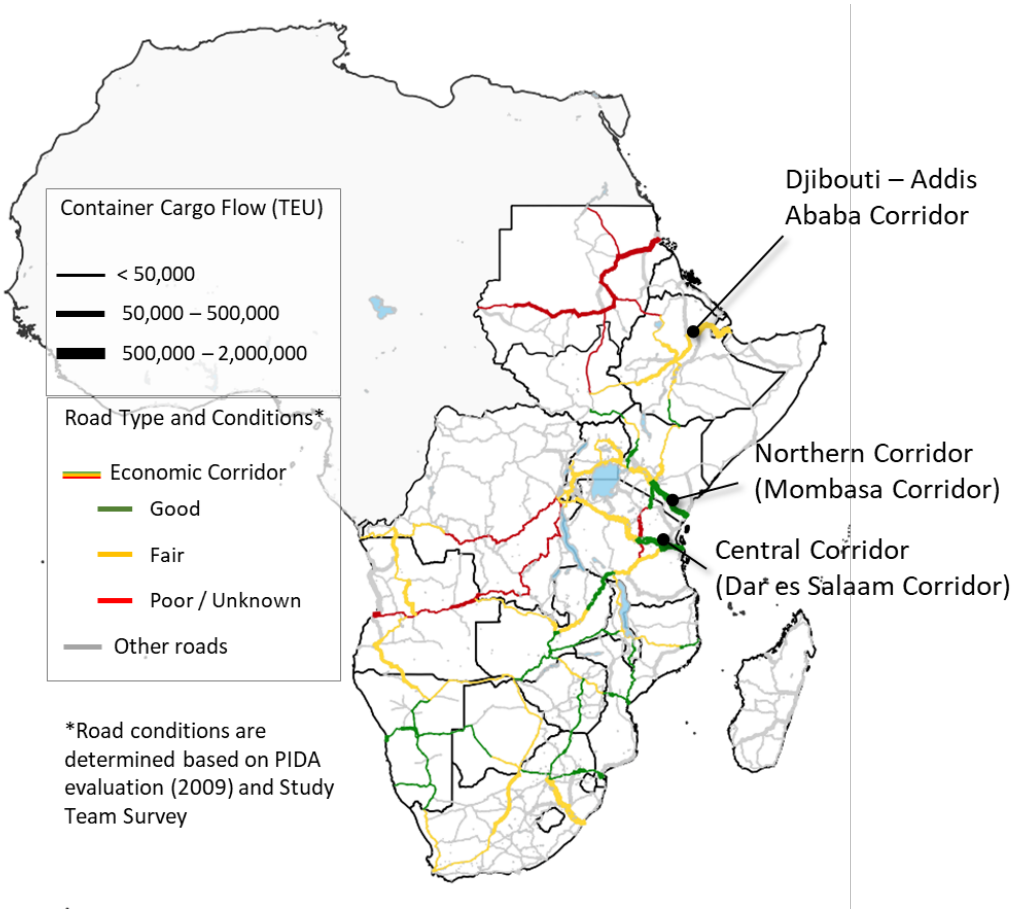


Figure 4-5-13: Present State of Freight Transport Road Networks and Freight Circulation Projections

2) Projections of Port Freight Handling Demand, and Present and Planned Port Handling Capacity

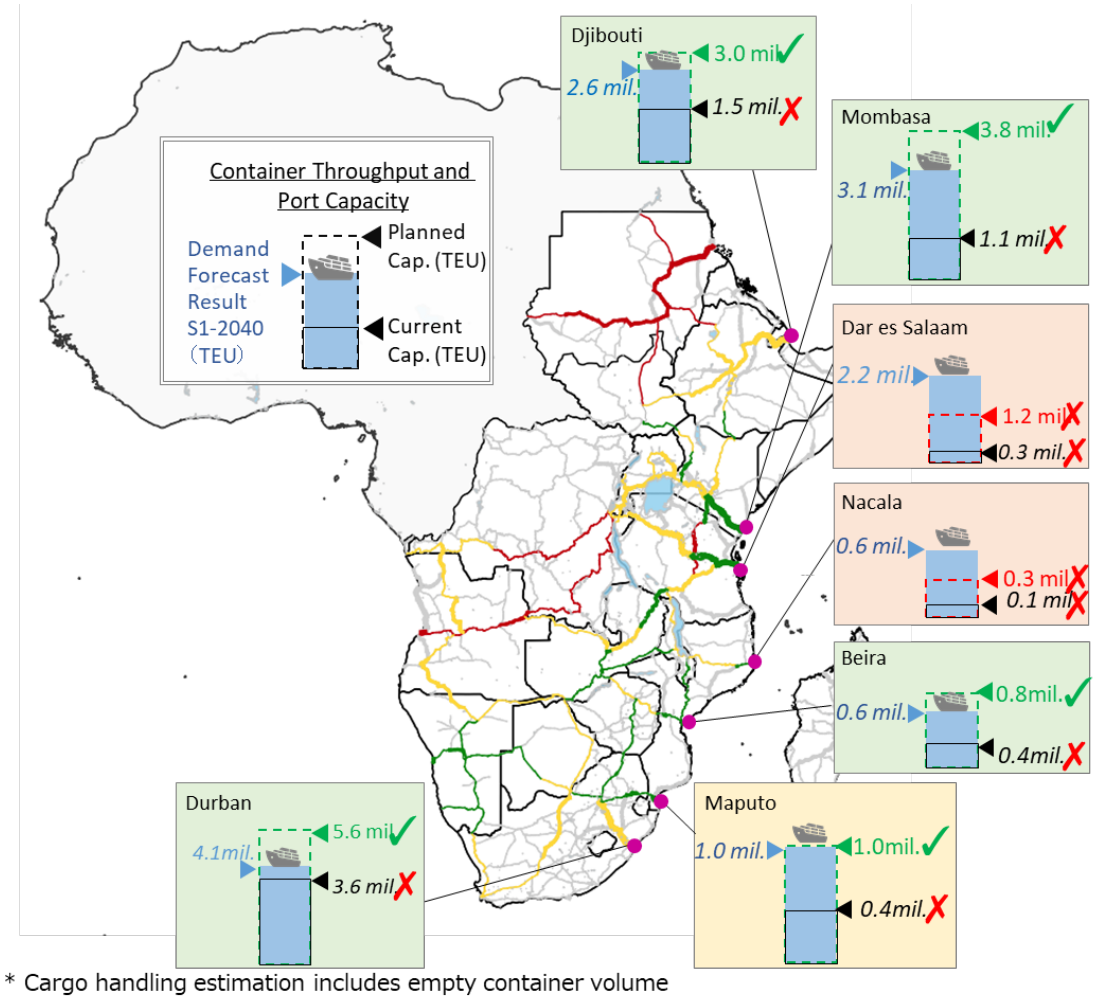
- Model-based freight volume projections and future handling capacity based on present and planned handling capacity at major ports on the east coast of Africa were compared to confirm the possibility of ports becoming bottlenecks due to projected increases in global marine container freight demand.
- The GTAP Model and the Logistics Model only factor in containers actually loaded with freight; empty containers are not factored in. Here, in the course of comparing port freight handling capacity, the volume of handling demand was double the larger of the volume of actual freight exported or imported.
- However, present and planned port handling capacity was set according to available documents. As for future plans, handling capacity was gathered and projected based on port development plans in action at the present stage.
- Therefore, it is worth noting that the future handling capacity settings here are not necessarily the values for 2040.
- Table 4-5-2 and Figure 4-5-14 are summaries of projections of freight handling demand and the present and planned port handling capacity.
- Additionally, Table 4-5-6 in the appendix shows detailed information and sources for the present and planned port handling capacity.

Table 4-5-2: Projections of Port Freight Handling Demand, and Present and Planned Port Handling Capacity

	Projection (S1, 2040): TEU			Port Handling Capacity: TEU	
	Exports	Imports	Total*	Present	Planned
Durban	1,535,271	2,050,340	4,100,679	3,600,000	5,600,000
Maputo	488,747	214,046	977,494	400,000	1,000,000
Nacala	281,503	170,850	563,006	100,000	300,000
Dar es Salam	568,860	1,077,176	2,154,351	300,000	1,200,000
Beira	304,915	208,002	609,830	400,000	800,000
Mombasa	519,782	1,532,618	3,065,235	1,100,000	3,800,000
Djibouti	534,828	1,323,805	2,647,610	1,500,000	3,000,000

*To factor in empty containers, projected totals are double the larger of the volume of freight exported or imported

- Regarding global marine container freight, planned port capacity should enable most ports to handle the freight volumes projected in this study; however, projected freight volumes are expected to exceed the planned handling capacities of the ports of Dar es Salaam and Nacala by roughly 1 million TEU and 300,000 TEU each year, respectively.
- Additionally, for the Port of Maputo, projected demand is essentially the same as the planned capacity.
- In light of these results, these ports are in particular need of sufficient port development to satisfy projected demand from landlocked countries.



