

Impact of Climate Change on Poverty in Laos

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Abstract

The climate change is global problems. It is predicted to have more severe impact on developing country which most of population are poor. The main impact of climate change on poverty is changing crop productivity and commodity prices. However, there are few studies on the relationship between climate change and poverty. Therefore, this study will use Laos which has a high share of agriculture sector on GDP and high poverty rates as a case study to assess the impact the climate change on national wide-economy and climate change using CGE model. The preliminary result shows that climate change has serious impact of Lao economy in term of declining GDP. On the other hand, the micro-simulation indicates that the impact on poverty was negligible. This is because the households in Laos are autarky and not affected by the changes of prices and wages due to climate change.

Keywords: Climate change, poverty, Laos, CGE model

Problems and objectives

The world population is estimated to increase from 6 billion (current situation) to more than 8.3 billion by 2025, and about 85 percent of the population will be living in developing countries. In order to have food security for them, cropland expansion and technical progress in farm production is needed. Unfortunately, we lack suitable land for cultivation and have low farming technologies. In addition, the changing climate conditions will have a severe impact on agriculture. The global mean temperature is estimated to increase by 1^oc above the present value by 2025 and by 3^oc by the end of the next century (Houghton, et al, 1990).

Climate change may lead to the significant impact on agricultural productivity in developing countries, including Laos, because changes in crop yields and trading agricultural prices are adjusted to world demand and supply. Therefore, yield and price changes will lead to economy-wide adjustments though the linkage between agricultural sectors and other sectors. As in many developing countries, the poor mainly depend on agriculture sector. Therefore, climate change has significant impact on poverty.

Laos has an agriculture based economy; the agriculture sector accounted for about half of Gross Domestic Product (GDP) in 2006. In addition, about 80% of the total population (especially poor) works in the agriculture sector. Therefore, the impact of climate change on agriculture will have a significant effect on poverty vulnerability in Laos.

There are various studies on the impact of climate change on national wide-economies and poverty though changes in crop productivity. However, there are very few studies on this issue in Laos. Therefore, the main objective of

this study is to examine the impact of climate change on the national wide-economy and poverty vulnerability in Laos using a Computable General Equilibrium (CGE) model.

Literature review

A number of studies have examined the impact of climate change on national economies in developing countries. Parry et al. (1992), Mathews et al. (1994) and Queshi and Hobbie (1994) estimated the impact of climate change on Southeast Asia. Wang and Zong-ci Zhao (1996) assessed the impact of climate change on the Chinese national economy. Shuze et al (1996) and Magadaza (1996) assessed the impact of climate change on Southern Africa. Downing (1992) studied the impact of climate change for Kenya, Senegal, Zimbabwe, and Chile; Muchena (1994) did the same for Zimbabwe.

Ahmed et. al (2009a) used CGE model to assess the impact of climate volatility on poverty vulnerability in developing countries. The results show that climate volatility has serve impact on poverty. Ahmed et. al (2009b) used GTAP model to assess the impact of climate volatility on poverty in Tanzania. The result shows that poverty vulnerability is highly correlated with climate volatility though changing crop productivity. There are also various studies on the impact of climate change. For instance, Adams et al. (1998) addresses possible effects of climate change on agriculture, such as change in crop and livestock yields, as well as the economic consequences of these potential yield changes. This paper reviews the extant literature on these physical and economic effects and interprets this research in terms of common themes or findings. Kane et al (1992) estimate the economic effects of a doubling of atmospheric carbon dioxide concentration on world agriculture include both changes in the prices of agricultural commodities. The results shows that the effects on national economic welfare are found to be quite modest. Isik and Devadoss (2006) develop an econometric model stochastic production function to quantify the impacts of climatic variables on the mean, variance, and covariance of crop yields. The empirical results show that the climate change will have modest effects on the mean crop yields, but will significantly reduce the variance and covariance for most of the crops considered.

The above studies highlight the impact of climate change across countries through different scenarios. These studies focused on the impact of domestic agricultural productivity changes for selected crops . However, it is still lack of the studies on the linkage between climate change and poverty. Despite the large number of studies on climate change in other developing countries, there has been no study on the impact of climate change on the Lao national wide-economy and poverty.

