

Mekong Institute

Research Working Paper Series 2015



The Impact of the Hongsa Lignite Power Plant on the Lao Economy: Input-Output Approach

Phousavanh Chanthasombath



PAPER NO. 7 / 2015

Mekong Institute
Research Working Paper Series 2015

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December, 2015

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This publication of Working Paper Series is part of the Mekong Institute – New Zealand Ambassador’s Scholarship (MINZAS) program. The project and the papers published under this series are part of a capacity-building program to enhance the research skills of young researchers in the GMS countries.

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Table of Contents

List of Abbreviations	v
List of Figures	vi
List of Tables	vi
Acknowledgements	vii
Abstract	viii
1. Introduction	1
1.1. Overview	1
1.2. Research Rationale	2
1.3. Research Objectives	2
1.4. Scope and Delimitations	2
2. Literature Review	3
2.1. Modeling the Growth of the Economy	3
2.2. Input-Output Table History	4
2.3. Literature Review	5
2.4. Conceptual Framework	6
3. Research Methodology	7
3.1. Data Sources	8
3.2. Technique of Analysis	8
4. Results and Discussion	9
4.1. The Impact of Investment in the Hongsa Lignite Power Plant	9
4.2. Backward Linkages	11
4.3. Forward Linkages	12

5. Conclusion and Recommendations	13
5.1. Conclusion	13
5.2. Recommendations	13
References	14
Appendixes	16
Appendix 1:	16
1.1. Lao PDR Input-Output Table in 2011	16
1.2. A-Matrix (Input Coefficient)	17
1.3. I-Matrix (Unit Matrix or Identity Matrix)	18
1.4. (I-A) Matrix	19
1.5. $(I-A)^{-1}$ -Matrix or Inverse of (I-A) Matrix	20
1.6. Estimation of Hongsa Lignite Power Plant Investment in 2015 by Industry	21
Appendix 2: Coal Mines and Water Resources	22
Appendix 3: Major Hongsa Lignite Power Plant Milestones	24
About MINZAS	26
Mekong Institute	27

List of Abbreviations

AREES	:	Association of Regional Econometrics and Environmental Studies
ASEAN	:	The Association of Southeast Asian Nations
Banpu	:	Banpu Public Company Limited
CGE	:	Computable general equilibrium
EDL	:	Electricité du Lao
EGAT	:	Electricity Generating Authority of Thailand
GDP	:	Gross Domestic Product
GO	:	Gross Output
HPC	:	Hongsa Power Company Limited
IC	:	Intermediate Consumption
IO	:	Input-Output
IOT	:	Input-Output Table
IRIO	:	Inter-regional Input-Output
Lao PDR	:	Lao People's Democratic Republic
LHSE	:	Lao Holding State Enterprise
NSEDP	:	National Socio-Economic Development Plan
RATCH	:	Ratchaburi Electricity Generating Holding Public Company Limited
SAM	:	Social Accounting Matrix
USD	:	United States Dollar
VA	:	Value Added

List of Figures

Figure 1:	The conceptual framework of the impact of the Hongsa Lignite Power Plant investment on the Lao economy: an IO approach	6
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List of Tables

Table 1:	The impact of investment in the Hongsa Lignite Power Plant on output in million kip	10
Table 2:	Backward linkages/output coefficients and their ranks	11
Table 3:	Forward linkages/input coefficients and their ranks	12

Acknowledgements

I would like to take this opportunity to express my heartfelt gratitude to all the lecturers at the Department of Economics, Faculty of Economics and Business Management, National University of the Lao PDR, who have given me valuable advice and helped me during my master's degree studies. In particular, I would like to express my special gratitude to my supervisors, Assoc. Prof. Dr. Phouphet Kyophilavong and Dr. Watcharas Leelawath, for their great support and encouragement, assistance and advice while I was carrying out this research.

I also would like to thank the Lao Statistics Bureau, Ministry of Planning and Investment for having allowed me to participate in their research methodology program from 9 March to 3 April 2015, and I would like to thank Mekong Institute and the New Zealand Ambassador for its financial support and kind arrangements during my stay in Khon Kaen, Thailand.

Furthermore, I would like to thank all the lecturers at the Mekong Institute who provided me with the lessons and experience in research methodology so that I was able to improve my research skills techniques during the monthly training program. Also, thanks to all my scholars in Cambodia, Myanmar and Thailand for their help during the training.

I would like also to thank Mr. Seang Sopheak and Ms. Jenisa Belardo for their hard work in arranging all the facilities before and during my attendance at the training and roundtable meetings at Mekong Institute, Khon Kaen, Thailand

Finally, I would like to thank all the members of my family, who have always encouraged and supported me to continue my graduate studies.

Abstract

The focus of this study was to analyze the impact of the investment in the Hongsa Lignite Power Plant on the Lao economy in 2015 using an input-output approach and data from the investment project (including data from a factory pre-feasibility study), as well as data from the sectors involved. The study concludes that the impact of the investment, which was worth 4,288 billion kip, in the Hongsa Lignite Power Plant on the electricity, construction and transport sectors, as well as on other services, has increased the Lao economy's total output by 6.7% for a value-added amount of 7,245 billion kip.

Based on the input-output table, the study also finds that the main sectors impacted by the economy's output and backward linkages are the sectors of wood and paper, transport equipment, textiles and apparel, and food and beverages. In addition, the study found that the sectors of the input multiplier are the sectors of financial intermediation and business activities, chemical, mineral and metal products, and wholesale trade. The outputs of these sectors are used as inputs by other sectors.

The study concludes that the Hongsa Lignite Power Plants has contributed to the Lao economy. More generally, it shows that an input-output table could be a useful tool for finding the main sectors involved in the generation of an economy's output. The table is also a tool used to set priorities for the effective planning and achieving of economic growth and investment goals.

1. Introduction

1.1. Overview

The Lao PDR's Seventh Five-Year National Socio-Economic Development Plan (7th NSEDP) 2011-2015 has set up a target for the energy sector to become a strategic sector both in the short and long term. The plan also aims to serve society by generating income in order to accumulate capital (resources) that is to be used in the country's socio-economic development, to elevate the standard of living, and to become the "battery of ASEAN". The energy sector is regarded as a core sector for modernization and industrialization.

During the years 2000 to 2013, the number of hydropower plants in the Lao PDR increased from 7 to 23, and the total capacity increased from 860 MW to 2,980 MW. In order to continue to boost economic growth and to meet the target of electricity production, the Lignite Power Plant was established in 2009 in the Hongsa District, Xayaboury Province, Lao PDR with a total installment capacity of 1,878 MW by an agreement between two companies, Banpu Public Company Limited (Banpu) with 40% share and Ratchaburi Electricity Generating Holding Public Company Limited (RATCH) with 40% share. The Lao Holding State Enterprise (LHSE) holds the remaining 20%.

Upon the completion of the project in 2016, the Hongsa Mine Mouth Power Plant is expected to make Laos widely renowned as the "Battery of ASEAN" with its capacity to produce 1,473 MW of electricity for sale to the Electricity Generating Authority of Thailand (EGAT) and 100 MW to the "Electricité du Laos" (EDL). In terms of installed electricity capacity, the Hongsa Lignite will become the biggest power station in the Lao PDR, covering about 63% of the total generation capacity of the country.

Nine Thai commercial banks, namely Bangkok Bank, Siam Commercial Bank, Krungthai Bank, Government Savings Bank, Kasikorn Bank, Export-Import Bank of Thailand, Bank of Ayudhya, Thanachart Bank and TMB Bank have committed to proportionate contributions toward a total financial package of HPC worth US\$3.71 billion in capital. As for long-term senior debts under the typically limited recourse project financing scheme, the financial close took place in August 2010, while the first drawdown was made in October 2010.

1.2. Research Rationale

The Hongsa Lignite Power Plan will be fully operational in March 2016. The plant consists of three units, of which one unit had already begun operations in June 2015. The other two units will begin in November 2015 and March 2016, respectively, (<http://www.hongsapower.com>, 14 August 2015) with 1,878 megawatts and a total investment of US\$3.71 billion. This project may have a positive impact on the Lao economy, mainly in the form an increase in investment, which will directly affect the country's GDP. Since there has yet been no study of the project's impact on and the contribution of this investment to the Lao economy, the overall impact of the Hongsa Lignite Power Plant is not well understood. Hence, the main objective of this thesis is to assess the impact of the Project on the Lao Economy by using an input-output table analysis.

This study will be important to researchers and policymakers who wish to know how the investment in the project would directly affect the Lao economy in terms of GDP and indirectly affect the short and long-term development of each sector of the economy.

1.3. Research Objectives

The objective of this research study is to analyze the impact of the Hongsa Power Plant on the Lao Economy through an input-output approach. Specific objectives are to estimate the contribution of the power plant and its investment on GDP growth in 2015, and to look at the backward linkages and forward linkages (output multipliers) within the input-output table.

1.4. Scope and Delimitations

The research study analyzes the impact of the Hongsa Lignite Power Plant on the Lao Economy in 2015 in terms of output by using the input-output table of the Lao PDR in 2011 compiled by the Centre for Integrated Sustainability Analysis, School of Physics A28, University of Sydney, and also using data from surveys, administrative reports and the Hongsa feasibility study, as well as the annual and five-year Lao National Socio-Economic Development Plans.

The Hongsa Lignite Power Plant will have the highest capacity of electricity generation among all the power plants in the country and will generate more than 70% of the country's

total electricity when all three units of the plant are operational by March 2016. However, the study does not focus directly on electricity production or on the production side, or on how much the company would benefit in other ways due to the lack of data for these aspects.

