STRIKING A BALANCE

MANAGING EL NIÑO AND LA NIÑA IN LAO PDR'S AGRICULTURE

William R. Sutton, Jitendra P. Srivastava, Mark Rosegrant, Jawoo Koo, and Ricky Robertson

WORLD BANK GROUP

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Abbreviations and Acronyms

AFS	Agriculture food system
ASEAN	Association of South East Asian Nations
ASI	Agriculture Stress Index
CBDRM	Community-based disaster risk management
CGE	Computable general equilibrium
DMH	Department of Meterology and Hydrology
ENSO	El Niño–Southern Oscillation
ECMWF	European Centre for Medium-Range Weather Forecasts
FAO	United Nations Food and Agriculture Organization
GDP	Gross domestic product
ha	hectare
IFPRI	International Food Policy Research Institute
kg	Kilograms
mm	Millimeter
MRC	Mekong River Commission
MPI	Ministry of Planning and Investment
MoNRE	Ministry of Natural Resources and Environment
MPWT	Ministry of Public Works and Transport
NOAA	National Oceanic and Atmospheric Administration
NGO	Nongovernmental organization
SAM	Social Accounting Matrix
THI	Temperature Humidity Index
UN	United Nations
UN-ESCAP	United Nations Economic and Social Commission for Asia and Pacific
UNICEF	United Nations Children's Fund
US$	United States dollar

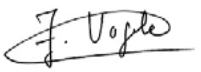
Foreword

In a world of climate change and headline grabbing cyclones, El Niño is one of the most unspoken climate risks in East Asia and the Pacific. It is a cyclical event that consistently ravages the region's economies and agricultural sectors with droughts and water scarcity. In turn, La Niña, the cool phase which typically occurs the year after an El Niño event, often brings extensive damage from floods and heavy rainfall. El Niño has occurred eight times since 1980, with the most recent event, from 2014 to 2016, being the most severe, causing billions of dollars in damage to the region. Experts forecast another El Niño event, predicted to affect East Asia and the Pacific in the winter of 2018–2019.

Given the cyclical nature of the El Niño–Southern Oscillation (ENSO) events, it is critical that governments have plans in place to face the threat. The research presented here is the first to carry out in-depth economic modeling to calculate changes in agricultural production, gross domestic product, household welfare, and poverty levels from both El Niño and La Niña in East Asia and the Pacific. It also estimates how certain policy interventions could mitigate these impacts. As such, the *Striking a Balance* reports could be important tools for policy makers in Cambodia, Lao PDR, Myanmar, the Philippines, and Vietnam—the five countries examined in the series.

The reports' findings are concerning: the authors estimate El Niño produces GDP, consumption, and income losses for all households, in all countries, regardless of income level, urban-rural location, or gender. El Niño threatens to raise food prices, with women and poor people set to suffer the most because they spend more of their income on food. Because of this, El Niño could threaten the region's poverty reduction and food security advances from the past decade. Fortunately, the reports also find there may be opportunities to harness the heavier rainfall which occurs during La Niña to achieve some GDP, consumption, and poverty reduction gains.

Regional governments have made inroads in preparing for climate events like floods and other natural disasters, but more could be done to prepare for ENSO specifically. This includes building resilience and preparedness by investing in early warning systems, developing national action plans, and cooperating with other East Asia–Pacific countries on ENSO-related challenges, which are regional in nature. Striking a balance among these various policy options, and between El Niño and La Niña management, demands concerted effort. It is our hope that this report will catalyze collective action and help governments and other national and subnational stakeholders achieve that balance.



Juergen Voegele
Senior Director
Food and Agriculture Global Practice
The World Bank

Acknowledgments

This report was prepared by a team led by William R. Sutton, Lead Agricultural Economist in the World Bank's Agriculture Global Practice, East Asia and Pacific Region, together with Jitendra P. Srivastava, Ioannis Vasileiou, and Maximillian Ashwill, and in collaboration with a team from the International Food Policy Research Institute (IFPRI) led by Mark Rosegrant and James Thurlow. We are grateful to Nathan M. Belete, Practice Manager (GFAO2), for his valuable support, guidance, and oversight throughout the course of this study. We are also grateful to Ellen Goldstein, the Country Director for Myanmar, Cambodia, and Lao PDR, and Nicola Pontara, the Country Manager for Lao PDR, for their support.

The World Bank team also comprised Chanhsom Manythong, Tam Thi Do, Asa Giertz, Vatthana Singharaj, Huyi Zhang, Manuela Hernandez, and Xinyu Weng. The IFPRI team also comprised Jawoo Koo, Angga Pradesha, Ricky Robertson, Rowena Valmonte-Santos, and Leocadio Sebastian (International Rice Research Institute). The report was edited by Maximillian Ashwill.

We would like to thank the peer reviewers for this study, Abigail Baca, Erick Fernandes, and David Treguer, for their valuable advice. Helpful guidance was also provided by Sudhir Shetty, Zoubida Allaoua, Marc Sadler, Steven Jaffee, Frauke Jungbluth, Paavo Eliste, Pauline Zwaans, Francesca de Nicola, and Lilanie Magdamo.

From the Government of Lao PDR, we are grateful for the guidance and support provided by the Ministry of Agriculture and Forestry, the Ministry of Planning and Investment, and the Ministry of Natural Resources and Environment. The study greatly benefitted from the important contributions made through valuable inputs, comments, advice, and support provided by academia, research institutions, civil society, NGOs, farmers, and development partners.

We gratefully acknowledge the generous financial support provided by the contributors to the Multi-Donor Global Food Price Crisis Response Trust Fund: the governments of Australia, Canada, the Republic of Korea, and Spain. The team also acknowledges the support provided by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Overview

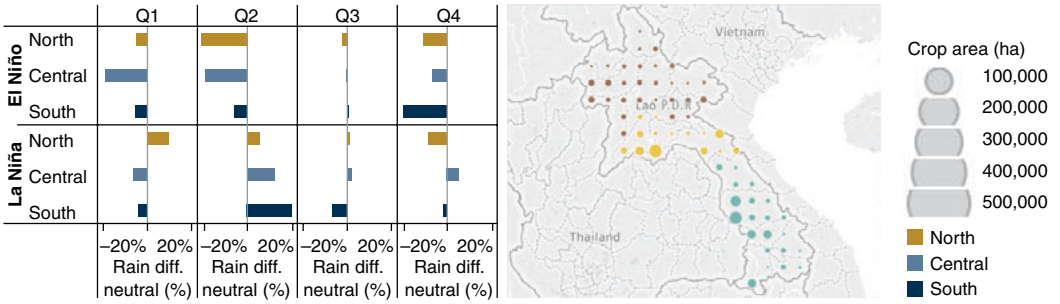
This report's purpose is to help Lao policy makers and stakeholders prepare for future El Niño–Southern Oscillation (ENSO) events. It does this by providing information on ENSO's impacts in Lao PDR and outlining ways forward. The report finds that ENSO's impacts vary from region to region and harm Lao PDR's people, economy, and agricultural sector. The country has sought to prepare for climate risks through climate change adaptation and disaster risk management but could do more to prepare specifically for ENSO events. Being proactive to prepare for ENSO is important because of Lao PDR's exposure to ENSO-related climate shocks, the prominence of the agricultural sector in the national economy, and the rural population's climate vulnerability. This report is timely given the lack of research on ENSO in Lao PDR and because there is a 70 percent chance of another El Niño event by winter 2018/2019.[1]

ENSO has important impacts on Lao PDR's climate, agriculture, economy, and society

Lao PDR is exposed to ENSO-related climate shocks. Historical data show that the two phases of ENSO, El Niño and La Niña, tend to depress and increase average rainfall, respectively. An analysis of rainfall patterns from 1980 to 2015 shows that average October-to-June rainfall was about 30 percent lower in El Niño years than in non-ENSO, or neutral, years. By contrast, rainfall is about 16 percent higher during La Niña spring months than during neutral year spring months (April–June). Lao PDR's extensive variation in climate and terrain makes ENSO impacts highly localized.[2] The left side of Figure A demonstrates some of this ENSO-related rainfall variation. Moreover, while floods have been associated with El Niño and La Niña in Lao PDR, droughts are also associated with El Niño. Since 1966, Lao PDR experienced 38 extreme climate events, which caused $625 million in damages. Of those

[1]NOAA (2018); http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml
[2]UN-FAO/WFP (2011).

FIGURE A: Regional Rainfall Differences between ENSO and Neutral Years from 1980–2015 (left) and Main Crop Areas (right).[3]



events, 27 occurred during El Niño or La Niña years, or in other words, 71 percent of flood or drought disasters in Lao PDR coincide with ENSO events. The most damaging event was the El Niño–related droughts and floods in 1992, which caused over $300 million in damages.

ENSO's impacts on agriculture have economy wide implications. Agriculture is an important economic sector in Lao PDR, providing over 68 percent of employment and a quarter of gross domestic product (GDP). Most poor people live in rural areas and work in agriculture, so are vulnerable to climate shocks. Agriculture is even more important when considering its linkages with downstream sectors and consumers in domestic and foreign markets. When considering these linkages, agriculture accounts for 73 percent of employment and 40 percent of GDP. As such, any shocks to agriculture lead to reverberations across the entire economy, with serious implications on welfare, food security, and national poverty levels. The right side of Figure A shows Lao PDR's main cropping areas.[3]

ENSO's subnational impacts show El Niño decreases crop yields, while La Niña increases crop yields. A comparison of subnational rice production changes from 1995 to 2015 shows, on average, rice production during El Niño years was lower compared to neutral non-ENSO years, and higher during La Niña. This trend is clearest in the south of Lao PDR where rice production was 4 percent lower during El Niño years and 4 percent higher during La Niña years compared to neutral years. In the central region, rice production was about 3 percent more during La Niña years, but unchanged during El Niño years. In the North, there was slightly lower rice production during both El Niño and La Niña years. These results are consistent with the agriculture stress

[3]Authors' reanalysis using UEA CRU-TS v4.0.

index (ASI),[4] which shows the southern parts of Lao PDR, particularly Attapeu, Saravane, and Savannakhet provinces, experience the most climate stress from droughts. Crop simulations carried out for this report show El Niño generally has a small negative effect on crop production and La Niña generally a small positive effect.

ENSO likely does not cause major damage to the livestock or fisheries sectors. This report's analysis shows there are nine more hot and humid days during La Niña compared to a neutral year. El Niño, by contrast, has more hot days from November to June. High temperatures can stress livestock and cause production declines. Different types of livestock have different levels of heat tolerance: cattle are the most tolerant, followed by poultry and then pigs, which are the least heat tolerant. That said, Lao PDR generally has a less heat stressed environment than other countries in southeast Asia, meaning temperature variations associated with ENSO are not a major concern. Fisheries are not a major economic sector in Lao PDR, though aquaculture provides income in some parts of the country and contributes to higher quality protein in diets, especially in rural communities. There is no direct evidence that ENSO causes much damage to the fisheries sector in this landlocked country.

A typical El Niño event causes modest losses to Lao PDR's GDP, while La Niña causes modest gains, though not enough to fully negate the effects of El Niño. Simulations conducted for this report show national GDP falls by 0.2 percent during an El Niño event relative to a neutral climate year. Even small percentage reductions in national GDP can imply sizable monetary losses. For example, a 0.2 percent drop in national GDP equals $21 million in lost value-added.[5] Relative losses are larger in agriculture itself, with GDP falling 0.8 percent. The south region suffers the largest crop and livestock GDP losses in percentages, equaling 1.1 percent. But, the central region suffers the largest crop and livestock GDP losses in dollar terms of $11 million. This is because agriculture activity is more heavily concentrated in the central region. In contrast, a typical La Niña event expands national GDP by 0.1 percent, and agricultural GDP by 0.5 percent. However, the gains during La Niña ($12 million) do not fully offset the losses incurred during El Niño ($21 million).

Lao PDR has made significant progress in reducing poverty and food insecurity, but El Niño threatens this trend. Lao PDR reduced national poverty from 34 percent

[4]ASI monitors and assesses vegetation indices across global crop areas during growing periods, and identifies hotspots where crops may be influenced by droughts. For more information on ASIs, see http://www.fao.org/climatechange/asis/en

[5]National income measured in 2014 prices.

in 2002 to 23 percent in 2012.[6] Most of this poverty is concentrated in rural areas. Overall, the rural poverty headcount ratio is 29 percent, while the urban poverty headcount ratio is 10 percent.[7] As such, continued poverty reduction requires continued growth in the agricultural sector. As discussed, El Niño causes GDP losses in the agricultural sector. Simulations reveal a typical El Niño event causes the national poverty rate to increase by 0.12 percentage points. This is equivalent to an additional 8,200 people living below the poverty line during El Niño. These negative impacts are partially mitigated by higher agricultural prices, which tend to benefit rural households. ENSO also threatens food security in Lao PDR, especially for poor households. Recent household surveys indicate that Lao households spend 60 percent of their income on food consumption, but the rural poor spend 90 percent of their income on food consumption. This makes any price increase, which our model predicts will occur during El Niño, potentially damaging to poor households. This could not only threaten their welfare but also their food security if not offset by increased incomes from grain production.

El Niño-related consumption losses are larger for more affluent and urban households. Simulations indicate that all households, regardless of income level or urban-rural location, experience a decline in consumption, or welfare, during a strong El Niño event. However, consumption losses are 0.60 percent for the poorest households during El Niño compared to 0.88 percent for all households. Similarly, consumption losses are 0.84 percent for rural households during El Niño compared to 0.94 percent for urban households. This is because urban households are net consumers of food products, so higher food prices hurt their consumption during El Niño in the simulation. This may also explain why poor households suffer fewer consumption losses, since poverty is more frequent and most pronounced in rural areas.[8] That said, there are other factors than are not considered in the modeling that may hide some of the resilience afforded to higher income households by virtue of their greater wealth. For example, poor households have fewer assets so are less able to smooth consumption by selling them during climate shocks. Also, poor households are more likely to experience health or food security consequences from ENSO events.

Women are vulnerable to ENSO events, but the exact impacts of these events on the sexes is unknown. There is little information on the gendered impacts of ENSO in Lao PDR, although these impacts can be inferred through other measures. For example, over half of all agricultural activities are carried out by women, making them

[6]WB-WDI (2018).
[7]2012 figures: http://databank.worldbank.org/data/source/world-development-indicators
[8]WB-WDI (2018).

vulnerable to extreme events.[9] In drought-prone regions, women and girls must travel longer distances to collect fuel and water, limiting their time for income generation. In a similar way, frequent floods increase women's socially ascribed household and family workloads.[10] These time constraints also reduce the opportunities for women to engage in community-level decision making on ENSO-related projects, leading to programs that do not address women's needs. This partly explains why women farmers have less access to agricultural information and extension services.[11] More importantly, in both urban and rural areas, female-headed households are generally poorer than male-headed households even after controlling for education, household composition, and other factors. Women also have fewer assets, less access to credit, and less access to productive land. Unfortunately, simulations were not able to measure the welfare impacts on female-headed households in Lao PDR.

Lao PDR has supported ENSO-related preparedness, but there are areas to improve

The Lao government has proactively prepared for climate risks and natural resource management challenges, but more could be done to prepare for ENSO events. In the first half of 2017, the government allocated more than $46 million, or 28 percent of 2017's total budget, on rural development and poverty reduction programs. About 86 percent of the $46 million was disbursed for land provision, job allocations, and the Poverty Reduction Fund.[12] Moving forward, the Lao government has signaled it will prioritize supporting farmers to improve national agricultural production.[13] In general, aside from rural development, Lao PDR has taken important steps to address disaster risk management and climate change adaptation, including shifting away from emergency response approaches to preventive risk reduction approaches. However, the government could do more to directly prepare for ENSO events.

These important efforts also demonstrate some areas to strengthen in Lao PDR's ENSO preparedness. These include the following:

- Lao PDR's proactive approach to managing climate risk could improve with a greater focus on ENSO. Slow-onset events, like water scarcity and drought, are folded into climate change, disaster risk, and water resource planning, although none of these areas properly capture ENSO's specific challenges.

[9]FAO (2017).
[10]Araujo and others (2007); https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1759-5436.2008.tb00473.x
[11]http://www.fao.org/docrep/012/k8496e/k8496e00.pdf
[12]ANN (2017).
[13]MOFA (2017).

- Government policies already in place could be more fully implemented. Despite areas to expand strategies for El Niño or La Niña, the Lao government has developed several plans for disaster risk management and climate change adaptation. These plans are highly relevant to ENSO events, but the implementation of these priorities could be more complete.[14]
- The government could focus more on nonstructural measures to reduce climate vulnerability. Structural measures—including dike construction for flood protection, reservoirs for water storages, embankments surrounding urban areas or key infrastructures, and other examples—are important, but it is often nonstructural measures—including early warning information, a data and communication system, adaptive and conservation farming practices, and many others—that improve a country's resilience to climate events.[15]
- Public and government knowledge of ENSO challenges and information sharing networks could improve. This is also true for disaster and climate change preparedness, but even more so for ENSO.
- Forecasting and early warning capacity is limited. There are areas to improve the government's human, financial, and technological capacity. Current capacity only permits the provision of basic information for weather forecasting and disaster response.

Policy interventions help neutralize ENSO-related losses

Policy interventions and investments, especially introducing drought-tolerant crop varieties, can mitigate some GDP losses during El Niño. In-depth modeling carried out under this study simulated six policy interventions—including introducing drought-tolerant crop varieties, expanding irrigation, restricting rice exports, storing and distributing grains, expanding social protection coverage (or social transfers), and applying all of these policy interventions simultaneously—to understand how they would mitigate El Niño's impacts on GDP, household welfare, and poverty. Simulations show that introducing drought-tolerant varieties reduces EL Niño–related national GDP losses from $21 million without interventions to $12 million with this intervention. Expanding irrigation offsets some GDP losses by making crop production more resilient to climate shocks and raising yields during normal years. Distributing stored grains also reduces national GDP losses during El Niño but worsens agricultural GDP losses.

[14] WB-GFDRR (2011).
[15] World Bank (2011); Peñalba and Elazegui (2013); GoL (2015).

This is because distributing grains through the local market increases competition and reduces price paid to farmers. Export restrictions and social transfers have little effect on overall GDP. This is because social transfers do not increase agricultural production, but do require offsetting tax increases for higher income households. However, there are poverty and consumption-side benefits from distributing stored grains and providing social transfers. Export restrictions, by contrast, adversely affect producers and international trading partners, so should be used with caution. Overall, even when all interventions are combined and implemented concurrently, there are still $2.4 million in GDP losses during a strong El Niño.

Policy interventions overcome El Niño consumption losses for all households, but social transfers disproportionately benefit the poor, and grain stores disproportionately benefit the rich. Cash transfers, used as a proxy for social transfers in this report's modeling, reduce poor household consumption losses from 0.6 percent with no interventions to 0.1 percent. At the same time, consumption outcomes for all households are largely unchanged under a cash transfer scenario. This means that outcomes for higher income households worsen as outcomes for lower income households improve. Distributing grains during El Niño, by contrast, reduces consumption losses for all households from 0.9 percent with no interventions to 0.2 percent. This was the largest no-intervention to intervention swing among all income groups and intervention scenarios and is likely because wealthier households are net food consumers while poorer households are largely producers. When all policy scenarios are implemented at the same time, total consumption losses during El Niño are reversed, with all households benefitting from the policy package.

Social transfers are the most effective in mitigating poverty impacts from El Niño. Simulations show, even during a strong El Niño event, cash transfers reduce Lao PDR's poverty headcount. By contrast, distributing stored grains increases the poverty headcount by even more than the El Niño already does. Overall, El Niño causes 8,200 additional people to live in poverty while distributing grain stores during El Niño causes 13,600 additional people to live in poverty. This is because distributing grains reduces grain prices, and consequently, a primary source of income for poor rural families. Investing in on-farm measures, such as irrigation and drought tolerant varieties, also has modest positive effects on poverty rates during an El Niño event. Implementing all interventions concurrently is, again, the most beneficial policy scenario, indicating that multiple interventions are needed to address ENSO's challenges.

Urban household welfare improves the most from policy interventions. Simulations show urban households generally benefit the most from distributing grain stores

and benefit the least from providing short-term cash transfers. This result mirrors the results for richer and poorer households, probably because poverty is largely a rural phenomenon. As such, urban households, which are wealthier, suffer the most from cash transfers. Also, distributing grain stores, which is the least effective in reducing poverty during El Niño, is also the most effective at mitigating consumption losses for urban households, which are net grain consumers. Besides grain stores, on-farm investments in irrigation and introducing tolerant crop varieties were also effective at mitigating welfare losses for all households, regardless of urban-rural location. Implementing all interventions together reverses consumption losses for all households but benefits urban households the most.

Lao PDR can take additional actions to improve ENSO preparedness and build resilience

There are many opportunities to improve ENSO preparedness and resilience. In Table A, recommendations are divided into two groups: preparedness and resilience. *Preparedness* are measures specifically geared toward ENSO and should, ideally, be in place before the next ENSO event occurs. These actions will significantly empower people to cope, respond, and recover from damaging ENSO events. *Resilience*, by contrast, are measures that are not specifically tailored to ENSO, but that will build individuals' and organizations' abilities to adapt to multiple forms of risks and shocks without compromising long-term development. Recommendations in blue are a high priority, recommendations in tan are a moderate priority. The final two columns denote short-term (S) actions that could be completed within a year, and medium-to-long term (M/L) actions that require more than a year to achieve.

TABLE A: Summary of Recommendations and Proposed Actions.