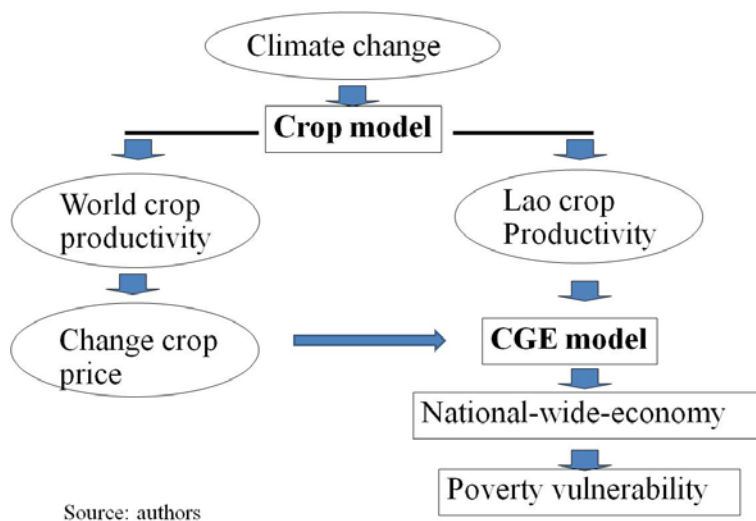
Framework of this study

The conceptual framework of this study is shown in Figure 1. There are two main components. Firstly, the impact of climate change on crop productivity

and world prices are estimated. This estimation will use a crop model based on the study of ADB (2009). It is important to note that this component will not be the focus of this study; the author will get the crop productivity change coefficient from the above study.

Secondly, the changes in crop productivities from crop modeling in the first step will be used as parameter inputs in the CGE model simulation. The CGE framework follows Hertel, Eds. (1997).

Figure 1. Conceptual framework of study



Scope of this study

There are various dimensions to impacts of climate change. However, this study will focus only on the impact of climate change on Lao national economy and poverty through changing domestic agricultural productivity and changing world agricultural commodity prices. In addition, a number of crops are vulnerable to climate change. However, this study will focus only on rice, the most important crops for Laos.

Policy and institutional framework of climate change

The national goal of Laos is to escape from LDC by 2020 while balancing the economy, society and the environment (GoL, 2004). Therefore, protecting the environment is one of the government of Laos (GoL)'s priorities.

In order to cope with climate change, GoL has established the National Committee for Climate Change in the Prime Minister's Office. This committee is playing a role in drafting a strategy plan on climate change. Recently, United Nations Development Programme (UNDP) and the Water Resources

and Environment Administration (WREA) have launched two programmes; National Adaptation Programme of Action to Climate Change (NAPA) and the National Capacity Needs Self Assessment for Global Environment Management. These programmes were instituted in order to strengthen the implementation of the UN Framework Convention on Climate Change, the UN Convention on Biological Diversity, and the UN Convention to Combat Desertification.

Lao economy and agriculture development

Laos is highly dependent on the agriculture sector. The agriculture sector accounted for 40 percent of GDP in 2006 (Table 1). The agriculture sector is divided into crops, livestock and fishery, and forestry (Table 2 and 3). In crops, paddy (rice) and corn are the two main crops. Therefore, changing rice and corn productivity due to climate change might have severe effects on the national economy.

In addition, about 80 percent of the total population belongs to the agriculture sectors, and 34 percent of the total population lives below the poverty line. It is clear that the impact of climate change through changing crop productivity and world agriculture commodities prices will bring have significant impact on Laos, especially for the poor.

Table 1. Share of agriculture sector in GDP

	2002	2003	2004	2005	2006	2007 Est.
Agriculture	9,174	10,829	12,378	13,593	14,943	15,891
Crops	5,439	6,280	7,216	7,929	8,688	8,958
Livestock and fishery	3,156	3,824	4,350	4,747	5,212	5,594
Forestry	578	725	811	917	1,043	1,339
Industry	4,492	5,783	7,190	8,800	11,058	13,185
Mining and quarrying	89	378	397	941	1,535	2,115
Manufacturing	3,483	4,277	5,373	6,276	7,696	9,077
Construction	390	508	700	761	940	1,101
Electricity, gas, and water	530	619	720	822	887	892
Services	4,554	5,703	6,785	7,799	8,826	9,813
Transportation, storage, and communication	1,115	1,408	1,703	1,913	2,193	2,457
Wholesale and retail trade	1,792	2,292	2,764	3,178	3,672	4,139
Banking, insurance, and real estate	76	100	84	110	132	158
Ownership of dwellings	509	603	682	750	821	871
Public wage bill	643	822	957	1,083	886	926
Nonprofit institutions	12	15	15	16	203	216
Hotels and restaurants	374	423	528	691	849	967
Other	32	41	51	59	68	79
Import duties	182	211	237	269	339	395
GDP at current market prices	18,401	22,525	26,590	30,462	35,167	39,284

Source: IMF(2008).