* Cargo handling estimation includes empty container volume

Figure 4-5-14: Projections of Port Freight Handling Demand, and Present and Planned Port Handling Capacity

4-5-3 Model-Based Impact Analysis for Cases with Individual Settings

(1) Results of Analysis in Individual Cases: Transshipments to Island Countries of East Africa

- The island countries of East Africa are located in geographically advantageous places in terms of trade between East Africa and Asia, and along Indian Ocean sea lanes. Thus, they can fulfill a crucial role in marine transport as transshipment ports amid the projected increase in marine trade between East Africa and Asia in the future.
- Additionally, increasing transshipments can benefit these countries through the development of port-related industries, reduced transport costs, and more.
- Figure 4-5-15 shows the locations of the three prominent ports of the island countries of East Africa: the Port of Toamasina in Madagascar, Port Louis in Mauritius, and the Port of Pointe des Galets in Réunion. The figure also shows the container trade volume between East Africa and each of South Asia, Southeast Asia, and East Asia in 2040 based on Scenario S1. Between 2016 and 2040, the freight volumes between East Africa and South Asia, Southeast Asia, and East Asia are projected to increase 700%, 420%, and 340%, respectively.

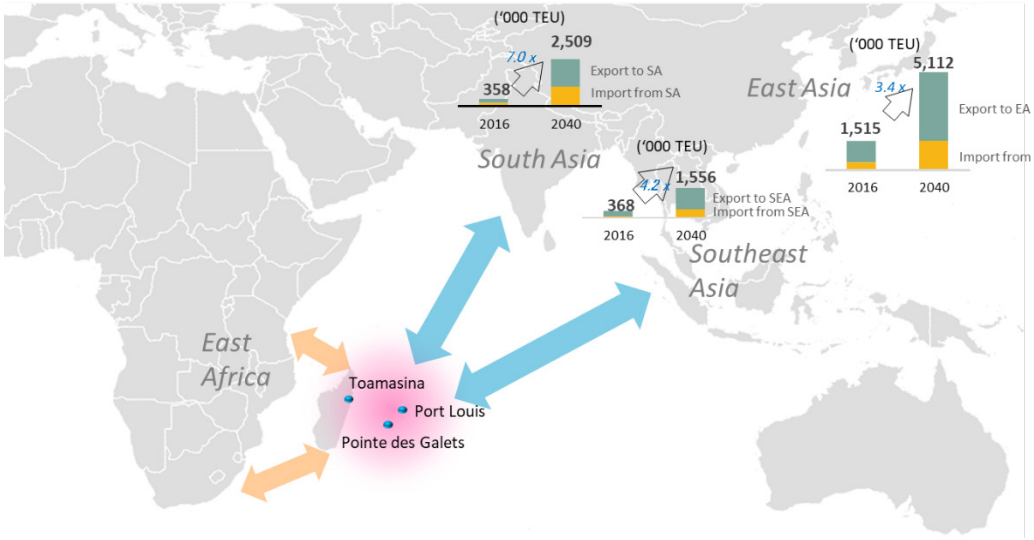


Figure 4-5-15: Locations of the Island Countries of East Africa and Projected Trade Value Trends Between East Africa and Asia

- In this case analysis, marine transport demand based on Scenario S1 (2040) was applied to the marine transport submodel of the Logistics Model to simulate changes in transshipment freight at the three ports of Toamasina, Port Louis, and Pointe des Galets.

- Additionally, to clearly indicate the impact of improved service levels on transshipments, the marine transport submodel was used to project transshipment freight volumes at the three ports with transshipment time reduced to one-third (from the present level of 72 hours to 24 hours, the level achieved at ports in advanced countries).
- As shown in Figure 4-5-16, the analysis results project a transshipment freight volume of 1.55 million TEU in 2040 (Scenario S1), a 490% improvement from the total of 317,000 TEU in 2016.
- Additionally, reducing transshipment time to one-third is expected to result in a 475,000-TEU increase in transshipment demand.

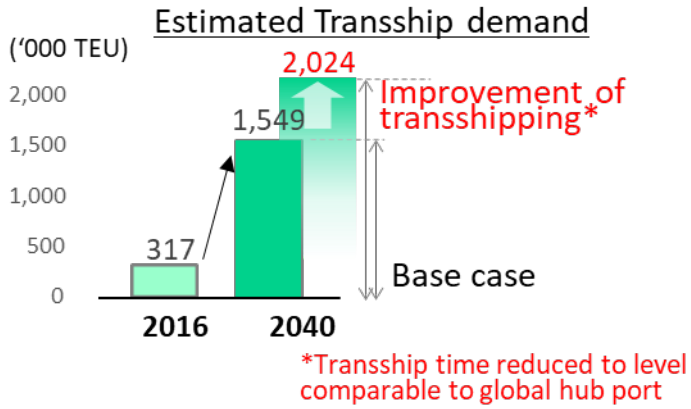
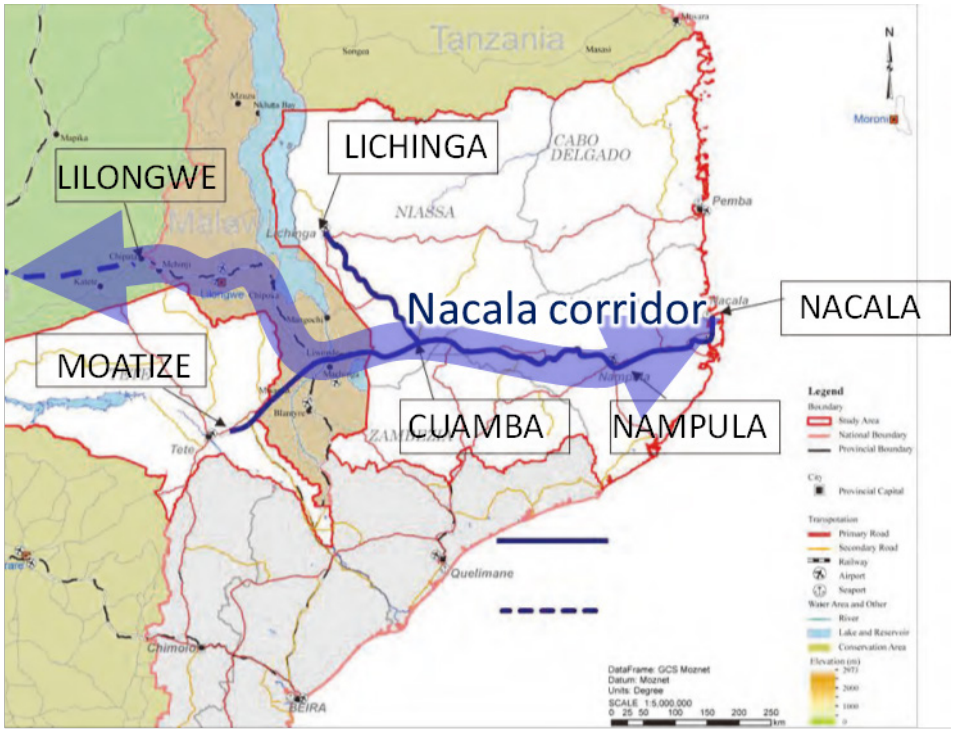


Figure 4-5-16: Projected Transshipment Freight Volume (Three-Port Total)

(2) Results of Analysis in Individual Cases: Impact of Railway Freight Transport (the Case of the Nacala Railway)

- Railways are excellent for transporting large volumes of freight over long distances and could be an effective mode of transport for covering the vast hinterlands of East Africa. However, the overall deterioration of existing railway infrastructure in the region limits its transport capacity. Thus, the share of railway transport in East Africa is small.
- However, plans exist to repair existing railway lines and add new lines in each East African country. The realization of these plans could substantially change the state of land transport in the region. Thus, the case of the Nacala Railway was selected for analysis of the impact of railway transport under theoretical conditions.
- Figure 4-5-17 is a map of the Nacala Railway lines. JICA is providing support for the development of the Nacala Corridor, and, along with roads, the Nacala Railway is a component of the infrastructure of the corridor.

- The recently opened railway line connecting Nacala to Moatize is now mainly used to transport coal produced in Moatize to the Port of Nacala.
- Meanwhile, a JICA study recommends the securing of multimodal transport on the Nacala Railway.

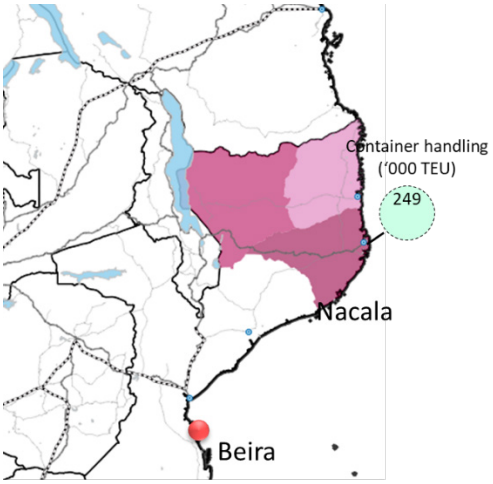


Source: Prepared by the study team based on the JICA report on "The Project for the Nacala Corridor Economic Development Strategies in the Republic of Mozambique"

Figure 4-5-17: Geographical Relationship of the Extension of Nacala Railway Lines

- For this case analysis, land transport conditions in 2040 (Scenario S1) were simulated based on the assumption that the Nacala Railway would be used for container freight transport.
- Figure 4-5-18 shows the changes in hinterlands and port handling volume resulting from the use of the Nacala Railway for container transport.
- When the Nacala Railway is not used for container transport (the "Without" case), the handling capacity of the Port of Nacala is 0.25 TEU. When container transport on the Nacala Railway is increased (the "With" case), the handling capacity of the Port of Nacala increases 72.7% to 0.43 TEU.
- Additionally, the With case appears to expand the port's hinterland to Malawi and the eastern part of Zambia.