	Recommendation	Actions	S	M/L
Preparedness	Prepare response measures for when ENSO-related climate events occur	• Establish a high-level interministerial committee tasked with ENSO response and preparedness.	X	
		• Develop local ENSO contingency plans and budgets.	X	
		• Ensure emergency response inputs and supplies are available, and connectivity infrastructure is adequate.	X	
	Form a national ENSO task force	• Appoint an ENSO task force to develop a comprehensive ENSO preparedness strategy.	X	
		• It should define the roles of government agencies.	X	
	Create a government focal point on ENSO	• Streamline government units, programs, and policies related to ENSO and oversee ENSO preparedness.	X	
		• Solicit and coordinate ENSO-related support from international partners.	X	X
	Improve financing mechanisms for ENSO events	• Assess constraints and improve the current contingency budgeting system.	X	
		• Develop a financial protection strategy to guarantee the delivery of funds.		X
		• Explore creating catastrophe bonds and index-based insurance.	X	
	Harness La Niña's rebound	• Improve water-use efficiency during El Niño.	X	
		• Reduce flood risks in flood-prone areas during La Niña.	X	
	Improve forecasting and early warning systems	• Make hydrometeorological information more relevant and actionable.	X	
		• Invest in agrometeorological and agroclimatic capacity to broaden nationwide coverage.		X
		• Invest in human technical expertise and effective communication channels.	X	X
	Adopt drought-tolerant seeds	• Expand research mandates for research institutes to develop tolerant crop varieties.	X	
		• Improve extension services, technologies, and management methods.		X
	Consider storing grain reserves or implementing temporary trade policy reforms	• Assess the benefits and costs of implementing a temporary export ban during food price shocks.	X	
		• Assess capacity constraints and investment needs of an expanded grain storage system.	X	
		• Establish trade protocols and procedures in advance to safeguard producers and limit trade losses.		X
	Expand and adjust social safety nets (SSNs)	• Assess constraints and impacts from expanding SSNs.	X	
		• Adjust these programs to make them more responsive to ENSO impacts through better targeting and expanding systems in times of ENSO-related crises.	X	

(continued)

TABLE A: Continued.

	Recommendation	Actions	S	M/L
Resilience	Raise national ENSO awareness and build capacity	• Develop a multi-sectoral communications program that promotes ENSO awareness and education.		X
		• Stakeholders should participate in local, national, and international forums or dialogues on ENSO risks and preparedness strategies.	X	
	Integrate a regional approach to ENSO	• Begin dialogues with potential regional and international partners in ENSO.	X	
		• Identify areas of cross-border vulnerability and potential infrastructural cost sharing.	X	
	Invest in rural infrastructure	• Assess the prevalence and condition of current irrigation systems and rural infrastructure.	X	
		• Explore reforming water resource policies to improve efficiency.	X	
		• Invest in building or maintaining rural infrastructure.		X
	Sustain and scale up good practices.	• Identify Lao best practices on ENSO-related themes and increase human and resource capacity to scale up.	X	X
	Target women	• Develop a strategy targeting women who are vulnerable to ENSO.	X	
		• Empower women in leadership positions in local- or national-level efforts to combat ENSO impacts.	X	

CHAPTER 1

Introduction

This report's purpose is to help Lao policy makers and stakeholders prepare for future El Niño–Southern Oscillation (ENSO) events. It does this by providing information on ENSO's poverty, economic, and agricultural impacts in Lao PDR and outlining ways forward. The report finds that ENSO's impacts vary from region to region and harm Lao PDR's people, economy, and agricultural sector. The country has sought to prepare for climate risks through climate change adaptation and disaster risk management but could do more to prepare specifically for ENSO events. Preparing for ENSO is important because of Lao PDR's exposure to ENSO-related climate shocks, the importance of agriculture in the national economy, the rural population's climate and economic vulnerability, and the lack of research on ENSO in Lao PDR.

Lao PDR is exposed to ENSO-related climate shocks. Historical data show that the two phases of ENSO, El Niño and La Niña, tend to depress and increase average rainfall, respectively. Moreover, while floods have been associated with El Niño and La Niña in Lao PDR, droughts are also associated with El Niño. Since 1966, Lao PDR experienced 38 extreme climate events, which caused $625 million in damages. Of those events, 27 occurred during El Niño or La Niña years, or in other words, 71 percent of flood or drought disasters in Lao PDR coincide with ENSO events. The most damaging event was the El Niño–related droughts and floods in 1992, which caused over $300 million in damages.

ENSO's impacts on agriculture have economy-wide implications. Agriculture is an important economic sector in Lao PDR, providing over 68 percent of employment and a quarter of gross domestic product (GDP). Most poor people live in rural areas and work in agriculture, so are vulnerable to climate shocks. Agriculture is even more important when considering its linkages with downstream sectors and consumers in

domestic and foreign markets. When considering these linkages, agriculture accounts for 73 percent of employment and 40 percent of GDP. As such, any shocks to agriculture lead to reverberations across the entire economy, with serious implications on welfare, food security, and national poverty levels.

The rural poor are particularly vulnerable to ENSO-related shocks. Poverty remains pervasive in Lao PDR, especially in rural areas, where 29 percent of the population lives below the poverty line, compared to urban areas, where only 10 percent of the population lives below the poverty line.[16] Despite this, national poverty rates have improved, from 34 percent in 2002 to 23 percent in 2012.[17] Nutritional outcomes have also improved. The percent of the population that is food insecure fell from 33 percent to 23 percent over the past decade.[18] Likewise, undernourishment in Lao PDR fell from 38 percent in 2000 to 17 percent in 2017.[19] However, despite these reductions, poverty and food insecurity remain troublingly high. Moreover, as shown in section 5, a strong El Niño can increase the impoverished population by 0.12 percentage points and decrease household consumption by 0.88 percent.

This report is timely given the lack of research on ENSO in Lao PDR and the high likelihood the country will face another El Niño in the near term. It is difficult to disentangle ENSO's impacts from those of other climate shocks, natural disasters, and economic cycles. This makes it more difficult to design policies and response mechanisms that help mitigate ENSO-related welfare losses and economic damages. There is a growing body of empirical evidence measuring the effects of climate change and natural disasters on Lao PDR's agricultural and national economies. Few studies, however, focus on the specific impacts of ENSO events and no studies measure economy-wide outcomes. Moreover, while there is a growing literature on how disasters are managed in Lao PDR, there are few quantitative assessments of these policies and how they can mitigate ENSO-related losses. At the time of writing this report, forecasts predict that there is at least a 70 percent chance of another El Niño event occurring by winter 2018/2019.[20]

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[16]WFP (2018); 2012 figures: http://databank.worldbank.org/data/source/world-development-indicators
[17]WB-WDI (2018).
[18]http://www1.wfp.org/countries/lao-peoples-democratic-republic
[19] WB-WDI (2018).
[20] NOAA (2018); http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml

Roadmap

This report evaluates El Niño and La Niña's impacts on Lao PDR's agricultural sector—particularly crops, livestock, and fisheries—and how these have implications for the economy and society. It then looks at the actions undertaken by the Lao government to mitigate the losses associated with climate risks. This includes actions to prepare and respond to climate change and natural disasters. Next, the report simulates how well certain policy options mitigate ENSO-related GDP and welfare losses. It concludes by recommending actions to enhance Lao PDR's preparedness for future ENSO events. Box 1 provides a brief description of the research's methodology.

BOX 1: Methodology.

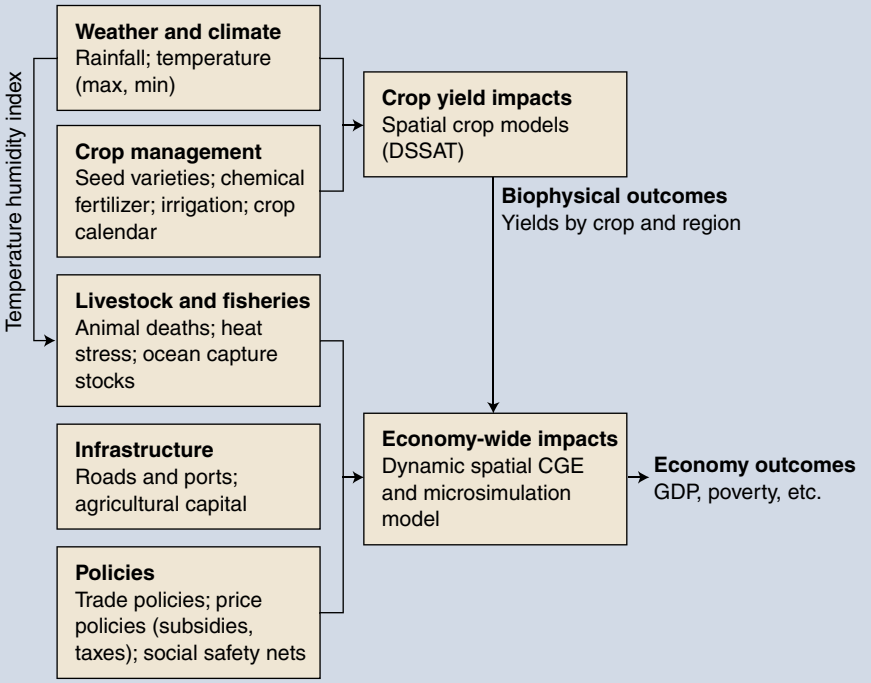
The report synthesizes available evidence and presents new analyses on ENSO's impacts on Lao PDR's weather, agricultural production, poverty levels, and the broader economy. The evidence comes from a secondary literature review, an analysis of historical data, and a series of simulations. Simulations were carried out using two models. The first is the Decision Support System for Agrotechnology Transfer (DSSAT) model, which is widely used by agricultural researchers to understand crop production system dynamics and simulate different farm management and environmental changes, including climate variability associated with ENSO. The second is a Computable General Equilibrium (CGE) model. The models simulate: (i) potential agricultural productivity under various conditions, including water scarcity, different planting months, and low or high fertilizer use; (ii) the indicative impacts of ENSO on livestock using the Temperature Humidity Index (THI); (iii) economic outcomes associated with these productivity losses (usually during El Niño) and gains (usually during La Niña); (iv) economic outcomes, including spillover effects associated with certain policy changes, such as providing drought-resistant crop varieties, increasing irrigated land, imposing trade restrictions, increasing grain storage and distribution, providing social transfers or income support to households, and a combination of these; and (v) poverty impacts on rural households with male and female household heads. Put simply, the model simulates the impact of historical ENSO events if they were to reoccur today and affect the current economy. This is valuable given the lack of systematic historical analyses of ENSO's impacts on poverty and broader economic growth. The models do not simulate water supply constraints because of a lack of useable data. For the detailed methodology refer to Annex 1.

(continued)

BOX 1: Continued.

Figure 1 depicts this report's analytical framework.

FIGURE 1: Integrated Analytical Framework.



CHAPTER 2

ENSO Affects Lao PDR

The El Niño Southern Oscillation, or ENSO, describes naturally occurring temperature fluctuations across the Pacific Ocean's east-central equator. These temperature fluctuations are considered ENSO when they are greater than one degree Celsius. ENSO can have large-scale impacts on ocean processes and global weather patterns. ENSO consists of two opposite phases: El Niño, the warm phase, and La Niña, the cold phase. El Niño and La Niña episodes typically occur every four years and last nine to twelve months or longer. Refer to Box 2 for a distinction between ENSO and climate change.

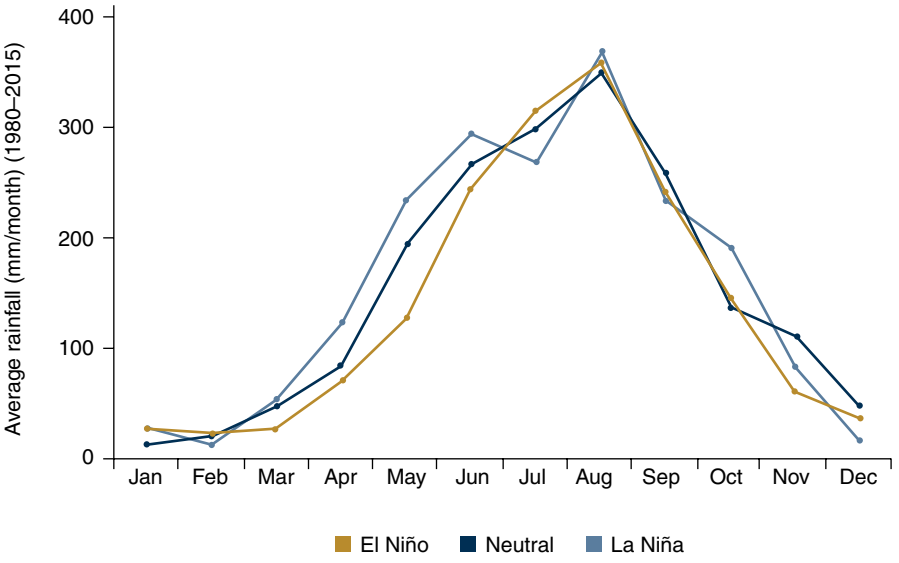
BOX 2: Distinguishing ENSO from Climate Change.

ENSO and climate change are two separate phenomena that share many attributes, and some key differences. Both are slow onset climate events that may not be immediately perceived by farmers or the wider society. This slow evolution of impacts creates policy challenges for both, since fast and large-scale disasters, such as hurricanes and earthquakes, are more likely to compel action, but slow moving disasters, like drought, may never compel change. As such, ENSO preparedness and climate change preparedness share many of the same actions and priorities. However, there are also key differences. While ENSO is cyclical with impacts that will come and go, climate change impacts are more permanent and are predicted to keep getting worse. Because of this, ENSO interventions in agriculture can be implemented in the short- and medium-term during ENSO years, and discontinued during non-ENSO years when climate conditions return to normal. Whereas climate change interventions in agriculture are long-term and permanent. In other words, with climate change there is no returning to normal. Climate change can also alter the impacts of ENSO. For example, climate change may make areas previously suitable for agriculture, unsuitable. It may also make areas drier and more water scarce, and in the process, make those areas more vulnerable to El Niño.

Lao PDR has three major climatic regions. These include: (1) the northern mountainous areas, which are 1,000 meters or more above sea level and have a temperate and hilly subtropical climate; (2) the central mountainous areas, which have a tropical monsoon climate; and (3) the tropical lowland plains along the Mekong River and its main tributaries.[21] Average annual rainfall varies from 1,400 to 3,500 millimeters across the climatic zones. The highest annual temperature is 35 to 38 degrees Celsius, and the lowest annual temperature is 16 to 18 degrees Celsius. Temperatures and rainfall patterns in each region are largely determined by the monsoon seasons. The southwest and northeast monsoons largely determine the climate during Lao PDR's two seasons: the rainy season from May to October and the dry season from November to April.

ENSO's main climate impact is on average rainfall, which falls during El Niño and rises during La Niña. This is especially true from October to June (Figure 2). An analysis of rainfall patterns from 1980 to 2015 shows that average October-to-June rainfall was about 30 percent lower in El Niño years than in non-ENSO, or neutral, years. By contrast, rainfall is about 16 percent higher during La Niña spring months than during neutral year spring months (April-June). These ENSO-related rainfall changes contribute to perennial droughts and floods in Lao PDR.[22]

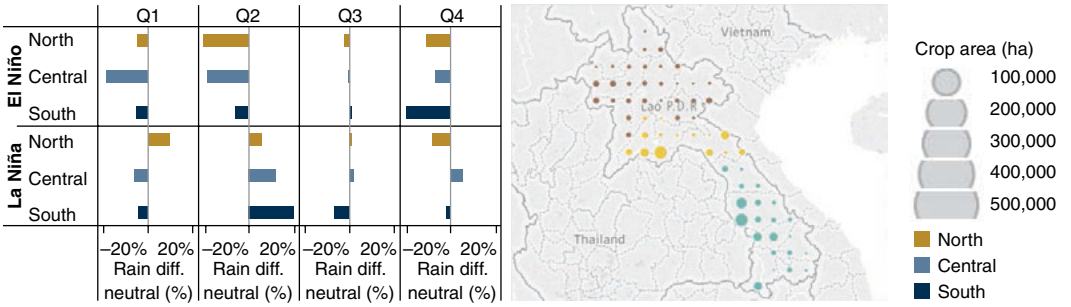
FIGURE 2: Monthly Rainfall Averages During ENSO Phases from 1980–2015.[23]



[21]WB (2011).
[22]Vision RI (2011); World Bank (2011); Eliste and Santos (2012); FAO (2015).
[23]Authors' reanalysis using the University of East Anglia Climatic Research Unit-Time Series (UEA CRU-TS) v4.0.

ENSO's climatic impacts vary markedly across subnational regions. Lao PDR's extensive variation in climate and terrain makes ENSO impacts highly localized.[24] The pattern of less rain during El Niño and more during La Niña is consistent across Lao PDR's three main regions, but notably stronger in the North during El Niño and in the South during La Niña (Figure 3). The North receives 26 percent less rain in the second quarter of the year during El Niño than in the same season during neutral years. The South, on the other hand, receives 25 percent more rain in the second quarter during La Niña years than in the second quarter during neutral years. The central region also shows significant rainfall swings between ENSO years and non-ENSO years.

FIGURE 3: Regional Rainfall Differences between El Niño and Neutral Phase from Each Quarter from 1980–2015 (left) and Main Crop Areas (right).[25]

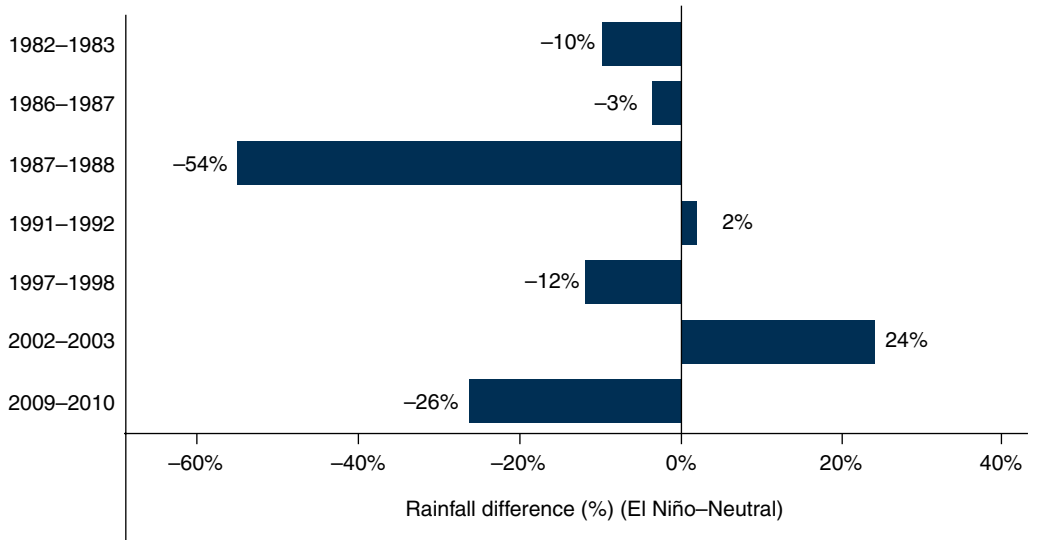


Lao PDR has experienced many ENSO events over the past few decades, each with different levels of severity. Over the last 50 years (1966–2016), there were 13 El Niño and 14 La Niña episodes. This includes seven severe ENSO events between 1980 and 2015. The most severe event was in 1987–88, when annual rainfall fell by 54 percent relative to historical levels. Some ENSO events had unpredictable impacts. For example, the 1991–92 El Niño had a 2 percent increase in rainfall and the 2002–03 El Niño had a 24 percent increase in rainfall (Figure 4). Despite these abnormalities, most El Niño years, on the whole, had less rain and most La Niña years had more rain. Box 3 demonstrates ENSO's impacts in Lao PDR in 2010 and 2015.

Droughts and floods are regular occurrences in Lao PDR. There are about 1.5 floods and droughts every year in Lao PDR.[26] Droughts can occur anywhere in the country but are most common in the central region. The most drought-prone provinces in Lao PDR are Saravane, Champasak, Khammuane, Xayabury, Vientiane, and Savannakhet, with over a fifth of households in these provinces vulnerable to drought

[24]FAO/WFP (2011).
[25]Authors' reanalysis using UEA CRU-TS v4.0.
[26]GFDRR (2014).

FIGURE 4: Annual Rainfall Differences between El Niño and Neutral Years.[27]

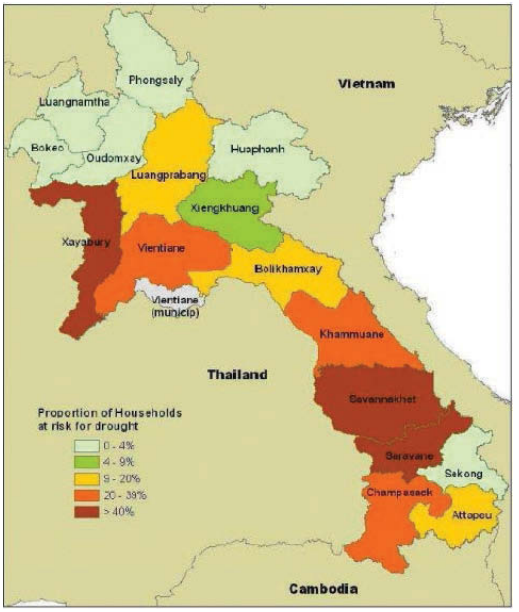


(Map 1).[28] In fact, droughts were more frequent in Lao PDR than in either Cambodia or Vietnam.[29] Droughts between 1995 and 2005 were associated with irregular temperature increases.[30] Floods are also very frequent, with 36 occurring over the last 50 years (Table 1).[31] Floods are mainly caused by heavy southwest monsoon rains.[32] Large floods are common in the central and southern provinces, and flash floods are common in the northern mountainous areas and eastern provinces (Map 2).[33] The six most flood-affected provinces in Lao PDR are Attapeu, Champasack, Khammouane, Savannakhet, Vientiane, and Bolikhamxay.[34]

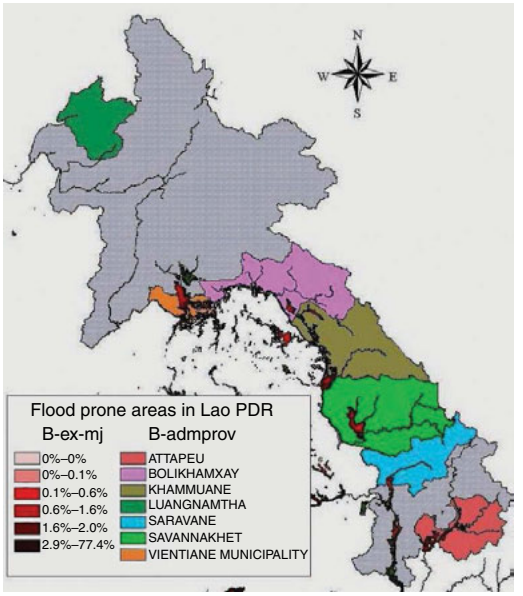
These droughts and floods cause significant damage. Table 1 shows there were 38 extreme climate events between 1966 and 2016, which caused $625 million in damages. Of those, 27 occurred during El Niño or La Niña years, or 71 percent. The most damaging event was the El Niño–related droughts and floods in 1992, which caused over $300 million in damages. From 1980 to 2010, droughts,

[27]Authors' reanalysis using UEA CRU-TS v4.0.
[28]Vision RI (2011).
[29] Vision RI (2011).
[30] World Bank (2011).
[31]Eliste and Santos (2012).
[32]Hazarika and others (2008).
[33]Vision RI (2011).
[34]Hazarika and others (2008).