Table 2. Output of major commodities

	2002	2003	2004	2005	2006	2007 Est.
Agriculture	9,174	10,829	12,378	13,593	14,943	15,891
Crops	5,439	6,280	7,216	7,929	8,688	8,958
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Source: IMF (2008)

Table 3. Growth by sectors

	2002	2003	2004	2005	2006	2007 Est.
Agriculture	4.0	2.2	3.5	2.5	2.9	2.7
Crops	3.5	0.0	4.0	2.5	2.6	-0.4
Livestock and fishery	4.6	4.9	3.0	1.9	2.8	3.7
Forestry	5.1	8.6	1.3	5.5	6.5	23.9
Industry	10.1	11.5	12.5	15.9	17.7	15.2
Mining and quarrying	10.1	267.5	-5.1	121.3	52.8	33.0
Manufacturing	13.0	6.3	13.7	9.0	14.8	13.9
Construction	-6.5	12.9	24.6	19.4	15.6	13.2
Electricity, gas, and water	6.3	1.2	5.3	6.4	1.1	-2.9
Services	5.7	7.2	7.5	6.7	7.2	7.4
Transportation, storage, and communication	8.4	9.3	9.5	4.7	7.5	8.1
Wholesale and retail trade	7.5	10.7	9.2	7.3	8.2	8.9
Banking, insurance, and real estate	-46.3	14.0	-24.0	22.2	12.4	15.9
Ownership of dwellings	2.5	2.5	2.5	2.5	2.5	2.5
Public wage bill	15.0	3.4	1.0	1.0	1.0	1.0
Nonprofit institutions	4.2	7.0	7.4	2.9	2.9	2.9
Hotels and restaurants	2.7	-5.0	16.5	22.0	15.1	10.0
Other	2.6	8.7	16.1	7.7	8.1	11.5
GDP at factor cost	5.9	5.7	6.9	7.2	8.4	7.9
Import duties	12.6	8.9	14.5	11.1	14.0	11.5
GDP at constant prices	5.9	5.8	6.9	7.3	8.4	7.9

Source: IMF (2008)

Poverty Profile of Laos

In order to eradicate poverty by 2020, the GoL has implemented the National Growth and Poverty Eradication Strategy (NGPES), the overall development and poverty alleviation framework (GoL, 2004). Individuals are defined as poor based on real household consumption (Richter et al, 2005).

Analysis of three Lao Expenditure and Consumption Surveys (LECS) from Magnus et al. (2005) showed that the incidence of poverty has fallen since LECS 1, though it fell slowly during 1997/98. The incidence of poverty had fallen from 46% in LECS 1 to 39% in LECS 2, and to 33.5% in LECS 3. Inequality has also changed since LECS; it increased between LECS 1 and LECS 2, but declined by LECS 3 (table 4 and 5).

The impact of climate change might decline employment opportunities and increase consumption prices, which could lead to a wider poverty and inequality. However, it is not clear what impact of climate change will have on inequality and poverty in the Lao context.

Table 4. Poverty in Laos

Province	LECS1 1992/93	LECS2 1997/98	LECS3 2002/03	Change 92/93 to 97/98	Change 97/98 to 02/03
Northern Region	51.6	47.3	37.9	-4.3	-9.3
Oudomxay	45.8	66.1	45.1	20.3	-21.0
Luangnamtha	40.5	51.1	22.8	10.6	-28.3
Huaphanh	71.3	71.3	51.5	0.0	-19.8
Phongsaly	72.0	57.9	50.8	-14.1	-7.2
Luangprabang	58.5	40.8	39.5	-17.7	-1.4
Xayabury	22.4	17.7	25.0	-4.6	7.3
Bokeo	42.4	38.9	21.1	-3.4	-17.8
Central Region	45.0	39.4	35.4	-5.6	-4.0
Borikhamxay	16.6	27.9	28.7	11.3	0.8
Khammuane	47.1	44.5	33.7	-2.6	-10.8
Vientiane Province	30.7	27.8	19.0	-2.9	-8.8
Savannakhet	53.1	41.9	43.1	-11.2	1.2
Xiengkhuang	63.0	42.9	41.6	-20.2	-1.3
Xaysomboun SR	-	62.8	30.6	-	-32.1
Southern Region	45.7	39.8	32.6	-5.9	-7.2
Saravane	43.6	39.2	54.3	-4.4	15.1
Champasack	41.4	37.4	18.4	-4.0	-19.0
Sekong	67.0	49.7	41.8	-17.2	-7.9
Attapeu	60.5	48.0	44.0	-12.4	-4.0
Vientiane	33.6	13.5	16.7	-20.0	3.2
Lao PDR	46.0	39.1	33.5	-6.9	-5.6