A. Without Case: No Container Transport on the Nacala Railway



B. With Case: Container Transport on the Nacala Railway

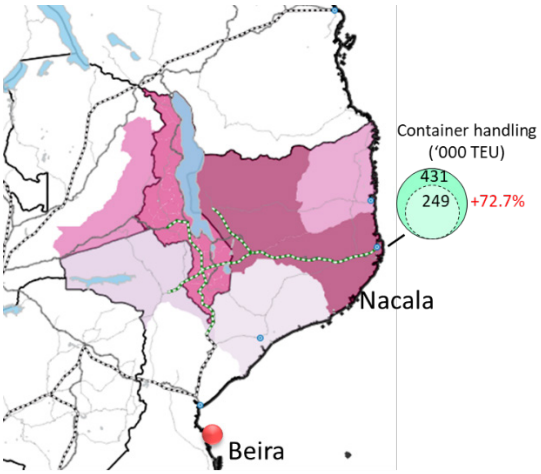


Figure 4-5-18: Changes in Hinterlands and Port Handling Volume Resulting from the Use of the Nacala Railway for Container Transport

- Figure 4-5-19 shows the parts of the hinterland of the Port of Beira that become the hinterland of the neighboring Port of Nacala due to the use of the Nacala Railway for container transport.
- The use of the Nacala Railway for container transport is expected to reduce the influence of the hinterland of the Port of Beira, which is south of the Port of Nacala, somewhat.
- The use of the Nacala Railway for container transport can deliver benefits to Malawi, Zambia, and other landlocked countries by giving them another port to choose from.

A. Without Case: No Container Transport on the Nacala Railway

B. With Case: Container Transport on the Nacala Railway

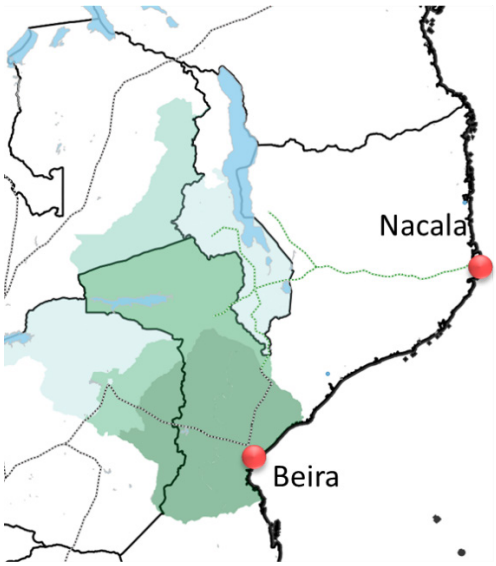


Figure 4-5-19: Changes in the Hinterland of the Port of Beira Resulting from the Use of the Nacala Railway for Container Transport

Appendices:

Table 4-5-3: Data for Creating Regional Economic Indicators

No.	Name of Country/Region	Administrative Divisions	Economic Indicator	Value	Source
1	Sudan	Red Sea	Population	1,447,800	City Population
		Al Jazirah		4,926,600	
		Khartoum		7,687,500	
		Al Qadarif		2,108,500	
		White Nile		2,410,300	
		Blue Nile		1,080,700	
		Northern		913,500	
		West Darfur		995,200	
		West Kordofan		1,737,700	
		South Darfur		3,672,400	
		South Kordofan		1,263,400	
		Kassala		2,438,800	
		River Nile		1,472,300	
		Sennar		1,847,500	
		North Darfur		2,296,100	
		North Kordofan		2,206,800	
		East Darfur		1,547,800	
		Central Darfur		729,900	
2	South Sudan	Upper Nile	Non-indigent population	1,385,500	THE SOUTH SUDAN MILLENNIUM DEVELOPMENT GOALS STATUS REPORT (P27)
		Jonglei		1,873,200	
		Unity		877,300	
		Warrap		1,380,000	
		Northern Bahr el Ghazal		1,023,400	
		Western Bahr el Ghazal		473,600	
		Lakes		1,053,200	
		Western Equatoria		803,300	
		Central Equatoria		1,574,700	
		Eastern Equatoria		1,393,800	
3	Eritrea	Northern Red Sea	Population	653,300	City Population
		Southern Red Sea		83,500	
		Anseba		549,000	
		Maekel		675,700	
		Debub		952,100	
		Gash-Barka		708,800	
5	Ethiopia	Addis Ababa	Population	3,273,000	City Population
		Afar		1,723,000	
		Amhara		20,401,000	
		Benishangul-Gumuz		1,005,000	
		Dire Dawa		440,000	
		Gambela		409,000	
		Harari		232,000	
		Oromia		33,692,000	
		Somali		5,453,000	
		Southern Nations, Nationalities, and Peoples' Region		18,276,000	
		Tigray		5,056,000	
5	Djibouti	Djibouti	Population	603,900	City Population
		Ali Sabieh		96,500	
		Arta		72,200	
		Dikhil		105,300	
		Obock		50,100	
		Tadjourah		121,000	
6	Somalia	Awdal	Population	673,263	City Population
		Bakool		367,226	
		Banaadir		1,650,227	
		Bari		719,512	
		Bay		792,182	
		Galguduud		569,434	
		Gedo		508,405	
		Hiran		520,685	
		Jubbada Dhexe/Middle Juba		362,921	
		Jubbada Hoose/Lower Juba		489,307	
		Mudug		717,863	
		Nugal		392,698	
		Sanaag		544,123	

No.	Name of Country/Region	Administrative Divisions	Economic Indicator	Value	Source
		Shabeellaha Dhexe/Middle Shebelle		516,036	
		Shabeellaha Hoose/Lower Shebelle		1,202,219	
		Sool		327,428	
		Togdheer		721,363	
		Woqooyi Galbeed		1,242,003	
7	Kenya	Central	Population	4,947,400	City Population
		Coast		4,054,900	
		Eastern		6,083,700	
		Nairobi		4,232,100	
		North Eastern		1,572,200	
		Nyanza		6,222,700	
		Rift Valley		12,231,900	
		Western		4,811,600	
8	Uganda	Central	GDP	14.400	Estimating District GDP in Uganda (P13)
		Eastern		1.443	
		Northern		1.602	
		Western		3.403	
9	Democratic Republic of the Congo	Kinshasa	Population	11,575,000	City Population
		Kongo Central		5,575,000	
		Kwango		2,152,000	
		Kwilu		5,490,000	
		Mai-Ndombe		1,852,000	
		Kasaï		2,801,000	
		Kasaï-Central		3,317,000	
		Kasaï-Oriental		3,145,000	
		Lomami		2,443,000	
		Sankuru		2,110,000	
		Maniema		2,333,000	
		South Kivu		5,772,000	
		North Kivu		6,655,000	
		Ituri		3,650,000	
		Haut-Uele		1,864,000	
		Tshopo		2,352,000	
		Bas-Uele		1,138,000	
		Nord-Ubangi		1,269,000	
		Mongala		1,740,000	
		Sub-Ubangi		2,458,000	
		Équateur		1,528,000	
		Tshuapa		1,600,000	
		Tanganyika		3,062,000	
		Haut-Lomami		2,957,000	
		Lualaba		2,570,000	
		Haut-Katanga		4,617,000	
10	Rwanda	Eastern	Population	2,595,703	City Population
		Kigali		1,132,686	
		Northern		1,726,370	
		Southern		2,471,239	
		Western		2,589,975	
11	Burundi	Bubanza		338,023	City Population
		Bujumbura Mairie		497,166	
		Bujumbura Rural		464,818	
		Bururi		313,102	
		Cankuzo		228,873	
		Cibitoke		460,435	
		Gitega		725,223	
		Karuzi		436,443	
		Kayanza		585,412	
		Kirundo		628,256	
		Makamba		430,899	
		Muramvya		292,589	
		Muyinga		632,409	
		Mwaro		273,143	
		Ngozi		660,717	
		Rumonge		352,026	
		Rutana		333,510	
		Ruyigi		400,530	
12	Tanzania	Arusha	GPD (Tshs)	2,322,031	Tanzania Human Development Report 2017
		Dar es Salaam		3,025,543	
		Dodoma		1,188,343	
		Geita		1,609,763	

No.	Name of Country/Region	Administrative Divisions	Economic Indicator	Value	Source
		Iringa		2,845,393	(P90)
		Kagera		1,075,268	
		Katavi		1,840,724	
		Kigoma		1,152,553	
		Kilimanjaro		2,387,031	
		Lindi		1,901,044	
		Manyara		1,930,722	
		Mara		1,776,538	
		Mbeya		2,301,974	
		Morogoro		1,870,508	
		Mtwara		1,792,305	
		Mwanza		2,004,353	
		Njombe		2,845,393	
		Pwani		1,403,185	
		Rukwa		1,840,724	
		Ruvuma		2,415,486	
		Shinyanga		1,596,344	
		Simiyu		1,624,905	
		Singida		1,113,241	
		Songwe		2,301,974	
		Tabora		1,380,413	
		Tanga		1,936,701	
		Zanzibar		1,632,000	
13	Zambia	Lusaka	Number of places of business	19,054	JICA, Unico (2016) "Republic of Zambia Quality/Productivity Improvement (Kaizen) Project Financial Report"
		Copperbelt		14,689	
		Southern		7,903	
		Central		6,185	
		Eastern		4,798	
		Western		3,410	
		North-Western		3,067	
		Luapula		2,968	
		Northern/Muchinga		4,669	
14	Malawi	Northern	Non-indigent population	685,902	Knoema (World Date Atlas)
		Central		2,585,947	
		Southern		1,375,484	
15	Mozambique	Cabo Delgado	GDP	13,273	Knoema (World Date Atlas)
		Gaza		14,350	
		Inhambane		18,853	
		Manica		14,424	
		Maputo City		47,379	
		Maputo Province		35,081	
		Nampula		38,911	
		Niassa		8,912	
		Sofala		33,042	
		Tete		16,493	
		Zambezia		28,629	
16	Madagascar	Antananarivo	Population	7,363,829	
		Antsiranana		2,088,976	
		Fianarantsoa		5,339,843	
		Mahajanga		2,955,198	
		Toamasina		4,052,997	
		Toliara		3,689,269	
17	Zimbabwe	Bulawayo	Number of employed people	956,669	Knoema (World Date Atlas)
		Harare		1,721,860	
		Manicaland		1,679,085	
		Mashonaland Central		1,121,402	
		Mashonaland East		1,257,533	
		Mashonaland West		1,389,032	
		Masvingo		1,409,350	
		Matabeleland North		705,574	
		Matabeleland South		636,704	
		Midlands		1,518,045	
18	Botswana	Central	Population	694,600	City Population
		Chobe		27,600	
		Ghanzi		62,200	
		Kgalagadi		57,300	
		Kgatleng		106,700	
		Kweneng		367,900	
		North-East		180,800	
		Ngamiland		174,800	
		South-East		403,200	