MAP 1: Drought-prone Provinces in Lao PDR.[35]



MAP 2: Flood-prone Provinces in Lao PDR.[36]



floods, and storms accounted for over 70 percent of all natural disasters in the country.[37] Moreover, Lao PDR is the 87th worst-affected country by extreme weather events since 1996.[38] During this period, there were, on average, almost six fatalities per year caused by extreme weather events, and $76 million in economic losses.[39]

TABLE 1: Natural Disaster Damages in Lao PDR, 1966–2016.[40,41]

No.	Year	Type of disaster	ENSO		Damage (US$)	Location
			El Niño	La Niña		
1	1966	Large flood			13,800,000	Central
2	1968	Flood		x	2,830,000	Central and Southern
3	1969	Flood	x		1,020,000	Southern
4	1970	Flood		x	30,000	Central
5	1971	Large flood		x	3,573,000	Central
6	1972	Flood and drought	x		40,000	Central

(continued)

[35]Vision RI (2011).
[36]Vision RI (2011).
[37]Eliste and Santos (2012).
[38]Lao PDR scored 82.5 in the 2017 Global Climate Risk Index; Kreft and others (2017).
[39]Measured in purchasing power parity.
[40]Note: Value of damages includes infrastructure damages, and not just agricultural losses.
[41]Eliste and Santos (2012).

TABLE 1: Continued.

No.	Year	Type of disaster	ENSO		Damage (US$)	Location
			El Niño	La Niña		
7	1973	Flood		x	3,700,000	Central
8	1974	Flood		x	180,000	
9	1976	Flash flood		x	9,000,000	Central
10	1978	Large flood			5,700,000	Central and Southern
11	1979	Flood and drought	x		3,600,000	Northern and Southern
12	1980	Flood			3,000,000	Central
13	1981	Flood			682,000	Central
14	1984	Flood		x	3,430,000	Central and Southern
15	1985	Large flood		x	1,000,000	Northern
16	1986	Flood and drought			2,000,000	Central and Southern
17	1990	Flood			100,000	Central
18	1991	Flood and drought	x		3,650,000	Central
19	1992	Flood and drought	x		302,151,200	Central and Northern
20	1993	Flood and drought	x		21,827,927	Central and Southern
21	1994	Flood			21,150,000	Central and Southern
22	1995	Flood	x		15,000,000	Central
23	1996	Large flood and drought		x	10,500,000	Central
24	1997	Flood and drought	x		1,860,300	Southern
25	1999	Flood		x	7,450,000	Central
26	2000	Flood		x	6,684,225	Central and Southern
27	2001	Flash flood			808,000	Central and Southern
28	2002	Large/flash flood, landslide			14,170,578	Nationwide
29	2004	Flood			750,399	Southern
30	2005	Flash flood and landslide	x		1,316,582	Central and Southern
31	2006	Flood		x	3,636,124	Central and Southern
32	2007	Flash flood	x		8,059,859	Nationwide
33	2008	Large flood and flash flood		x	4,384,407	Central and Northern
34	2010	Flash flood	x		21,000,000	Central and Southern
35	2011	Flood		x	65,000,000	Central
36	2013	Flood and landslide			62,000,000	Nationwide
37	2015	Drought	x			
38	2016	Drought	x			

BOX 3: Impacts from the 2010 and 2015 ENSO.

The 2010 ENSO event in Lao PDR caused water shortages and decreased rice yields, with serious impacts on livelihoods. This event gave insight into the effects of El Niño on the rice sector and how these impacts ripple through the economy. In 2010, there was a prolonged dry period at the start of rice cropping season, which led to widespread resowing and late transplanting[42] and had detrimental impacts on rice growth and production. The South of the country was generally more affected by the extended dry period than the North.[43] Low water levels restricted the supplementary irrigation of rice fields and upland farmers with limited seed supplies and resources were forced to abandon their farms.[44] Overall, rice production fell by 6.7 percent during the 2010 El Niño.[45]

Poor rice production triggered price increases for the country's main staples.[46] The price of glutinous rice (equal to 85 percent of rice intake) rose substantially in late 2010.[47] The Lao government distributed rice reserves in July, but the impact was minimal. Furthermore, in the Champasack market in the south of the country rice prices doubled, and in Vientiene province rice prices increased by 40 percent.[48] Rice prices stabilized by February 2011, but they were still 26 to 58 percent higher than February 2010 prices[49] By this time, low-income families could no longer afford rice and began to experience food insecurity.

Similarly, the 2015 ENSO-related drought significantly affected crop production. Over 1,000 hectares of upland crops were affected by the 2015 ENSO.[50] The districts of Ngeun, Phieng, Xienghon, and Kaenthao lost 48,000 hectares of newly planted rice seedlings, or 5 to 10 percent of the national rice area.[51] About 8,000 hectares of maize, fruit, and sesame were damaged with almost 4,000 hectares destroyed.[52] Furthermore, Champasak, Luang Prabang, Savannakhet, and Vientiane provinces and Vientiane Prefecture, which together account for 50 percent of the nation's rice demand, had below-average rainfall in May–June 2015, leading to very low production levels.[53]

[42]UN-FAO/WFP (2011).
[43]UN-FAO/WFP (2011).
[44]UN-FAO/WFP (2011).
[45]UN-FAS-USDA (2014).
[46]UN-FAO/WFP (2011).
[47]UN-FAO/WFP (2011).
[48]Compared to prices from November 2009.
[49]UN-FAO/WFP (2011).
[50]RFA Lao Service (2015).
[51]RFA Lao Service (2015).
[52]RFA Lao Service (2015).
[53]FAO (2015).

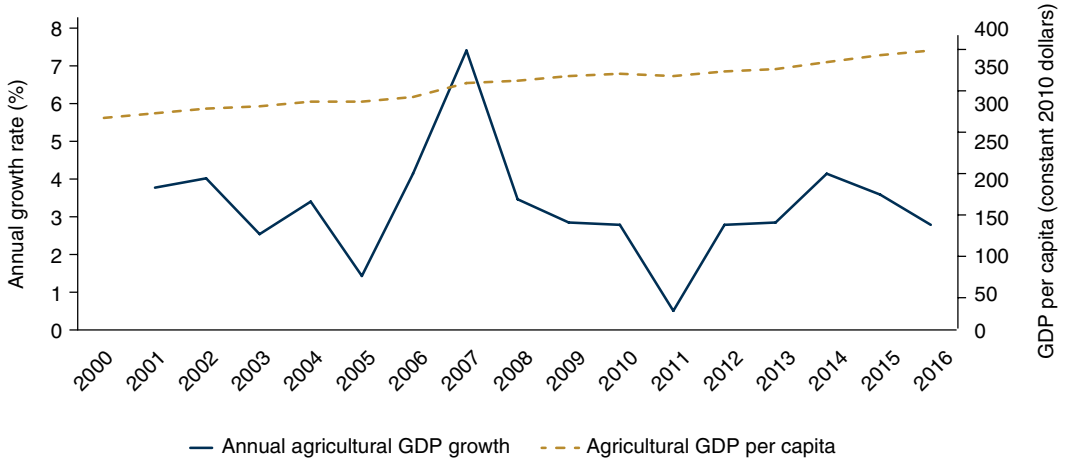
CHAPTER 3

ENSO Affects the Agricultural Sector

Agricultural context

Agriculture is an important part of the Lao economy, though its sectoral growth has not matched overall economic growth. Agriculture in Lao PDR contributed 19 percent to the national GDP in 2016, down from 45 percent of GDP in 2000. Agricultural employment, which remains the dominant source of livelihoods in Lao PDR, has fallen more slowly, from 85 percent in 1995 to 78 percent in 2017.[54] This underscores agriculture's continued importance as a household income source. These GDP and employment declines were not caused by any declines in agriculture. Figure 5 shows

FIGURE 5: Growth and Variability of Agricultural GDP in Lao PDR.[55]



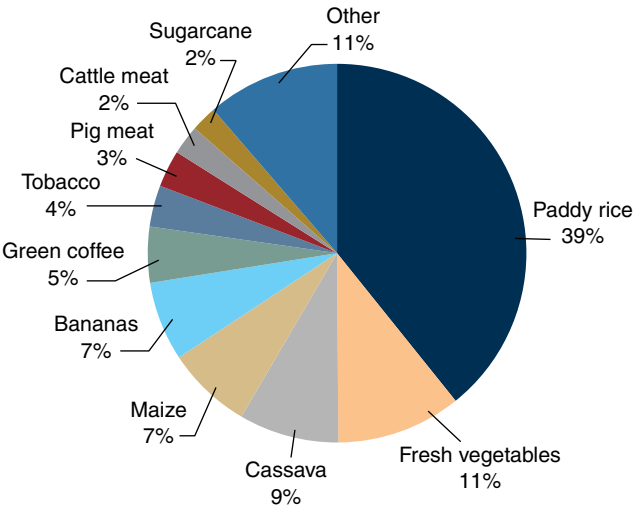
[54]Note: These figures differ from the figures calculated for this report using a Social Accounting Matrix (SAM).

[55]Authors' calculations using World Development Indicators (WB-WDI 2018).

that annual agricultural GDP growth has been positive every year since 2000, and agricultural GDP per capita has also increased every year since 2000. However, this growth has not matched overall economic and employment growth rates in Lao PDR, which averaged 7.5 percent from 2010 to 2016.[56]

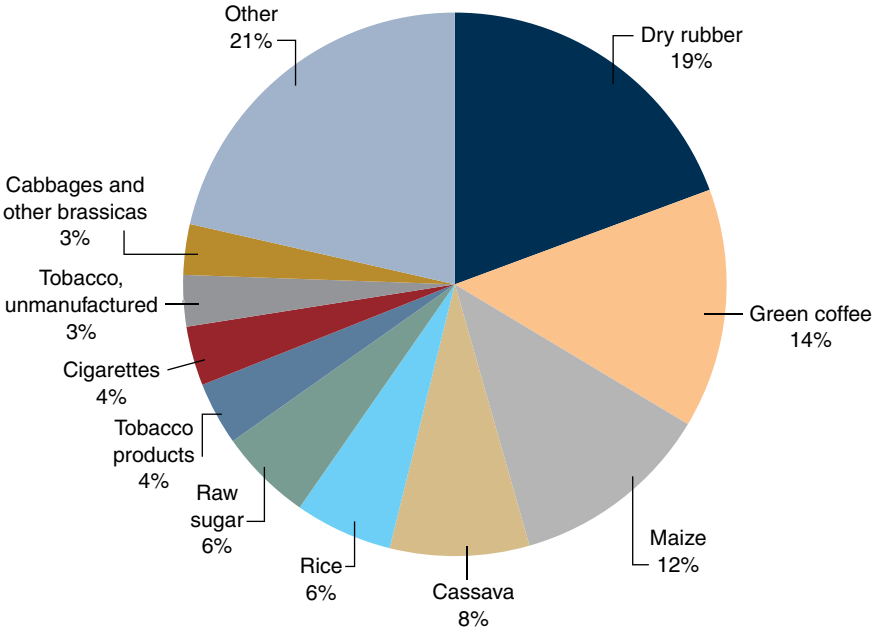
Agricultural production in Lao PDR is dominated by rice, though rice is less important for export markets. Only 7 percent of Lao PDR's total land is considered arable.[57] Of this, 70 to 80 percent is devoted to rice. Cultivated rice areas rose from 650,000 hectares in 1990 to nearly 960,000 hectares in 2014. Because of this, since 2000, Lao PDR has been able to meet its entire domestic rice demand with domestic production, achieving full self-sufficiency.[58] Despite dominating cultivated areas, rice contributes only about 40 percent to total agricultural production value. This is still over three times as high as beans, the next most valuable agricultural commodity (Figure 6). Maize cultivation, which is more resilient to dry weather than rice, has expanded as maize prices increased.[59] Swine and cattle livestock contribute about 5 percent to total agricultural production value, though poultry and small ruminants are also important commodities. Fisheries and aquaculture are important sectors for household incomes and food consumption even though Lao PDR is a landlocked

FIGURE 6: Agricultural Production, as a Share of Total Value (2014–2016), Constant (2004–2006 $).[60]



[56]All data from WB-WDI (2018).
[57]WB-WDI (2018).
[58]FAOSTAT, FAO (2017).
[59]UN-FAO/WFP (2011).
[60]FAOSTAT, July 2018.

FIGURE 7: Agricultural Export, Share of Total Value (2014–2016), Constant (2004–2006 $).[61]



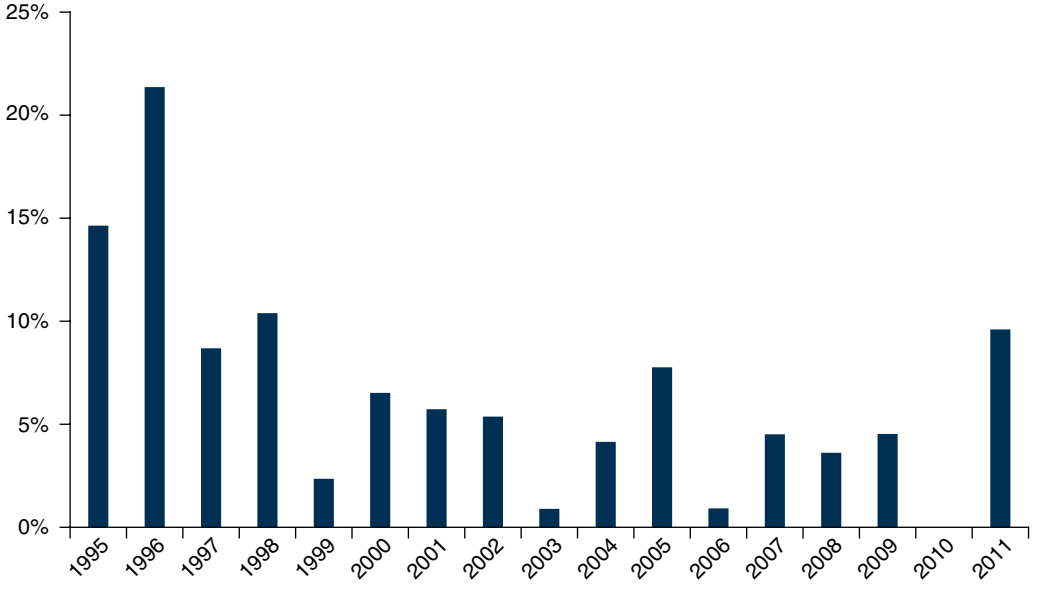
country. Agro-food exports account for about one-fifth of Lao PDR's total exports. Rubber, coffee, maize, and cassava are the most important agricultural export commodities (Figure 7). The top three export markets for raw agricultural products in order of importance are China, Vietnam, and Thailand; while the top three markets for processed foods are Vietnam, China, and Thailand (2016).[62]

Crops

Extreme weather events reduce or damage Lao PDR's croplands. Figure 8 shows that extreme weather events affected over 5 percent of total planting areas nine years out of the last 17. The large flood and drought in 1996 had the strongest effect, reducing Lao PDR's crop planting area by one-fifth. As shown in Table 1, 70 percent of extreme weather events occur during ENSO years. Despite this, even smaller weather changes can lead to disasters, for example, rainfall of less that 2,000 millimeters annually can cause drought. In 2010, extremely low Mekong River water levels caused irrigation water shortages, affecting 22,000 hectares of dry season crops in Khamoune,

[61]FAOSTAT, July 2018.
[62]http://www.intracen.org/layouts/CountryTemplate.aspx?pageid=47244645034&id=47244652178

FIGURE 8: Percentage of Total Planting Area Affected Extreme Weather Events from 1995 to 2011.[63]



Vientiane, Luang Namtha, and Bolikhamxay.[64] Similarly, lower than average rainfall in May and June 2015 reduced planting areas and yields for early-planted rice and maize crops in the country's main cereal growing areas: the Champasak, Savannakhet, Luang Prabang, and Vientiane provinces.[65] Meanwhile, rainfall greater than 200 millimeters in two successive days has resulted in flooding in the Mekong Delta,[66] which comprises 20 percent of the country's total crop area.[67]

Historical examples show drought negatively impacts the rice sector. As shown in Table 1, drought is strongly associated with El Niño. In 1988–1989, severe droughts associated with El Niño caused $40 million in agricultural production losses,[68] with national production declining by about a third.[69] In early 2010, droughts significantly reduced lowland rainfed rice production in the Mekong region.[70] Other studies show late season drought reduced grain yields by 30 percent.[71] Even light and moderate severity droughts, which delay the rice planting season, can prolong the dry season,

[63]Eliste and Santos (2013).
[64]Vision RI (2011).
[65]FAO (2015).
[66]UNISDR (2012).
[67]Vision RI (2011).
[68]Vision RI (2011).
[69]Eliste and Santos (2012).
[70]Eliste and Santos (2012); Miyan (2015).
[71]Fukai and others (1998).

negatively impacting rice production. This occurred in 2011 with rice farmers in Luang Prabang and Savannakhet provinces.[72] In this case, rice farmers from rainfed upland areas incurred a 13 percent income loss and rice farmers from rainfed lowland areas incurred a 7 percent income loss. In the irrigated lowlands, income losses from decreased production were minimized: rice farmers incurred only a 5 percent income loss,[73] demonstrating the effectiveness of irrigation as an ENSO preparedness measure.

Flooding in Lao PDR regularly causes damage to cropping areas. For example, the 2002 flood destroyed about 34,000 hectares of cropland, reduced production area by nearly 250,000 hectares, and resulted in total economic losses of more than $14 million. From 1966 to 2008, floods caused $341 million worth of damages.[74] Floods in 1995–1996, 2000–2001, and 2005–2006 destroyed 43,000 to 66,000 hectares of rainfed areas.[75] Lowland rainfed rice production was particularly hard hit: from 2006 to 2010, floods affected 11,000 to 42,000 hectares.[76] The 2005–2006 floods also caused over $5 million worth of damage to irrigation systems. Flood modeling found that a 1-in-10-year flood event directly affects 67,000 people, 196 square kilometers of agricultural land, 66 square kilometers of forest area, and 259 kilometers of roads.[77]

Aggregate national-level statistics mask ENSO's subnational impacts on crop production. Figure 9 shows national rice yield trends over the past 50 years. It shows that above-trend yields are just as likely as below-trend yields during ENSO phases. Other major crops, such as maize, vegetables, coffee, cassava, groundnuts, sugarcane, bananas, and pulses, also did not show a discernable pattern at the aggregate national level. One possible exception is sugarcane, which had national yields consistently increasing during La Niña conditions. However, national crop yield trends during ENSO events depend on many factors, including the event's severity, its location relative to major production areas, the resiliency of the crop lands that are affected, and the exact time during the growing season in which the event occurs. Also, impacts from ENSO events may lead to human actions that can affect yields. For example, if an ENSO event disrupts planting or if farmers anticipate a poor season, they may not plant that year, or they may plant different crops. This would mask the real impacts of ENSO on national yield statistics for specific crops.

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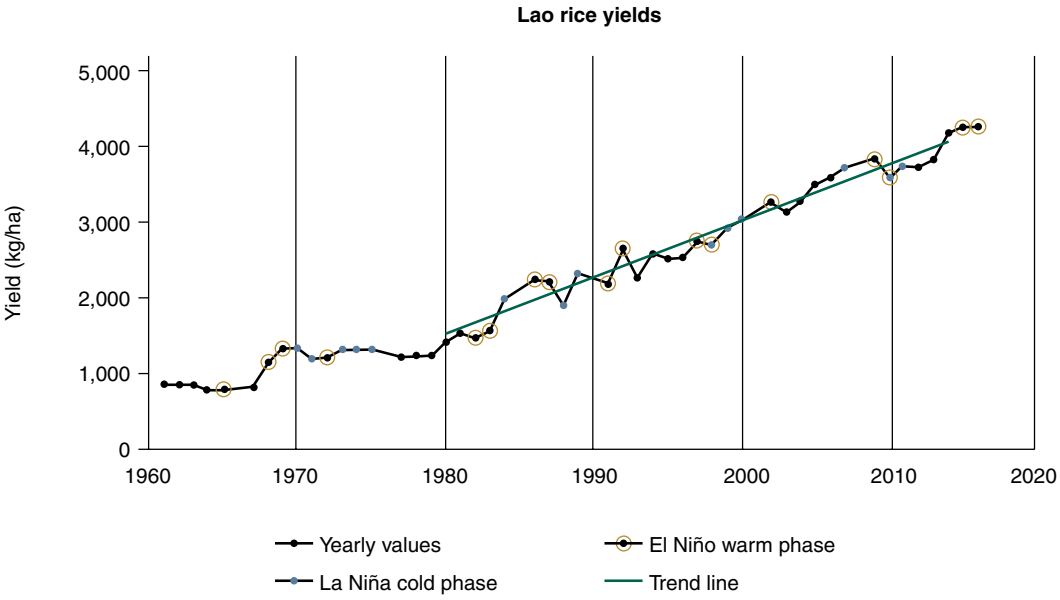
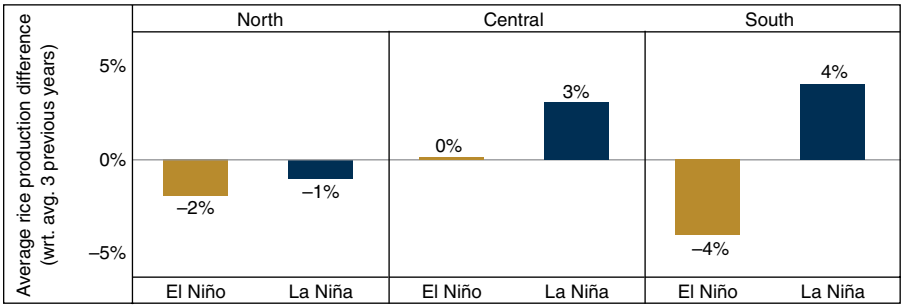
[72]Peñalba and Elazegui (2013).
[73]Peñalba and Elazegui (2013).
[74]Vision RI (2011).
[75]World Bank (2011).
[76]GoL (2014).
[77]Hazarika and others (2008).