Richter , K., R. Van Der Weide, and Phonesaly Souksavath (2005),

Table 5. Inequality in Laos

	LECS1 1992/93	LECS2 1997/98	LECS3 2002/03	Change 92/93 to 97/98	Change 97/98 to 02/03
Gini	30.5	34.9	32.6	4.4	-2.3
Quintile					
First	9.3	8.1	8.6	-1.2	0.5
Second	12.9	12.0	12.4	-0.9	0.4
Third	16.2	15.5	16.1	-0.6	0.5
Fourth	21.6	20.7	21.4	-0.9	0.6
Fifth	40.0	43.7	41.6	3.7	-2.0

Richter , K., R. Van Der Weide, and Phonesaly Souksavath (2005).

CGE Model

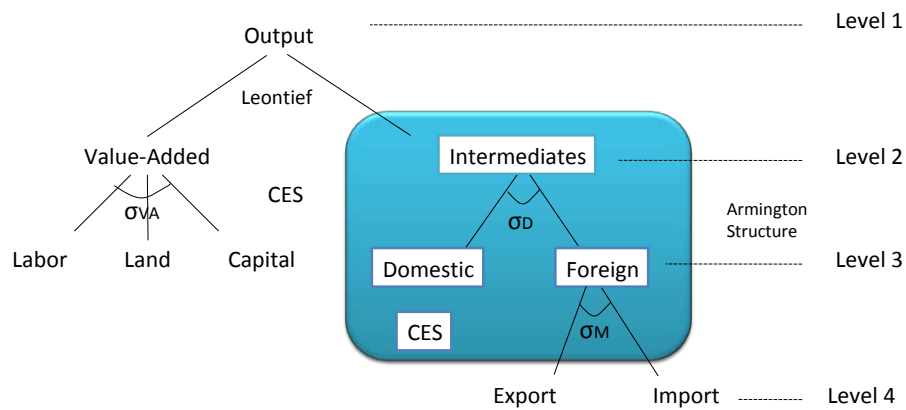
This study will employ a standard static GDP model (Hertel et, 1997) for our analysis. The GTAP model, a multi-region computable equilibrium (CGE) model, is one of the most popular models for estimating the impact of climate change, trade policy, and global crises on national economies. Since it is a multi-regional model of world production and trade, it can take into account

the impact of climate change on the Lao economy as well as third-party countries.

The GTAP model assumes perfectly competitive markets, where the zero profit condition holds, and that all the markets are cleared. The regional household allocates expenditures across three categories: private household, government, and savings. It derives income from the ‘sale’ of primary factors to the producers, which combines them with domestically produced and imported intermediate composites to produce final goods. These final goods are in turn sold both domestically to private households and the government, and exported to the rest of the world. Both government and private households also import final consumption goods from the rest of the world.

A global bank intermediates between global savings and regional investments by assembling a portfolio of regional investment goods and selling shares in this portfolio to regional households in order to meet their savings demands. Finally, a global transport sector assembles regional exports of trade, transport and insurance services and produces a composite goods used to move merchandise trade among regions(Hertel and Tsigas, 1997). The flowchart of the model is shown in Figure 2. The specification of economic behaviors is as follows; the production structure in the GTAP model is illustrated in Figure 3.

Figure 3. Production structure in GTAP model



Source: Hertel (1997)

Database for model

The latest version of the GTAP database, version 7, would be used for this study. This version has 113 countries and 57 sectors. To facilitate our

analysis, we have aggregated the sectors into 10 sectors and the countries into 10 regions. The breakdown of sectors and regions is shown in Table 6 and Table 7.

However, in order to use Dynamic GTAP model, it is important to develop the baseline scenarios which can reflect the results of policy simulation. My work on development baseline scenarios will followed by Adam and Parmenter,2000; Walmsley and Strutt, 2009 and Dixon and Rimmer,2002.