This study focuses on how much the plant will contribute to and the generated multiplier in all industry sectors on the basis of the input-output table. However, the IOT is not officially calculated by any Lao institutions. Therefore, the table will be not sufficient to show the real economic transactions. Moreover, in a least-developed country, such as the Lao PDR, the structure of the economy changes very quickly, affecting the input coefficient. Therefore, estimating the effects of the Hongsa Lignite Power Plant can result in under- or overvaluing the actual effects on the Lao economy. Therefore, a following study would be required to use the IOT from a Lao institutional agency.

2. Literature Review

2.1. Modeling the Growth of the Economy

The model to measure the economic growth is based on the growth of the Gross Domestic Product (GDP) as estimated by the following formula:

$$Y = C + G + I + X - M \quad (2.1)$$

Where

- Y= Total expenditure on GDP
- C= Consumption
- G= Government expenditure
- I= Investment
- X= Exports
- M= Imports

Equation (2.1) intends to explain the GDP by expenditure; therefore we can rewrite the equation as below:

$$Y = GDP = C + G + I + X - M \quad (2.2)$$

From the formula on gross domestic product compilation or added value, we can also have the following:

$$GO - IC = VA = C + G + I + X - M \quad (2.3)$$

Where
 GO= Gross Output
 IC= Intermediate consumption as input
 VA= Value added

From Equation 2.3:

$$\begin{aligned} GO - IC &= VA \\ \frac{GO}{GO}(GO - IC) &= VA \\ GO(1 - \frac{IC}{GO}) &= VA, \text{ let } a = \frac{IC}{GO} \\ GO(1 - a) &= VA \\ GO &= (1 - a)^{-1}VA \end{aligned}$$

Where $(1 - a)^{-1}$ is the Leontief Inverse, the later a or $\frac{IC}{GO}$ is the intermediate consumption coefficient or technical coefficient, which is derived from the input-output table (Tantr, T. and Mei T.S., 2009).

2.2. Input-Output Table History

The input-output table was successfully developed by Dr. Wassily Leontief (1951), who published the US I-O tables in 1919, 1929 and 1936, followed by a series of publications that resulted in the awarding of the 1973 Nobel Prize in Economics for the development of the I-O method and for its application to important economic problems (Tadayuki, 2008). Dr. Walter Isard started to focus on regional economic impact analysis in the 1940s, and initiated a new academic field entitled, ‘regional science’, which is roughly explained as ‘applied geographical economics’. The Regional Science Association International was founded by Dr. Isard in 1954 (Tadayuki, 2008).

Many researchers have expanded the depth and width of applied research using quantitative methods to address issues of regional economic analyses. Scholars in this field have contributed considerably toward the development and application of I-O models in order to help solve economic problems. In addition, the structure still remains the core of sophisticated modeling, such as SAM or CGE modeling, and an understanding of this structure is a de-facto prerequisite to other types of modeling, including the TSA framework, which is based on the I-O structure (Tadayuki, 2008).

2.3. Literature Review

Aroca, P. (2001) studied the impact of the mining sector on Chilean region II and evaluated the conditions that affect the magnitude of this impact. Employing an input-output matrix for region II, he assessed the impact on output, income and employment. In addition, the study also compares the impacts of private and state-owned firms on the labor market. The findings show that the mining sector there is not important in terms of backward and forward linkages within the region, but is very important in terms of the volume of production. When the main linkages of the mining sector (with the three sectors that have the highest backward and forward linkages) are considered along with mining's level of production, mining is by far the most important sector of Chilean region II. The analysis also finds that significant differences in the management system of each firm result in different costs and benefits for regional development.

Ali Bekhet, H. (2011) investigated the success and failure of development policies for Malaysia's economy over the period 1983-2000 by examining the multiplier indices. The study used four input-output tables published by the Department of Statistics of Malaysia. The study employs the Leontief Inverse model, which is open with respect to households for simple multipliers of output, income and employment. The study resulted in four findings. First, that there is still a high dependency on the primary sectors, such as oil palms, rubber and wood. Second, the output and income multipliers for the agricultural sector are still very weak, even though some success has resulted from planning policies. Third, the main result of the investment policy was to transform Malaysia from a country of surplus labor to one with a shortage. Fourth, there is no consideration of efficiency or comparative costs in the selection of 'key' sectors by reference to multiplier indices.

Al Zoubi, O.M (2013) assessed the impacts of different sectors in the Jordanian economy by using input-output multipliers analysis. The paper attempts to prove the impact of economic sectors by using input-output tables of the Jordanian economy for the years 1987, 2000 and 2009. The study applies input-output techniques to determine the economic effects and gauging the significance of Jordanian industries in generating output, income and employment. The multipliers were obtained in 2009. The manufacturing sector showed the highest output multiplier. The services sector (especially finance) gained the highest income multiplier. Finally, the construction sector had the highest employment multipliers.

Trinh, B. et al. (2010) measured and analyzed the interdependent economic relations between Thailand and Vietnam by constructing a bilateral input-output (I-O) table to estimate the magnitude of an external “shock” on major macroeconomic indicators, such as output, value added, income and employment. Actually, unlike its single-regional counterpart, an IRIO table is able to capture and assess the inter-regional spillover and feedback effects arising from an exogenous change in demand for the output of any one of the study regions. In other words, constructing an IRIO table not only allows for the estimation of the stimulus to production outside a region benefiting from, say, an increase in foreign demand for its output, but also the resultant impact on its output arising from the production stimulus it causes in other regions. This study is deemed to be a prototype of what AREES would need to support its ongoing efforts to develop an integrated database for its proposed research project, titled: “Impact Analysis of Infrastructure Investment in the Indochina Region: An Input-Output (I-O) Approach.”

2.4. Conceptual Framework

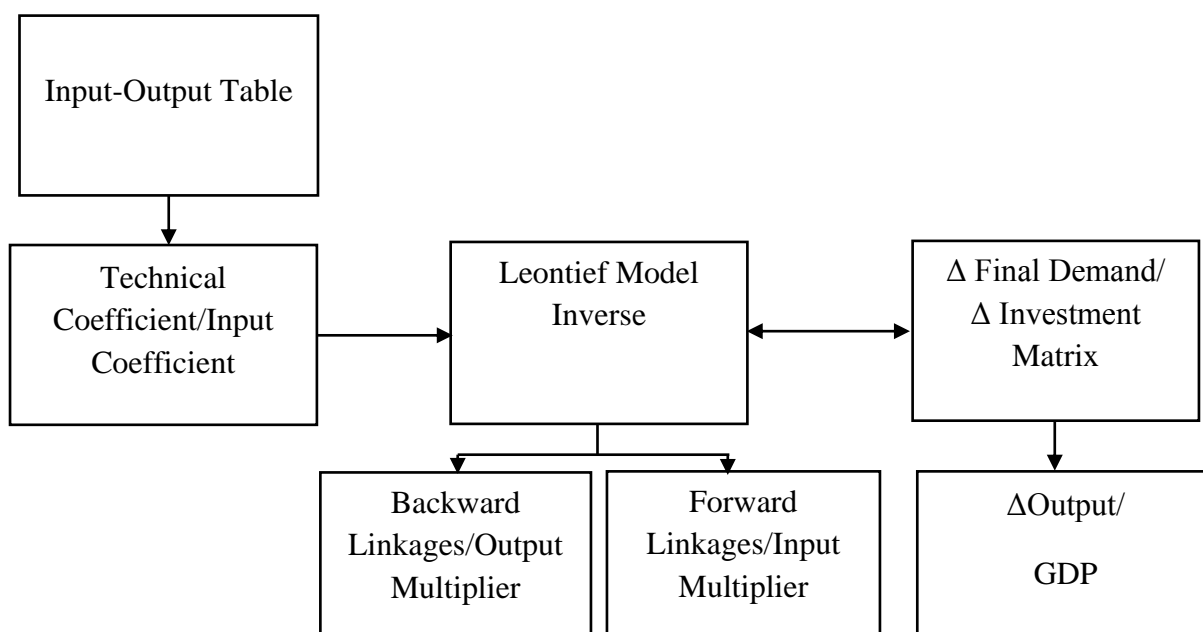


Figure 1: The conceptual framework of the impact of the Hongsa Lignite Power Plant investment on the Lao economy: an IO approach

Source: Modified by the author, based on multiplier calculations in the input-output framework, (Tadayuki, 2008)

Figure 1 displays the conceptual framework of the research on the impact of the investment in the Hongsa Lignite Power Plant on the economy and how to derive the Leontief model inverse and multipliers.

3. Research Methodology

Following the literature, this research uses an input-output table analysis to assess the impact of the Lignite Power Plan on the Lao economy (Aroca, 2001; Ivanova et al., 2007; Treloara, 1997; San Cristóbal and Biezmab, 2006).

In economics, an input-output model is a quantitative economic technique that represents the interdependencies among different regional economies or branches of a national economy. Since the input-output model is fundamentally linear in nature, it lends itself to rapid computation, as well as flexibility, of the effects of changes in demand. The structure of the input-output model has been incorporated into the national accounting of many developed countries, and so, can be used to calculate important measures, such as national GDP (Leontief, 1970).

The basic analysis of an input-output table can be explained as follows.