No.	Name of Country/Region	Administrative Divisions	Economic Indicator	Value	Source
		Southern		238,000	
19	South Africa	Western Cape	GDP	6,621,100	Knoema (World Date Atlas)
		Northern Cape		1,225,600	
		Eastern Cape		6,522,700	
		KwaZulu-Natal		11,384,700	
		Free State		2,954,300	
		North-West		3,979,000	
		Gauteng		14,717,000	
		Mpumalanga		4,523,900	
		Limpopo		5,797,300	
20	Swaziland	Hhohho	Population	320,651	City Population
		Lubombo		212,531	
		Manzini		355,945	
		Shiselweni		204,111	
21	Lesotho	Berea	Population	262,616	City Population
		Butah-Buthe		118,242	
		Leribe		337,521	
		Mafeteng		178,222	
		Maseru		519,186	
		Mohale's Hoek		165,590	
		Mokhotlong		100,442	
		Qacha's Nek		74,566	
		Quthing		115,469	
		Thaba-Tseka		135,347	

Table 4-5-4: List of Ports Included in the Model

NO	Name of Port	Country	Regional Classification in the Model	Annual Handling Volume (1,000 TEU) 2016 (Present State)	Annual Handling Volume (1,000 TEU) 2040 (Scenario S1)	Transfer Time Tra (hour)
1	Tokyo	Japan	Japan	2,910	7,074	24
2	Yokohama	Japan	Japan	1,664	4,043	24
3	Shimizu	Japan	Japan	232	563	24
4	Nagoya	Japan	Japan	1,367	3,323	24
5	Osaka	Japan	Japan	1,188	2,889	24
6	Kobe	Japan	Japan	1,270	3,084	24
7	Hakata	Japan	Japan	464	1,129	24
8	Vladivostok	Russia	South Korea	201	485	48
9	Busan	South Korea	South Korea	6,168	14,875	12
10	Yeosu/Gwangyang	South Korea	South Korea	1,271	3,065	12
11	Pyongtaek	South Korea	South Korea	267	644	12
12	Incheon	South Korea	South Korea	1,046	2,522	12
13	Dalian	China	China	1,946	4,624	48
14	Tianjin	China	China	2,537	6,029	48
15	Yantai	China	China	132	313	48
16	Qingdao	China	China	6,725	15,982	48
17	Lianyungang	China	China	501	1,190	48
18	Shanghai	China	China	12,254	29,122	48
19	Ningbo	China	China	5,532	13,146	48
20	Fuzhou	China	China	511	1,215	48
21	Xiamen	China	China	2,606	6,193	48
22	Shantou	China	China	132	314	48
23	Shenzhen (Yantian)	China	China	4,342	10,319	48
24	Shenzhen (Shekou)	China	China	3,802	9,035	48
25	Guangzhou	China	China	2,005	4,764	48
26	Hong Kong	Hong Kong	China	5,970	14,195	12
27	Keelung	Taiwan	Taiwan	615	1,468	24
28	Taipei New Port	Taiwan	Taiwan	802	1,914	24
29	Taichung	Taiwan	Taiwan	648	1,546	24
30	Kaohsiung	Taiwan	Taiwan	3,203	7,644	24
31	Manila	Philippines	Philippines	1,417	4,096	48
32	Cebu	Philippines	Philippines	389	1,127	48
33	Davao	Philippines	Philippines	201	580	48
34	Haiphong	Viet Nam	Viet Nam	613	1,885	48
35	Ho Chi Minh	Viet Nam	Viet Nam	3,920	12,065	48
36	Cai Mep	Viet Nam	Viet Nam	963	2,965	48
37	Sihanoukville	Cambodia	Cambodia	261	726	72
38	Laem Chabang	Thailand	Thailand	4,437	13,395	24
39	Bangkok	Thailand	Thailand	697	2,103	24
40	Pasir Gudang (Johor)	Malaysia	Malaysia	411	1,277	24
41	Tanjung Pelepas	Malaysia	Malaysia	399	1,242	24
42	Port Klang	Malaysia	Malaysia	2,871	8,927	24
43	Penang	Malaysia	Malaysia	697	2,168	24
44	Singapore	Singapore	Singapore	2,785	8,783	12
45	Yangon	Myanmar	Myanmar	191	643	48
46	Tanjung Perak	Indonesia	Indonesia	1,441	4,420	48
47	Tanjung Priok (Jakarta)	Indonesia	Indonesia	2,806	8,607	48
48	Belawan	Indonesia	Indonesia	380	1,165	48
49	Chittagong	Bangladesh	Bangladesh	1,033	4,011	72
50	Mongla	Bangladesh	Bangladesh	19	72	72
51	Kolkata	India	India	158	675	72
52	Haldia	India	India	5	23	72
53	Visakhapatnam	India	India	111	474	72
54	Krishnapatnam	India	India	25	107	72
55	Chennai	India	India	485	2,069	72
56	Tuticorin	India	India	86	367	72
57	Cochin	India	India	88	376	72
58	New Manglore	India	India	2	9	72
59	Mormugao	India	India	1	4	72
60	Jawaharlal Nehru	India	India	1,726	7,369	72
61	Hazira	India	India	71	303	72
62	Pipavav	India	India	276	1,177	72
63	Mundra	India	India	1,232	5,257	72

NO	Name of Port	Country	Regional Classification in the Model	Annual Handling Volume (1,000 TEU) 2016 (Present State)	Annual Handling Volume (1,000 TEU) 2040 (Scenario S1)	Transfer Time Tra (hour)
64	Colombo	Sri Lanka	Sri Lanka	524	1,578	48
65	Male	Maldives	Sri Lanka	19	61	72
66	Port Mohammad Bin Qasim	Pakistan	Pakistan	578	1,963	72
67	Karachi	Pakistan	Pakistan	1,018	3,457	72
68	St Petersburg	Russia	Russia Baltics	660	1,427	48
69	Prince Rupert	Canada	Canada Pacific Coast	392	813	24
70	Vancouver BC	Canada	Canada Pacific Coast	1,500	3,114	24
71	Seattle/Tacoma	United States	USA_North Pacific	2,243	4,675	24
72	Oakland	United States	USA_South Pacific	1,593	3,332	24
73	Los Angeles	United States	USA_South Pacific	4,977	10,381	24
74	Long Beach	United States	USA_South Pacific	4,446	9,274	24
75	Manzanillo (Mexico)	Mexico	Mexico Pacific & Central America	1,670	3,361	24
76	Lazaro Cardenas	Mexico	Mexico Pacific & Central America	705	1,420	24
77	Balboa	Panama	Mexico Pacific & Central America	210	421	24
78	Colon/Manzanillo (Panama)	Panama	Mexico Pacific & Central America	362	725	24
79	Puerto Limon	Costa Rica	Mexico Pacific & Central America	360	721	48
80	Puerto Cortes	Honduras	Mexico Pacific & Central America	194	389	48
81	Veracruz	Mexico	N. America Atlantic & Carib	716	1,407	24
82	Altamira	Mexico	N. America Atlantic & Carib	508	998	24
83	San Juan	United States	N. America Atlantic & Carib	461	916	24
84	Caucedo	Dominican Rep.	N. America Atlantic & Carib	781	1,529	48
85	Kingston	Jamaica	N. America Atlantic & Carib	153	300	48
86	Freeport	Bahamas	N. America Atlantic & Carib	11	22	48
87	Houston	United States	N. America Atlantic & Carib	1,404	2,791	24
88	Miami	United States	N. America Atlantic & Carib	503	1,000	24
89	Port Everglades	United States	N. America Atlantic & Carib	571	1,135	24
90	Jacksonville	United States	N. America Atlantic & Carib	596	1,184	24
91	Savannah	United States	N. America Atlantic & Carib	2,861	5,686	24
92	Charleston	United States	N. America Atlantic & Carib	1,588	3,157	24
93	Virginia (Hampton Roads)	United States	N. America Atlantic & Carib	2,114	4,202	24
94	Baltimore	United States	N. America Atlantic & Carib	563	1,118	24
95	New York/New Jersey	United States	N. America Atlantic & Carib	4,610	9,162	24
96	Montreal	Canada	N. America Atlantic & Carib	1,173	2,298	24
97	Buenaventura	Colombia	N. America Atlantic & Carib	312	610	48
98	Guayaquil	Ecuador	Ecuador	625	1,295	48
99	Callao	Peru	Peru	1,155	2,581	48
100	Valparaiso	Chile	Chile	633	1,343	48
101	San Antonio	Chile	Chile	893	1,894	48
102	San Vicente	Chile	Chile	352	746	48
103	Cartagena	Colombia	N. America Atlantic & Carib	477	934	48
104	Puerto Cabello	Venezuela	N. America Atlantic & Carib	331	648	48
105	Manaus	Brazil	Brazil	315	685	48
106	Rio De Janeiro	Brazil	Brazil	291	631	48
107	Santos	Brazil	Brazil	2,269	4,927	48
108	Paranagua	Brazil	Brazil	484	1,050	48
109	Navegantes	Brazil	Brazil	589	1,280	48
110	Itajai	Brazil	Brazil	128	277	48
111	Rio Grande	Brazil	Brazil	458	994	48
112	Montevideo	Uruguay	Other S.E. Coast of S. America	413	903	48
113	Buenos Aires	Argentina	Argentina	1,098	2,439	48
114	Shahid Rajaee	Iran	Arabian Gulf	1,205	3,255	48
115	Dammam	Saudi Arabia	Arabian Gulf	1,130	3,046	48
116	Khalifa Bin Salman	Bahrain	Arabian Gulf	247	670	48
117	Mina Zayed	UAE	Arabian Gulf	186	500	24
118	Dubai	UAE	Arabian Gulf	4,925	13,214	24
119	Sharjah/Khor Fakkan	UAE	Arabian Gulf	80	215	24
120	Sohar/Mina Qabos (Mascut)	Oman	Arabian Gulf	341	922	24
121	Salalah	Oman	Arabian Gulf	156	423	24
122	Jeddah	Saudi Arabia	Arabian Gulf	1,839	4,959	48
123	Aqaba	Jordan	E. Med & Black Sea	563	1,356	48
124	Sokhna	Egypt	Egypt	329	1,469	48
125	Port Said	Egypt	Egypt	216	963	48
126	Damietta	Egypt	Egypt	416	1,858	48
127	Alexandria/El Dekheila	Egypt	Egypt	760	3,393	48
128	Tangier Med	Morocco	W. Med	94	240	24
129	Casablanca	Morocco	W. Med	380	975	24
130	Las Palmas De Gran Canaria	Spain	W. Med	360	928	24
131	Ashdod	Israel	E. Med & Black Sea	830	2,000	24