Table 6. Regions in model

No	Region code	Comprising	Region description
1	Oceania	AUS(Australia) NZL(New Zealand) XOC (Rest of Oceania)	Australia, New Zealand
2	EastAsia	CHN(China) HKG (Hong kong)JPN (Japan)KOR(Korea) TWN(Taiwan) XEA (Rest of East Asia)	East Asia
3	SEAsia	KHM(Cambodia) IDN(Indonesia) MMR(Myanmar) MYS(Malasia) PHL(Philippines) SGP(Singapore) THA(Thailand) VNM(Vietnam) XSE(Rest of Southeast Asia)	Southeast Asia
4	SouthAsia	BGD(Bangladesh) IND(india) PAK(Pakistan) LKA (Sri Lanka)XSA (Rest of South Asia)	South Asia
5	NAmerica	CAN (Canada)USA(United States Of America) MEX(Mexico) XNA (Rest of North America)	North America
6	LatinAmer	ARG (Argentina)BOL(Bolivia) BRA (Brazil)CHL(Chile) COL(Colombia) ECU (Ecuador)PRY(Paraguay) PER (Peru)URY(Uruguay) VEN (Venezuela)XSM (Rest of South America)CRI(Costa Rica) GTM(Guatemala) NIC(Nicaragua) PAN(Panama) XCA(Rest of Central America) XCB (Caribbean)	Latin America
7	EU_25	AUT (Austria)BEL(Belgium) CYP (Cyprus)CZE(Czech Republic) DNK (Denmark)EST (Estonia)FIN (Finland)FRA(France) DEU (Germany)GRC(Greece) HUN(Hungary) IRL(Ireland) ITA (Italy)LVA (Latvia)LTU(Lithuania) LUX(Luxembourg) MLT (Malta)NLD (Netherlands)POL (Poland)PRT(Portugal) SVK(Slovakia) SVN (Slovenia)ESP (Spain)SWE (Sweden)GBR (United Kingdom)	European Union 25
8	SSA	NGA(Nigeria) SEN(Senegal) XWF(Rest of Western Africa) XCF(Rest of Central Africa) XAC(Rest of South Central Africa) ETH (Ethiopia)MDG(Madagascar) MWI (Malawi)MUS (Mauritius)MOZ(Mozambique) TZA(Tanzania) UGA(Uganda) ZMB(Zambia) ZWE(Zimbabwe) XEC (Rest of Eastern Africa)BWA (Botswana)ZAF(South Africa) XSC (Rest of South Africa Customs Union)	Sub-Saharan Africa
9	LAOS	LAO (Lao People's Democratic Republic)	Laos
10	RestofWorld	CHE(Switzerland) NOR (Norway)XEF(Rest of EFTA) ALB(Albania) BGR(Bulgaria) BLR (Belarus)HRV(Croatia) ROU (Romania)RUS(Russian Federation) UKR(Ukraine) XEE(Rest of Eastern Europe) XER(Rest of Europe) KAZ (Kazakhstan)KGZ (Kyrgyzstan)XSU (Rest of Former Soviet Union)ARM (Arenia)AZE (Azerbaijan)GEO(Georgia) IRN (Iran,Islamic Republic of)TUR (Turkey)XWS(Rest of Western Asia) EGY (Egypt)MAR (Morocco)TUN (Tunisia)XNF (Rest of North Africa)	Rest of World

Source: Author's adaptation from GTAP database 7.

Table 7. Sectors in model

No.	Code	Description	Sectors
1	Rice	Paddy rice	Paddy rice
2	GrainsCrops	Grains and Crops	Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Processed rice.
3	MeatLstk	Livestock and Meat Products	Cattle,sheep,goats,horses; Animal products nec; Raw milk; Wool, silk-worm cocoons; Meat: cattle,sheep,goats,horse; Meat products nec.
4	Extraction	Mining and Extraction	Forestry; Fishing; Coal; Oil; Gas; Minerals nec.
5	ProcFood	Processed Food	Vegetable oils and fats; Dairy products; Sugar; Food products nec; Beverages and tobacco products.
6	TextWapp	Textiles and Clothing	Textiles; Wearing apparel.
7	LightMnfc	Light Manufacturing	Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec; Manufactures nec.
8	HeavyMnfc	Heavy Manufacturing	Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and
9	Util_Cons	Utilities and Construction	Electricity; Gas manufacture, distribution; Water; Construction.
10	TransComm	Transport and Communication	Trade; Transport nec; Sea transport; Air transport; Communication.
11	OthServices	Other Services	Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings.

Source: Author's adaptation from GTAP database 7.

Measure poverty and income distribution

In the various types of the integrated- microsimulation- CGE model approach, this study will use top-down approach with micro accounting to estimate the impact of Laos' WTO accession on poverty and income distribution (Chen and Ravallion, 2004; Ravallion & Lokshin, 2008). There are three steps for estimating the effect of climate change on household welfare. Firstly, we will use existing references for the impact of climate change on domestic crop productivity and crop global prices. Secondly, we will use changing domestic crop productivity and crop global prices to shock in GTAP model in order to estimate producers and consumers prices changes and factor production prices changes. Thirdly, the price changes from the GTAP model are used with Lao household expenditure survey to estimate household welfare changes.