Say that we have an economy with n sectors. Each sector produces x_i units of a single homogeneous good. Assume that in order to produce one unit, the i th sector must use a_{ij} units from sector j . Furthermore, assume that each sector sells some of its output to other sectors and some of its output to consumers (final demand). Calling final demand in the i th sector d_i , we can write:

$$x_i = a_{i1}x_1 + a_{i2}x_2 + \dots + a_{in}x_n + d_i,$$

or total output equals intermediate use plus final demand. If we let A be the matrix of coefficients a_{ij} , x be the vector of total output, and d be the vector of final demand, then our expression for the economy becomes:

$$x = Ax + d$$

which after re-writing becomes $(I - A)x = d$. If the matrix $I - A$ is invertible, then this is a linear system of equations with a unique solution, and so, given some final demand vector, the required output can be found. Furthermore, if the principal minors of the matrix $I - A$ are all positive (known as the Hawkins–Simon condition), the required output vector x is non-negative.

3.1. Data Sources

The present study lacks official country data, as there is no input-output table produced by the Lao PDR official organization. However, many international organizations and research institution, such as the Global Trade Analysis Project and the Centre for Integrated Sustainability Analysis of the School of Physics, University of Sydney, have analyzed the Lao PDR IO table. Due to the requirements of the analysis, this study used the Lao Input-Output Table compiled by the latter institution (<http://worldmrio.com/national/co.jsp?tab=IOTABLE>). The Table uses 2011 as the base year (Appendix 1).

The IO table consists of 25 industries. However, to focus on finding out the effects of the investment on the output by industry, the study has grouped the data into 22 sectors (Input-Output Table of 22x22), has converted the value from USD to the Lao currency (kip), and applied the RAS method on the maximum difference, or the balancing of the columns and rows of input and output (Trinh and Phong, 2013). Finally, the study compared the value added in the IO table to the Lao PRD's official gross domestic products in 2011, which has a difference of less than 2%. According to the investment data derived from the Ministry of Energy and Mines, Electricité du Lao (EDL), the original Hongsa Lignite Power Plant website, the pre-feasibility study of the project, the Lao State Holding Enterprise and other sources, the investment in 2015 will concern three main industries: the electricity, gas and water sector for 304,757 million kip, the construction sector for 3,524,097 million kip, the transport sector for 72,003 million kip, and other services for 387,872 million kip (Appendix 1.6).

3.2. Technique of Analysis

The IO table model assumes that all goods and services produced will be used for intermediate goods, final consumption and export. Therefore, changes in final demand drive the whole economic system. Changes in final demand can be caused by changes in the

consumption patterns of domestic residents, firms or governments, or by the export of goods and services. The impacts of the changes in final demand can be called direct impacts, direct shocks, direct effects or initial impacts, because this is the exogenous (external) shock that stimulates the entire economic system. When the shock is caused by a change in the final demand, the economy responds to it by producing up to a new level of total output through inter-industry transactions in the regional economy (Tadayuki, 2008).

This study uses the Leontief Inverse matrix model. Using the conceptual framework, we can write the formula:

$$(I-A)^{-1}\Delta Y=\Delta X.$$

Where:

ΔX is the level of output caused by gross fixed capital formation (investment) shock

ΔY is the change of gross fixed capital formation,

ΔX is the change of the output level, which responds to the change in the form of the investment. ΔY is the level of change in investment by industry.

4. Results and Discussion

4.1. The Impact of Investment in the Hongsa Lignite Power Plant

The construction of the Hongsa Lignite Power Plant started in 2009 for a total investment of 3.71 billion USD or 30,021,320 million kip (8,092 kip/1 USD), and will be officially and fully operational for generating electricity in 2016. During the period of 2009 to 2015, the average investment per year is 4,288,760 million kip, which is about 4.27% of GDP. This investment will have a direct impact on infrastructures, such as roads, buildings, factories and transportation.

According to the IO table approach, the 4,288,760 million kip invested in three main sectors and other services in 2015 will contribute 7,245,039 million kip to the Lao PDR's gross output in goods and service, or a gross output growth of 6.7% in 2015. This means that the direct impact is 4,288,760 million kip, and the indirect or multiplier impact is 2,956,039

million kip. The study also finds that the investment in the Hongsa Lignite Power Plant has created the highest output in the construction sector with a value of 3,591,268 million kip, and the second highest output with a value of 659,666 million kip in chemical, mineral and metal products. For electricity, gas and water, and for transportation, the values are 399,596 million, 394,996 million and 241,803 million kip, respectively. In addition, if we look at the percentage growth caused by the investment in 2015 broken down by sector, the highest is other services with 64.4% growth, followed by construction with 50.7%. The electricity, gas and water sector is 12.7%. The mining and quarrying sector is 10.0%. The chemicals, minerals and metals sector is 9.2%, and the transportation sector is 5.7% (Table 1).

Table 1: The impact of investment in the Hongsa Lignite Power Plant on output in million kip

No	Sector	Hongsa Lignite Investment 2015	effect after shock	Percent change by Shock
1	Agriculture	0	14,731	0.3
2	Fishing	0	1,120	0.5
3	Mining and Quarrying	0	115,202	10.0
4	Food & Beverages	0	9,892	0.3
5	Textiles and Wearing Apparel	0	5,465	0.4
6	Wood and Paper	0	51,787	1.1
7	Chemical, Minera and Metal Produ	0	659,666	9.2
8	Electrical and Machinery	0	231,417	4.2
9	Transport Equipment	0	53,020	2.2
10	Other Manufacturing	0	52,570	5.5
11	Recycling	0	3,660	1.2
12	Electricity, Gas and Water	304,757	394,996	12.7
13	Construction	3,524,097	3,591,268	50.7
14	Maintenance and Repair	0	7,085	2.0
15	Wholesale Trade	0	234,241	3.6
16	Retail Trade	0	149,122	2.9
17	Hotels and Restraurants	0	26,819	0.7
18	Transport	72,033	241,803	5.7
19	Post and Telecommunications	0	116,762	2.9
20	Finacial Intermediation and Busines	0	819,896	3.5
21	Public Administration	0	64,918	0.4
22	Others service *	387,872	399,596	64.1
Total		4,288,760	7,245,039	6.7

4.2. Backward Linkages

In the structure of the I-O table, the industrial sectors depend on each other because they need inputs from other industrial sectors, including the same sectors (Tadayuki, 2008). This input can be named backward linkages or output multiplier. The backward linkage is a measure that is expressed in terms of a sector's use of inputs from other sectors in the economy, and can be calculated for the direct demand of the inputs or for the total demand of the inputs, which includes the direct, indirect and induced demands of inputs. The larger this value is for a sector, the greater is the sector's dependence on others in the economy for its inputs, and therefore, the higher the expectation of the economy being stimulated by an increase in this sector's output (Aroca, 2001).

Table 2 shows that the most important sectors in terms of the output multiplier are wood and paper, transport equipment, textiles and wearing apparel, and food and beverages.

Table 2: Backward linkages/output coefficients and their ranks

No	Sector	Coefficient	Rank
1	Agriculture	1.3193	20
2	Fishing	1.0579	22
3	Mining and Quarrying	1.3570	18
4	Food & Beverages	1.9166	4
5	Textiles and Wearing Apparel	1.9646	3
6	Wood and Paper	2.0212	1
7	Chemical, Minera and Metal Products	1.8267	5
8	Electrical and Machinery	1.7774	9
9	Transport Equipment	1.9867	2
10	Other Manufacturing	1.8103	7
11	Recycling	1.8194	6
12	Electricity, Gas and Water	1.3557	19
13	Construction	1.7298	11
14	Maintenance and Repair	1.2673	21
15	Wholesale Trade	1.3587	17
16	Retail Trade	1.3974	16
17	Hotels and Restraurants	1.6303	12
18	Transport	1.7313	10
19	Post and Telecommunications	1.5613	14
20	Finacial Intermediation and Business Ac	1.4961	15
21	Public Administration	1.7972	8
22	Others service *	1.5759	13
Average		1.6254	

4.3. Forward Linkages

The forward linkage or input multiplier indicates the proportion of a sector's output that serves as inputs to all sectors of the regional economy. The larger a sector is as a forward linkage, the more is its output used as an input to production in the regional economy. Thus, it can be argued that the larger a sector's forward linkage, the greater would be the stimulation of this sector by an increase in the regional economy's production (Aroca, 2001).

Table 3 shows that the sectors particularly relevant for the input multiplier are financial intermediation and business activities, chemical, mineral and metal products, and wholesale trade.

Table 3: Forward linkages/input coefficients and their ranks

No	Sector	Coefficient	Rank
1	Agriculture	1.3592	10
2	Fishing	1.0747	18
3	Mining and Quarrying	1.5684	8
4	Food & Beverages	1.2766	13
5	Textiles and Wearing Apparel	1.0713	20
6	Wood and Paper	1.2199	15
7	Chemical, Minera and Metal Prod	3.1970	2
8	Electrical and Machinery	1.9837	4
9	Transport Equipment	1.3038	12
10	Other Manufacturing	1.1493	17
11	Recycling	1.0318	21
12	Electricity, Gas and Water	1.6693	6
13	Construction	1.4677	9
14	Maintenance and Repair	1.0272	22
15	Wholesale Trade	2.0830	3
16	Retail Trade	1.2374	14
17	Hotels and Restraurants	1.1623	16
18	Transport	1.8851	5
19	Post and Telecommunications	1.6259	7
20	Finacial Intermediation and Busine	4.9564	1
21	Public Administration	1.3356	11
22	Others service *	1.0727	19
Average		1.6254	

5. Conclusion and Recommendations

5.1. Conclusion

The study on the impact on the Lao PDR economy of the investment in the Hongsa Lignite Power Plant is based on the Leontief Inverse model of the input-output table and its output multiplier effect. One research finding is that in 2015, the estimated total investment of 4,288,760 million kip will be generating an output of goods and services with a value of 7,245,039 million kip, or in other words, an output increase of 6.7%. The direct effect contribution is 4,288,760 million kip and the indirect effect is 2,956,279 million kip. The higher growth output effect by sector is on other services with a 64.4% increase, followed by construction with 50.7%. The electricity, gas and water sector is 12.7%, while the mining and quarrying sector is 10.0%. The chemicals, minerals and metals sector is 9.2%, and the transportation sector is 5.7%.