FIGURE 9: Rice Yields (kg/ha) and ENSO Events, Lao PDR, 1961–2016.[78]



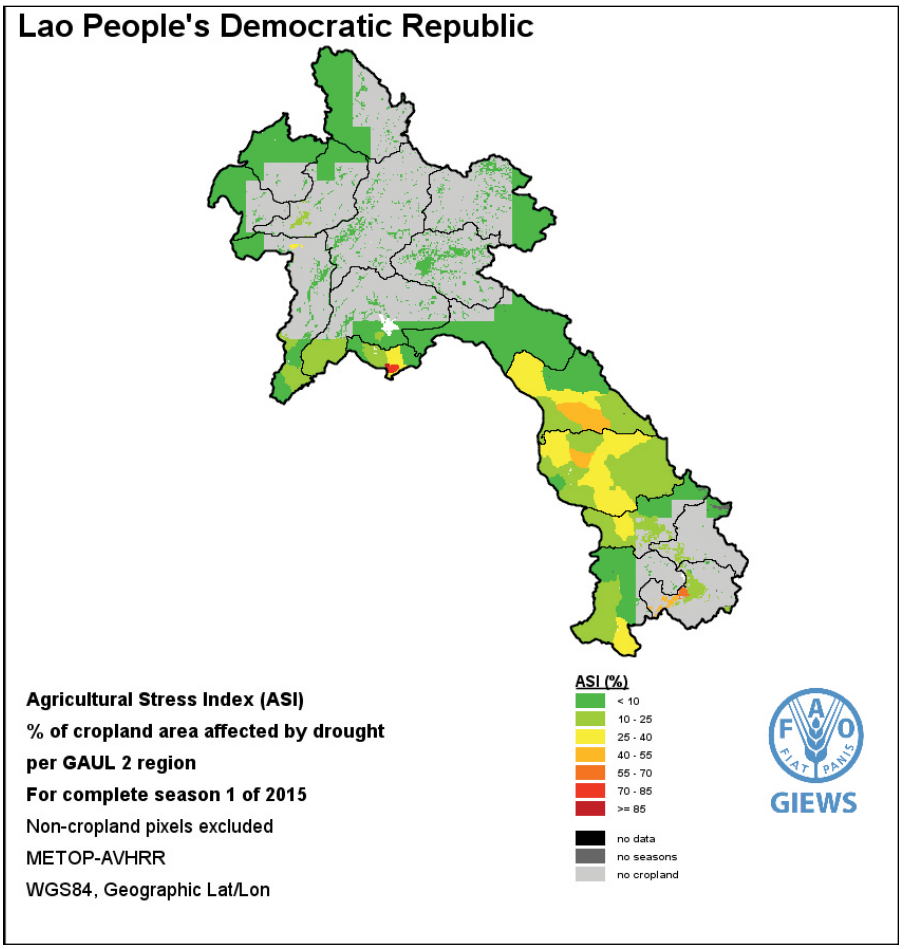
ENSO's subnational impacts show El Niño decreases rice yields, while La Niña increases rice yields. Figure 10 compares subnational rice production changes from 1995 to 2015 during ENSO years compared to neutral years. It shows, on average, rice production during El Niño years was lower compared to neutral years, and higher during La Niña. This trend was the most obvious in the south of Lao PDR where rice production was 4 percent lower during El Niño years and 4 percent higher during La Niña years compared to neutral years. In the Central region, rice production was

FIGURE 10: Changes in Annual Average Rice Production from the 1995–2015 Average.[79]



[78]Own calculations using historical data from FAO (2018).
[79]Authors' reanalysis using historical rice production data from the Lao Statistics Bureau.

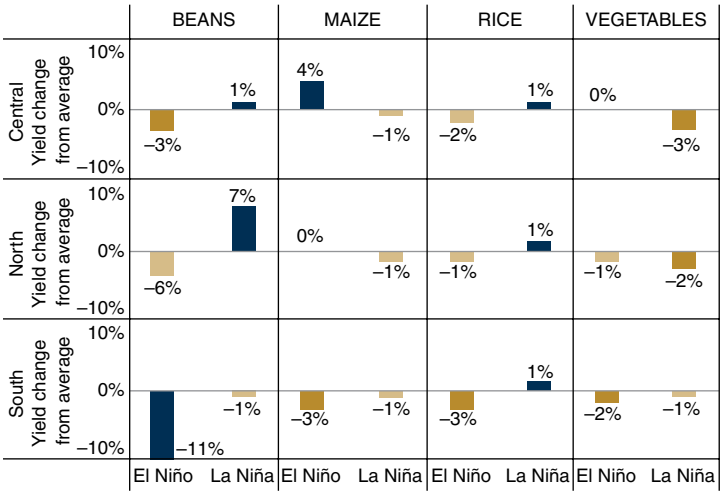
MAP 3: Agricultural Stress Index (ASI) of Lao PDR, 2015.[80]



about 3 percent more during La Niña years, but unchanged during El Niño years. In the North, there was slightly lower rice production during both El Niño and La Niña years. These results are consistent with the agriculture stress index (ASI),[81] which shows the southern parts of Lao PDR, particularly Attapeu, Saravane, and Savannakhet provinces, experienced the most climate stress from droughts in 2015 (Map 3).

[80]FAO (2015); http://www.fao.org/giews/earthobservation/country/index.jsp?lang=en&type=16&code=LAO#
[81]ASI monitors and assesses vegetation indices across global crop areas during growing periods, and identifies hotspots where crops may be influenced by droughts. For more information on ASIs, see http://www.fao.org/climatechange/asis/en

FIGURE 11: Changes in Beans, Maize, Rice, and Tomato Yields During El Niño and La Niña Years Compared to Average Years.[82]



Crop simulations carried out for this report find only small crop productivity changes during El Niño and La Niña. Figure 11 shows the Central region has 2 percent lower yields during El Niño events, and 1 percent higher yields during La Niña. The South region, which has the highest proportion of rice lands, is only slightly worse off during El Niño. Maize production is concentrated in the North, where crop simulations show almost no effect on maize yields during either El Niño or La Niña. Vegetable production is spread throughout the country, but with slightly more production in the South. Tomatoes, which act as a proxy for vegetables in the crop simulations, show small yield declines in all regions during both El Niño and La Niña.

Livestock

There are more humid and high temperature days during a La Niña year, which places greater heat stress on livestock, but generally poses little danger in Lao PDR. This report models Lao PDR's Temperature Humidity Index (THI), which measures heat based on temperature and relative humidity, to characterize heat stress levels in cattle and poultry. Once the daily THI exceeds 75, cattle begin to experience the ill effects of heat stress, such as slower growth or declining milk productivity.[83] Poultry experience strong declines in feed intake, egg size, and egg quality at 80 THI.[84] Swine

[82]Authors' analysis using DSSAT crop models.
[83]West (2003).
[84]Lara and Rostangno (2013).

see negative outcomes at 68 THI. Modeling shows La Niña increases the number of moderate and severe heat stress days–days with a THI of 80 to 90–by nine days compared to a neutral year. Similarly, NASA's POWER dataset[85] shows there are seven more such days per year during La Niña. Although, El Niño does not increase the number of high THI days, it has higher THI values than La Niña from November to June. La Niña has higher values from July to October. Generally, the highest heat stress for livestock in Lao PDR is in the South during the warmest parts of the year. That said, Lao PDR has a low heat stress environment compared to other countries in southeast Asia, meaning temperature variations associated with ENSO are not a major concern.

Fisheries

Fisheries are not a major economic sector in Lao PDR, and there is no data on how fisheries are affected by ENSO. Any damages to Lao PDR's fisheries from ENSO could have implications for household health and food security. Despite being landlocked, there are still many freshwater sources of fish in Lao PDR. Available information on fisheries indicate aquaculture provides income in certain parts of the country and contributes to higher quality protein in diets, especially in rural communities. It is estimated that over half of all fishers in Lao PDR are women. Women are also notable stakeholders in fisheries because of their roles in family health, nutrition, and overall well-being.[86]

[85]See http://power.larc.nasa.gov/
[86]Mosser (2015).

CHAPTER 4

ENSO Contributes to Economic Impacts

Agriculture represents a much larger share of Lao PDR's economy when the entire Agriculture Food System (AFS) is considered. This report uses a Social Accounting Matrix (SAM) to measure the AFS, which includes not only direct agriculture, but also indirect contributions to agriculture like input production, downstream processing, and trading and transporting. When considering these indirect contributions, Lao PDR's AFS accounts for 40 percent of the economy, with primary agriculture accounting for 25 percent (see Table 2). Table 3 shows that direct agriculture is a smaller economic sector than the industry and service sectors. However, agriculture becomes the largest

TABLE 2: Agriculture Food System GDP and Employment, 2014.[87]

	Share of national total (%)	
	GDP	Employment
National economy	**100**	**100**
Agriculture food system	**39.6**	**72.8**
Direct production	**33.1**	**68.3**
Agriculture	24.6	66.1
Agro-processing	8.5	2.1
Input production	**1.3**	**0.4**
Agriculture	1.1	0.4
Agro-processing	0.2	0.0
Trade and transport	**5.2**	**4.1**
Agriculture	1.9	1.5
Agro-processing	3.3	2.6

[87]Lao CGE model and 2014 SAM.

TABLE 3: National Economic Structure, 2014.[88]

	Share of total (%)			
	GDP	Employment	Exports	Imports
All sectors	**100**	**100**	**100**	**100**
Agriculture	**24.6**	**66.1**	**9.9**	**1.2**
North	10.4	27.3	9.9	1.2
Center	9.3	26.2	9.95	1.2
South	4.9	12.6	9.9	1.2
Industry	**36.7**	**7.9**	**71.7**	**91.6**
Mining	5.5	0.3	27.1	1.0
Manufacturing	18.1	3.8	36.5	89.4
Agro-processing	8.5	2.1	0.9	10.5
Other manufactures	9.6	1.6	35.7	78.8
Other industry	13.1	3.8	8.1	1.3
Services	**38.7**	**26.0**	**18.4**	**7.2**

sector when considering the entire AFS. Likewise, the agriculture sector, even when excluding indirect contributions, dominates national employment: direct agriculture employs 68 percent of the working population, the AFS employs 73 percent. AFS's large share of the national economy and employment means any ENSO-related shocks to agriculture would reverberate across the entire economy.

Simulations show a typical El Niño event causes modest losses to Lao PDR's GDP, while La Niña causes modest gains, though not enough to fully negate El Niño losses. Table 4 shows national GDP falls by 0.2 percent during an El Niño event relative to a neutral climate year. Even small percentage reductions in national GDP can imply sizable monetary losses. For example, a 0.2 percent drop in national GDP equals $21 million in lost value-added.[89] Losses are larger in agriculture itself, with GDP falling 0.8 percent. The South region suffers the largest crop and livestock GDP losses in percentages, equaling 1.1 percent. But, the Central region suffers the largest crop and livestock GDP losses in dollar terms of $11 million. This underscores the Central region's larger concentration of agriculture activity. By contrast, a typical La Niña event expands the economy by 0.1 percent, or 0.5 percent in agriculture. However, the gains during La Niña ($12 million) do not offset all of the losses during El

[88]Lao CGE model and 2014 SAM. Notes: GDP is gross domestic product; employment is workers in primary jobs.
[89]National income measured in 2014 prices.

TABLE 4: GDP Changes During Typical ENSO Events.[90]

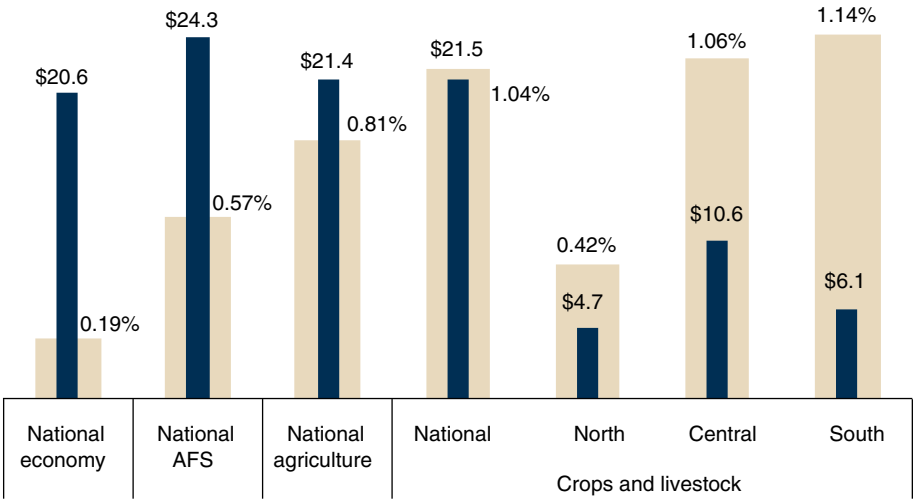
	El Niño events	La Niña events
Percentage change in GDP (%)		
National	–0.19	0.11
AFS	–0.57	0.34
Agriculture	–0.81	0.48
Crops and livestock	–1.04	0.62
North	–0.42	0.45
Central	–1.06	0.57
South	–1.14	0.39
Absolute change in GDP (US$ million)		
National	–20.55	12.08
AFS	–24.35	14.44
Agriculture	–21.43	12.75
Crops and livestock	–21.53	12.82
North	–4.71	5.01
Central	–10.64	5.66
South	–6.07	2.08

Niño ($21 million) in any sector or region, except in the North region, which sees a $5 million gain in agricultural GDP during La Niña but only a $4.7 million loss during El Niño.

Lao PDR's AFS suffers the greatest losses among simulated sectors during El Nino years. Figure 12, which summarizes GDP losses in different economic sectors during El Niño, shows AFS losing $24 million, compared to primary agricultural and the national economy losing $21 million each. Crops and livestock GDP losses ($21.5 million) are nearly equal to agricultural losses ($21.4 million) because there is almost no predicted damage to forestry or fisheries during a typical El Niño event. AFS losses are greater than national economy losses in dollar terms because nonagricultural sectors stand to gain during La Niña as labor shifts to those sectors and lower agricultural production constrains the supply of raw materials to agriculture-related processing and trading. In Lao PDR, these factors outweigh the lower demand for non-AFS products.

[90]Simulation results from the Lao CGE model.

FIGURE 12: GDP Losses During Typical El Niño Events ($ millions and percentage reductions).[91]



Simulations show the agriculture sector's GDP stands to gain the most during La Niña. Figure 13 shows the AFS' GDP gains the most in dollar value ($14.4 million) while direct agriculture's GDP gains the most in percentages (0.6 percent). Economic linkages also explain the sectoral distribution of these GDP gains. However, in this case, higher crop and livestock productivity attract labor from other parts of the AFS and the broader economy. This decline in nonagricultural employment outweighs increased demand for nonagricultural products caused by higher national incomes. The net result is smaller, but still positive, gains in national GDP.

Food and agricultural product prices change only slightly during ENSO events. More specifically, *real* agriculture prices increase by 0.2 percent during an El Niño event, and food prices increase by 0.1 percent (Figure 14). La Niña, by contrast, causes both agriculture and food prices to decrease by 0.1 percent. In this model, food prices include commodities produced by downstream food industries that use raw agricultural products, which are directly affected by ENSO. Together with income changes, these price changes explain why real consumption falls and poverty rises, albeit only slightly, for both rural farmers and urban consumers (as described below).[92]

[91]Simulation results from the Lao CGE model.
[92]Note these are "real" price changes, which means they are net of the general change in the consumer price index caused by the ENSO event.

FIGURE 13: GDP Gains During Strong La Niña Events ($ millions and percentage increases).[93]

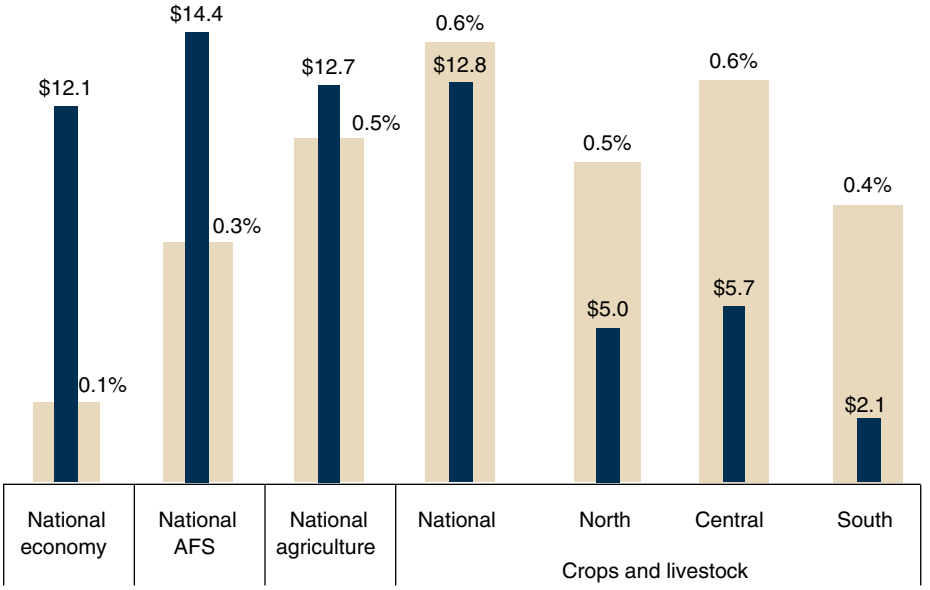
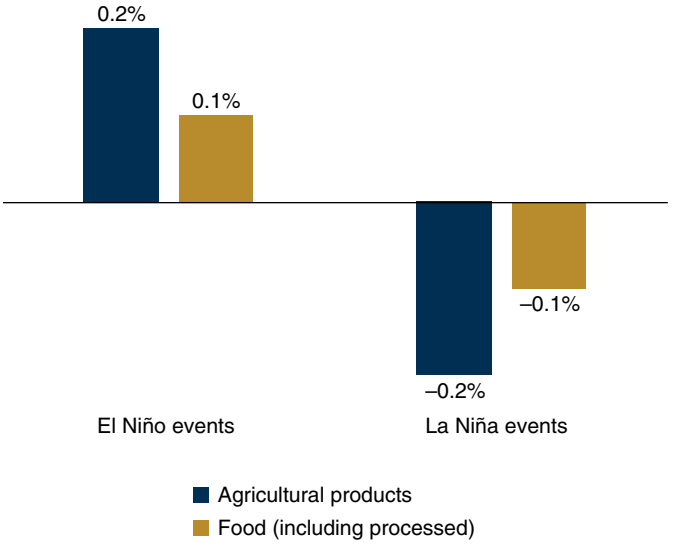


FIGURE 14: Real Food and Agricultural Price Changes During ENSO Events (percentage).[94]



[93]Simulation results from the Lao CGE model.
[94]Simulation results from the Lao CGE model.

CHAPTER 5

ENSO Contributes to Social Impacts

Lao PDR has made significant progress in reducing poverty, but El Niño threatens this trend. Lao PDR reduced national poverty from 34 percent in 2002 to 23 percent in 2012.[95] Most of this poverty is concentrated in rural areas. Overall, the rural poverty headcount ratio is 29 percent, while the urban poverty headcount ratio is 10 percent.[96] The CGE model and SAM estimate that rural households consume about half that of urban households (Table 5). As such, continued poverty reduction requires continued growth in the agricultural sector. As discussed, El Niño causes GDP losses in the agricultural sector. Using the CGE model, we can also simulate El Niño's precise impacts on the national poverty rate and the number of poor people. Simulations reveal a typical El Niño event causes the national poverty rate to increase by 0.12 percentage-points (Figure 18). This is equivalent to an additional 8,200 people living below the poverty line during El Niño. These negative impacts are partially mitigated by higher agricultural prices, which tend to benefit rural households.

Simulations show that El Niño–related consumption losses are larger for more affluent and urban households. Table 6 shows all households, regardless of income level or urban-rural location, experience a decline in consumption, or welfare, during a strong El Niño event. However, consumption losses are 0.6 percent for the poorest households during El Niño compared to 0.88 percent for all households. Similarly, consumption losses are 0.84 percent for rural households during El Niño compared to 0.94 percent for urban households. This is because urban households are net consumers of food products, so higher food prices hurt their consumption during El Niño in

[95]WB-WDI (2018).
[96]2012 figures: http://databank.worldbank.org/data/source/world-development-indicators

TABLE 5: Household Income and Consumption, 2014.[97]

	National	Rural	Rural poor	Urban
Population (millions)	**6.6**	**5.0**	**1.1**	**1.6**
Consumption per capita (US$)	**776**	**618**	**173**	**1,265**
All foods (%)	**100**	**100**	**100**	**100**
Cereals, roots	37.2	35.6	48.1	40.0
Vegetables	12.6	13.5	25.7	11.2
Fruits				
Meat, fish, eggs	0.4	0.4	0.5	0.3
Milk, dairy	1.1	0.8	0.3	1.7
Pulses, oilseeds	1.1	0.9	0.8	1.3
Other foods	47.6	48.7	24.6	45.5
Food consumption share (%)	**59.5**	**62.5**	**90.2**	**55.0**
Processed share (%)	**65.4**	**65.9**	**62.9**	**64.5**
All income (%)	**100**	**100**	**100**	**100**
Cropland returns	10.7	17.5	2.4	2.2
Labor remuneration	43.7	39.3	95.2	49.2
Capital profits	45.6	43.1	2.4	48.6
Other sources	0.0	0.1	0.0	–0.1

TABLE 6: Household Consumption Changes by Location and Income During El Niño Events (percentages).[98]

	National	Rural	Urban	Poorest quintile
Consumption losses during El Niño	–0.88	–0.84	–0.94	–0.6

the CGE model. This may also explain why poor households suffer fewer consumption losses, since poverty is more frequent and most pronounced in rural areas.[99] That said, there are other factors that are not considered in the CGE modelling that may hide some of the resilience afforded to higher income households by virtue of their greater wealth. For example, poor households have fewer assets so are less able to smooth consumption by selling them during climate shocks. Also, poor households are more likely to experience health or food security consequences from ENSO events.

[97]Lao CGE model and 2014 SAM.
[98]Simulation results from the Myanmar CGE model.
[99]WB-WDI (2018).