The household welfare change is calculated using the formula in (Chen and Ravallion, 2004; Ravallion & Lokshin, 2008). In this approach, household welfare changes from climate change consist of four factors: price effect, production effect, labor income and consumption. The changes in the price

and production of particular food and non-food items alter household welfare which based on the share of the revenue of these items. The changes of international demand for particular goods affect household incomes which depend on the proportion to their marketed production of goods. Wage changes influences household income according to its share of wage income. The price changes also affect the consumption of households, and the increase of the prices decreases household welfare.

The monetary value of the change in utility for household i can expressed as follow:

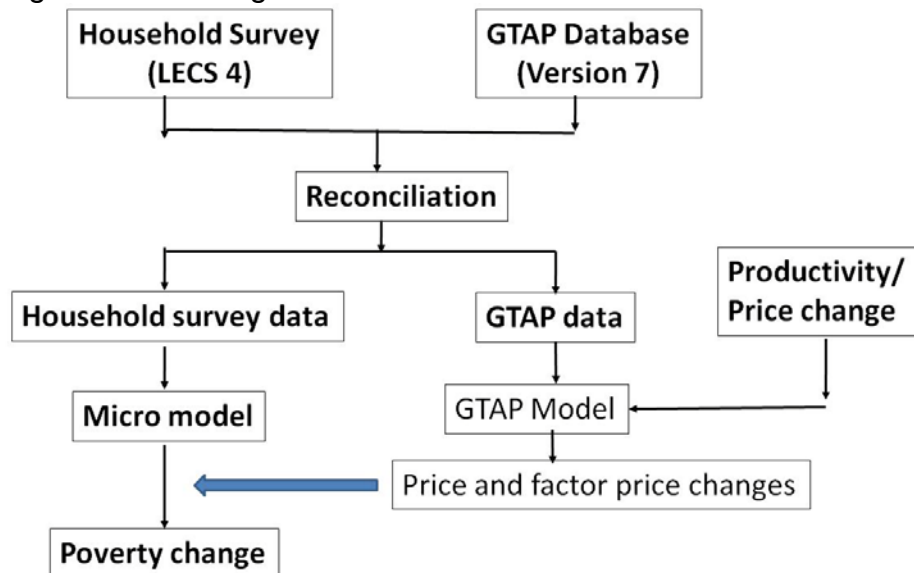
$$g_i = \sum_{j=1}^{57} \left[p_{ij}^s q_{ij}^s \frac{dp_{ij}^s}{p_{ij}^s} - p_{ij}^d (q_{ij}^d + z_{ij}) \frac{dp_{ij}^d}{p_{ij}^d} \right] + \sum_{k=1}^2 \left(w_k L_{ik}^s \frac{dw_k}{w_k} \right)$$

= (change in revenue) - (change in expenditure) - (change in input) + (change in wage)

Data Matching

It is important steps to match data household survey data to GTAP database. We will use the third Lao Expenditure and Consumption Survey (LECS 3) in 2002/2003 to match with GTAP database (version 7). See framework of matching data in figure 4.

Figure 4 Matching data



Source: authors adopted from Ivanic (2006)

1. Consumption and production

We used GTAP Database version 7 which consists of 57 sectors to this study, and factors product included land, capital, skill labor and un-skilled labor. We matched consumption and production from LECS 3 to GTAP database. In LECS 3 there are 357 categories for consumption and 117 categories for production.

Since the agricultural section in LECS 3 does not contain the value of sale and cost of the agricultural products, we cannot use the information of the section. However, the diary section of LECS 3 records the monthly transaction of agricultural income and costs. So, we can obtain the information on the agricultural income although it is possible that agricultural income is underestimated because the reference period is monthly and shorter in the diary section than the agricultural season in the agriculture section in LECS 3.

2. Labor

There are two types of labors in Lao GTAP model: skilled labor and un-skilled labor, so we categorize wage income in the household survey into skilled and unskilled labor income in this study. We define wage income as that from skilled labors if wage earners have completed at least primary education, and as that from unskilled labors if wage earners have not completed primary education. Since each entry of wage incomes in LECS 3 has a person ID but does not have the information on the industry, the industry in which the person engaged for the longest days and hours is chosen as the industry of the wage income.

3. Household income

The change of per capita income is used as the welfare indicator in this study. Household income included agriculture, non-agriculture business, and wage income, and the expenditure on owned produced agriculture products since own-produced consumption shares the large portion of household consumption and neglecting this portion in income fail to underestimate income. New income in the simulation is calculated by adding the estimated gain to income in the baseline as in (Chen and Ravallion, 2004).