The study also finds that the main sectors affected in terms of increase in output by backward linkages or the output multiplier are wood and paper, transport equipment, textiles and wearing apparel, and food and beverages.

In addition, it is interesting to note that the main sectors relevant for the input multiplier or forward linkages are financial intermediation and business activities, as well as chemical, mineral and metal products, and wholesale trade.

5.2. Recommendations

Even though the government may invest much effort and funds to achieve the goals of the five annual National Social Economic Development Plans, the goals are not always reached as expected.

To achieve the goals, the proper economic tools and models need to be utilized in the policy-making process in order to prioritize the sectors allocated for investment. As the study suggests, an input-output table is an efficient tool that can be used by the government when prioritizing national investments. Thus, it is recommended to take the table into consideration, especially, when the Lao PDR has a complete lack of knowledge of this tool.

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Appendix

Appendix 1:

1.1. Lao PDR Input-Output Table in 2011 (Unit: Million Kip)

Sector	Industries																						Final Demand						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
	Agriculture	Fishing	Quarrying	Food & Beverage	Textiles and Wearing Apparel	Wood and Paper	Chemical, Mineral and Metal Products	Electrical and Machinery	Transport Equipment	Other Manufacturing	Recycling	Gas and Water	Electricity, Gas and Water	Construction	Maintenance and Repair	Wholesale Trade	Retail Trade	Hotels and Restaurants	Post and Telecommunications	Financial Intermediation and Business	Public Administration	Others	Total Intermediation	Household final consumption P.3h	Non-profit institutions serving households P.3n	Government final consumption P.3g	Gross fixed formation P.51	Exports	Total
1 Agriculture	112,534	29	324	485,566	28,515	330,862	6,067	346	30	504	112	103	12,809	77	1,387	3,121	30,202	460	104	40,792	17,176	25	1,071,136	308,768	3,041	515	17,881	3,667,641	5,068,983
2 Fishing	955	480	9	147,904	121	75	267	16	11	3,674	61	9	11	125	10	4,529	21,628	35	13	2,847	4,907	39	187,725	17,666	98	366	1,406	15,399	222,660
3 Mining and Quarrying	10,318	154	11,810	4,383	1,995	20,951	436,808	1,182	1,751	460	47,800	262,734	71,051	41	1,342	664	1,500	39,656	968	15,746	30,893	493	962,702	32,375	34	452	17,865	136,801	1,150,230
4 Food & Beverages	137,033	656	62	184,726	14,465	13,278	13,024	158	39	1,502	1,268	199	118	1,257	7,515	38,651	307,696	838	338	54,281	198,567	1,720	977,394	2,114,884	29,372	6	24,036	96,690	3,242,381
5 Textiles and Wearing Apparel	1,506	75	107	1,813	58,405	17,871	6,456	5,168	3,231	4,581	83	320	5,416	118	4,410	3,477	1,836	1,754	996	9,572	26,233	417	153,845	244,572	3,247	41	21,430	1,060,403	1,483,537
6 Wood and Paper	7,895	23	337	37,936	12,319	172,191	31,340	12,167	2,231	19,096	651	1,097	65,968	412	21,943	10,693	13,937	8,622	23,753	221,780	137,835	1,407	803,633	132,441	1,518	1,340	7,739	3,565,394	4,512,066
7 Chemical, Mineral and Metal Products	159,529	1,222	22,289	223,746	230,989	471,382	940,646	629,989	205,208	124,690	61,863	34,274	925,008	2,082	63,022	44,875	68,894	318,698	54,305	431,269	926,081	13,755	5,953,816	910,673	16,582	5,380	98,176	158,599	7,143,226
8 Electrical and Machinery	12,223	329	14,599	22,077	15,362	94,290	160,045	530,027	534,568	60,354	247	17,676	292,010	2,589	57,754	53,188	21,356	45,597	74,875	371,547	457,900	4,651	2,843,254	638,412	4,642	103,341	1,750,149	148,270	5,488,068
9 Transport Equipment	3,487	356	2,505	5,227	1,058	4,123	22,652	72,578	235,580	18,991	197	671	58,830	1,704	11,165	46,586	2,407	62,634	7,375	117,272	192,637	1,535	869,569	670,429	12,676	85,247	691,507	68,613	2,398,042
10 Other Manufacturing	2,848	237	802	10,026	22,656	50,366	14,273	15,294	29,047	8,523	336	2,305	81,990	604	18,620	13,035	14,415	8,599	11,290	108,496	87,776	1,226	502,764	228,506	4,456	12,499	131,605	78,946	958,776
11 Recycling	188	2	168	884	659	22,762	24,091	382	5	247	2,528	4,077	527	14	36	702	255	1,510	887	4,381	3,530	10	67,843	160,259	4,683	1,807	19,568	51,881	306,040
12 Electricity, Gas and Water	57,137	75	21,900	81,792	61,947	331,726	337,623	66,842	15,288	10,197	2,647	23,954	40,322	2,775	38,572	80,502	120,932	64,521	38,314	312,532	484,201	4,878	2,198,678	849,254	13,046	6	26	53,602	3,114,611
13 Construction	14,805	68	26,432	17,809	10,609	62,407	81,115	26,187	5,048	5,409	47	76,629	10,041	1,493	29,720	34,027	37,343	66,970	59,703	780,366	503,335	4,634	1,854,197	21,886	658	252,817	4,821,585	132,940	7,084,082
14 Maintenance and Repair	3,212	22	202	4,671	3,952	14,267	8,017	5,496	1,568	1,446	44	343	9,755	35	2,487	1,320	4,118	2,843	824	8,800	9,735	160	83,316	134,205	2,285	434	15,026	123,167	358,433
15 Wholesale Trade	101,097	1,130	9,012	246,564	127,228	437,745	388,173	326,396	96,696	61,864	491	17,511	281,994	3,284	45,440	61,581	147,667	76,384	38,760	305,513	454,115	6,510	3,235,154	1,702,166	25,226	22,446	591,395	974,867	6,551,255
16 Retail Trade	16,224	235	2,173	7,185	17,488	20,337	29,812	18,794	9,227	17,493	214	1,369	259,278	872	14,751	18,444	68,846	74,736	8,321	138,314	74,770	1,621	800,506	4,013,603	70,785	1,459	171,350	131,539	5,189,242
17 Hotels and Restaurants	1,772	8	395	9,734	5,627	35,323	21,732	9,395	1,896	3,307	27	13,511	12,628	560	14,226	12,792	11,182	24,506	32,303	293,900	178,774	2,173	685,769	2,749,124	35,872	8	12	395,944	3,866,728
18 Transport	76,033	525	21,802	120,621	54,739	284,327	229,491	70,259	25,342	26,237	32,451	81,447	175,506	5,070	176,250	91,498	51,672	144,358	61,754	315,641	337,887	9,341	2,392,250	1,114,173	12,662	13,722	86,425	586,867	4,206,098
19 Post and Telecommunications	5,273	116	1,942	12,708	13,651	82,207	49,154	75,559	6,845	7,827	147	14,082	79,625	5,635	173,024	102,702	71,059	175,956	196,231	656,730	591,683	22,630	2,344,786	1,123,088	21,611	9,518	326,376	199,185	4,024,563
20 Financial Intermediation and Business	270,817	1,636	122,877	324,328	180,818	402,357	880,132	704,991	177,942	84,936	804	160,731	735,866	30,644	763,012	657,446	456,484	764,016	718,212	2,581,335	3,464,461	109,629	13,593,474	8,782,697	159,881	89,238	963,738	14,796	23,603,823
21 Public Administration	13,401	542	1,446	12,028	5,780	22,492	28,590	13,039	3,497	3,674	64	10,299	24,197	1,183	22,116	27,804	63,347	32,230	92,601	437,575	440,947	37,375	1,294,225	6,455,832	143,869	6,688,823	2,272,893	597,203	17,452,846
22 Others service	5,533	66	600	8,015	11,940	28,747	19,525	11,367	872	1,506	170	3,799	9,037	375	22,834	2,306	6,198	7,805	6,752	53,021	26,664	439	227,569	265,548	7,592	2,773	22	120,305	623,808
23 Total at Basic Prices	1,013,818	7,985	261,795	1,969,733	880,322	2,920,083	3,729,031	2,595,632	1,355,910	466,521	152,253	727,139	3,151,989	60,949	1,489,637	1,309,941	1,522,972	1,922,729	1,428,678	7,261,710	8,650,106	224,668	43,103,603	32,670,561	573,835	7,292,238	12,030,210	12,379,051	108,049,498
24 Imported Products	94,469	43,667	80,338	196,779	119,966	224,178	781,019	715,163	371,518	118,176	51,990	118,897	278,807	57,146	359,010	109,284	138,574	317,761	173,716	503,692	729,463	114,003	5,697,615	729,463	835	948,735			
25 Taxes on production	73,399	1,914	24,153	41,752	2,693	8,723	43,401	12,098	2,961	2,081	100	64,559	31,263	6,677	163,463	137,103	49,366	20,488	31,322	191,687	38,698	835	948,735						
26 Value Added	4,055,165	214,675	888,435	1,272,648	603,215	1,591,983	3,414,195	2,892,436	1,042,132	492,255	153,787	2,387,472	3,932,093	297,484	5,061,618	3,879,301	2,343,755	2,283,369	2,595,885	16,342,113	8,802,740	399,140	64,945,895						
27 Gross Domestic Product	4,128,564	216,589	912,588	1,314,400	605,908	1,600,706	3,457,596	2,904,534	1,045,092	494,336	153,887	2,452,031	3,963,357	304,161	5,225,081	4,016,404	2,393,121	2,303,858	2,627,207	16,533,799	8,841,438	399,975	65,894,630						
28 Gross output	5,068,983	222,660	1,150,230	3,242,381	1,483,537	4,512,066	7,143,226	5,488,068	2,398,042	958,776	306,040	3,114,611	7,084,082	358,433	6,551,255	5,189,242	3,866,728	4,206,098	4,024,563	23,603,823	17,452,846	623,808	108,049,498						