ENSO threatens food security in Lao PDR, especially for poor households. A survey found that daily dietary energy consumption (DES) for urban families was 10 percent higher than daily DES for rural families.[100] Cereals remain the most important source of food energy (67 percent), with rice comprising more than 90 percent of cereal intake. Fish and livestock meat, especially pig and cattle, are the most important sources of animal protein. In 2014, families spent 41 percent of their income on food.[101] But studies suggest food expenditures have been rising in Lao PDR, especially in rural areas.[102] According to CGE and SAM calculations for this report, Lao households spend 60 percent of their income on food consumption, with urban families spending 55 percent and rural families spending 63 percent. However, the rural poor spend 90 percent of their income on food consumption. This makes any price increase, which is predicted to occur during El Niño (Figure 14), particularly damaging to poor households. This could not only threaten their welfare but also their food security.

Lao PDR has improved the health of its population, but ENSO can increase the incidence of infectious diseases. In Lao PDR, undernourishment fell from 38 percent in 2000 to 17 percent in 2017.[103] Similarly, the incidence of child wasting fell from 18 percent in 2000 to 6 percent in 2011.[104] However, extreme weather events, like those associated with ENSO, lead to more infectious diseases like dengue fever, typhoid fever, and hepatitis.[105] For dengue fever, mean temperatures, relative humidity, and the strength of ENSO showed a strong association. For typhoid fever, dry matter intake (DMI) related to human nutrition showed the strongest association.[106] And for hepatitis, relative humidity showed the strongest association in Northern and Southern Lao PDR, but no association in the Central region. As we have seen, El Niño can increase temperatures and La Niña can increase THI, or humid temperatures.

Women are vulnerable to ENSO events, but the exact impacts of these events on the sexes is unknown. There is little information on the gendered impacts of ENSO in Lao PDR, although these impacts can be inferred through other measures. For example, over half of all agricultural activities are carried out by women, making them vulnerable to extreme events.[107] In drought-prone regions, women and girls must travel longer distances to collect fuel and water, limiting their time for income generation.

[100]Lao PDR Expenditure and Consumption Survey from 2003–2008; http://www.fao.org/3/a-at765e.pdf
[101]UN Food and Nutrition Security Profiles (2014).
[102]http://www.fao.org/3/a-at765e.pdf
[103]WB-WDI (2018).
[104]Under 5 years old; WB-WDI (2018).
[105]Lydia (2014).
[106]Lydia (2014).
[107]FAO (2017).

In a similar way, frequent floods increase women's socially ascribed household and family workloads.[108] These time constraints also reduce the opportunities for women to engage in community-level decision making on ENSO-related projects, leading to programs that do not address women's needs. This partly explains why women farmers have less access to agricultural information and extension services.[109] More importantly, in both urban and rural areas, female-headed households are generally poorer than male-headed households even after controlling for education, household composition, and other factors. Poverty differences are even starker among women ethnic communities.[110] Women also have fewer assets, less access to credit, and less access to productive land. Lao national-level data show the average size of female-owned land is 16 percent smaller than the average size of male-owned land. Further, the proportion of female-headed households with access to more than one plot of land is less than half that of male-headed households.[111] Unfortunately, the CGE model was not able to measure the welfare impacts on female-headed households. Only 6 percent of households in the national household survey used for the microsimulation are headed by women, so the sample was too small to simulate El Niño–related consumption outcomes by gender.

[108]Araujo and others (2007); https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1759-5436.2008.tb00473.x
[109]http://www.fao.org/docrep/012/k8496e/k8496e00.pdf
[110]https://www.adb.org/sites/default/files/institutional-document/33755/files/cag-lao-pdr.pdf
[111]http://www.fao.org/docrep/012/k8496e/k8496e00.pdf

CHAPTER 6

Lao PDR Indirectly Supports ENSO Preparedness

The Lao government has proactively prepared for climate risk and natural resource management challenges, but could do more to prepare for ENSO. In the first half of 2017, the government allocated more than $46 million, or 28 percent of 2017's total budget, on rural development and poverty reduction programs. About 86 percent of the $46 million was disbursed for land provision, job allocations, and the Poverty Reduction Fund. As a result, over 6,000 families rose above poverty by mid-2017.[112] Moving forward, the Lao government has signaled it will prioritize supporting farmers to improve national agricultural production.[113] As an initial result, Lao grassland areas increased from 5,000 hectares in 2016 to 21,000 hectares in 2017 for pasture to support livestock production. The government also committed to expanding agricultural markets. In general, aside from rural development, Lao PDR has taken important steps to address disaster risk management and climate change adaptation, including shifting away from emergency response approaches to preventive risk reduction approaches. However, the government has not taken actions to directly prepare for ENSO events. This section will outline the government's ENSO-related strategic framework, institutional framework, and funding mechanisms, before looking at sources of international support. In this context, "ENSO-related" refers to efforts involving climate, natural resources, disaster risk, agricultural, and environmental management. Greater detail on national plans and government agencies is presented in Annexes 2 and 3.

[112]ANN (2017).
[113]MOFA (2017).

Strategic framework

Lao PDR committed to numerous international agreements on climate change and disaster risk management. Lao PDR is a signatory to the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Hyogo Framework for Action, the ASEAN Agreement on Disaster Management and Emergency Response, the ASEAN Declaration on Strengthening Social Protection, and the Sendai Framework for Disaster Risk Reduction, and was the first ASEAN signatory to the Paris Agreement. Lao PDR is also a member of the Mekong River Commission (MRC), which was established in 1995 by the governments of Thailand, Vietnam, Cambodia, and Lao PDR for water resource management in the Lower Mekong River Basin.

Lao PDR's efforts to manage agricultural and climate risks are guided by several policies and strategic frameworks. Not all of these policies are solely dedicated to these areas, but these areas are often mainstreamed within them. The following is a list of ENSO-related plans, laws, and strategies:

- ***The National Disaster Management Plan (2001–2020)*** develops early warning and information systems in 142 districts; constructs warehouses for storing emergency assistance materials in all provinces and some disaster-prone districts; raises public awareness; and raises national- and community-level capacity.[114]
- ***The Strategic Plan on Disaster Risk Management (2010–2020)*** reduces damage from natural or manmade disasters by promoting ex ante disaster prevention.[115]
- ***The National Adaptation Program of Action (2009)*** involves 45 projects for $85 million related to climate change adaptation.[116]
- ***The National Strategy on Climate Change (2010)*** outlines key strategic priorities for climate change adaptation and mitigation in multiple sectors.[117] These priorities were then embedded in the *7th National Socio-Economic Development Plan (2011–2015)*.[118]
- ***The Climate Change Action Plan for Laos (2013–2020***) identifies the climate change adaptation and mitigation actions. The Action Plan is also integrated with Lao PDR's UNFCCC contributions.[119]

[114]NIDM (2014).
[115]GoL (2003).
[116]GoL (2009).
[117]GoL (2010).
[118]UNDP (2017).
[119]GoL (2015).

- ***The Environmental Protection Law (2013)*** protects natural resources and biodiversity. Section 3 of the law regulates natural disaster prevention. Article 19 appoints the National Disaster Prevention and Control Committee (discussed below).[120]
- ***The Intended Nationally Determined Contribution (INDC) (2015)*** implements six activities for climate change mitigation and identifies five key sectors for climate change adaptation.[121]
- ***The 8th Five-Year National Socio-economic Plan (2016–2020)*** contains Lao PDR's long-term national development goal to transition from a Least Developed Country (LDC) to a middle income country by 2030, also known as the "2030 Vision." This plan recognizes the link between economic development and environmental considerations.[122] It also prioritizes gender equality.
- ***The Climate Change and Disaster Law*** provides the overarching legal framework for climate change and disaster risk management. At the time of writing, the law was being developed but had not yet been approved.[123]
- ***The National Strategy for Gender Equality (2016–2025)*** seeks gender equality by tackling constraints for women and girls. The strategy is based on the *Second National Strategy for the Advancement of Women, the Five-Year Action Plan (2016–2020)*, and the *2030 Vision*.[124]
- ***The Agricultural Development Strategy (2016–2020)*** outlines Lao PDR's overall agricultural strategy to boost production and improve access to international markets.[125] The strategy considers smallholder farmers as key actors in climate-resilient agriculture. Accordingly, it aims for 50 percent of smallholders to have access to agricultural land and credit from the Poverty Reduction Fund or Village Development Fund. The strategy also aims to have women make up 45 percent of the strategy's participating farmers.[126]

Institutional structures

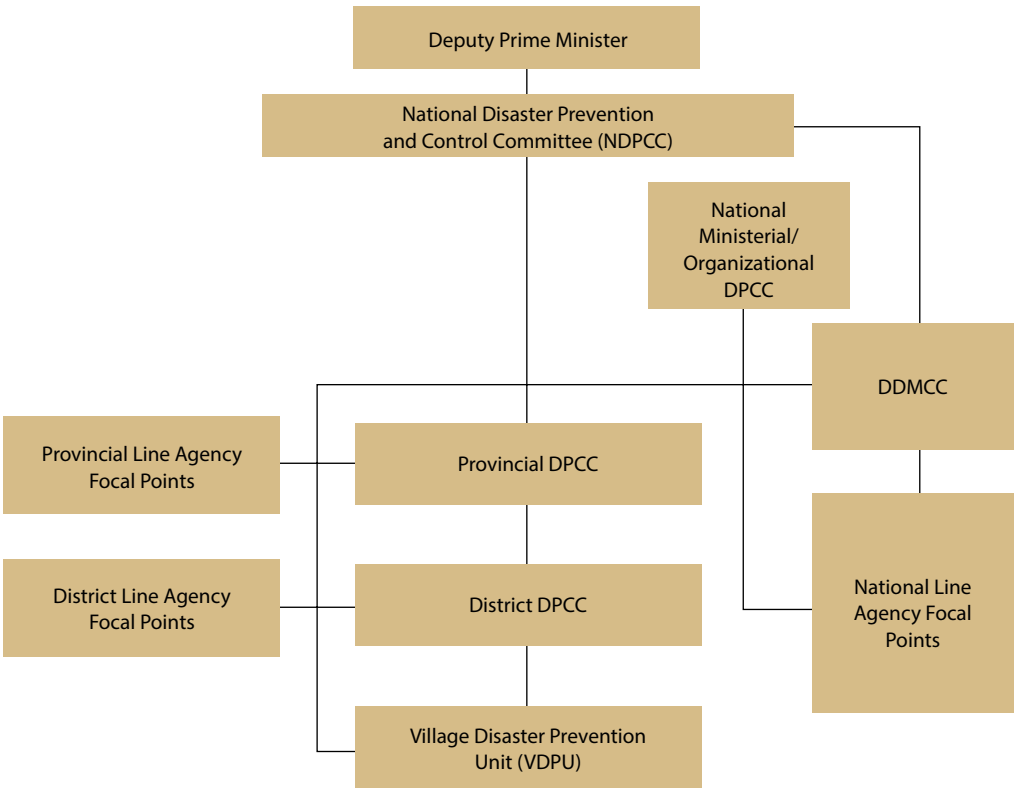
The Lao government has a strong institutional framework governing disaster risk and natural resource management, but again there is no institution dedicated to ENSO. These institutional structures encompass the village, district, and provincial levels.[127] The disaster management structure started as a single national-level

[120]GoL (2013).
[121]GoL (2015).
[122]GoL (2015).
[123]GoL (2015).
[124]Lilao and others (2016).
[125]GoL (2016).
[126] Lilao and others (2016).
[127](CFE-DMHA, 2014).

committee in 1999 but evolved into its current structure (Figure 15).[128] The structure involves the following committees:[129]

- ***National Disaster Prevention and Control Committee (NDPCC)*** is chaired by the Vice Prime Minister and Ministry of National Defense and includes ministers from the Ministry of Natural Resource and Environment (MoNRE), Ministry of Agriculture and Forestry (MAF), Ministry of Public Works and Transport (MPWT), and Ministry of Labor and Social Welfare (MoLSW).[130] NDPCC's mandate is to (1) define DRM strategy and mechanisms, (2) facilitate international support, (3) report incidents, and (4) lead DRM in the country. The NDPCC established its network at the village, district, and provincial levels (Figure 15).
- ***Provincial Disaster Prevention and Control Committee (PDPCC)*** is chaired by the Vice Provincial Governor and oversees disaster risk management (DRM) within the districts and provinces and coordinates national and international support.

FIGURE 15: The Lao Disaster Risk Management Institutional Arrangement.[131]



[128](Boupha, 2017).
[129]Thanthathep and others (2016).
[130]Boupha (2017).
[131]Thanthathep and others (2016).

- ***District Disaster Prevention and Control Committee (DDPCC)*** is chaired by the District Governor or Vice District Governor and implements district-level DRM activities.
- ***Village Disaster Prevention Units (VDPU),*** also known as the Village Disaster Prevention and Control Committee (VDPCC), is chaired by the Village Head and implements DRM activities at the village level.

Several other government agencies manage natural resources or provide services during natural disasters. These agencies include the following:

- *Department of Waterways (DOW)* in the *Ministry of Public Works and Transport (MPWT)* manages flood management, dike protection, urban drainage and sewer systems, and hydrology monitoring along the Mekong River.
- *Ministry of Labour and Social Welfare (MLSW)* is responsible for macroeconomic management in the labor and social welfare sectors. Under the management of MLSW, the Lao Red Cross coordinates emergency relief operations at national, provincial, and municipal levels.
- *National Disaster Management Office (NDMO)* in the MLSW coordinates DRM activities with regional and international partners.[132]
- *Ministry of Natural Resources and Environment (MoNRE)* is the lead technical ministry for climate change matters and the UNFCCC process.[133] The ministry leads on land and water resource issues.
- *Department of Water Resources (DWR),* within MoNRE, is the Secretariat of the Lao National Mekong Committee. It implements the National Water Resources Policy and the National Water Resource Strategy and Action Plan.
- *Department of Meteorology and Hydrology (DMH),* within MoNRE, provides weather forecasts, crop yield forecast, water quality assessments, climatology reports, meteorological information, and early warning information for floods, droughts, and other natural disasters. All forecasts and warnings are sent directly to government agencies, local and national stakeholders, and the general public through radio, televisions, and the Internet.[134]
- *Ministry of Agriculture and Forestry (MAF)* is responsible for agricultural development in Lao PDR.[135] MAF's Department of Planning and Finance (DPF) develops agriculture and forestry development plans. Climate change is mainstreamed in the MAF, but ENSO is not. MAF recently established the Research Center for Climate

[132]Vision RI (2011).
[133]Roehrml and Tirpak (2014).
[134]UNISDR (2012); http://dmh.gov.la
[135]GoL (2014).

Change and Resilience in Agriculture (RCRA) under the National Agriculture and Forestry Research Institute (NAFRI) to improve its knowledge capacity.

- *Department of Agriculture (DOA),* within MAF, develops cropping guidelines for Lao PDR. It has divisions for crop production, fertilizers, green agriculture, and others. The DOA guides agricultural relief efforts, such as a seed fund program.[136]
- *Department of Irrigation (DOI),* within MAF, leads irrigation planning and drought risk management through irrigation. At the national level, DOI develops irrigation plans and provides guidance to provinces. The actual implementation of irrigation systems is done by the provinces. Similar to land use planning, an irrigation plan is developed every five years and updated yearly.
- *Agriculture extension (AE),* within MAF, has a wide network operating from the national to village levels. The AE provides advisories of farming practice, crop production, and food security. It develops new farming techniques and organizes farming groups. AE works to improve agricultural processing, product-market linkages, information systems, and marketing programs.
- *National Agriculture and Forestry Research Institute (NAFRI),* within MAF, consolidates agriculture and forestry research activities and coordinates the National Agriculture and Forestry Research System. NAFRI researches land use planning and zoning; germplasm collection and screening; seed variety improvement; and new technologies, and carries out monitoring and evaluation. NAFRI serves as secretariat of the MAF Scientific Council.
- *National Center for Environmental Health and Water Supply* encourages communities to reduce water consumption.[137] It works with the MRC to evaluate low-flow conditions in the Mekong River.[138]

National risk and disaster funding

There are three funding sources for natural disaster risk management in Lao PDR. These include the National Disaster Fund, the National Contingency Fund, and the State Accumulation Fund.[139]

- ***The National Disaster Fund*** is a specialized fund for natural disasters. It is managed by the NDPCC and comes from both domestic budgets and international donor support. The fund is allocated mostly for emergency relief and recovery activities,

[136]According to Mr. Phanpradith Phandara, director of the Division of Planning and Cooperation.
[137]Mahachaleun and Phongpachith (2014).
[138]Mahachaleun and Phongpachith (2014).
[139]Eliste and Santos (2012).

including loss and damage assessments, humanitarian relief, infrastructure recovery, and more.

- ***The National Contingency Fund*** is managed by MAF's Department of Budget with an annual value of $12.5 million. In order to access this fund, provincial governments and line ministries must develop recovery plans with estimated budgets. Once approved by the Ministry of Finance and the Ministry of Planning and Investment, funds are disbursed directly to ministries and provincial governments.
- ***The State Accumulation Fund,*** which is also a national rice contingency fund, was set up in 2013.[140] The fund receives 3 percent of the government's annual budget. The fund functions similarly to the National Contingency Fund, requiring approval from the National Assembly.[141]

International support

The Lao government works with a variety of international partners on ENSO-related challenges. From 2000 to 2017, Lao PDR received funding assistance through 25 projects from foreign governments, regional programs, and international organizations. This support has been for improved irrigation, early warning systems, risk management capacity, climate change adaptation, and more. Each of these support areas are discussed below.

International partners have supported strengthening irrigation systems in Lao PDR. From 2008 to 2013, the World Bank financed the Nam Theun 2 Dam and power plant, which included a downstream irrigation system. The French government funded the upgrading and maintenance of the Ban Tan Piao pumping system in Vientiane province from 2003 to 2005. The South Korean government, through the Economic Development Cooperation Fund, provided $37 million for 12 kilometers of riverbank protection and flood embankment constructions along the Mekong River from 2009 to 2013. The Asian Development Bank (ADB) provided technical assistance on Community Managed Irrigation systems to DOI from 2005 to 2010 and the *National Water Resources Policy and Strategy Development* to the Water Resources and Environment Administration (WREA) from 2009 to 2010. In 2006, the ADB, AFD, AusAID, and the World Bank co-supported a *Scoping Report on Strengthening Laos Institutional Capacity* for integrated water resource management, and the *Mekong Water Resources*

[140]Lao PDR, Governmental Notification no.832/GO, 2011; PM Decree no. 291, 2013.
[141]http://documents.worldbank.org/curated/en/974261493731413612/text/114700-WP-PUBLIC-rcfs-2014-laopdr.txt

Assistance Strategy. AusAID also contributed to the *National Water Resources Policy, Strategy and Action Plan (2011–2015)*.

Lao PDR received bilateral and multilateral support on meteorological, hydrological, and early warning systems. Lao PDR renovated and equipped several hydrometeorological stations across the country with funding from the Mekong Hydrological Cycle Observing System (2010), the Mekong Integrated Water Resources Management Program (2011–2014), and the Japanese government (2006–2010). In late 2010, FAO and the Regional Integrated Multi-Hazard Early Warning System (RIMES) implemented a project on seasonal forecasts for food security decision making. Under this project, Monsoon Forums were set up to supplement existing weather forecasts. Currently, FAO is implementing the *Strengthening agroclimatic monitoring and information systems to improve adaptation to climate change and food security in Laos* (SAMIS) project. This four-year project (2017–2020) installs and upgrades agrometeorological stations and monitors and analyzes climate data. This project also helps DMH improve data coding and communication between stations, and between provincial and national centers. From 2011 to 2013, the World Bank, through a Global Facility for Disaster Reduction and Recovery (GFDRR) project, helped DMH renovate its hydrometeorological network in the southern provinces of Sekong, Attapeu, and Salavan.

International partners help strengthen risk management capacity in Lao PDR. The World Bank, through a GFDRR grant, supported the *Strategic Plan for Disaster Management* and "Mekong-Integrated Water Resources Management," by building capacity and other nonstructural measures (2009–2012). More recently, the World Bank helped Lao PDR build disaster resilience (2013–2017),[142] establish a public financing system to manage natural hazard risk (2015–2017), and enhance the government's capacity to provide hydrometeorological services and disaster response (2017–2022).[143] The Lao Red Cross is strengthening community-based disaster preparedness. The UN Development Program and Global Environmental Facility help MAF build agricultural resilience to climate change. The ADB is supporting rural infrastructure strategies. The Japan International Cooperation Agency is helping MPWT identify urban risks.

[142]https://www.gfdrr.org/en/projects-and-results-pages?country=2808
[143]http://projects.worldbank.org/P160930?lang=en

FAO and others support Lao PDR in adapting to climate change impacts on wetland areas. In 2010, Lao PDR joined FAO's project on climate change adaptation in wetlands areas (CAWA-Laos). This project helped local wetland communities of Champasak and Savannakhet provinces. FAO's ongoing Strengthening Agroclimatic Monitoring and Information System (SAMIS) project is also helping Lao PDR design policy options for land management planning in the context of climate change. This project improves climate information, creates scenarios, and tests and adapts resiliency strategies. WREA, the MRC, and the ADB are helping Lao PDR enhance water resource management in the Mekong River.

CHAPTER 7

There are Still Areas to Improve ENSO Preparedness

Lao PDR's proactive approach to managing climate risk could improve with a greater focus on ENSO. Slow onset events, like water scarcity and drought, are folded into climate change, disaster risk, and water resource planning although none of these areas properly capture ENSO's specific challenges. For example, analyses show the national government's measures to manage climate risks are limited in scope and scale despite the country's decades-long experience managing extreme weather events.[144] This is especially true for ENSO, for which the government could do more to specifically plan. Missed opportunities to focus on ENSO also means there is no individual or government agency in charge of promoting or coordinating government actions to prepare for ENSO. As such, the responsibility for ENSO does not fall to any specific person or agency in the Lao government. This also means there are no permanent or contingency budget lines to build resilience to ENSO events.

Government policies already in place could be more fully implemented. Despite areas to expand strategies for El Niño or La Niña, the Lao government has developed or signed on to several plans for disaster risk management and climate change adaptation. Most of these promote preparedness measures, and ex ante actions, to minimize impacts from both slow onset and rapid onset climate events. Such strategies are highly relevant to ENSO events, but the implementation of these priorities could be more complete.[145] There is also room to more strictly enforce laws on natural resource management and environmental conservation.[146]

[144]Peñalba and Elazegui (2013).
[145]WB-GFDRR (2011).
[146]WB-GFDRR (2011).