NO	Name of Port	Country	Regional Classification in the Model	Annual Handling Volume (1,000 TEU) 2016 (Present State)	Annual Handling Volume (1,000 TEU) 2040 (Scenario S1)	Transfer Time Tra (hour)
132	Haifa	Israel	E. Med & Black Sea	751	1,811	24
133	Beirut	Lebanon	E. Med & Black Sea	798	1,921	48
134	Mersin	Turkey	E. Med & Black Sea	811	1,954	48
135	Izmir	Turkey	E. Med & Black Sea	443	1,067	48
136	Ambarli	Turkey	E. Med & Black Sea	1,070	2,580	48
137	Constantza	Romania	E. Med & Black Sea	407	980	48
138	Odessa/Ilchevsk	Ukraine	E. Med & Black Sea	180	433	48
139	Novorossiysk	Russia	E. Med & Black Sea	240	579	48
140	Piraeus	Greece	E. Med & Black Sea	500	1,203	24
141	Koper	Slovenia	Slovenia	449	954	48
142	Marsaxlokk	Malta	C. Med	117	255	24
143	Cagliari	Italy	C. Med	382	829	24
144	Gioia Tauro	Italy	C. Med	54	118	24
145	Leghorn	Italy	C. Med	349	757	24
146	La Spezia	Italy	C. Med	930	2,019	24
147	Genoa	Italy	C. Med	1,675	3,638	24
148	Marseilles - Fos	France	France Mediterranean	593	1,393	24
149	Barcelona	Spain	W. Med	1,097	2,830	24
150	Valencia	Spain	W. Med	1,391	3,588	24
151	Algeciras	Spain	W. Med	241	622	24
152	Felixstowe	United Kingdom	United Kingdom	1,503	3,250	24
153	London	United Kingdom	United Kingdom	521	1,126	24
154	Southampton	United Kingdom	United Kingdom	794	1,717	24
155	Liverpool	United Kingdom	United Kingdom	116	250	24
156	Dublin	Ireland	Ireland	63	134	24
157	Sines	Portugal	W. Med	207	532	24
158	Lisbon	Portugal	W. Med	145	372	24
159	Leixoes	Portugal	W. Med	162	416	24
160	Bilbao	Spain	France/Spain North Atlantic	218	466	24
161	Le Havre	France	France/Spain North Atlantic	1,981	4,249	24
162	Zeebrugge	Belgium	North Sea	169	358	24
163	Antwerp	Belgium	North Sea	4,032	8,540	24
164	Rotterdam	Netherlands	North Sea	5,046	10,688	24
165	Bremen/Bremerhaven	Germany	North Sea	1,462	3,097	24
166	Hamburg	Germany	North Sea	3,450	7,308	24
167	Gdansk	Poland	North Sea	783	1,658	24
168	Kotka	Finland	North Sea	187	396	24
169	Gothenburg	Sweden	North Sea	265	562	24
170	Abidjan	Côte d'Ivoire	W. Africa	869	5,361	48
171	Tema	Ghana	W. Africa	1,095	6,695	48
172	Lagos/Apapa	Nigeria	W. Africa	771	4,779	48
174	Pointe Noire	Cameroon	C. Africa	118	577	48
175	Douala	Gabon	C. Africa	40	197	72
177	Libreville	Gabon	C. Africa	17	84	72
173	Luanda	Congo	C. Africa	219	1,070	72
176	Port Gentil/Mayumba	Angola	Angola	147	404	72
178	Cabinda	Angola	Angola	12	33	72
179	Lobito	Angola	Angola	68	186	72
180	Namibe	Angola	Angola	16	43	72
181	Soyo	Angola	Angola	6	17	72
182	Luderitz	Namibia	Namibia	1	4	72
183	Walvis Bay	Namibia	Namibia	29	179	72
184	East London	South Africa	SE. Africa	38	132	48
185	Richards Bay	South Africa	SE. Africa	3	9	48
186	Cape Town	South Africa	SE. Africa	385	1,390	48
187	Port Elizabeth/Coega	South Africa	SE. Africa	76	277	48
188	Durban	South Africa	SE. Africa	1,320	4,693	48
189	Maputo	Mozambique	SE. Africa	85	307	72
190	Nacala	Mozambique	SE. Africa	57	207	72
191	Dar es Salam	Tanzania	E. Africa -South	319	1,690	72
192	Zanzibar	Tanzania	E. Africa -South	32	167	72
193	Beira	Mozambique	SE. Africa	155	557	72
194	Pemba	Mozambique	SE. Africa	3	9	72
195	Quelimane	Mozambique	SE. Africa	1	3	72
196	Mahajanga	Madagascar	Madagascar	25	133	72
197	Tanga	Tanzania	E. Africa -South	1	6	72
198	Nosy Be	Madagascar	Madagascar	7	40	72
199	Mombasa	Kenya	E. Africa -North	501	2,079	72

NO	Name of Port	Country	Regional Classification in the Model	Annual Handling Volume (1,000 TEU) 2016 (Present State)	Annual Handling Volume (1,000 TEU) 2040 (Scenario S1)	Transfer Time Tra (hour)
200	Kismayu	Somalia	NE. Africa	0	2	72
201	Mogadiscio	Somalia	NE. Africa	12	63	72
202	Berbera	Somalia	NE. Africa	8	43	72
203	Assab	Eritrea	NE. Africa	14	70	72
204	Massawa	Eritrea	NE. Africa	5	27	72
205	Port Sudan	Sudan	NE. Africa	223	1,147	72
206	Djibouti	Djibouti	NE. Africa	631	3,241	72
209	Port Victoria	Madagascar	Madagascar	98	531	72
207	Mutsamudu	Seychelles	Seychelles	47	208	72
208	Toamasina	Comoros	Comoros	3	15	72
210	Pointe des Galets	Reunion	Reunion	0	0	72
211	Port Louis	Mauritius	Mauritius	146	444	72
212	Moroni	Comoros	Comoros	2	9	72
213	Brisbane	Australia	Australia	416	826	24
214	Sydney	Australia	Australia	1,615	3,204	24
215	Melbourne	Australia	Australia	1,692	3,358	24
216	Fremantle	Australia	Australia	121	241	24
217	Auckland	New Zealand	New Zealand	601	1,107	24
218	Tauranga	New Zealand	New Zealand	673	1,240	24