Source: Manfred L. et al, Mapping the Structure of the World Economy, Centre for Integrated Sustainability Analysis, School of Physics A28, The University of Sydney, NSW 2006, Australia and calculate by researcher
<http://worldmrio.com/national/co.jsp>

1.2. A-Matrix (Input Coefficient)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Agricultur	Mining	Food &	Textiles	Chemical,	Chemical,	Electrical	Other	Electricity,	Maintena	Hotels	Post and	Intermediat	Finacial								
		e	and	s	and	and	and	and	Manufact	Gas and	nce and	and	Telecom	ion and	Wholesale	Retail	Restraura	Transport	ns	Business	Public	Administrat	Others
No	Sector	Fishing	Quarrying	Beverage	Wearing	Wood and	Minera	Machinery	Equipment	Water	Repair	Trade	Trade	ns	Trade	Trade	nts	Transport	ns	Activities	ion	service	
1	Agriculture	0.0222	0.0001	0.0003	0.1498	0.0192	0.0733	0.0008	0.0001	0.0000	0.0005	0.0004	0.0000	0.0018	0.0002	0.0002	0.0006	0.0078	0.0001	0.0000	0.0017	0.0010	0.0000
2	Fishing	0.0002	0.0022	0.0000	0.0456	0.0001	0.0000	0.0000	0.0000	0.0000	0.0038	0.0002	0.0000	0.0000	0.0003	0.0000	0.0009	0.0056	0.0000	0.0000	0.0001	0.0003	0.0001
3	Mining and Quarrying	0.0020	0.0007	0.0103	0.0014	0.0013	0.0046	0.0611	0.0002	0.0007	0.0005	0.1562	0.0844	0.0100	0.0001	0.0002	0.0001	0.0004	0.0094	0.0002	0.0007	0.0018	0.0008
4	Food & Beverages	0.0270	0.0029	0.0001	0.0570	0.0098	0.0029	0.0018	0.0000	0.0000	0.0016	0.0041	0.0001	0.0000	0.0035	0.0011	0.0074	0.0796	0.0002	0.0001	0.0023	0.0114	0.0028
5	Textiles and Wearing Apparel	0.0003	0.0003	0.0001	0.0006	0.0394	0.0040	0.0009	0.0009	0.0013	0.0048	0.0003	0.0001	0.0008	0.0003	0.0007	0.0007	0.0005	0.0004	0.0002	0.0004	0.0015	0.0007
6	Wood and Paper	0.0016	0.0001	0.0003	0.0117	0.0083	0.0382	0.0044	0.0022	0.0009	0.0199	0.0021	0.0004	0.0093	0.0011	0.0033	0.0021	0.0036	0.0020	0.0059	0.0094	0.0079	0.0023
7	Chemical, Minera and Metal Pro	0.0315	0.0055	0.0194	0.0690	0.1557	0.1045	0.1317	0.1148	0.0856	0.1301	0.2021	0.0110	0.1306	0.0058	0.0096	0.0086	0.0178	0.0758	0.0135	0.0183	0.0531	0.0220
8	Electrical and Machinery	0.0024	0.0015	0.0127	0.0068	0.0104	0.0209	0.0224	0.0966	0.2229	0.0629	0.0008	0.0057	0.0412	0.0072	0.0088	0.0102	0.0055	0.0108	0.0186	0.0157	0.0262	0.0075
9	Transport Equipment	0.0007	0.0016	0.0022	0.0016	0.0007	0.0009	0.0032	0.0132	0.0982	0.0198	0.0006	0.0002	0.0083	0.0048	0.0017	0.0090	0.0006	0.0149	0.0018	0.0050	0.0110	0.0025
10	Other Manufacturing	0.0006	0.0011	0.0007	0.0031	0.0153	0.0112	0.0020	0.0028	0.0121	0.0089	0.0011	0.0007	0.0116	0.0017	0.0028	0.0025	0.0037	0.0020	0.0028	0.0046	0.0050	0.0020
11	Recycling	0.0000	0.0000	0.0001	0.0003	0.0004	0.0050	0.0034	0.0001	0.0000	0.0003	0.0083	0.0013	0.0001	0.0000	0.0000	0.0001	0.0001	0.0004	0.0002	0.0002	0.0002	0.0000
12	Electricity, Gas and Water	0.0113	0.0003	0.0190	0.0252	0.0418	0.0735	0.0473	0.0122	0.0064	0.0106	0.0086	0.0077	0.0057	0.0077	0.0059	0.0155	0.0313	0.0153	0.0095	0.0132	0.0277	0.0078
13	Construction	0.0029	0.0003	0.0230	0.0055	0.0072	0.0138	0.0114	0.0048	0.0021	0.0056	0.0002	0.0246	0.0014	0.0042	0.0045	0.0066	0.0097	0.0159	0.0148	0.0331	0.0288	0.0074
14	Maintenance and Repair	0.0006	0.0001	0.0002	0.0014	0.0027	0.0032	0.0011	0.0010	0.0007	0.0015	0.0001	0.0001	0.0014	0.0001	0.0004	0.0003	0.0011	0.0007	0.0002	0.0004	0.0006	0.0003
15	Wholesale Trade	0.0199	0.0051	0.0078	0.0760	0.0858	0.0970	0.0543	0.0595	0.0403	0.0645	0.0016	0.0056	0.0398	0.0092	0.0069	0.0119	0.0382	0.0182	0.0096	0.0129	0.0260	0.0104
16	Retail Trade	0.0032	0.0011	0.0019	0.0022	0.0118	0.0045	0.0042	0.0034	0.0038	0.0182	0.0007	0.0004	0.0366	0.0024	0.0023	0.0036	0.0178	0.0178	0.0021	0.0059	0.0043	0.0026
17	Hotels and Restaurants	0.0003	0.0000	0.0003	0.0030	0.0038	0.0078	0.0030	0.0017	0.0008	0.0034	0.0001	0.0043	0.0018	0.0016	0.0022	0.0025	0.0029	0.0058	0.0080	0.0125	0.0102	0.0035
18	Transport	0.0150	0.0024	0.0190	0.0372	0.0369	0.0630	0.0321	0.0128	0.0106	0.0274	0.1060	0.0261	0.0248	0.0141	0.0269	0.0176	0.0134	0.0343	0.0153	0.0134	0.0194	0.0150
19	Post and Telecommunications	0.0010	0.0005	0.0017	0.0039	0.0092	0.0182	0.0069	0.0138	0.0029	0.0082	0.0005	0.0045	0.0112	0.0157	0.0264	0.0198	0.0184	0.0418	0.0488	0.0278	0.0339	0.0363
20	Finacial Intermediation and Busin	0.0534	0.0073	0.1068	0.1000	0.1219	0.0892	0.1232	0.1285	0.0742	0.0886	0.0026	0.0516	0.1039	0.0855	0.1165	0.1267	0.1181	0.1816	0.1785	0.1094	0.1985	0.1757
21	Public Administration	0.0026	0.0024	0.0013	0.0037	0.0039	0.0050	0.0040	0.0024	0.0015	0.0038	0.0002	0.0033	0.0034	0.0033	0.0034	0.0054	0.0164	0.0077	0.0230	0.0185	0.0253	0.0599
22	Others service	0.0011	0.0003	0.0005	0.0025	0.0080	0.0064	0.0027	0.0021	0.0004	0.0016	0.0006	0.0012	0.0013	0.0010	0.0035	0.0004	0.0016	0.0019	0.0017	0.0022	0.0015	0.0007
23	Total at Basic Prices	0.2000	0.0359	0.2276	0.6075	0.5934	0.6472	0.5220	0.4730	0.5654	0.4866	0.4975	0.2335	0.4449	0.1700	0.2274	0.2524	0.3939	0.4571	0.3550	0.3076	0.4956	0.3602
24	Imported Products	0.0186	0.1961	0.0698	0.0607	0.0809	0.0497	0.1093	0.1303	0.1549	0.1233	0.1699	0.0382	0.0394	0.1594	0.0548	0.0211	0.0358	0.0755	0.0432	0.0213	0.0418	0.1828
25	Taxes on production D.29	0.0145	0.0086	0.0210	0.0129	0.0018	0.0019	0.0061	0.0022	0.0012	0.0022	0.0003	0.0207	0.0044	0.0186	0.0250	0.0264	0.0128	0.0049	0.0078	0.0081	0.0022	0.0013
26	Value Added	0.8000	0.9641	0.7724	0.3925	0.4066	0.3528	0.4780	0.5270	0.4346	0.5134	0.5025	0.7665	0.5551	0.8300	0.7726	0.7476	0.6061	0.5429	0.6450	0.6924	0.5044	0.6398
28	Gross Domiesticu Product	0.8145	0.9727	0.7934	0.4054	0.4084	0.3548	0.4840	0.5292	0.4358	0.5156	0.5028	0.7873	0.5595	0.8486	0.7976	0.7740	0.6189	0.5477	0.6528	0.7005	0.5066	0.6412
27	Gross output	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