4. Income poverty lines

Since official income poverty lines are not established in Laos as far as we know, they should be obtained by this study. Since official per capita expenditure poverty lines in LECS 3 are established, the income poverty lines are obtained by taking the mean per capita expenditures for the poor households based on the expenditure poverty lines. The means are taken separately in four regions for the urban and rural since the expenditure poverty lines in LECS 3 are in the same way. Therefore, the poverty rates using income poverty lines match those using the expenditure poverty rates in LECS 3.

Macro-Simulation design

There are various dimension of the impact of climate change on crop and commodity prices. However, we will focus on changing domestic crop yield and changing crop prices in the world market. The following three simulation scenarios (Table 8) are considered in this study.

Simulation 1 Changing crop yields (Climate change)

This scenario assumes changing crop yields in Laos due to climate change but neglects the impact of climate change on the rest of the world. The changing crop yields from climate change followed from ADB (2009), rice yield of Laos will reduce 10% in 2050 from base year (2004) due to climate change.

Simulation 2. Changing crop prices in world markets (Climate change)

This scenario assumes that climate change has a minor impact on Laos and does not effect crop yields here, but that climate change has a severe impact on other countries. This impact leads to changing crop prices in world markets, which have an indirect impact on the Lao economy. We assume that rice price in the world market increases to 15% from base year 2004.

Simulation 3. Combine simulation 1 and 2

We assume the worst case of climate change which have two direction of impact though changing productivity and world price.

Table 8. Simulation design

	Changing crop	Changing crop price
	yield	in world market
	(Internal effect)	(External effect)
	%	%
simulation 1	-10	
simulation 2		15
simulation 3	-10	15

Source: Authors.

Preliminary Result of Macro-economic Impact

There are various routes of the impact of climate change on Lao economy. We focus on these impact on macroeconomic variables and domestic output as follows:

Changes in macroeconomic variables resulting from the simulations are shown in table 9. The climate change (simulation 3) has a negative impact on equivalent variation (EV), real GDP and the terms of trade in both countries.

EV declines by US\$ 80 million, real GDP declines by 2.8 per cent and the terms of trade decline by 2 per cent, although the trade balance also increases by US\$ 84 million.

Table 9 Impact on macroeconomic variables

Macroeconomic variables	Impact of climate change		
	Simulation 1	Simulation 2	Simulation 3
	Productivity change	World price change	(1+2)
Change in trade balance (\$US million)	45.62	38.56	84.18
Equivalent Variation (EV) (\$US million)	-43.73	-36.38	-80.11
GDP quantity index (%)	-1.56	-1.28	-2.84
Term of trade (%)	-1.05	-0.95	-2
Source: authors' estimation from GTAP model.			

The climate change (simulation 3) has significant negative impact on output of rice, grains and crops and livestock, meat products and processed food in both countries. Rice production in Laos declines by 7 percent, grains and crops declines by about 5 percent and livestock and meat products decline by 7 percent and 5 percent for processed food (table 10).

As Table 11 shows, the results from the CGE model using simulation 3 show that the prices of agricultural products increase, and those of the industry sectors decrease. In addition, wage rates of unskilled and skilled labor decline.

Table 10. Impact on industry output

	Impact of Climate Change		
	Simulation 1	Simulation 2	Simulation 3
	Productivity change	Productivity change	(1+2)
Rice	-3.76	-2.47	-6.23
Grains and crops	-2.57	-2.23	-4.8
Livestock and meat products	-3.91	-3.16	-7.07
Mining and extraction	0.86	0.59	1.45
Processed food	-2.98	-2.13	-5.11
Textiles and clothing	3.91	2.5	6.41
Light manufacturing	5.08	3.7	8.78
Heavy manufacturing	1.92	1.26	3.18
Utilities and construction	-4.67	-4.04	-8.71
Transport and communications	-0.19	-0.29	-0.48
Other services	-0.1	-0.11	-0.21

Source: authors' estimation from GTAP model.

Table 11. Impact on price changes

Simulation 3	Percentage change						
	Output	Producer Price	Consumer Price	Land Price	Wage Unskilled	Wage Skilled	Rental Rate
Rice	-6.12	27.4	27.4	19.71	-1.89	-4.15	-3.71
GrainsCrops	-5.49	5.69	5.69	3.77	-1.89	-4.15	-3.71
MeatLstk	-6.1	1.88	1.88	2.93	-1.89	-4.15	-3.71
Extraction	2.89	-2.62	-2.62	10.42	-1.89	-4.15	-3.71
ProcFood	-3.93	-0.14	-0.14	1.31	-1.89	-4.15	-3.71
TextWapp	0.4	-0.15	-0.15	2.93	-1.89	-4.15	-3.71
LightMnfc	8.24	-1.93	-1.93	6.37	-1.89	-4.15	-3.71
HeavyMnfc	3	-1.52	-1.52	4.07	-1.89	-4.15	-3.71
Util_Cons	-7.16	-1.71	-1.71	-0.57	-1.89	-4.15	-3.71
TransComm	-0.92	-2.56	-2.56	1.61	-1.89	-4.15	-3.71
OthServices	-0.6	-2.05	-2.05	2.42	-1.89	-4.15	-3.71

Sources: Author's estimation using micro-simulation.