Table 4-5-5: Variables and Variable Settings for Each Country

ID	Country	Port Loading and Unloading				Border Crossing							
		Number of Days Required		Cost (USD/TEU)		Number of Days Required				Cost (USD/TEU)			
						Exports		Imports		Exports		Imports	
		Exports	Imports	Exports	Imports	Documents	Customs	Documents	Customs	Documents	Customs	Documents	Customs
1	Japan	2	2	250	250	5	2	5	2	120	75	140	135
2	South Korea	2	2	100	100	3	1	2	1	55	15	65	30
5	China	3	3	140	140	14	2	15	4	305	80	260	80
6	Hong Kong	2	1	265	265	2	1	2	1	105	0	100	0
8	Taiwan	2	2	180	180	5	1	5	1	175	100	240	100
9	Philippines	3	3	225	200	8	2	8	2	105	85	90	185
10	Viet Nam	3	4	150	175	12	4	12	4	160	100	130	95
12	Cambodia	3	4	158	167	14	3	15	3	220	275	225	280
13	Thailand	3	2	160	160	8	1	8	2	175	50	135	255
14	Malaysia	2	2	120	120	5	1	3	1	85	60	120	60
15	Singapore	1	1	150	150	2	1	1	1	120	50	100	50
16	Myanmar	3	6	165	165	12	3	10	4	175	80	165	80
17	Indonesia	2	4	165	165	11	1	13	4	165	125	210	125
20	Bangladesh	5	7	450	650	14	6	18	6	225	150	370	150
23	India	4	5	158	155	8	2	8	4	365	130	400	200
24	Sri Lanka	3	2	185	185	9	2	7	2	135	160	140	285
25	Pakistan	4	3	115	150	10	3	10	2	110	200	155	220
26	Russia	3	2	480	490	13	1	12	2	200	550	285	650
33	United States	2	1	400	420	2	1	2	1	230	60	205	90
34	Canada	1	2	600	650	4	1	3	1	295	35	205	75
35	Mexico	2	3	200	300	5	2	4	2	200	150	290	200
36	Costa Rica	3	3	220	250	6	2	7	2	240	105	215	155
39	Panama	1	1	65	265	5	1	6	1	160	50	150	200
41	Honduras	1	2	50	215	8	2	8	4	260	135	255	130
44	Dominican Republic	1	2	325	410	3	2	5	2	215	200	235	200
45	Bahamas	4	2	200	950	10	3	7	3	375	130	300	220
46	Jamaica	3	2	495	740	10	4	10	3	450	235	490	550
48	Peru	3	5	330	395	5	2	7	3	150	130	150	185
49	Chile	3	3	210	210	7	2	5	2	220	100	170	100
51	Ecuador	2	4	360	320	10	4	15	4	375	200	350	250
52	Colombia	3	2	170	150	5	2	6	2	300	350	250	170
53	Venezuela	12	15	800	800	34	7	54	10	690	500	695	700
54	Argentina	2	3	550	800	6	2	22	3	450	150	610	400
55	Brazil	3	3	500	500	6	3	8	4	325	400	275	450
56	Uruguay	3	3	350	450	8	2	7	3	325	250	440	250
60	Iran	4	5	225	250	12	2	24	2	270	175	330	220
61	Bahrain	2	3	110	110	6	2	8	3	380	70	380	110
65	United Arab Emirates	1	1	190	190	4	1	4	1	230	30	190	30
66	Saudi Arabia	4	3	75	174	6	1	6	6	145	115	135	200
67	Oman	3	2	135	105	5	1	5	1	285	65	250	65
69	Jordan	3	2	110	130	6	2	8	3	135	80	385	65
70	Israel	3	3	200	200	4	1	4	1	110	110	120	70
71	Lebanon	4	6	125	400	11	3	16	6	370	285	315	400
74	Turkey	3	3	270	355	6	2	8	2	220	200	280	200
78	Greece	2	3	300	380	11	1	8	2	160	230	140	265
79	Italy	3	3	345	345	11	2	10	2	180	145	130	145
80	Portugal	5	5	260	260	7	1	6	1	195	125	200	265
81	Spain	2	2	250	250	4	1	4	2	30	18	30	18
86	Romania	3	2	300	300	7	1	8	1	410	75	420	75
87	Slovenia	3	3	200	200	10	1	9	1	135	60	195	85
88	Morocco	2	2	250	350	6	1	10	2	125	100	300	150
94	Egypt	2	3	170	250	7	1	8	2	125	100	210	100
96	Malta	2	2	275	410	6	1	4	2	280	50	260	50
98	Belgium	2	2	300	300	3	1	4	1	190	100	270	100
100	Finland	2	2	160	160	4	1	3	1	170	85	180	85
101	France	3	3	315	315	4	1	5	1	310	80	300	150
102	Germany	2	1	250	250	4	1	3	1	175	30	185	55
103	United Kingdom	2	1	205	205	3	1	2	1	175	75	180	75
104	Ireland	1	2	220	253	5	1	5	1	205	185	165	70
106	Netherlands	1	1	260	250	4	1	3	1	160	90	220	90
107	Sweden	2	2	200	200	3	1	2	1	120	55	130	55
111	Poland	3	2	140	140	10	1	9	1	145	65	120	65
116	Ukraine	3	3	430	600	22	1	20	2	250	300	555	350

ID	Country	Port Loading and Unloading				Border Crossing							
		Number of Days Required		Cost (USD/TEU)		Number of Days Required				Cost (USD/TEU)			
						Exports		Imports		Exports		Imports	
		Exports	Imports	Exports	Imports	Documents	Customs	Documents	Customs	Documents	Customs	Documents	Customs
130	Ghana	3	8	100	100	10	4	26	5	125	150	310	450
131	Côte d'Ivoire	3	6	800	1000	15	5	19	7	290	200	410	300
133	Nigeria	4	5	450	605	12	3	14	12	280	350	330	360
139	Congo	4	6	365	900	32	8	34	10	790	400	690	400
142	Angola	6	8	400	500	25	5	25	7	560	400	825	400
147	Djibouti	3	3	270	270	13	2	11	2	295	170	320	170
148	Rwanda	-	-	-	-	12	4	11	2	230	170	250	125
149	Burundi	-	-	-	-	8	2	13	5	230	170	250	250
150	Kenya	6	8	375	390	12	4	11	3	305	375	250	510
151	Madagascar	2	2	225	550	15	2	14	3	200	270	190	315
152	Malawi	-	-	-	-	8	2	11	2	270	170	490	125
153	Mauritius	2	2	175	175	5	1	5	1	285	75	295	100
154	Mozambique	4	5	320	400	12	2	16	2	230	250	490	340
155	Uganda	-	-	-	-	8	2	11	5	230	170	575	250
156	Ethiopia	-	-	-	-	8	2	13	5	230	170	575	125
157	Tanzania	4	7	320	540	8	4	13	5	270	250	575	250
158	Zambia	-	-	-	-	8	2	11	2	270	250	490	250
159	Zimbabwe	-	-	-	-	8	2	11	2	230	250	490	250
160	Botswana	-	-	-	-	8	2	7	2	230	250	490	250
161	South Africa	4	9	285	450	8	2	7	2	355	65	405	125
162	Namibia	5	8	350	617	8	4	7	2	270	250	490	125
163	Australia	1	2	400	400	5	1	3	1	285	65	200	170
164	New Zealand	2	1	300	300	5	1	5	1	220	50	175	50
216	Reunion	7	8	215	220	5	3	4	4	260	130	225	130
219	Seychelles	7	8	215	220	5	3	4	4	260	130	225	130
220	Comoros	8	10	630	630	15	5	11	2	265	150	265	150
241	Maldives	6	8	500	550	9	4	9	4	375	200	460	200
401	Cameroon	4	6	429	651	17	5	23	9	371	275	435	378
402	Gabon	4	6	429	651	17	5	23	9	371	275	435	378
404	Eritrea	4	5	291	370	25	5	25	7	270	400	575	400
405	Somalia	3	3	291	370	25	5	25	7	270	400	575	400
406	Sudan	4	5	291	370	25	5	25	7	270	400	575	400
407	South Sudan	-	-	-	-	25	5	25	7	270	400	575	400
408	DR Congo	-	-	-	-	25	5	13	10	270	400	575	400
409	Lesotho	-	-	-	-	5	2	7	2	230	65	250	125

Table 4-5-6 : Present and Planned Container Handling Capacity at Major East African Ports