1.3. I-Matrix (Unit Matrix or Identity Matrix)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
No	Sector	Agriculture	Fishing	Mining and Quarrying	Food & Beverages	Textiles and Wearing Apparel	Wood and Paper	Chemical, Mineral and Metal Products	Electrical and Machinery	Transport Equipment	Other Manufacturing	Recycling	Electricity, Gas and Water	Construction	Maintenance and Repair	Wholesale Trade	Retail Trade	Hotels and Restaurants	Transport	Post and Telecommunications	Financial Intermediation and Business Activities	Public Administration	Others service
1	Agriculture	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Fishing	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Mining and Quarrying	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Food & Beverages	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Textiles and Wearing Apparel	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Wood and Paper	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Chemical, Mineral and Metal Products	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Electrical and Machinery	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Transport Equipment	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Other Manufacturing	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11	Recycling	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
12	Electricity, Gas and Water	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
13	Construction	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14	Maintenance and Repair	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
15	Wholesale Trade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
16	Retail Trade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
17	Hotels and Restaurants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
18	Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
19	Post and Telecommunications	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
20	Financial Intermediation and Business Activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
21	Public Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
22	Others service	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1.4. (I-A) Matrix

No	Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Agriculture	Fishing	Mining and Quarrying	Food & Beverages	Textiles and Wearing Apparel	Wood and Paper	Chemical, Mineral and Metal Products	Electrical and Machinery	Transport Equipment	Other Manufacturing	Recycling	Electricity, Gas and Water	Construction	Maintenance and Repair	Wholesale Trade	Retail Trade	Hotels and Restaurants	Transport	Post and Telecommunications	Financial Intermediation and Business Activities	Public Administration	Others service
1	Agriculture	0.9778	-0.0001	-0.0003	-0.1498	-0.0192	-0.0733	-0.0008	-0.0001	0.0000	-0.0005	-0.0004	0.0000	-0.0018	-0.0002	-0.0002	-0.0006	-0.0078	-0.0001	0.0000	-0.0017	-0.0010	0.0000
2	Fishing	-0.0002	0.9978	0.0000	-0.0456	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0038	-0.0002	0.0000	0.0000	-0.0003	0.0000	-0.0009	-0.0056	0.0000	0.0000	-0.0001	-0.0003	-0.0001
3	Mining and Quarrying	-0.0020	-0.0007	0.9897	-0.0014	-0.0013	-0.0046	-0.0611	-0.0002	-0.0007	-0.0005	-0.1562	-0.0844	-0.0100	-0.0001	-0.0002	-0.0001	-0.0004	-0.0094	-0.0002	-0.0007	-0.0018	-0.0008
4	Food & Beverages	-0.0270	-0.0029	-0.0001	0.9430	-0.0098	-0.0029	-0.0018	0.0000	0.0000	-0.0016	-0.0041	-0.0001	0.0000	-0.0035	-0.0011	-0.0074	-0.0796	-0.0002	-0.0001	-0.0023	-0.0114	-0.0028
5	Textiles and Wearing Apparel	-0.0003	-0.0003	-0.0001	-0.0006	0.9606	-0.0040	-0.0009	-0.0009	-0.0013	-0.0048	-0.0003	-0.0001	-0.0008	-0.0003	-0.0007	-0.0007	-0.0005	-0.0004	-0.0002	-0.0004	-0.0015	-0.0007
6	Wood and Paper	-0.0016	-0.0001	-0.0003	-0.0117	-0.0083	0.9618	-0.0044	-0.0022	-0.0009	-0.0199	-0.0021	-0.0004	-0.0093	-0.0011	-0.0033	-0.0021	-0.0036	-0.0020	-0.0059	-0.0094	-0.0079	-0.0023
7	Chemical, Mineral and Metal P	-0.0315	-0.0055	-0.0194	-0.0690	-0.1557	-0.1045	0.8683	-0.1148	-0.0856	-0.1301	-0.2021	-0.0110	-0.1306	-0.0058	-0.0096	-0.0086	-0.0178	-0.0758	-0.0135	-0.0183	-0.0531	-0.0220
8	Electrical and Machinery	-0.0024	-0.0015	-0.0127	-0.0068	-0.0104	-0.0209	-0.0224	0.9034	-0.2229	-0.0629	-0.0008	-0.0057	-0.0412	-0.0072	-0.0088	-0.0102	-0.0055	-0.0108	-0.0186	-0.0157	-0.0262	-0.0075
9	Transport Equipment	-0.0007	-0.0016	-0.0022	-0.0016	-0.0007	-0.0009	-0.0032	-0.0132	0.9018	-0.0198	-0.0006	-0.0002	-0.0083	-0.0048	-0.0017	-0.0090	-0.0006	-0.0149	-0.0018	-0.0050	-0.0110	-0.0025
10	Other Manufacturing	-0.0006	-0.0011	-0.0007	-0.0031	-0.0153	-0.0112	-0.0020	-0.0028	-0.0121	0.9911	-0.0011	-0.0007	-0.0116	-0.0017	-0.0028	-0.0025	-0.0037	-0.0020	-0.0028	-0.0046	-0.0050	-0.0020
11	Recycling	0.0000	0.0000	-0.0001	-0.0003	-0.0004	-0.0050	-0.0034	-0.0001	0.0000	-0.0003	0.9917	-0.0013	-0.0001	0.0000	0.0000	-0.0001	-0.0001	-0.0004	-0.0002	-0.0002	-0.0002	0.0000
12	Electricity, Gas and Water	-0.0113	-0.0003	-0.0190	-0.0252	-0.0418	-0.0735	-0.0473	-0.0122	-0.0064	-0.0106	-0.0086	0.9923	-0.0057	-0.0077	-0.0059	-0.0155	-0.0313	-0.0153	-0.0095	-0.0132	-0.0277	-0.0078
13	Construction	-0.0029	-0.0003	-0.0230	-0.0055	-0.0072	-0.0138	-0.0114	-0.0048	-0.0021	-0.0056	-0.0002	-0.0246	0.9986	-0.0042	-0.0045	-0.0066	-0.0097	-0.0159	-0.0148	-0.0331	-0.0288	-0.0074
14	Maintenance and Repair	-0.0006	-0.0001	-0.0002	-0.0014	-0.0027	-0.0032	-0.0011	-0.0010	-0.0007	-0.0015	-0.0001	-0.0001	-0.0014	0.9999	-0.0004	-0.0003	-0.0011	-0.0007	-0.0002	-0.0004	-0.0006	-0.0003
15	Wholesale Trade	-0.0199	-0.0051	-0.0078	-0.0760	-0.0858	-0.0970	-0.0543	-0.0595	-0.0403	-0.0645	-0.0016	-0.0056	-0.0398	-0.0092	0.9931	-0.0119	-0.0382	-0.0182	-0.0096	-0.0129	-0.0260	-0.0104
16	Retail Trade	-0.0032	-0.0011	-0.0019	-0.0022	-0.0118	-0.0045	-0.0042	-0.0034	-0.0038	-0.0182	-0.0007	-0.0004	-0.0366	-0.0024	-0.0023	0.9964	-0.0178	-0.0178	-0.0021	-0.0059	-0.0043	-0.0026
17	Hotels and Restaurants	-0.0003	0.0000	-0.0003	-0.0030	-0.0038	-0.0078	-0.0030	-0.0017	-0.0008	-0.0034	-0.0001	-0.0043	-0.0018	-0.0016	-0.0022	-0.0025	0.9971	-0.0058	-0.0080	-0.0125	-0.0102	-0.0035
18	Transport	-0.0150	-0.0024	-0.0190	-0.0372	-0.0369	-0.0630	-0.0321	-0.0128	-0.0106	-0.0274	-0.1060	-0.0261	-0.0248	-0.0141	-0.0269	-0.0176	-0.0134	0.9657	-0.0153	-0.0134	-0.0194	-0.0150
19	Post and Telecommunications	-0.0010	-0.0005	-0.0017	-0.0039	-0.0092	-0.0182	-0.0069	-0.0138	-0.0029	-0.0082	-0.0005	-0.0045	-0.0112	-0.0157	-0.0264	-0.0198	-0.0184	-0.0418	0.9512	-0.0278	-0.0339	-0.0363
20	Financial Intermediation and Bu	-0.0534	-0.0073	-0.1068	-0.1000	-0.1219	-0.0892	-0.1232	-0.1285	-0.0742	-0.0886	-0.0026	-0.0516	-0.1039	-0.0855	-0.1165	-0.1267	-0.1181	-0.1816	-0.1785	0.8906	-0.1985	-0.1757
21	Public Administration	-0.0026	-0.0024	-0.0013	-0.0037	-0.0039	-0.0050	-0.0040	-0.0024	-0.0015	-0.0038	-0.0002	-0.0033	-0.0034	-0.0033	-0.0034	-0.0054	-0.0164	-0.0077	-0.0230	-0.0185	0.9747	-0.0599
22	Others service	-0.0011	-0.0003	-0.0005	-0.0025	-0.0080	-0.0064	-0.0027	-0.0021	-0.0004	-0.0016	-0.0006	-0.0012	-0.0013	-0.0010	-0.0035	-0.0004	-0.0016	-0.0019	-0.0017	-0.0022	-0.0015	0.9993