The government could focus more on nonstructural measures to reduce climate vulnerability. Structural measures include dike construction for flood protection, reservoirs for water storages, small-scale irrigation retention, embankments surrounding urban areas or key infrastructures, and other examples. While important, it is often nonstructural measures that improve a country's resilience to climate events. Examples include forecasting and early warning information, a data and communication system, adaptive and conservation farming practices, integrated and sustainable agriculture, agroforestry, soil restoration practices, pest outbreak management, and research and dissemination of tolerant crops and different animal varieties, among many others.[147]

There are opportunities to improve public and government knowledge of ENSO challenges and communication channels. This is also true for disaster and climate change preparedness, but even more so for ENSO. For example, the DOA has a number of researchers on drought, floods, climate change, and agriculture but no one on ENSO.[148] This stems from the lack of ENSO policies and a need for greater capacity and knowledge on forecasting and drought or flood monitoring.[149] Likewise, for climate information, MAF relies on data shared by MoNRE and international sources but lacks the human and scientific capacities to downscale General Circulation Models (GCMs) to Lao PDR's conditions.[150] Another problem is that if there is knowledge, it fails to reach farmers. For example, most rice farmers in Lao PDR do not receive early warnings on climate events from national or provincial agencies. Instead, these farmers rely on informal dissemination channels for climate forecasts or early warnings, such as information from their neighbors or television stations from Thailand or Vietnam.

Forecasting and early warning capacity could improve. DMH is only able to provide basic information for weather forecasting and disaster response. DMH staff are not involved in research activities, which hinders the department's mandate to provide quality hydrometeorological services.[151] Although the accuracy of DMH's climate forecasts was assessed as acceptable—forecasts for drought and flood events were 80 percent accurate—existing DMH facilities could be improved to run complex numerical weather prediction models. In general, DMH has unfulfilled human, financial, and technological capacity. For example, DMH only has one doppler radar, which is located at the headquarters with a limited 120 kilometer range. Hence, DMH

[147]World Bank (2011); Peñalba and Elazegui (2013); GoL (2015).
[148]According to Mr. Phanpradith Phandara, director of the Division of Planning and Cooperation.
[149]Mahachaleun and Phongpachith (2014).
[150]According to Mr. Phanpradith Phandara, director of the Division of Planning and Cooperation.
[151]UNISDR (2012).

must coordinate with Thailand and Vietnam to acquire sufficient radar data to formulate weather forecasts for several provinces.[152] DMH also requires more meteorological and hydrological stations and a reliable telecommunication system to collect and disseminate information. In consultations with DMH, they said they rely on projects funded by JICA, FAO, ADB, and others to strengthen their capacity.[153] These areas for improvement have implications for other agencies that rely on DMH information. DOA, for example, updates agricultural land use plans yearly, but the plan is not well localized, and maps are not accurate. Agricultural extension services also depend on climate information and weather forecasts to provide farming advisories to farmers.

[152]UNISDR (2012).
[153]Meeting on 4 October 2017 with Mr. Viengxai Manivong, director of general affair division.

CHAPTER 8

Policy Interventions Help Neutralize ENSO-Related Losses

There are additional policy interventions that can negate ENSO-related losses. This section simulates, through CGE modeling, the effectiveness of six policy options. These include: (i) Introducing drought-tolerant crop varieties to limit on-farm production losses. (ii) Expanding irrigation, which currently covers 39 percent of rice lands in the North, 60 percent in the Center, and 32 percent in the South. (iii) Restricting rice exports, as the government has done previously,[154] to reduce domestic rice prices for consumers and lower producer prices for would-be rice exports. Complete export bans are, at most, short-term measures that should be removed once a crisis passes because they carry longer term trade risks and can adversely affect other countries. (iv) Storing more grains and distributing these through domestic markets. The largest stock drawdown for Lao PDR was 167,000 metric tons of rice, but this was in 1976 and there is no information available after 1998.[155] This suggests the country, which emphasized the importance of grain storage and its infrastructure at the village level as part of a national disaster preparedness program, has some capacity to build more grain reserves, but further investments may be required. As with export restrictions, intervening in grain markets can adversely affect farmers, so caution is warranted, even during emergencies. (v) Providing social transfers, or expanding social protection programs, by providing conditional cash transfers to poor households. Cash was transferred to households living in affected areas during the 2015–2016 ENSO event, but there is no formal government transfer program that provides emergency relief. Finally, (vi) applying all these policy interventions simultaneously.[156] The model considers costs associated with implementing these interventions if they specifically

[154]Eliste and Santos (2012).
[155]This is according to FAO Food Balance sheets.
[156]The above simulations should be treated as indicative of broad categories of on-farm, market, and social policies. For instance, cash transfers could be replaced by food aid or crop insurance payments to smallholders, and irrigation infrastructure could be replaced by improvements in crop water use efficiency.

mitigate ENSO's impacts but does not consider infrastructure investments, which lead to a stream of benefits that are not limited to ENSO years. See Annex 1 for methodological specifics for each of these simulated interventions. The rest of this section shows that a combination of policy interventions can be applied to mitigate and even reverse GDP, welfare, and poverty losses during El Niño for all households, regardless of income or urban-rural location.

Introducing drought-tolerant crop varieties is the most effective policy measure to mitigate GDP losses during El Niño. Table 7 reports GDP losses, in absolute and percentage terms, with and without the effects of the policy interventions. It shows introducing drought-tolerant varieties, as modeled here, reduces EL Niño–related national GDP losses from $21 million without interventions to $12 million with this intervention. Expanding irrigation offsets some GDP losses by making crop production more resilient to climate shocks and raising yields during normal years. Distributing stored grains also reduces national GDP losses during El Niño but worsens agricultural GDP losses. This is because introducing stored grains into local markets increases competition and lowers prices paid to farmers. Export restrictions and social transfers have little effect on overall GDP. This is because cash transfers do not increase agricultural production and require offsetting tax increases for higher income households. Overall, even when all interventions are combined and implemented concurrently, there are still $2.4 million in GDP losses during a strong El Niño event.

TABLE 7: GDP Changes During El Niño Events with Intervention Scenarios.[157]

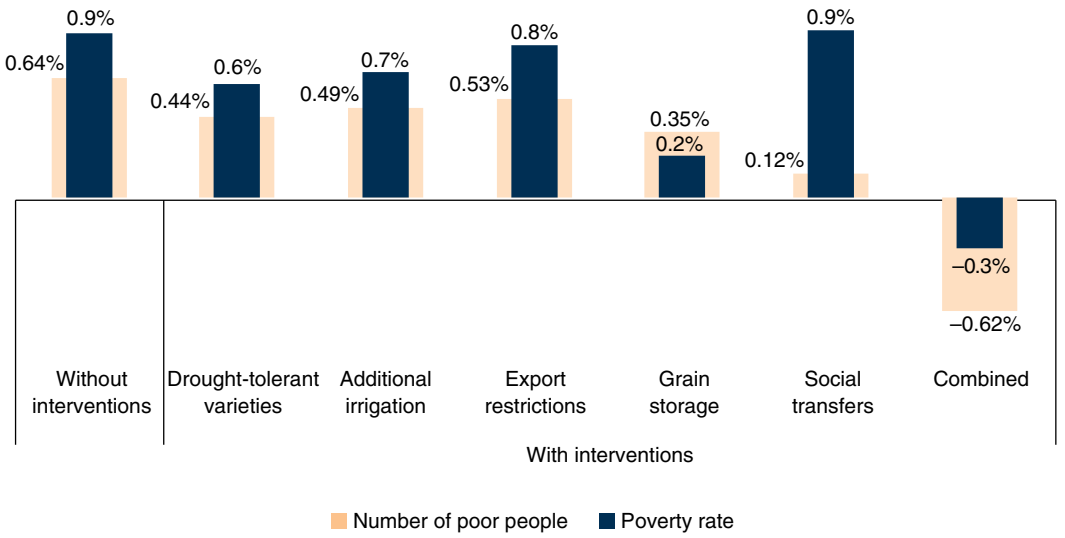
	Without interventions	With interventions					
		Drought-tolerant varieties	Additional irrigation	Export restrictions	Grain storage	Social transfers	All combined
Percentage change in GDP (%)							
National	–0.19	–0.11	–0.15	–0.19	–0.14	–0.19	–0.02
AFS	–0.57	–0.33	–0.45	–0.58	–0.54	–0.57	–0.20
Agriculture	–0.81	–0.46	–0.63	–0.81	–0.89	–0.81	–0.38
Absolute change in GDP (US$ million)							
National	–20.55	–11.95	–15.67	–20.72	–15.23	–20.56	–2.43
AFS	–24.35	–14.15	–18.95	–24.88	–23.06	–24.33	–8.50
Agriculture	–21.43	–12.23	–16.71	–21.42	–23.52	–21.37	–9.98

[157]Simulation results from the Lao CGE model.

Policy interventions overcome El Niño consumption losses for all households, but social transfers disproportionately benefit the poor, and grain storage disproportionately benefits the rich. Figure 16 shows household consumption losses during a strong El Niño event with and without intervention scenarios. Social transfers reduce poor household consumption losses from 0.6 percent with no interventions to 0.1 percent. However, consumption outcomes for all households are largely unchanged, implying that outcomes for higher income households worsen as outcomes for lower income households improve. This is because higher income households finance cash transfers through higher tax payments, which reduces their consumption levels. Distributing grains during El Niño, by contrast, reduces consumption losses for all households from 0.9 percent with no interventions to 0.2 percent. This was the most effective intervention at curbing consumption losses for all households. This is because cereals are a major food expenditure item for all households, regardless of their income levels. Higher income households, as net consumers, benefit more from lower food prices, whereas poorer households, as rural farmers and net grain producers, benefit the least. When all policy scenarios are implemented at the same time, then total consumption losses during El Niño are reversed, with all households benefitting from the policy package (Figure 17).

Social transfers are the most effective in mitigating poverty impacts from El Niño. Figure 18 shows poverty changes during a strong El Niño with and without interventions. Predictably, social transfers, particularly cash transfers that target

FIGURE 16: Household Consumption Losses During Strong El Niño Events with Intervention Scenarios (gains if negative).[158]



[158]Simulation results from the Lao CGE model.

FIGURE 17: Household Consumption Losses by Expenditure Quintile with and without All Interventions Combined (gains if negative).[159]

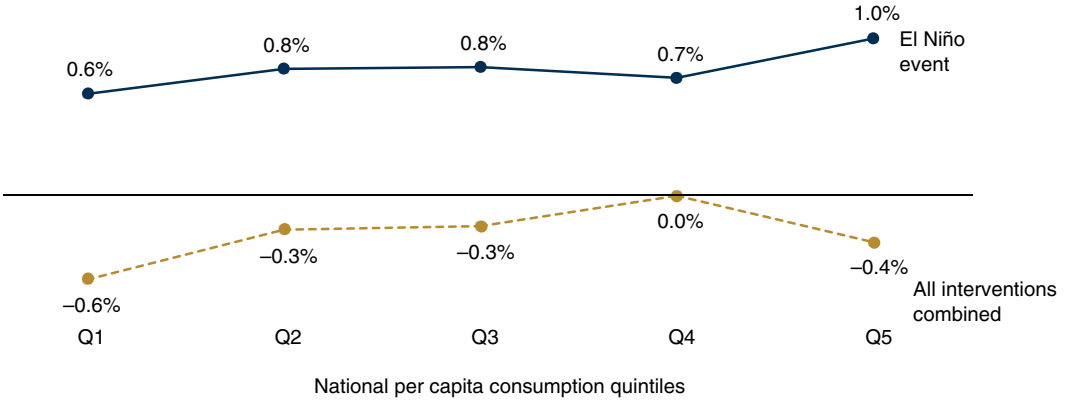
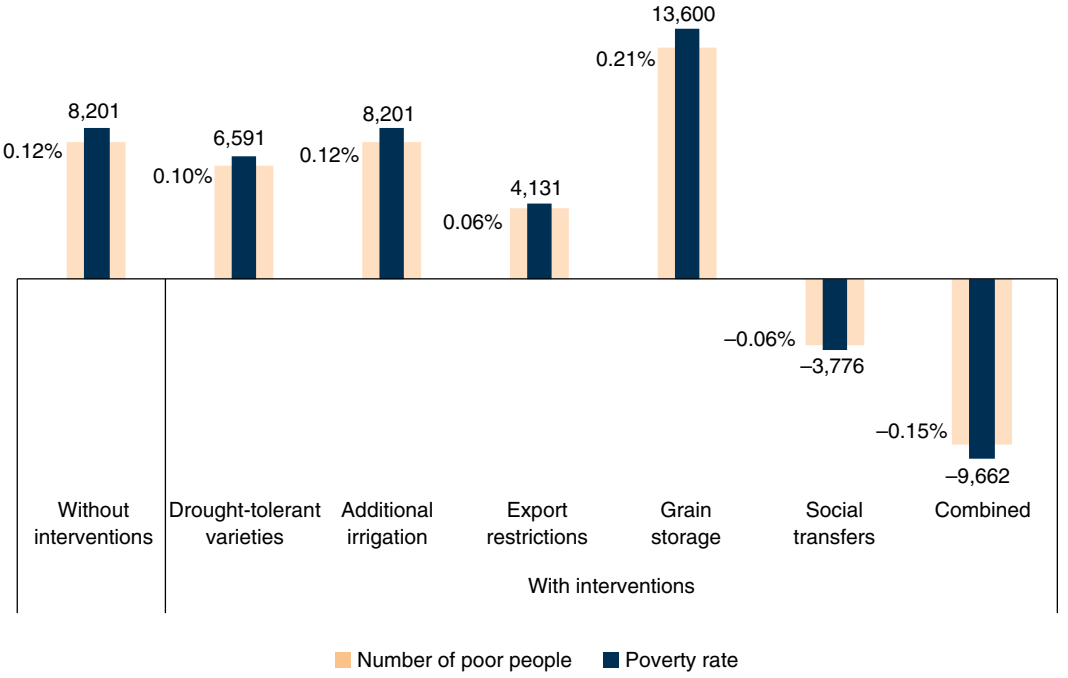


FIGURE 18: Changes in National Poverty Headcount Rate and Number of Poor People During Strong El Niño Events with Intervention Scenarios (percentage points and number of people).[160]



[159]Simulation results from the Lao CGE model.
[160]Simulation results from the Lao CGE model.

the poor, are the most effective at reducing the increase in poverty caused by El Niño. In fact, even during a strong El Niño event, social transfers reduce the poverty headcount. By contrast, distributing stored grains increases the poverty headcount by even more than the El Niño already does. El Niño pushes an additional 8,200 people below the poverty line, while distributing grain stores increases the number of people below the poverty line to 13,600. This is because distributing grain stores reduces grain prices and the incomes of the poor who are overwhelmingly smallholder farmers. These income losses outweigh the benefits of lower food prices for poor households. Investing in on-farm measures, such as irrigation and drought-tolerant varieties, also has modest positive effects on poverty rates during an El Niño event. Implementing all interventions concurrently is, again, the most beneficial policy scenario, implying that multiple policies are needed to address ENSO's impacts.

Urban household welfare improves the most from policy interventions. Table 8 shows consumption changes for urban and rural households during an El Niño event. Urban households generally benefit the most from distributing grain stores and benefit the least from providing short-term cash transfers. This result mirrors the results for richer and poorer households, probably because poverty is largely a rural phenomenon. As such, urban households, which are wealthier, suffer the most from cash transfers. On the other hand, distributing grain stores during El Niño potentially harms the poor but is the most effective at mitigating consumption losses for urban households. Alternatively, on-farm investments in irrigation and introducing tolerant crop varieties were among the most effective policies at mitigating welfare losses for all households, regardless of urban-rural location. Implementing all interventions together reverse consumption losses for all households but benefit urban households the most.

TABLE 8: Rural and Urban Household Consumption Changes During El Niño Events With Intervention Scenarios (percentages).[161]

	National	Rural	Urban
Without interventions	–0.88	–0.84	–0.94
Drought-tolerant varieties	–0.60	–0.56	–0.67
Additional irrigation	–0.68	–0.66	–0.71
Export restrictions	–0.81	–0.78	–0.87
Grain storage	–0.22	–0.37	0.01
Social transfers	–0.91	–0.83	–1.02
Combined	0.28	0.15	0.47

[161]Simulation results from Lao CGE model.

CHAPTER 9

Lao PDR Can Take Additional Actions to Improve ENSO Preparedness and Build Resilience

There are many opportunities to improve ENSO preparedness and resilience in Lao PDR. In the section below these opportunities are divided into two groups: preparedness and resiliency. While there is some overlap between these two concepts, for the purposes of this report they are defined as the following. *Preparedness* are measures specifically geared toward ENSO and should, ideally, be in place before the next ENSO event occurs. These actions will significantly empower people to cope, respond, and recover from damaging ENSO events. *Resilience*, by contrast, are measures that are not specifically designed for ENSO, but that will build individuals' and organizations' ability to adapt to multiple forms of risk and shock without compromising long-term development. Included in this section are various best practices from around the world that can be emulated. Table 9 outlines these recommendations and prescribes steps that should be taken for each.

Preparedness

Prepare response measures for when ENSO-related climate events occur. Response measures take place during an emergency and include actions to save lives and prevent further property damage. A proper response system requires several plans and actions that should be in place prior to an El Niño or La Niña event. These include, first establishing a high-level interministerial committee or commission tasked with ENSO response and preparedness (see next paragraph). Second, developing local drought and flood contingency plans that can be activated when ENSO-related climate events occur. Third, making sure contingency budgets, or other ENSO-related budget lines,

can be accessed to provide humanitarian or relief support to affected areas and populations. Fourth, ensuring that emergency response inputs and supplies are available. This includes relief supplies, such as water and food, and agricultural inputs, such as seeds and fertilizers. Fifth, ensuring that infrastructure needed for emergency responses—main roads, water ports, and other connectivity-related infrastructure—is sufficiently climate proofed. These will safeguard "last mile" delivery capacity.

Form a national task force to develop a comprehensive framework to prepare for future ENSO events. The Lao government could have a more focused approach, nationally or sub-nationally, to El Niño and La Niña. Most of the country's climate-related policies and programs focus on climate change or natural hazards, such as floods, cyclones, and some drought. To improve upon this, the government could appoint an ENSO task force with representatives from various government agencies to develop a comprehensive strategy to enhance the country's ENSO preparedness. It could help define the roles of government agencies and guide relevant ministries in developing their own ENSO strategies. This task force could build off the three-level committee on disaster risk management or emulate the Philippines' El Niño Task Force, which developed a *Roadmap to Address the Impacts of El Niño* (RAIN). RAIN is described in Box 4. This would help the Lao government change its approach to climate risk from reactive to proactive.

Create a government focal point on ENSO to improve preparedness coordination. As discussed, in Lao PDR there is a proliferation of plans, strategies, and policies addressing water risks, climate issues, and natural disasters, among other related themes; however, those efforts could be more integrated and specifically designed for ENSO issues. In order to avoid this fragmentation, government units, programs, and policies related to ENSO and other natural shocks should be streamlined. This process could be initiated through the ENSO task force, but eventually a government ministry or department should be tasked with overseeing ENSO preparedness efforts. They would coordinate responses within the government, at both the local and national levels, and with nongovernmental stakeholders. The focal point could solicit and coordinate ENSO-related support from international partners for preparedness projects or technical assistance. Such a coordinating mechanism would bring focus and clarity to ENSO preparedness measures. Box 5 describes how Vietnam integrated disaster risk management and climate change adaptation into national development plans.

Harness the rebound from La Niña to mitigate damage from El Niño events. In other southeast Asia countries where CGE modeling was applied for ENSO, production increases during La Niña did not cancel out El Niño production declines.

BOX 4: Roadmap to Address the Impacts of El Niño (RAIN) in the Philippines.

The Philippines developed the Roadmap to Address the Impact of El Niño (RAIN), which directly addresses ENSO. The Philippines' National Economic and Development Authority (NEDA) leads the government's El Niño Task Force, which developed RAIN. The president appointed[162] NEDA to lead the interagency task force, which also has membership from a variety of government agencies,[163] during the 2015/2016 El Niño. NEDA's appointment shows the government views ENSO as an economic development issue not just an agriculture issue. RAIN focuses on 67 provinces affected by El Niño and has several components, including cloud seeding, Cash-for-Work, food distribution, public information, water system improvements, and seeds and fertilizer distribution. NEDA says[164] RAIN stabilized food prices and food supplies by supporting crop production in unaffected or mildly affected regions at times when other areas were broadly impacted by drought. During the most recent El Niño, NEDA recommended allotting $165 million for 2015 and $257 million for 2016 to prepare for El Niño.[165] Allocations included $83 million to manage water supplies, $20 million to provide food stamps, and another $40 million to support affected urban households.

However, in Lao PDR they often do. Simulations show that La Niña events increase rainfall and positively impact agricultural production in the central regions more than El Niño negatively impacts it. In the South, La Niña benefits equal El Niño costs. As such, there is an opportunity to take advantage of positive La Niña-related impacts, like increased rainfall in rainfed rice paddies, for example. This could be done by expanding planting and improving water catchment during La Niña. It would also be important to implement flood prevention policies during La Niña. The modeling does not account for damaging floods, which are a pervasive threat in Lao PDR, especially during La Niña. Therefore, according to simulations, if policies are enacted to mitigate El Niño's negative impacts and harness La Niña's rebound while limiting flood damage, Lao PDR could see a net benefit from ENSO events.

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[162] *Philippine Star.* (2016, April). Palace: Gov't started preparing for El Niño in August 2015. Retrieved November 2017, from *Philippine Star:* http://www.philstar.com/headlines/2016/04/03/1569015/palace-govt-started-preparing-el-nino-august-2015

[163] Other members of the El Niño Task Force include: Bureau of Animal Industry, BFAR, Bureau of Soils and Water Management (BSWM), National Disaster Risk Reduction and Management Council (NDRRMC), Mindanao Rural Development Program, Philippine Carabao Center, Philippine Center for Postharvest Development and Mechanization, Philippine Crop Insurance Corporation (PCIC), Philippine Rice Research Institute (PhilRice), and Sugar Regulatory Board.

[164] NEDA (2016).