Results of Micro-simulation

The micro-simulation in which the prices from simulation 3 above are used calculates the impacts on household welfare, inequality and poverty. As seen in Table 12, household welfare decreases for the entire country, but the size of increase is less than one percent of total income. Both urban and rural households have decreased welfare, but the size of the decrease is larger in urban areas than in rural areas. These are probably because the decline in wage rates and prices of industry sectors affects more on urban households than on rural households. The table also shows that both the poor and non-poor have negative welfare. Overall, negative welfare changes are found, but the magnitude of the decreasing welfare is relatively small (less than 3 percent at most according to the table).

The changes in inequality and poverty are negligible. As seen in the table, the difference in Gini coefficients and poverty headcount indexes is less than one percent between the baseline and simulation. So, we do not find any significant impacts on poverty although the results from the macro-simulation indicated large negative impacts. Two possible reasons can be considered. First, the poor in Laos are autarchy and do not rely on the market very much. Thus, the negative macro impacts through the price and wage changes do not influence the welfare of poorer (households that potentially become poor) or poor households. Another reason is that the micro-simulation used the changes of prices and wages, so the finding fails to include the impacts through the changes in output and consumption. To address this problem, we need to use a more complex micro-simulation.

Table 12. Impact of climate change (simulation 3) on household welfare, inequality and poverty

1. Mean welfare change			
		Welfare Change Per Capita (kip)	Percentage in income
National		-3123.1	0.00
Rural		-572.0	0.01
Urban		-11675.4	0.00
Region			
Vientiane Capital		-20296.7	0.01
North		-1085.6	0.00
Central		592.8	0.01
South		-3291.8	0.00
Expenditure poverty in Base			
Non-poor		-3978.1	0.01
Poor		-1426.3	0.00
rural non-poor		-624.9	0.01
rural poor		-484.3	0.00
urban non-poor		-12710.9	0.01
urban poor		-7456.1	-0.03
2. Gini index as percentage			
	Baseline	Simulated	Change
Total	0.488	0.490	0.002
rural	0.436	0.439	0.003
urban	0.414	0.416	0.002
Region:			
Vientiane Capital	0.387	0.388	0.001
North	0.458	0.461	0.003
Central	0.466	0.468	0.002
South	0.458	0.458	0.001
3. Poverty impacts (headcount index, percentage)			
	Baseline	Simulated	Change
National:	0.31	0.31	-0.002
rural	0.29	0.29	-0.003
urban	0.37	0.37	0.002
Region:			
Vientiane Capital	0.37	0.37	-0.003
North	0.31	0.31	0.002
Central	0.31	0.30	-0.006
South	0.27	0.27	0.000

Sources: Authors' computations based on the GTAP model and LECS 3.

Preliminary Conclusion

This study attempts to the impact of climate change on Lao economy and poverty using top-down approach. According to the result from macro-simulation (GTAP model) we have preliminary conclusion as follows.

The climate change has negative impact on Lao economy. The impact of climate change declined GDP by about 3% and Equivalent variation will be declined by 80 \$US million. Therefore, we can conclude that climate change will have significant impact on Lao economy. However, the impact of climate change on poverty is under estimated.

The CGE model is widely used for studies on the impact of climate change. However this study has the following weakness. Firstly, this study only focuses on the impact of climate change through changing crop yields and crop commodity prices. It neglects other crop, rising sea levels, changes in energy demand, the impact on tourism, and potential water shortages. Secondly, this study neglects future economic structure changes and uses coefficients from other predictions of climate change because we assume that the economic structure in two countries is the same in 2004 and 2050. Thirdly, this study only focus on rice which it is important for Laos. It is important to consider price change in other crop which might have significant impact on these economies.

On the other hand, the micro-simulation indicates that the impact on poverty was negligible. This is because the households in Laos are autarky and not affected by the changes of prices and wages due to climate change. Given the importance of rice in production and consumption in Laos, this small impact on poverty seems a little surprising. But the fraction of purchased rice to consumed rice is about 25 percent in 2007/08, which indicates that people in Laos are not dependent on the market and that this fact weakens the impact of climate change on poverty.

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