1.5. (I-A)⁻¹-Matrix or Inverse of (I-A) Matrix

No	Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
		Agriculture	Fishing	Mining and Quarrying	Food & Beverages	Textiles and Wearing Apparel	Wood and Paper	Chemical, Mineral and Metal Products	Electrical and Machinery	Transport Equipment	Other Manufacturing	Recycling	Electricity, Gas and Water	Construction	Maintenance and Repair	Wholesale Trade	Retail Trade	Hotels and Restaurants	Transport	Post and Telecommunications	Financial Intermediation and Business Activities	Public Administration	Others	Forward linkage
1	Agriculture	1.0278	0.0007	0.0010	0.1653	0.0244	0.0804	0.0029	0.0015	0.0013	0.0038	0.0022	0.0007	0.0039	0.0014	0.0014	0.0028	0.0224	0.0018	0.0018	0.0041	0.0053	0.0020	1.3592
2	Fishing	0.0016	1.0023	0.0001	0.0489	0.0009	0.0006	0.0003	0.0002	0.0002	0.0042	0.0005	0.0001	0.0003	0.0006	0.0002	0.0014	0.0097	0.0003	0.0003	0.0005	0.0012	0.0004	1.0747
3	Mining and Quarrying	0.0071	0.0014	1.0156	0.0135	0.0216	0.0254	0.0800	0.0137	0.0137	0.0155	0.1794	0.0891	0.0239	0.0027	0.0034	0.0043	0.0078	0.0202	0.0051	0.0063	0.0126	0.0062	1.5684
4	Food & Beverages	0.0301	0.0033	0.0009	1.0670	0.0138	0.0081	0.0040	0.0018	0.0016	0.0039	0.0058	0.0011	0.0021	0.0046	0.0023	0.0092	0.0868	0.0026	0.0024	0.0049	0.0151	0.0054	1.2766
5	Textiles and Wearing Apparel	0.0005	0.0004	0.0003	0.0012	1.0417	0.0049	0.0015	0.0016	0.0023	0.0057	0.0008	0.0003	0.0014	0.0005	0.0009	0.0010	0.0009	0.0009	0.0006	0.0008	0.0021	0.0011	1.0713
6	Wood and Paper	0.0035	0.0005	0.0026	0.0167	0.0141	1.0445	0.0088	0.0065	0.0054	0.0249	0.0053	0.0021	0.0137	0.0030	0.0059	0.0048	0.0080	0.0067	0.0101	0.0130	0.0134	0.0065	1.2199
7	Chemical, Mineral and Metal Products	0.0481	0.0087	0.0379	0.1126	0.2162	1.1614	1.1791	0.1655	0.1630	0.1846	0.2603	0.0285	0.1772	0.0175	0.0255	0.0262	0.0461	0.1137	0.0383	0.0444	0.0946	0.0475	3.1970
8	Electrical and Machinery	0.0080	0.0031	0.0216	0.0207	0.0295	0.0407	0.0406	1.1236	0.2870	0.0894	0.0166	0.0132	0.0616	0.0142	0.0170	0.0210	0.0166	0.0300	0.0322	0.0289	0.0474	0.0207	1.9837
9	Transport Equipment	0.0023	0.0021	0.0047	0.0056	0.0057	0.0062	0.0078	0.0195	1.1162	0.0268	0.0054	0.0023	0.0137	0.0069	0.0042	0.0123	0.0038	0.0208	0.0055	0.0086	0.0169	0.0064	1.3038
10	Other Manufacturing	0.0016	0.0013	0.0022	0.0057	0.0190	0.0146	0.0047	0.0056	0.0164	1.0120	0.0031	0.0020	0.0142	0.0028	0.0043	0.0042	0.0060	0.0049	0.0052	0.0068	0.0084	0.0044	1.1493
11	Recycling	0.0003	0.0000	0.0004	0.0009	0.0015	0.0061	0.0042	0.0008	0.0007	0.0011	1.0094	0.0015	0.0009	0.0002	0.0002	0.0003	0.0004	0.0009	0.0005	0.0005	0.0008	0.0003	1.0318
12	Electricity, Gas and Water	0.0174	0.0014	0.0249	0.0413	0.0630	0.0941	0.0644	0.0276	0.0237	0.0284	0.0296	1.0138	0.0218	0.0119	0.0117	0.0218	0.0422	0.0290	0.0189	0.0220	0.0422	0.0181	1.6693
13	Construction	0.0082	0.0012	0.0303	0.0178	0.0229	0.0298	0.0265	0.0175	0.0144	0.0180	0.0142	0.0316	1.0134	0.0098	0.0123	0.0149	0.0205	0.0303	0.0270	0.0424	0.0444	0.0205	1.4677
14	Maintenance and Repair	0.0009	0.0001	0.0004	0.0021	0.0034	0.0039	0.0016	0.0015	0.0014	0.0021	0.0007	0.0003	0.0019	1.0002	0.0006	0.0005	0.0015	0.0011	0.0005	0.0007	0.0011	0.0006	1.0272
15	Wholesale Trade	0.0291	0.0067	0.0163	0.1005	0.1149	0.1249	0.0757	0.0837	0.0779	0.0910	0.0247	0.0130	0.0620	0.0152	1.0149	0.0211	0.0561	0.0361	0.0225	0.0261	0.0470	0.0235	2.0830
16	Retail Trade	0.0051	0.0014	0.0048	0.0070	0.0178	0.0108	0.0090	0.0077	0.0089	0.0230	0.0059	0.0034	0.0409	0.0043	0.0048	1.0062	0.0214	0.0228	0.0060	0.0100	0.0099	0.0064	1.2374
17	Hotels and Restaurants	0.0022	0.0004	0.0029	0.0073	0.0092	0.0132	0.0077	0.0062	0.0051	0.0078	0.0035	0.0062	0.0059	0.0037	0.0051	0.0055	1.0068	0.0110	0.0126	0.0159	0.0159	0.0083	1.1623
18	Transport	0.0224	0.0036	0.0262	0.0574	0.0605	0.0885	0.0513	0.0293	0.0293	0.0463	0.1278	0.0337	0.0414	0.0193	0.0340	0.0254	0.0276	1.0494	0.0260	0.0236	0.0358	0.0260	1.8851
19	Post and Telecommunications	0.0068	0.0016	0.0093	0.0183	0.0274	0.0376	0.0218	0.0290	0.0189	0.0235	0.0132	0.0109	0.0254	0.0223	0.0359	0.0292	0.0308	0.0585	1.0633	0.0392	0.0516	0.0513	1.6259
20	Financial Intermediation and Business Activities	0.0889	0.0141	0.1481	0.1916	0.2342	0.2035	0.2188	0.2212	0.1887	0.1845	0.1034	0.0937	0.1915	0.1178	0.1613	0.1737	0.1890	0.2707	0.2486	1.1695	0.2936	0.2499	4.9564
21	Public Administration	0.0056	0.0030	0.0052	0.0108	0.0126	0.0136	0.0113	0.0095	0.0081	0.0106	0.0054	0.0064	0.0100	0.0068	0.0084	0.0104	0.0229	0.0163	0.0310	0.0246	1.0347	0.0685	1.3356
22	Others service	0.0018	0.0004	0.0012	0.0043	0.0105	0.0087	0.0045	0.0038	0.0024	0.0035	0.0021	0.0018	0.0029	0.0016	0.0042	0.0013	0.0029	0.0034	0.0029	0.0033	0.0032	1.0019	1.0727
	Backward Linkage	1.3193	1.0579	1.3570	1.9166	1.9646	2.0212	1.8267	1.7774	1.9867	1.8103	1.8194	1.3557	1.7298	1.2673	1.3587	1.3974	1.6303	1.7313	1.5613	1.4961	1.7972	1.5759	

1.6. Estimation of Hongsa Lignite Power Plant Investment in 2015 by Industry (million kip)

No	Sector	Hongsa Lignite Investment 2015
1	Agriculture	0
2	Fishing	0
3	Mining and Quarrying	0
4	Food & Beverages	0
5	Textiles and Wearing Apparel	0
6	Wood and Paper	0
7	Chemical, Minera and Metal Produ	0
8	Electrical and Machinery	0
9	Transport Equipment	0
10	Other Manufacturing	0
11	Recycling	0
12	Electricity, Gas and Water	304,757
13	Construction	3,524,097
14	Maintenance and Repair	0
15	Wholesale Trade	0
16	Retail Trade	0
17	Hotels and Restraurants	0
18	Transport	72,033
19	Post and Telecommunications	0
20	Finacial Intermediation and Busines	0
21	Public Administration	0
22	Others service *	387,872
Output		4,288,760

Source: The Preliminary Project Status Report, author's calculation. <http://www.Hongsapo.com/index.php?model=cmsandview=itemandlayout=pageandid=17> (11 May 2015)

** This sector included various server sectors that have not been included in the matrix activity. This is one of the constraints of the study, therefore the study will explain more and focus on the assumption of the investment in the Hongsa Lignite Power Plant to sectors 12 Electricity, Gas and Water, 13 Construction and 18 Transportation.*

Appendix 2: Coal Mines and Water Resources

- **Coal Mines Used as Primary Fuel**

The lignite will be supplied from the mine located adjacent to the power plant. A geological lignite resource figure of 577.4 million tons has been delineated within the Hongsa deposit to a 350-meter depth below the ground surface. While a total lignite reserve of 436.9 million tons has been estimated, HPC plans to excavate a proven lignite reserve of approximately 370.8 million tons. The average annual lignite production of 14.3 million tons as a reserve of the Hongsa opencast mine would last for 26 years of operations.