[165] *Philippine Star.* (2015, October). P19.2-B budget recommended to fight El Niño. Retrieved October 2017, from *Philippine Star:* http://www.philstar.com/headlines/2015/10/15/1510871/p19.2-b-budget-recommended-fight-el-nino

BOX 5: Integrating Disaster Risk Management and Climate Change Adaptation into the Social Economic Development Plans for the Tra Vinh Province in Vietnam.[166]

The Tra Vinh Provincial People's Committee (PPC) mainstreamed Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) into the *National Target Program to Respond to Climate Change in Tra Vinh.* Oxfam supported this process by supporting a local government-appointed task force comprised of commune leaders and sector staff specializing in CCA and DRM, and shared with them information on DRM and climate change vulnerability. As a result of these interactions, climate change, disaster vulnerabilities, and risk reduction issues that arose from the commune risk assessments were integrated into commune *Social Economic Development Plans* (SEDPs) and then district SEDPs. The Tra Vinh Department for Planning and Investment (DPI) drafted planning guidelines to integrate DRM, CCA, and gender into SEDPs.

In 2014, with Oxfam support, DPI used this approach with 19 communes in two districts (Chau Thanh and Cau Ngang) to incorporate key DRM and CCA issues into their SEDPs. After several years, this participatory and integrated planning approach helped achieve national strategies and meet program targets. Similarly, people in the SEDP Planning Task Groups, technical support groups, and community-based groups benefitted from training, capacity building, and peer-to-peer support. The process integrated gender, climate change, and disaster risk into SEDP planning and raised awareness on these in local communities.

Improve forecasting and early warning systems. DMH oversees the monitoring of potential weather risks and issues early warnings. It does this by providing hydrometeorological information on the National Early Warning Center (NEWC) website.[167] However, these warnings could be more complete, timely, and locally relevant. The NEWC publishes daily maps, but does not interpret how forecasts impact the country, especially how they impact agriculture and other natural resource management. Besides making this information more relevant and actionable, DMH should invest in further agrometeorological and agroclimatic capacity, including building and updating hydrometeorological networks, to broaden nation-wide coverage. DMH should also invest in effective communication channels. During natural disasters, the Department of Social Welfare (DSW) issues additional daily updates via fax, e-mail, and telephone. This information should be made public on the NEWC website and other social media

[166]Adapted from: Global Facility for Disaster Reduction and Recovery. 2017. "Toward Integrated Disaster Risk Management in Vietnam: Recommendations Based on the Drought and Saltwater Intrusion Crisis and the Case for Investing in Longer-Term Resilience." World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/28871 License: CC BY 3.0 IGO." Source: VUFO-NGO Resource Centre Vietnam 2015.
[167]http://newcdmh.com

BOX 6: Turning Forecasting into Action: South Korea's Anticipatory Response.[168]

The Korean government fully integrated drought forecasting into a comprehensive *Agricultural Drought Policy and Action Plan*. Since 2010, South Korea has experienced an increase in droughts—the worst taking place in 2015. This plan, launched in 2015 and updated in 2017, includes (1) agricultural drought monitoring, (2) drought damage evaluation, and (3) an anticipatory action plan. The Ministry of Public Safety and Security oversees the forecasting system known as the *Agriculture Drought Forecasting and Warning System*, which integrates meteorological and water-level data. The ministry coordinates closely with other government agencies.

The forecasting system offers new information on drought preparedness and mitigation planning. This includes a long-term plan and water-saving strategies. It analyzes previous droughts using agricultural drought maps, predicts drought damages, and considers capacity constraints, such as those in irrigation facilities. The government uses this forecasting data to prioritize drought-prone regions and target assistance to the most vulnerable areas. The government also implements an irrigation plan to guide farmers on what crops are best and what are optimal planting times. The *Action Plan* emphasizes education campaigns for farmers on water management techniques. This campaign includes in-person workshops, animated videos, and printed promotional material. This new approach helps the Korean government better coordinate among agencies, determine drought responses, and improve the quality of decision making for effective drought management.

platforms. Generally, any good early warning system requires four basic elements: knowledge of risk severity, continuous climate monitoring, effective dissemination channels, and response capability. Box 6 details South Korea's forecasting system.

Expand the use of drought-tolerant crops and seed varieties. The crop modeling and CGE analysis shows expanding the use of drought-tolerant seeds can generate large economic benefits, reduce consumption losses, and mitigate poverty impacts during El Niño. The International Rice Research Institute (IRRI) has developed and disseminated, through small-scale pilot projects, region-specific drought-tolerant rice varieties in Lao PDR. However, scaling-up seed adoption would require improvements in both seed and farmer extension systems. It would also require increased investment in agricultural research and development, with an emphasis on identifying seed

[168]Jong Hoon Park et al. 2016. "Agricultural Drought Forecasting and Early Warning System" World Irrigation Forum http://www.icid.org/wif2_full_papers/wif2_w.2.2.23.pdf; Lee Kwangya. May 2018, "Agricultural Drought Policy and Action Plan: Republic of Korea" PowerPoint presentation.

varieties tolerant to drought, flood, and increased temperatures and respond well to subnational soil and climate conditions.

Distributing stored grains or restricting rice exports improves food security and reduces consumer losses during El Niño, but may create harmful grain market distortions. Managing fluctuations in food and agricultural prices is a major policy concern during ENSO events. Banning rice exports, for example, does not significantly reduce GDP losses during El Niño, but does improve consumption and reduce welfare losses for poor consumers in both urban and rural areas. However, trade protocols and procedures should be established in advance to ensure that, if export restrictions are implemented, they safeguard farmers and can readily be removed once a crisis passes. This is crucial since export restrictions can harm both domestic producers and foreign trading partners. In fact, export restrictions should generally be viewed as a last resort. Drawing down grain stores, on the other hand, is beneficial for urban households and net consumers, but can adversely impact the poor, especially in rural areas. This is because distributing stored grains lowers grain prices paid to poor rural farmers. Consequently, while an important policy option, the government should be cautious in implementing market-distorting policies because they can have unintended consequences for poor households.

The government should expand social safety net coverage and make them more responsive to ENSO events. Targeted social safety nets, including cash transfers and public works programs, can mitigate the impacts of environmental shocks caused by ENSO by supporting livelihoods and improving food security and nutrition. Providing safety nets improves the resilience of the poor during times of crisis through increased assets and services. However, the government's social protection programs have limited coverage, covering mainly urban formal sector workers.[169] Social transfers are also not included as a disaster response and recovery mechanism in the country's latest disaster management report.[170] In 2017, less than 10 percent of the labor force was enrolled in the national social security fund. Likewise, the national health insurance program is the only program that reaches most poor people. As such, the government, with support from international development partners, could explore how to use cash transfers, or other forms of social transfers, as part of relief programs during crises. The net effect of safety nets should be considered beforehand. The CGE analysis shows that financing social transfer programs can leave wealthier households slightly worse off. That said, social safety net expansion

[169]SPSL (2015).
[170]CFE-DMHA (2014).

BOX 7: Ethiopia's Productive Safety Net Program Integrated with Early Warning Systems and Disaster Risk Management.[171]

Ethiopia's *Productive Safety Net Program* (PSNP) is a large national social safety net (SSN) program that includes elements of climate resilience. The PSNP's goal is to improve food security among Ethiopia's poor and mitigate the impacts from shorter term shocks, mainly droughts. The PNSP is implemented almost entirely through national government systems, which are decentralized through regional and local administrations. The unique aspect of this system is its incorporation of early warning and disaster risk management into its institutional structure.

The Ministry of Agriculture is responsible for program management, with the Disaster Risk Management and Food Security Sector tasked with overall program coordination. The Early Warning and Response Directorate provides early warning information on natural hazards and ensures the PSNP's emergency responses are linked to relief and hazard response activities. The Natural Resource Management Directorate oversees the public works and the Ministry of Finance and Economic Development oversees financial management.[172] These federal implementation arrangements are replicated within the PSNP's eight regions and 319 woredas (districts).

could mitigate welfare and poverty losses during ENSO events, particularly for poor households. Temporary social safety nets in times of crisis would require a short-term external financing mechanism to support the expansion. Box 7 shows how such a temporary system is implemented in Ethiopia.

The government should improve financing mechanisms for ENSO events. This includes improvements to the government's own contingency budget system and agriculture or disaster insurance payments. Alternatively, this could include the creation of a new ENSO-specific contingency fund. The government should carry out an assessment to identify constraints to the current contingency budgeting system and develop a financial protection strategy to guarantee the delivery of funds. This would ensure that federal agencies and local governments have access to quick post-disaster resources, especially for vulnerable rural populations. Another possibility would be to create catastrophe bonds, such as those created in Mexico (see Box 8 for details). Also, Lao PDR could establish crop and agriculture insurance mechanisms. Agricultural insurance products for farmers, such as weather index–based insurance,

[171]GFDRR (2013), "Ethiopia's Productive Safety Net Program (PSNP) Integrating Disaster and Climate Risk Management," http://www.wcdrr.org/wcdrr-data/uploads/482/SPL_DRM_TK_CS2_Ethiopia%20PSNP.pdf
[172]World Bank (2010).

BOX 8: Mexico's Catastrophe Bonds for Disaster Risk.[173]

In 1996 the Mexican government created a fund for natural disasters—FONDEN—to which it transfers budgetary funds for disaster relief and reconstruction efforts. Mexico is one of the most experienced emerging market countries in disaster risk management and has benefitted from global diversification by sharing risks with international capital markets. FONDEN uses various instruments, including reserve funds and risk transfer solutions, to support local states and entities in responding to natural disasters. In 2006, FONDEN issued a $160 million catastrophe bond (CatMex) to transfer Mexico's earthquake risk to the international capital markets.

Catastrophe bonds, or cat bonds, are risk transfer instruments that trigger payments on the occurrence of a specified event, such as a hurricane or an earthquake. The bond's triggers are spelled out in the contract, which can be expressed in terms of the issuer's losses from a predefined disaster, the hazard event's characteristics, or the catastrophe's location. If the defined catastrophic event occurs, part or all of the interest and principal payments are forgiven. If the defined catastrophic event does not occur, investors receive their principal plus interest equal to the risk-free rate and a spread. The typical maturity of a cat bond is one to five years.

Mexico was the first country to issue cat bonds using the World Bank's MultiCat Program. These bonds helped the government transfer a pool of disaster risk to the capital markets and reduce the potential pressure on the public budget. In August 2017, $360 million in catastrophe bonds were issued under IBRD's "capital at risk" notes program, providing Mexico with financial coverage against three types of disasters over three years: earthquakes, Atlantic tropical cyclones, and Pacific tropical cyclones. If a natural disaster is eligible for coverage, some or all of the bond proceeds will be made available to FONDEN. Mexico has gained credibility in the international markets because of its continued investment in risk transfer. For example, a $50 million payout was triggered by Hurricane Patricia, and a $150 million payout was triggered by the 8.1 magnitude earthquake in September 2017.

could be designed and piloted. Index-based insurance is standardized, more transparent, and cannot be easily manipulated because it relies on publicly available information. It is also cheaper to administer than general insurance programs. However, index-based insurance has shortcomings as well, for example, poor meteorological forecasting can lead to payouts that do not match losses, as illustrated in India (see Box 9).

[173]World Bank GFDRR. (2012). "Mexico MultiCat Bond: Transferring Catastrophe Risk to the Capital Markets," http://siteresources.worldbank.org/EXTDISASTER/Resources/MexicoMultiCat_Final.pdf

BOX 9: Challenges Associated with Index-Based Agricultural Insurance in India.

Between 2012–2013, the National Agricultural Insurance Scheme, India's national weather insurance program covered 21 percent of farm holdings and 19 percent of crop acreage in the country. However, the insured sum covered only 5.5 percent of the value of total crop output. Because of this, insured farmers were not satisfied. However, to rectify this, data estimates indicate risk coverage would need to increase to 50 percent of crop output, and the program would be about ten times more expensive. Thus, the National Institution for Transforming India concluded that agriculture insurance was not working, and the country's strategy should shift toward a comprehensive *Agricultural Calamity Compensation Fund* to offset partial crop losses faced by farmers. Under this new *Fund*, the State would insure each crop field for yield or production losses, but premiums remain with the state rather than being paid to insurance. In this more cost-effective manner, instead of subsidizing the insurance premium for all farmers, the government is required to cover crop losses only for the farmers affected by the calamity.[174]

Resilience

Invest in rural infrastructure, such as roads and irrigation systems. Statistical modeling shows expanding irrigation generates GDP benefits during El Niño, and mitigates household consumption losses, particularly for poor households. Irrigation also raises yields during normal years, further increasing longer term resilience. That said, drought and water scarcity are not nationwide problems so investments should target areas in the more water scarce central and southern provinces. Investments should be allocated to the entire irrigation system, including building new reservoirs, drainage channels, and flood protection dikes. At the moment, irrigation covers 39 percent of rice lands in the North, 60 percent in the Central, and 32 percent in the South. This shows there is still room to grow. Concurrently, water resource policies should be reformed to improve efficiency between and within sectors at the river basin or watershed level. Moreover, Alternative Wetting and Drying (AWD) techniques can be applied to irrigated fields to limit water use without limiting yields. Box 10 describes how AWD is being used successfully in Vietnam and Bangladesh. Although not explored in this report, there may also be opportunities to improve upon the rural transportation network by investing in road construction and maintenance. This would improve farmers' access to input and output markets, and better link remote villages to services during ENSO events.

[174]https://mail.google.com/mail/u/0/?tab=wm#inbox/164902e54cf622a5?projector=1&messagePartId=0.1

BOX 10: Alternative Wetting and Drying (AWD) in Vietnam and Bangladesh.[175]

Vietnam and Bangladesh successfully use AWD to limit water use in irrigation. AWD is a paddy rice management practice that can enhance yields, improve climate hazard resilience, and reduce greenhouse gas emissions. In AWD, irrigation water is used a few days after ponded water is exhausted. Hence, the rice paddy becomes alternately flooded and non-flooded. AWD reduces the number of times a field is irrigated, reducing water fees and allowing farmers to adapt to water scarcity challenges. For Bangladesh, AWD created water savings of 22 to 26 percent, saving between 2,580 and 3,590 cubic meters of water per hectare. For Vietnam, AWD created water savings of 40 to 50 percent.[176]

Sustain and scale up good practices. There are many local Lao best practices on ENSO-related themes that have been tested and piloted by different actors, mostly International Nongovernmental Organizations (INGOs) and Nongovernmental Organizations (NGOs), and could be effective at a larger scale. For example, studies found that women's participation in local fishery projects improved food security, the health of river ecosystems, and the conservation of subsistence fisheries.[177] Likewise, farmers are the most knowledgeable on drought's local impacts and local strategies to cope with these impacts, such as single cropping or dryland cropping. This knowledge would be valuable to share at a wider scale. However, many externally funded best practices cannot be scaled up because of a lack of human or logistical capacity or simply end when funding runs out. As such, there is also a need to build capacity and develop policies to sustain funding sources.

Raise national ENSO awareness and build capacity. The government and its international partners should make efforts to mainstream the concept of ENSO within government and development agencies and the general public's consciousness. This could include a multi-sectoral communication program that promotes awareness and education about droughts, floods, and the cyclical nature of ENSO. Policy makers, especially in local governments, should have a better understanding of forecasts and their specificity to particular seasons and locations. Consultations conducted for this report identified the government's lack of capacity as an important challenge in responding effectively to ENSO. Also, the general public should be equipped with information

[175]Dinesh, D., Frid-Nielsen, S., Norman, J., Mutamba, M., Loboguerrero, A. M. and Campbell, B. M., 2015. "Is Climate-Smart Agriculture effective? A review of selected cases." CGIR.
[176]Basak (2016).
[177]Mosser (2015).

to be more proactive in their ENSO mitigation activities. To boost knowledge, stakeholders should participate in forums or dialogues to better understand ENSO risks and preparedness strategies. These forums and dialogues can take place locally, nationally, or internationally.

Target women to lead agriculture projects or target them as beneficiaries. As discussed, much of the Lao agricultural workforce is composed of women. They participate in many aspects of agriculture and, as such, are well positioned to carry out agriculture-related ENSO preparation. This is because they are highly knowledgeable of their crops, fish, and livestock and the climatic conditions of their local environment. They are also technically proficient counterparts in agriculture at the local level. Further, as we have seen, women lag behind men in many key socioeconomic indicators, such as income and access to credit. In this sense, targeting women creates the double benefit of establishing project counterparts and building the resilience of a vulnerable group.

Lao PDR should cooperate with other south and southeast Asian countries on ENSO-related challenges, which are regional in nature. For example, ENSO-related flooding, salinization, and water scarcity issues are persistent in all the countries of the Mekong Delta, which runs from Vietnam, through Lao PDR, to China.[178] Increased regional cooperation to develop preparedness measures and meteorological and hydrological services and forecasting would lower common infrastructure costs, and allow for more knowledge exchange on best practices. There are already a number of regional and global institutions that could facilitate such cooperation. These include:

- The World Meteorological Organization (WMO), which houses the Southeast Asia Flash Flood Guidance System, the European Center for Medium-Range Weather Forecasts (ECMRWF), and the Global Flood Awareness System;
- The United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP); which coordinates a regional Typhoon Committee;[179]
- The Association of Southeast Asian Nations (ASEAN), which coordinates a Regional Climate Outlook Forum, runs a Subcommittee on Meteorology and Geophysics, and implements the Southeast Asia Radar Network and Composite project;

[178]World Bank GFDRR (2018), "Strengthening the Regional Dimension of Hydromet Services in Southeast Asia: A Policy Note with a Focus on Cambodia, Lao PDR, and Vietnam," June.
[179]14 members: Cambodia; China; Democratic People's Republic of Korea; Hong Kong SAR, China; Japan; Lao PDR; Macao SAR, China; Malaysia; the Philippines; Republic of Korea; Singapore; Thailand; Vietnam; and the United States.

- The Mekong River Commission (MRC), which shares hydrological data among the Mekong Basin countries, including Thailand, Vietnam, Cambodia, and Lao PDR;[180]
- The Asian Disaster Preparedness Center, which facilitates satellite imagery and geospatial technology exchanges among Mekong Basin countries;[181] and
- The World Bank is also developing a South East Asia flood monitoring and risk assessment platform, or the SEA DRIF Platform, that assesses near-real-time flood impacts in Myanmar, Cambodia, and Lao PDR.[182]

TABLE 9: Recommendations and Proposed Actions for pre-ENSO Preparedness and Long-term Resiliency.

In Table 9, recommendations are divided into two groups: preparedness and resilience. Recommendations in blue are a high priority, recommendations in tan are a moderate priority. The last two columns denote which actions are short term (S), or should be completed within a year, and which actions are medium-to-long term (M/L), or would not be achievable in less than a year.

	Recommendation	Actions	S	M/L
Preparedness	Prepare response measures for when ENSO-related climate events occur	• Establish a high-level ministerial committee or commission tasked with ENSO response and preparedness.	X	
		• Develop local drought and flood contingency plans that can be activated when ENSO-related climate events occur.	X	
		• Make sure contingency budgets, or other ENSO-related budget lines, can be accessed to provide humanitarian or relief support to affected areas and populations.	X	
		• Ensure emergency response inputs and supplies are available. This includes relief supplies, such as water and food, and agricultural inputs, such as seeds and fertilizers.	X	
		• Ensure infrastructure needed for emergency responses—main roads, water ports, and other connectivity-related infrastructure—is sufficiently climate proofed.	X	

[180]http://www.mrcmekong.org/about-mrc/
[181]World Bank GFDRR (2018), "Strengthening the Regional Dimension of Hydromet Services in Southeast Asia: A Policy Note with a Focus on Cambodia, Lao PDR, and Vietnam," June.
[182]Deltares (2018), "*South-East Asia platform for NRT flood impact assessment*" May (working paper for the World Bank).

	Recommendation	Actions	S	M/L
Preparedness	Form a national ENSO task force	• Appoint an ENSO task force with representatives from various government agencies.	X	
		• The task force should develop a comprehensive strategy to enhance the country's ENSO preparedness.	X	
		• It should define the roles of government agencies and guide relevant ministries in developing their own ENSO strategies.	X	
		• This task force could build off the three-level committee on disaster risk management.	X	
	Create a government focal point on ENSO	• The purpose would be to coordinate responses within the government, at both the local and national levels, and with nongovernmental stakeholders.	X	
		• Streamline government units, programs, and policies related to ENSO and other natural shocks.	X	
		• Solicit and coordinate ENSO-related support from international partners for preparedness projects or technical assistance.	X	X
		• Initiated this process through the ENSO task force, but eventually a government ministry or department would be tasked with overseeing ENSO preparedness efforts.	X	X
		• Maintain as an institution that can integrate ENSO considerations into future environmental and agricultural planning.	X	X
	Improve financing mechanisms for ENSO events	• Assess constraints to the current contingency budgeting system.	X	
		• Make improvements to the government's contingency budget system.	X	
		• Develop a financial protection strategy to guarantee the delivery of funds.		X
		• Establish agriculture or disaster insurance mechanisms.		X
		• Explore creating catastrophe bonds.	X	
		• Pilot weather index–based insurance.	X	
	Harness La Niña's rebound	• Appoint a committee, or the task force, to explore agricultural strategies for La Niña.	X	
		• Make plans to rehabilitate water storage facilities, increase water catchment, expand planting, and generally improve water-use efficiency.	X	
		• Take measures to reduce flood risk in flood-prone areas.	X	

(continued)

TABLE 9: Continued.