Present										Planned									
Name of Port	Facility Name	Seawall Length		Depth of Water	Draft	Yard Area	Handling Capacity	Annual Handling Volume	Remarks	Year	Name of Port	Facility Name	Seawall Length		Depth of Water	Yard Area	Handling Capacity		Remarks
Djibouti	Port of Djibouti Container Terminal No01	180 m	400 m	12.5 m	-	15,000 m²	-	987,189 TEU (as of 12/31/2016)	Reference : WSE	-	Djibouti	Port of Djibouti Container Terminal No01	180 m	400 m	12.5 m	15,000 m²?	-	-	Reference: http://portdedjibouti.net/Pages/NewProjects.php?ProjectID=2
	Port of Djibouti Container Terminal No02	220 m		9.5 m	-							Port of Djibouti Container Terminal No02	220 m		9.5 m				
	Doraleh Container Terminal No01	-	1,050 m	20.0 m	18.0 m	-	1,500,000 TEU			Phase 2		Doraleh Container Terminal No01	-	2,000 m	20.0 m	-	-	3,000,000 TEU	Reference: "Ports" magazine, July 2009 https://www.phaj.or.jp/distribution/lib/world_watching/Africa/Africa008b.pdf
	Doraleh Container Terminal No02	-		20.0 m	18.0 m							Doraleh Container Terminal No02	-		20.0 m	-			
	Doraleh Container Terminal No03	-		20.0 m	18.0 m							Doraleh Container Terminal No03	-		20.0 m	-			
												(New) Doraleh Container Terminal No04	-		-	-			
												(New) Doraleh Container Terminal No05	-		-	-			
												(New) Doraleh Container Terminal No06	-		-	-			
Mombasa	Mombasa Container Terminal 16	177 m	839 m	-	12.5 m	-	1,100,000 TEU	1,190,000 TEU (as of 12/31/2017)	Reference : WSE Reference : https://www.kpa.co.ke/OurBusiness/pages/mombasa-container-terminal.aspx	-	Mombasa	Mombasa Container Terminal 16	177 m	839 m	-	-	1,100,000 TEU		Reference: http://open_jicareport.jica.go.jp/pdf/12246674_01.pdf
	Mombasa Container Terminal 17	182 m		-	12.5 m	-						Mombasa Container Terminal 17	182 m		-	-			
	Mombasa Container Terminal 18	239 m		-	12.5 m	-						Mombasa Container Terminal 18	239 m		-	-			
	Mombasa Container Terminal 19	240 m		-	13.5 m	-						Mombasa Container Terminal 19	240 m		-	-			
	Second Container Terminal 20	235 m	-	11.0 m	-	4,135 m²	-					Second Container Terminal 20	235 m	-	11.0 m	4,135 m²	-		
	Second Container Terminal 21	350 m	-	15.0 m	-		-					Second Container Terminal 21	350 m	-	15.0 m		-	-	
												(New) Mombasa Container Terminal 14	300 m	-	15.0 m	-	-		
												(New) Second Container Terminal 22	300 m	-	15.0 m	-	-		
												(New) Second Container Terminal 23	300 m	-	15.0 m	-	-		
												(New) Second Container Terminal 24	300 m	-	15.0 m	-	-		
												(New) Second Container Terminal 25	300 m	-	15.0 m	-	-		
Dar es Salaam	Tanzania International Container Terminal Services (TICTS) 08	148n	-	10.5 m	-	12,000 m²	250,000 TEU	578,103 TEU (as of 6/30/2013)	Reference : WSE Reference : https://www.kpa.co.ke/OurBusiness/pages/mombasa-container-terminal.aspx	-	Dar es Salaam	Tanzania International Container Terminal Services (TICTS) 08	148n	-	10.5 m	12,000 m²	-	1,200,000 TEU	Reference: http://open_jicareport.jica.go.jp/pdf/12150504.pdf (P15)
	Tanzania International Container Terminal Services (TICTS) 09	180 m	-	10.5 m	-							Tanzania International Container Terminal Services (TICTS) 09	180 m	-	10.5 m				
	Tanzania International Container Terminal Services (TICTS) 10	180 m	-	10.5 m	-							Tanzania International Container Terminal Services (TICTS) 10	180 m	-	10.5 m				
	Tanzania International Container Terminal Services (TICTS) 11	162 m	-	10.5 m	-							Tanzania International Container Terminal Services (TICTS) 11	162 m	-	10.5 m				
												(New) Berth 13	-	-	-	-	-		
												(New) Berth 14	-	-	-	-			
Durban	Durban Container Terminal 108	273 m	545 m	12.1 m	11.8 m	-	700,000 TEU	2,980,000 TEU (as of 12/31/2018)	Reference : WSE Reference : https://www.transnetportterminals.net/Ports/Pages/Durban_Container.aspx	2046	Durban	Durban Container Terminal 108	273 m	545 m	12.1 m	233 ha	5,600,000 TEU	-	*Container yard expansion, berth addition Reference: National Ports Plan 2017 update (national ports authority)
	Durban Container Terminal 109	272 m		12.4 m	12.1 m	-						Durban Container Terminal 109	272 m		12.4 m				
	Durban Container Terminal 200	236 m		12.0 m	11.7 m	-	2,900,000 TEU					Durban Container Terminal 200	236 m		12.0 m				
	Durban Container Terminal 201	216 m	668 m	12.2 m	11.9 m	-						Durban Container Terminal 201	216 m	668 m	12.2 m				
	Durban Container Terminal 202	216 m		12.6 m	12.3 m	-						Durban Container Terminal 202	216 m		12.6 m				
	Durban Container Terminal 203	305 m	915 m	12.5 m	12.2 m	-						Durban Container Terminal 203	305 m	915 m	12.5 m				
	Durban Container Terminal 204	305 m		11.4 m	11.1 m	-						Durban Container Terminal 204	305 m		11.4 m				
	Durban Container Terminal 205	305 m		11.7 m	-	-						Durban Container Terminal 205	305 m		11.7 m				
												(New) Durban Container Terminal 1	-	-	-				
												(New) Durban Container Terminal 2	-	-	-				
												(New) Durban Container Terminal 3	-	-	-				

			Durban Dig Out Port *New plan	(New) Container Terminal 1	-	-	-	141 ha	4,800,000 TEU	-	*Plan for new port Reference: National Ports Plan 2017 update (national ports authority)
				(New) Container Terminal 2	-	-	-				
				(New) Container Terminal 3	-	-	-				
				(New) Container Terminal 4	-	-	-				
				(New) Container Terminal 5	-	-	-				
				(New) Container Terminal 6	-	-	-				
				(New) Container Terminal 7	-	-	-				
				(New) Container Terminal 8	-	-	-				

5. Logistics Strategy in the Indo-Pacific Region

5-1 Identifying Bottlenecks in Logistics Infrastructure

- This chapter identifies bottlenecks in ports and roads (economic corridors) based on intense freight traffic and cross-border freight flows, as well as the results of the logistics model simulations performed in the previous chapter.

5-1-1 Ports

- Based on the results of comparing the freight demand forecasts and port capacities (Figure 5-1-1) in the previous chapter, ports are prioritized for development.
- The amount and ratio of freight exceeding the capacity of each port are shown in Table 5-1-1 and Table 5-1-2, respectively.
- While the port rankings slightly differ between the excess amount and excess rate, Dar es Salaam and Nacala should be given high priority for development, as they will most likely face capacity shortages.

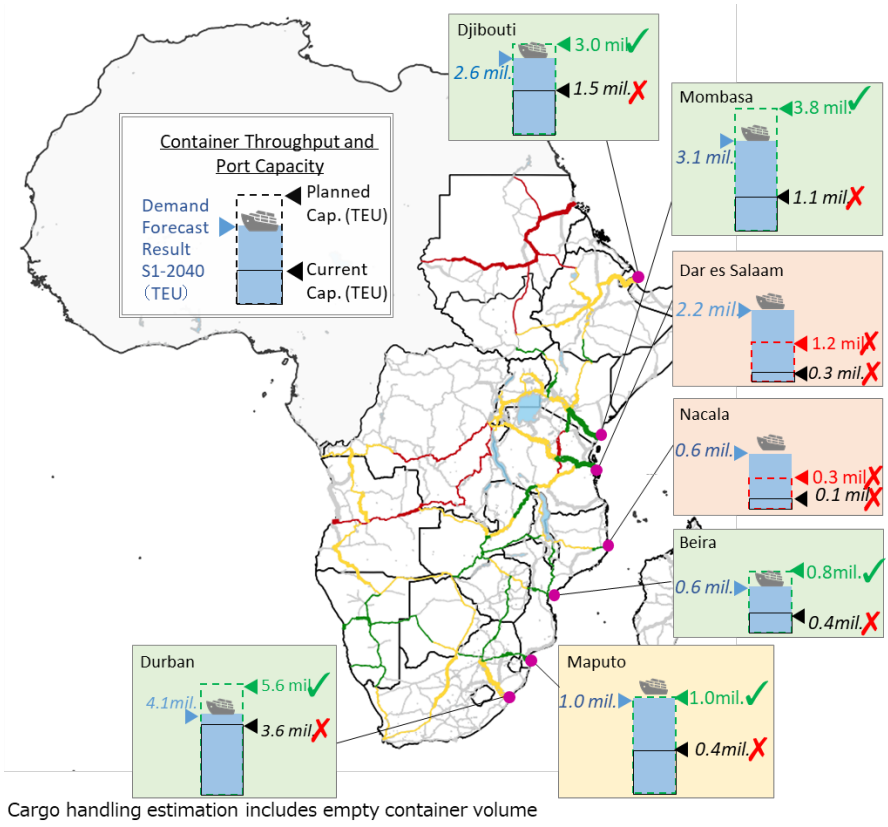


Figure 5-1-1: Projections of Port Freight Handling Demand, against Current and Planned Port Handling Capacity (reshown)

Table 5-1-1: Freight flow exceeding port capacity

No	Port	Excess freight flow* (in 10,000 TEU)
1	Dar es Salaam	+95.4
2	Nacala	+31.3
3	Maputo	-0.2
4	Beira	-14.0
5	Djibouti	-35.2
6	Mombasa	-72.4
7	Durban	-149.9

*Excess freight flow = Port freight flow (estimate) – Port capacity

Table 5-1-2: Ratio of freight exceeding port capacity

No	Port	Excess ratio (%)*
1	Nacala	+125.2
2	Dar es Salaam	+79.5
3	Maputo	-2.3
4	Djibouti	-11.7
5	Beira	-18.7
6	Mombasa	-19.1
7	Durban	-26.8

*Excess ratio = Port freight flow (estimate) / Port capacity – 1

5-1-2 Roads

- Based on the present conditions of the freight road network and freight flow forecasts compiled in the previous chapter (Figure 5-1-2), roads are prioritized for development.
- Freight flow of each economic corridor is shown in Table 5-1-3.
- North-South Corridor has the largest freight flow, followed by Northern Corridor and Central Corridor.
- Growth in freight flow is expected especially in the road sections connecting ports and large cities, for which steady development needs to be ensured.
- Attention needs to be paid to railroad development, as it could affect the freight transport capacity.