- **Water System**

The water to be used in the power plant will come from the lakes located to the east and west of the plant. The water from the west lake will be used in the construction of the plant, and will eventually become part of the runoff flow control system from the mine. The water from the east lake, to be sourced from Nam Ken and Nam Luok dams, will be used in the operation of the plant. While water from the Nam Luok Dam, located southeast of the plant, can be drawn by gravity, a pumping station has to be constructed to pump water to the plant from the Nam Ken Dam, located northeast of the plant. At its full capacity, the east lake will be able to support at least five days of Power Plant operations.

- **Road Access**

Overall, a road of approximately 62 kilometers will be constructed and upgraded. Out of the total length, 38 kilometers will be used as main roads to the project, developed according to the standards of the Thai Department of Highways and the American Association of State Highways and the Transportation Office. The remaining 24 kilometers will be used for three access roads within the project, leading to the limestone quarry, Nam Ken Dam and Nam Luok Dam. Details of the roads to be constructed or upgraded are:

- Main Road Linking Lao-Thai Border to the power plant: 32 km
- Ban Han bypass road (Hongsa district): 6 km
- Access road to limestone quarry (Ngeun district): 7 km
- Access road to Nam Ken Dam (Hongsa district): 12 km

- Access road to Nam Luok Dam (Hongsa district): 5 km

Appendix 3: Major Hongsa Lignite Power Plant Milestones

Month/Year	Activity
February, 2009	Banpu Power Co., Ltd. (BPP) together with Ratchaburi Electricity Generating Holding PCL (RATCH) and Lao Holding State Enterprise (LHSE) developed the project by signing the shareholders' agreements for the Hongsa Power Company (HPC) and Phu Fai Mining Company (PFMC).
November, 2009	The Government of Laos granted the Coal and Limestone Mining Concession Agreement to PFMC, and the Power Plant Concession Agreement to HPC
December, 2009	HPC signed the Power Plant Engineering Procurement Construction Contract with a Chinese Consortium (China National Electric Equipment Corporation, Harbin Power Engineering Co., Ltd., Harbin Boiler Co., Ltd., Harbin Turbine Co., Ltd. and Harbin Electric Machinery Co., Ltd.).
April, 2010	Electricity Generating Authority of Thailand (EGAT) signed the Power Purchase Agreement (PPA) with HPC.
August, 2010	HPC entered into Financing Documents with nine syndicated Thai lenders (Financial Closed).
November, 2010	Resettlement village 1st Column Ceremony presided over by Than Dr. Laine Thykeo, Xayabouly Provincial Governor
May, 2011	Electricity du Laos (EDL) signed Power Purchase Agreement with HPC.
November, 2011	Cornerstones Laying Ceremony presided by H.E. Than Azang Laoly, Deputy Prime Minister of Lao PDR.
April, 2012	HPC signed Mining Fixed Equipment Services Agreements with Sandvik Mining and Construction Materials Handling GmbH and Co KG, and MMD Asia Pacific Limited
June, 2012	Powerhouse First Column Ceremony presided over by Than Dr. Liane Tykeo, Xayabouly Provincial Governor.
July, 2012	The relocation for project-affected people from project's concession area to new resettlement villages was completed.

November, 2012	Concrete work of 245-meter high stack was completed.
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Source: <http://www.hongsapower.com/index.php?model=cmsandview=itemandlayout=pageandid=19>

About MINZAS

MINZAS program is a partnership program of Mekong Institute and New Zealand Embassy in Bangkok. The objective of this program is to enhance research capacity of young GMS researchers by providing a structured learning and field research application program for 36 master's degree students from provincial universities in Cambodia, Lao PDR, Myanmar and Thailand.

Through a comprehensive supports – trainings, roundtable meeting, constructive advices from MI advisors including financial supports – which are to be and have been provided to scholarship grantees, students' research skills and conduction of research deem to be developed. The completed research works will be published in 'MI Working Paper Series' and disseminated to related agents among the GMS.

The MINZAS Program is designed for 3 cycles; each cycle lasts for one year with 4 phases:

- Phase One: Training on Research Methodology
- Phase Two: Implementation of Sub-regional Research in Respective Countries
- Phase Three: Research Roundtable Meeting
- Phase Four: Publication and Dissemination of Students' Works in 'MI Working Paper Series'

The research cycle involves:

- One month training course on GMS Cooperation and ASEAN Integration, research development and methodology. The students will produce their research designs and action plans as training outputs;
- Technical assistance and advisory support to MINZAS scholars by experienced mentors and academicians in the course of the research process;
- The scholars will present their research papers in a round table meeting attended by subject experts and their peers;
- Scholars will revise their research papers and improve as necessary, based on experts and peer review during the roundtable meeting;
- Publication of reports as MI working paper series.

Mekong Institute (MI) is an intergovernmental organization with a residential learning facility located on the campus of Khon Kaen University in the northeastern Thailand. It serves the countries of the Greater Mekong Subregion (GMS), namely, Cambodia, Lao P.D.R., Myanmar, Thailand, Vietnam, Yunnan Province and Guangxi Zhuang Autonomous Region of PR. China.

MI is the only GMS-based development learning institute, chartered by the six GMS Governments, offering standard and on-demand capacity development programs focusing on regional cooperation and integration issues.

Our programs and activities focus on three main thematic areas: Trade and Investment Facilitation, Agricultural Development and Commercialization, and Innovation and Technological Connectivity. Gender equality, Environmental sustainability and Labor mobility are present throughout as cross-cutting themes.

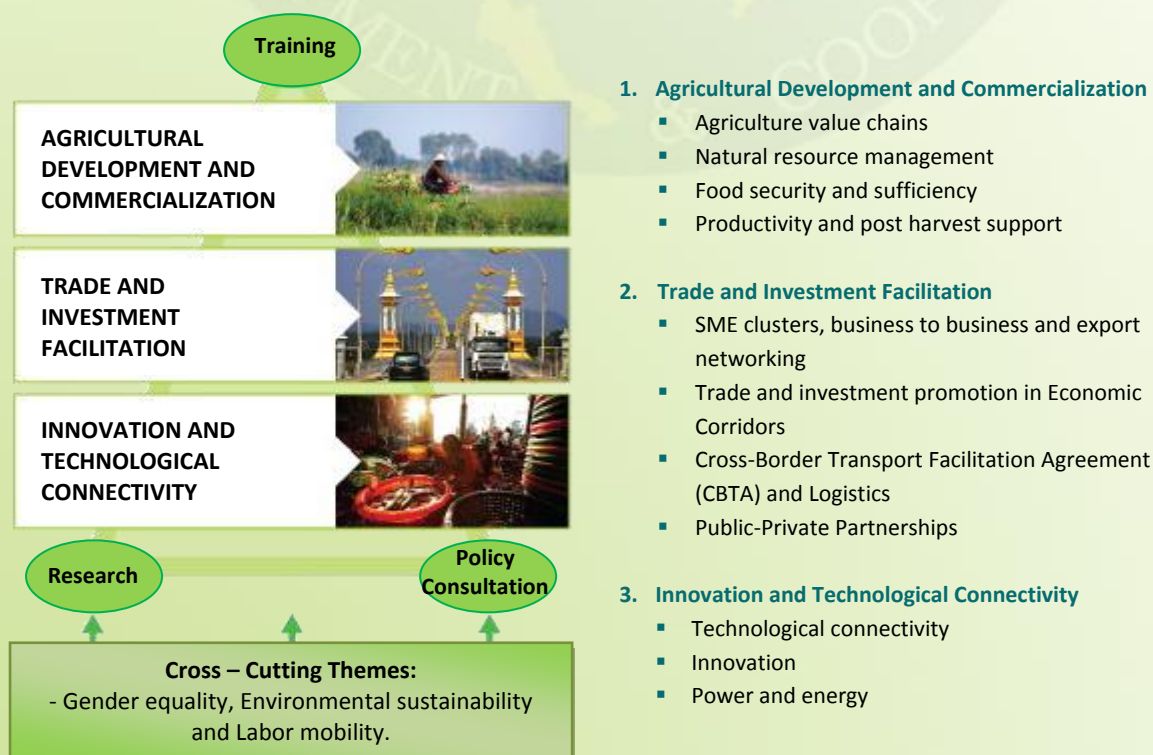
Vision

Capable and committed human resources working together for a more integrated, prosperous and harmonious GMS.

Mission

To contribute through human resource development and capacity building to the acceleration of sustainable economic and social development and poverty alleviation in the Greater Mekong Sub-region and promote regional cooperation and integration.

MI Program Thematic Areas



For more information, visit
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This publication of Working Paper Series is part of the Mekong Institute – New Zealand Ambassador’s Scholarship (MINZAS) program. A collaboration project between New Zealand Embassy in Bangkok and Mekong Institute aims to bring forth the research development within the Greater Mekong Subregion (GMS) through educational provision that will be given to master’s degree students from Cambodia, Lao PDR, Myanmar and Thailand.