	Recommendation	Actions	S	M/L
Preparedness	Improve forecasting and early warning systems	• DMH should make hydrometeorological information on the National Early Warning Center (NEWC) website more relevant and actionable.	X	
		• DMH should invest in further agrometeorological and agroclimatic capacity, including building and updating hydrometeorological networks, to broaden nationwide coverage.		X
		• DMH should invest in human technical expertise.	X	X
		• DMH should also invest in effective communication channels.	X	X
		• Make DSW daily updates public on the NEWC website and other social media platforms.	X	
	Adopt drought-tolerant seeds	• The purpose is to insulate ENSO-related production and consumption shocks.	X	X
		• Work with the IRRI, which has developed and disseminated, via small-scale pilot projects, region-specific drought-tolerant rice varieties in Lao PDR.	X	
		• Improve relevant seed and farmer extension systems.		X
		• Increase investment in agricultural research and development, with an emphasis on traits that respond well to flood, drought, increased temperatures, and subnational soil and climate conditions.	X	X
	Consider storing grain reserves or implementing temporary trade policy reforms	• Assess the benefits and costs of implementing a temporary rice export ban during food price and food security shocks.	X	
		• Establish trade protocols and procedures in advance to ensure that, if export bans are implemented, they safeguard producers, limit trade losses, and can be readily removed once a crisis passes.		X
		• Assess capacity constraints and investment needs of an expanded grain storage system.	X	
		• Put contingency policies in place to protect poor families who are highly reliant on grain farming for their incomes.		X
	Expand and adjust social safety nets (SSNs)	• Assess constraints to establishing or expanding current SSNs.	X	
		• Consider the net effect of implementing SSNs, for example on wealthier households.	X	
		• With the support of international partners, move toward increased funding, skills development, and capacity building in order to implement SSNs.		X
		• Target poor, rural areas with food-for-work programs, expanded labor market programs, and conditional cash transfers.	X	X
		• Adjust these programs to make them more responsive to droughts and other ENSO impacts through better targeting or by expanding these systems in times of ENSO-related crises.	X	

	Recommendation	Actions	S	M/L
Resilience	Raise national ENSO awareness and build capacity	• Mainstream the concept of ENSO within government and development agencies and the general public's consciousness.	X	
		• Develop a multi-sectoral communications program that promotes awareness and education about droughts, floods, and the cyclical nature of ENSO.		X
		• Stakeholders should participate in local, national, and international forums or dialogues to better understand ENSO risks and preparedness strategies.	X	
	Integrate a regional approach to ENSO	• Begin dialogues with potential partners in ENSO, including WMO, ESCAP, ASEAN, MRC, the Asian Disaster Preparedness Center, and the World Bank's SEA DRIF Platform.	X	
		• Identify areas of cross-border vulnerability and potential infrastructural cost sharing.	X	
	Invest in rural infrastructure	• Assess the prevalence and condition of current irrigation systems and rural transportation systems (roads).	X	
		• Develop plans to expand irrigation in Lao PDR, especially in area's prone to drought.		X
		• Explore reforming water resource policies to improve efficiency between and within sectors at the river basin or watershed level.	X	
		• Apply Alternative Wetting and Drying (AWD) techniques to irrigated fields to limit water use without limiting yields.	X	
		• Invest in building new reservoirs, drainage channels, and flood protection dikes.		X
		• Develop plans to improve rural roads with a focus on connecting agricultural production to markets.		X
	Sustain and scale up good practices.	• Identify Lao best practices on ENSO-related themes that have been tested and piloted by different actors, mostly INGOs and NGOs.	X	
		• Increase human and resource capacity to scale up these practices.		X
	Target women	• Develop a strategy targeting women who are vulnerable to ENSO (agriculture workers, rural inhabitants, natural resource managers).	X	
		• Develop quotas or guidelines to empower women in leadership or coordination positions in local- or national-level efforts to combat ENSO impacts.		X
		• Introduce resource-efficient, low-carbon practices for women.	X	
		• Target women in SSNs.	X	

Annexes

Annex 1: Detailed methodology

General

The assessment in this report is based on an analytical framework that combines a detailed review of the available evidence with new analysis of ENSO impacts on crop agriculture, as well as spillover impacts on the rest of the economy.

First, historic climate data is examined, including variability in rainfall and temperature, followed by an assessment of the frequency of ENSO events in the historical record. More specifically, short-term climate fluctuations during ENSO event years are compared with recent "neutral" weather years (without ENSO shocks) to identify deviations in rainfall and temperature variables.

Second, changes in weather variables during the crop growing season are translated into physical, agricultural productivity outcomes using a combination of statistical and process-based models. Process-based crop models to estimate ENSO-affected seasonal yield deviations of major crops in a grid-based spatial analysis framework are also applied to isolate ENSO impacts from other events. Daily historical weather data (spatially interpolated from weather station data), linked with the corresponding ENSO phase, were used as input to the crop modeling framework that estimated crop yield changes for important crops: rice, maize, and tomatoes. Rice and maize are major crops in the country, and tomatoes act as a proxy for a broader array of vegetables (a standard approach in climate studies). The crop models also estimate how yield responses differ when using improved or traditional seed varieties, and with and without chemical fertilizer, or depending on the water management regime (with and without irrigation infrastructure).

Third, non-crop impact channels are also considered, such as livestock and fisheries. In the absence of sophisticated models for these subsectors, we rely on secondary

evidence compiled from other studies. These studies typically focus on a specific ENSO year, such as the severe 2016 event. The livestock sector analysis is supplemented with estimated Temperature Heat Indices to estimate heat stress levels and productivity losses for cattle and poultry.

Finally, the estimated impacts of ENSO events on crop, livestock, and fisheries yields are imposed on a dynamic computable general equilibrium (CGE) model. This class of model captures all producers and consumers in an economy, including the government and interactions with the rest of the world (e.g., imports and exports). All sectors and households are disaggregated across major subnational regions. Region- and crop-specific productivity shocks thus translate into changes in agricultural and national GDP, employment and prices. The model reacts to crop and sector-specific productivity changes by reallocating resources and products between sectors and households to minimize overall losses to the economy (i.e., autonomous adaptation). The model is linked to a survey-based microsimulation module that tracks changes in national and subnational poverty rates.

The integrated approach to measure economy-wide impacts of climate shocks is similar to what is often used for long-term climate change impact studies. The DSSAT and CGE models represent some of the most sophisticated tools available for such analysis, and the high-resolution spatial databases used in both types of models are quite unique, both for Lao PDR and developing countries in general. The framework makes it possible to isolate the impacts of ENSO events, as well as to assess outcomes in hypothetical alternative policy environments, such as changes to trade policies or the scaling up of social safety nets.

CGE model

RIAPA is a recursive dynamic computable general equilibrium (CGE) model that simulates the functioning of a market economy, including markets for products and factors (i.e., land, labor, and capital). RIAPA measures how impacts are mediated through prices and resource reallocations, and ensures that resource and macroeconomic constraints are respected, such as when inputs or foreign exchange are limited. RIAPA provides a consistent "simulation laboratory" for quantitatively examining value-chain interactions and spillovers at national, sub-national, and household levels.

RIAPA divides the national economy into different sectors and household groups that act as individual economic agents. Producers maximize profits and supply output to national markets, where it may be exported and/or combined with imports depending

on relative prices, with foreign prices affected by exchange rate movements. Producers combine factors and intermediate inputs using sector-specific technologies. Maize farmers, for example, use a unique combination of land, labor, machinery, fertilizer, and purchased seeds. Workers are divided by education levels, and agricultural capital is separated into crop and livestock categories. Labor and capital are in fixed supply, but less-educated workers are treated as underemployed. Producers and households pay taxes to the government, who uses these and other revenues to finance public services and social transfers. Remaining revenues are added to private savings and foreign capital inflows to finance investment, i.e., investment is driven by levels of savings. RIAPA is dynamic, with past investment determining current capital availability.

RIAPA tracks changes in incomes and expenditures for different household groups, including changes in food and nonfood consumption patterns. Poverty impacts are measured using survey-based microsimulation analysis. Individual survey households map to the model's household groups. Estimated consumption changes in the model are applied proportionally to survey households, and post-simulation consumption values are recalculated and compared to a poverty line to determine households' poverty status.

Policy scenarios

In order to understand if and how different policy options can mitigate impacts from ENSO events, different policy options are incorporated into the model. Some of the scenarios reflect existing policies in the country, such as relaxing import protections for cereals or expanding current social transfer programs. Other scenarios consider policies that they may not exist today or be considered central to the national debate, e.g. irrigation infrastructure, stored grains, and cash transfers. The scenarios are therefore a combination of current and potential policy options, benchmarked to existing policies and evidence to ensure that the scale of policy change is plausible and relevant.

We consider the following five policy scenarios:

- *Drought-tolerant varieties:* It's assumed that drought-resistant varieties for beans, maize, rice, and tomato are adopted by farmers in regions that anticipate the greatest water challenges. The International Rice Research Institute (IRRI), working together with national research institutes, has developed and disseminated drought-tolerant rice varieties. Scaling up the adoption of these seeds would require improvements in both seed and farmer extensive systems.
- *Additional irrigation:* The amount of cultivated land in the model that uses irrigation infrastructure is increased. Rice is already irrigated in Laos, although coverage of irrigable lands is incomplete (i.e., 39 percent coverage of rice land in the North,

60 percent in the Central, and 32 percent in the South). Further expansion is possible. We simulate modest increases in irrigation use (i.e., to 43 percent coverage for the North, 66 percent in the South, and 35 percent for the Central). These are small increases in irrigation, but rice is a major crop, and so even small increases can affect many farmers and a large amount of land. Maize is rarely grown on irrigated lands, and so we only consider a small increase in the South (from 1 to 2 percent coverage). Our irrigation scenario assumes that there is adequate water to operate additional irrigation systems. Although we focus on irrigation infrastructure, an alternative option may be to improve water use efficiency. Since we do not capture potential water supply constraints, the scenario is equivalent to one that maintains yields during ENSO shocks through more efficient water use.

- *Rice export restrictions:* A partial ban on rice exports implemented over the course of a year is applied in the model. Laos has used this policy instrument in the past to respond to concerns about supply shortages (see Eliste and Santos, 2012). The goal of an export ban, in the context of a supply shock, is to reduce domestic prices for rice consumers, but this also lowers the producer price for exporters. The impact on the poor, who tend to be smallholder farmers but also net consumers of rice, depends on the complex income and expenditure structures of households living close to the poverty line. Unlike export taxes, export bans do not directly generate revenues for the government. The indirect economic costs of an export ban are internalized in the model, however, via changes to government revenues and fiscal deficits.
- *Supply 150,000 tons of rice from public and private stocks:* Depleting stocks addresses short-term supply shortfalls during ENSO events and offsets some of the price increases caused by production losses. Like export bans, depleting grain stores benefits consumers but may prevent market forces from limiting farm revenue losses via higher prices for agricultural products. The scenario assumes that storage facilities already have or can be expanded to achieve this capacity. Historical evidence on stock changes is limited. The largest stock drawdown for Laos in the FAO Food Balance Sheets was for 167,000 metric tons of rice, but this was in 1976—there is no information available after 1998. The grain storage scenario may therefore require significant prior investment to operationalize—a cost that is not considered here. The financial cost of restocking public and private grain stores during the years following an ENSO event is not estimated. That said, our grain storage scenario is equivalent to an alternative scenario in which the government procures grain in foreign markets (financed by foreign borrowing) and distributes the grain in domestic markets.
- *Provide short-term cash transfers to poorer households (Quintiles 1–2) equal to just over US$0.5 per person:* This is a modest transfer, even compared to poor

rural households' current consumption levels of US$173 per person per year (see Table 5). As will be seen, it is sufficient to offset most of the damages caused during a typical ENSO event. Households in the model can use these funds to offset higher food costs, or to purchase nonfood products, whose prices may also rise during ENSO events as economic shocks spill over from agriculture to nonfarm sectors. The fiscal cost of expanding social transfers is internalized through higher direct taxes (e.g., pay-as-you-earn and corporate taxes). The scenario assumes that the distribution of new cash transfers occurs through existing social protection systems or their equivalent, and does not increase administrative costs. This is similar to assuming that additional administrative costs (not actual transfers) are borne by foreign development partners.

- *Combined:* All the above policies implemented concurrently.

While these scenarios are incomplete, they provide an insight into the effects of possible measures available for the Government to better manage the impacts of future ENSO. These scenarios do not capture all possible government responses to ENSO shocks, nor are the scenarios designed to reflect the complexities of specific policies. Such detailed analysis is beyond the scope of this study. Instead, the scenarios are purposefully selected to reflect the range of policy instruments available to the government, including investments in farm production (i.e., seeds and irrigation); trade and price policies (i.e., export bans); and standard emergency responses (i.e., grain stock management and social safety nets). Within each type of instrument there are further options to be considered, such as the targeting and distribution mechanisms for emergency cash transfers.

Annex 2: National plans and roles of other agencies

Resilience preparedness and policy

In 2003, Laos developed the **National Disaster Risk Strategic Plan** (GOL, 2003), which aims to: (1) safeguard sustainable development and reduce the damage of natural or man-made disasters to the community, society, and country's economy; (2) shift the strategy of government organizations from relief and mitigation to preparedness, focusing on floods, drought, landslides, and fires, in parallel with continuing mitigation in a post-disaster period; (3) turn from government agency only to people-centered responsibility in dealing with disasters by building the capability of the community; and (4) promote continuous protection of the environment and the country's rich resources such as forest, land, and water.

In the **8th Five-Year National Socio-economic Development Plan** (2016–2020), the government has set the target to be out of the list of Less-Developed Countries by 2020 (GOL, 2016). The ADB also committed to provide US$421 million to help Laos in reaching the target through a new strategic partnership with the Laos government (MOFA, 2017).

In Laos, sectoral policies and strategies have integrated climate and disaster considerations, such as:

- The Ministry of Natural Resources and Environment (MoNRE) has included a chapter on disaster risk management and climate change in its Vision 2030, Strategy 2025, and Action Plan 2020;
- The Ministry of Planning and Investment (MPI) has issued a ministerial decision in 2017 to establish a public investment review process that takes into account climate and disaster risk considerations; and
- The Ministry of Agriculture and Forestry (MAF) has developed the Agricultural Development Strategy 2016–2020 and Vision 2030, based on the following legal foundations: Agriculture Law, Forestry Law, Law on Aquatic Resources and Wildlife, Law on Livestock and Veterinary Services, Plant Protection Act, Fisheries Act, and Irrigation Law. For disaster risk reduction and resilience preparedness, the strategy provides a platform for social protection for vulnerable producers and climate-resilient agriculture through smallholder farmers.

To reduce the impacts of flooding and enhance the government's capacity to provide hydrometeorological services and disaster response, the Ministry of Finance and the World Bank have recently signed an agreement for a five-year project (2017–2022). The total budget of US$34 million will be invested in strengthening flood protection and resilient urban planning in Muang Xay province, which includes both structural and nonstructural measures; improving the delivery of weather, climate, and hydrological services and end-to-end early warning systems throughout the country; the financial planning for disaster resilience; knowledge and coordination, especially mainstreaming DRM in planning and investment; and reallocation of credit proceeds to provide emergency recovery and reconstruction support following an eligible crisis or emergency (World Bank, 2017).

Annex 3: Government initiatives for agriculture and farming households

The economy of Laos and its people are experiencing the impacts of climate change and climate hazards, particularly floods and droughts. For this, high priority is placed toward increasing climate resilience with respect to agriculture, especially food security and the provision and management of water resources (GoL, 2015). For agriculture, Laos gives priority to:

1. Promoting climate resilience in farming systems and agriculture infrastructure through
   - Improving appropriate resilient agricultural farming system practices.
   - Using technologies to address climate change impacts.
   - Developing and improving crops and animal diversification and resilience especially in the risk, flood, and drought areas.

2. Promote appropriate technologies for climate change adaptation through
   - Promoting and enhancing development of appropriate technologies to cope with climate change. This may include the conservation of agricultural soil, animal health and disease outbreak monitoring and control, long-term feed storage improvement, climate resilience crops, efficient water use cropping systems, short rotation cropping and maximizing the use of indigenous climate resilient knowledge.
   - Upgrading agricultural research and extension services to define and promote existing agricultural practices to reduce the negative effects of climate change.
   - Promoting two seasons of rice cultivation in flood areas by adaptive and short rotation rice verities.
   - Promoting appropriate techniques for crop and animal productions and meteorological-agricultural technologies in natural disaster risk areas.

Governmental plans

The Strategic Plan on Disaster Risk Management in Laos 2020, 2010, and Action Plan (2003–2005) (GoL, 2003) emphasized promotion of community-based disaster risk management (CBORM), such as building a disaster management institution from the center to village levels; granting for communities to timely receive basic needed information and be able to effectively take appropriate measures in dealing with

disaster when it strikes; and organizing public education activities for communities with explaining real courses of disasters and their impact.

In 2014, the Laos government developed the Plan of Action for Disaster Reduction and Management in Agriculture for the period 2014–2016 under technical assistance of the Food and Agriculture Organization of the United Nations (FAO) (GoL, 2014). The action plan aimed to integrate disaster risk management, which strongly focuses on disaster reduction measures, such as poverty reduction, food security, and climate change challenges. The action plan focused on five priority areas: (1) strengthening good governance, institutional and technical capacities for Disaster Risk Reduction and Management (DRRM); (2) assessing and monitoring climate risk and vulnerabilities and issuing early warnings for food and nutrition security and transboundary threats; (3) improving knowledge management, awareness raising, and education on DRRM, climate change impacts, and adaptation; (4) reducing underlying risks and vulnerabilities by promoting technical options and community-based planning for disaster risk reduction/climate change adaptation in agriculture sectors; and (5) enhancing capacities, facilities, and procedures for effective disaster preparedness and response and integrating climate change adaptation in recovery initiatives. However, the implementation of the 2014–2016 action plan was not clearly mentioned in government documents.

In terms of the Agricultural Development Strategy to 2025 and Vision to 2030 (Choulamany, 2015), the goals are food and nutrition security and increasing the agricultural sector growth with a focus on rice and other cash crops (i.e., maize, coffee, sugarcane, cassava, and more) (Choulamany, 2015). With regard to the rice sector, the main goal is to ensure food security, ensuring farmer's incomes and livelihoods, export earning, and environment conservation and natural resources and climate change adaptation. The aim is to:

1. Develop 600,000 ha more in 10 rice producing provinces (in addition to the existing 900,000 hectares (ha) of land in rice production)
2. Expand irrigation facilities to 400,000 ha by 2020 and to 450,000 ha by 2025.
3. Raise average yield of 3.75 tons/ha to 4.5 tons/ha in 2020 and to 5.0 tons/ha in 2025.

The 13 relevant policies are:

- Agriculture investment (e.g., irrigation schemes)
- Land management and development (e.g., land titling)
- Promotion of production and processing (value chain)

- Finance and banking (e.g., credit schemes)
- Good agricultural practices (e.g., comparative advantage)
- Energy (e.g., price of electricity for processors)
- Marketing and price stability (e.g., coordination with commerce)
- Agricultural labor (e.g., shortage of labor, youth)
- Intellectual property standards and measurement (e.g, rice brand)
- Research and production of improved seeds
- Monitoring and evaluation
- Integrate rural development planning
- Promotion of foreign investment

Currently, the government is in the process of building the National Socio-Economic Development Plan III (2016–2020) (Lassa and Sembiring, 2017), which includes disaster risks and climate change preparedness, stabilizing agricultural production under the impact of disasters, and ensuring markets and prices for the agricultural products.

The director of International Cooperation Division (Department of Planning and Finance—MAF), Mr. Phommy Inthichack, reported that the 2016–2020 plan has three pillars: agriculture, forestry, and wealth development. Currently, MAF is implementing four national research programs: eco-biology, productivity improvement, agricultural climate change adaptation, and agricultural policy. For each of these programs, responsive and resilient agriculture is integrated into its action plan.

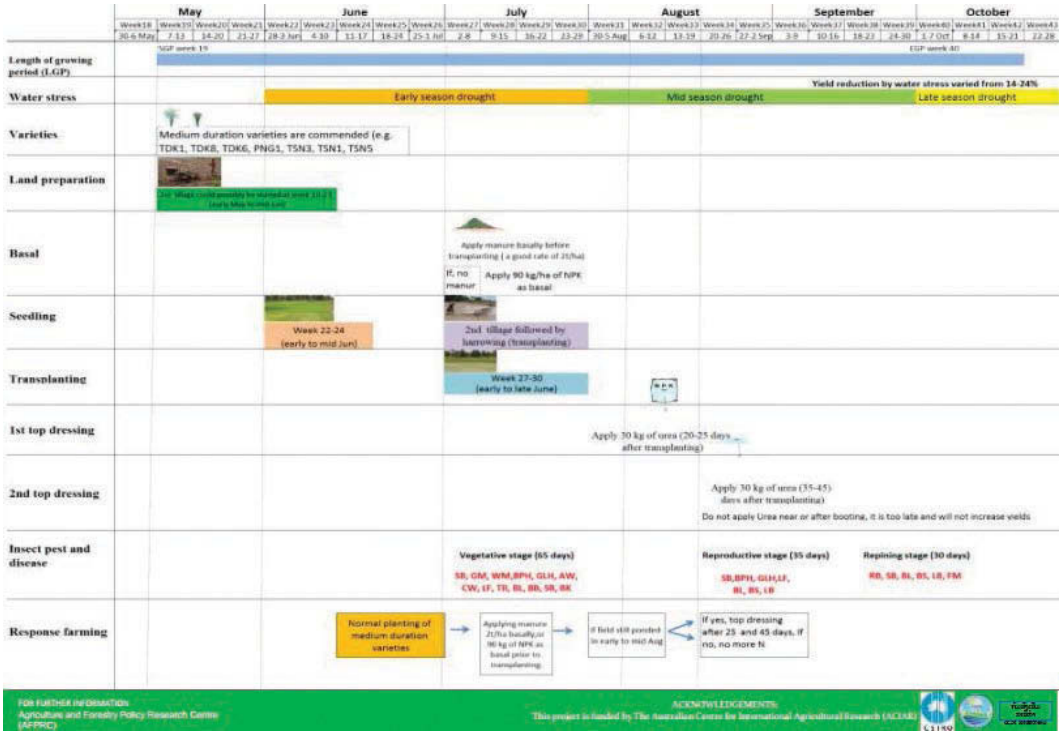
Structural measures

The left bank tributaries of Mekong River in Laos are in rapid development stage. A number of reservoirs are being operated and planned to attenuate the flood peaks in rainy seasons and also to increase flows in dry seasons. In the 6th National Socio-Economic Development Plan (NSRDP) (2006–2010), 52 priority irrigation projects were identified for investment. The 7th National Socio-Economic Development Plan (2011–2015) emphasized the rehabilitation of existing large-scale pumping and gravity-fed irrigation systems in the Vientiane plains as priority projects for intervention. It was also emphasized the construction and/or improvement of existing small-scale irrigation systems in order to ensure potential benefits of villagers in upstream. Accordingly, a total of 80 irrigation projects were prioritized.

Agro-advisory services

From 2012–2017, with supports of the International Fund for Agricultural Development (IFAD), Australian Center for International Agricultural Research (ACIAR) and the Consultative Group on International Agriculture Research (CGIAR) program on Climate Change, Agriculture and Food Security (CCAFS), the National Agriculture and Forestry Research Institute developed the Dynamic Crop Calendar (Figure A3.1) to provide rice farmers guidance on variety, planting date, fertilizer treatment, and other management practices to cope with droughts in different stages of rainy seasons.

FIGURE A3.1: The Dynamic Crop Calendar for Rice in Wet Season 2017 of Savannakhet Province.



Relief

In case of disasters, farmers received support from the government through tax reduction or exemption depending on the extent of damage (Peñalba and Elazegui, 2013). Local governments extend financial and technical support to help farmers recover from the effects of droughts.

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