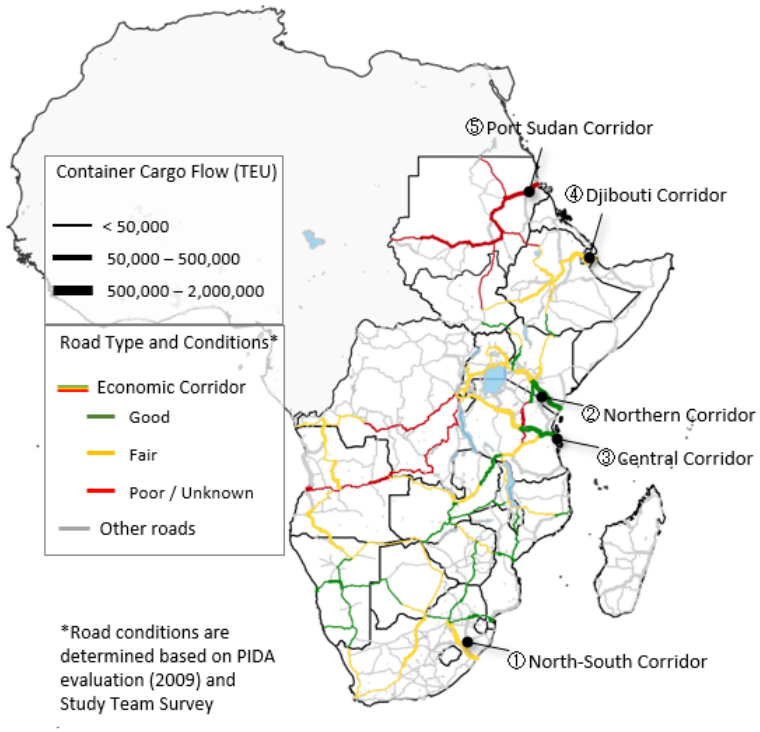


Figure 5-1-2: Present State of Freight Transport Road Networks and Freight Flow Forecast (reshown)

Table 5-1-3: Freight Flow by Economic Corridor

No	Economic corridor: section	Freight flow in million TEU (both ways)
1	North-South Corridor: Durban-Johannesburg	1.65 – 1.28
2	Northern Corridor: Mombasa-Nairobi	1.39 – 1.3
3	Central Corridor: Dar es Salaam-Morogoro	1.06 – 0.97
4	Djibouti Corridor: Djibouti-Ethiopia border	0.99 – 0.52
5	Port Sudan Corridor (tentative name): Port Sudan-Atbarah	0.74 – 0.55

Note 1: International maritime container freight flow, excluding empty containers.

Note 2: Freight flows tend to be greater in road sections closer to ports. The figures in the above table indicate the largest and smallest TEUs of each section.

5-1-3 Intense Freight Traffic and Cross-Border Freight Flows

- Figure 5-1-3 shows the distribution of locations with intense freight traffic, superimposed on Figure 5-1-2, which shows freight flow forecast. The Figure indicates greater freight demand in inland locations.
- Freight flows of cross-border points are shown in Table 5-1-4.
- The Galafi Ethiopia-Djibouti border has the largest freight flow, followed by the Gatuna Rwanda-Uganda border and the Bukavu-Rusizi DR Congo-Rwanda border.
- Support for the establishment of OSBPs between countries will be key to reducing the cost of inland transportation in the region, thereby enhancing the competitiveness of the local products.

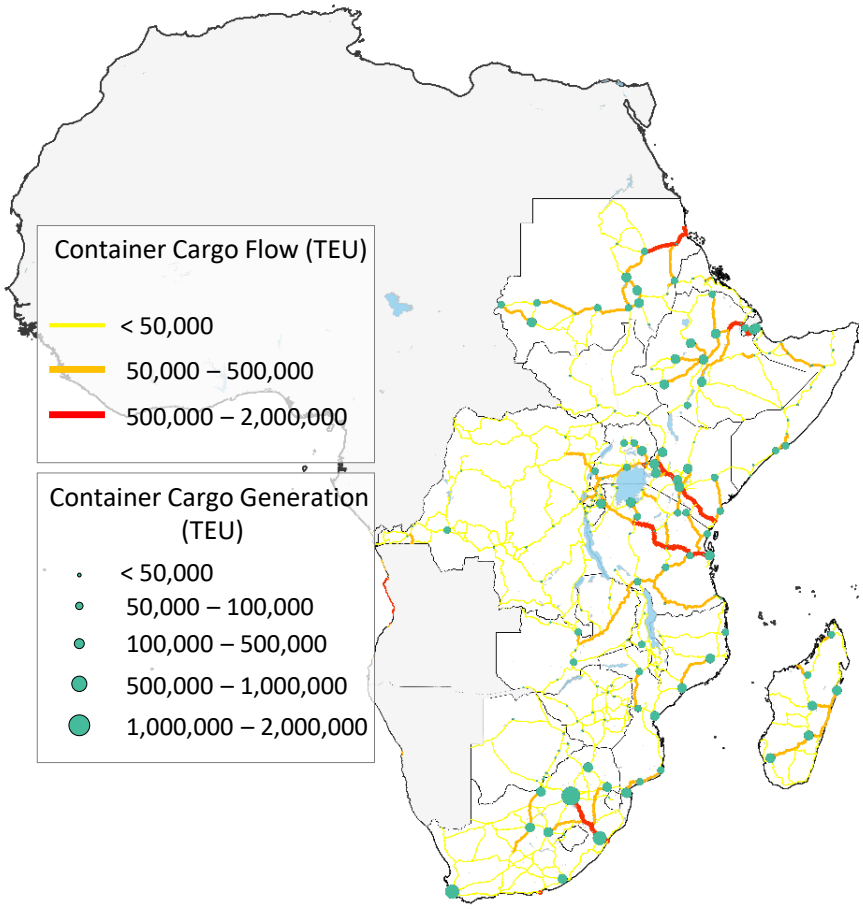


Figure 5-1-3: Freight-Volume/Flow Forecast of Locations with Intense Freight Traffic (reshown)

Table 5-1-4: Freight flows at border-crossing points

No	Border-crossing point	Freight flow TEU* (both ways)
1	Ethiopia-Djibouti: Galafi border	54,0000
2	Rwanda-Uganda: Gatuna	20,0000
3	D.R. Congo-Rwanda: Bukavu-Rusizi border	110,000
4	Uganda-Kenya: Tororo-Malaba border	80,000
5	D.R. Congo-Uganda: Kasindi Mpondwe border	70,000
6	Tanzania-Zambia: Nakonde border	60,000
7	Rwanda-Tanzania: Rusumo border	60,000
8	Tanzania-Kenya: Namanga border	50,000

*International maritime container freight flow, excluding empty containers.

5-2 Review of Findings and Formulation of Logistics Infrastructure Strategy

5-2-1 Challenges of Logistics Infrastructure Indicated from the Study

(1) Facilitation of Integrated Development of Economic Corridors and OSBPs for Sustainable Growth

- As explained in 4-5-2 (2), the calculation results of the logistics model suggest that physical measure of developing economic corridor while providing institutional measure of developing OSBPs to improve custom procedures would contribute to reducing the average land freight transport cost for coastal countries and inland countries by 12% and18% respectively. Thus, it was implied that the impact on trade cost reduction would be higher in inland countries.
- In order to further facilitate growth of the inland countries, it is important to take wholistic approach, that is, to promote development and improvement of port facilities in coastal countries, while at the same time enhance connectivity through economic corridor development and OSBP facilitation.

(2) Formulation of Ports Development Strategy with regards to Hinterland Connectivity

- As explained in 4-5-2 (3), the analysis of ports with high economic benefits from international import/ export of maritime container freight in the East African region indicated that the development of economic corridors and trade facilitation by OSBP can diversify the port selections. In particular, the major ports such as Mombasa, Dar es Salaam, Beira, Durban also transport freights to several inland countries and plays an important role in the economic development of these regions.
- In order to formulate a port development strategy in the future, it is important to consider the changes in the transport network in the hinterland and also the freight transport demand of inland regions and countries that result from the development of economic corridors and the facilitation of OSBP.

(3) Facilitation of proportionate infrastructure development with regards to the future growth of freight demand

- As explained in 4-5-2 (4), the integrated analysis of freight flow by transport route in the eastern African region and the road condition as of 2009 indicated by PIDA showed that it is imperative to have develop and maintain the road conditions to a sufficient level, especially for the roads with poor conditions and huge freight transport demand.
- In addition, the results of freight transportation demand forecasts in the eastern African region and network allocations indicated that there were ports with

sufficient planned capacities for future demands and ports with insufficient capacities (such as Dar es Salaam and Nacala). Furthermore, as outlined in section 5-1, the infrastructures that should be developed with priority were identified.

- In order to achieve sustainable economic growth in the eastern African region, it is important to fully consider the freight demand in the hinterland, as well as to develop ports in the surrounding area with considerations into the development plans of transport infrastructure in the hinterland.

5-2-2 Recommendations for JICA's Development Assistance Policy and Opportunity

- In view of the findings of the previous section, the strategy for logistics infrastructure projects (JICA's development assistance policy and opportunity) consists of the following:

① Promote the infrastructure development and institutional improvement for ports and inland logistics facilities

(Specific Examples)
Development of transportation infrastructures (roads, railways, etc.) and One Stop Border Post (OSBP) in economic corridors, development of Special Economic Zones and inland Free Trade Zones, facilitation of customs clearance operations, etc.

② Formulate port strategies considering hinterland connectivity

(Specific Examples)
Formulation of a national / regional level port development master plan and development plans and individual port development plans based on freight demand and connectivity in the hinterland and other neighboring countries.

③ Consider measures to improve cargo handling efficiency and expansion for ports where capacity gap is expected