



Natural resources and ecosystem services have been seriously undervalued in development planning in the Lower Mekong Basin (LMB), which spans Cambodia, Laos, Thailand, and Vietnam. Intensive agriculture has initially led to higher yields, a lower poverty rate, and economic growth. However, it is destroying the very resources it needs, such as water. The excessive use of chemical fertilizers and pesticides has contaminated soils and threatened critical inland fisheries. Significant coastal erosion, soil salinity, and deteriorating marine ecosystems and climate change add to an urgent need to take into account the value of ecosystem resources to improve policymaking.

This volume presents up-to-date case studies and surveys trends and challenges for natural resource-based livelihoods by researchers and institutes collaborating across the LMB under the Lower Mekong Public Policy Initiative. Its recommendations include: coordinating national and transboundary water governance along the Mekong River; pursuing alternatives to massive hydropower expansion for Lao PDR; harnessing renewable energy for efficient and less polluting electricity generation in Vietnam; a fund to improve the health and yields of shrimp in aquaculture; diversifying mixed rice and aquaculture/fishing systems for economic sustainability and better incomes; improving choices, processing and markets for Cambodian rice farmers; adapting a national rural development program in the Vietnamese Mekong Delta; recognizing the adverse impacts of economic corridors on vulnerable forest-dependent populations; acknowledging, and supporting women in their changing economic roles; and empowering local government to help local communities deal with problems caused by a private rubber land concession in Cambodia.



RESOURCE GOVERNANCE,
AGRICULTURE AND SUSTAINABLE
LIVELIHOODS IN THE LOWER MEKONG BASIN



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edited by

**LE VIET PHU, NGUYEN VAN GIAP, LE THI QUYNH TRAM,
CHU THAI HOANH AND MALCOLM MCPHERSON**

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Abbreviations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BDP2	Basin Development Plan 2
BTU	British Thermal Unit
CEDAC	Cambodian Center for the Study and Development of Agriculture
DARD	Department of Agriculture and Rural Development
DWRPIS	Division of Water Resources Planning and Investigation for the South of Vietnam
EDL	Électricité du Laos
EGAT	Electricity Generating Authority of Thailand
ELC	economic land concession
EVN	Electricity Vietnam
EWEC	East-West Economic Corridor
FAO	United Nations Food and Agriculture Organization
FGD	focus group discussions
FPA	flood plain areas
GHG	greenhouse gases
GMS	Greater Mekong Subregion
GOL	Government of Lao People's Democratic Republic
HH	household
LCOE	levelized cost of energy
LMB	Lower Mekong Basin
LNG	liquified natural gas
LVI	Livelihood Vulnerability Index
MAFF	Ministry of Agriculture, Forestry and Fisheries
MARD	Ministry of Agriculture and Rural Development
MEA	Millennium Ecosystem Assessment
MEM	Ministry of Energy and Mines
MPI	Ministry of Planning and Investment
MRC	Mekong River Commission
NGO	nongovernmental organizations
NRD	natural resource-dependent
NRDP	National Rural Development Program

NTFP	non-timber forest products
OECD	Organisation for Economic Development and Cooperation
PCR	polymerase chain reaction
PDP	Power Development Plans
PES	Payments for Ecosystem Services
PPP	Purchasing Power Parity
RGC	Royal Government of Cambodia
RLC	rubber land concessions
RSS	rice-shrimp system
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEEA	System of Environmental-Economic Accounting
SEZ	Special Economic Zone
SLA	Sustainable Livelihood Approach
SLC	Social Land Concessions
SMS	shrimp monoculture system
TRS	triple rice system
UNDP	United Nations Development Programme
WWF	World Wildlife Fund
ICRAF	World Agroforestry Centre
IUCN	World Conservation Union
VARHS	Vietnam Access to Resources Household Survey
VHLSS	Vietnam Household Living Standards Survey
VMD	Vietnamese Mekong Delta
VND	Vietnam Dong
WTP	willingness-to-pay

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The LMPPI Team

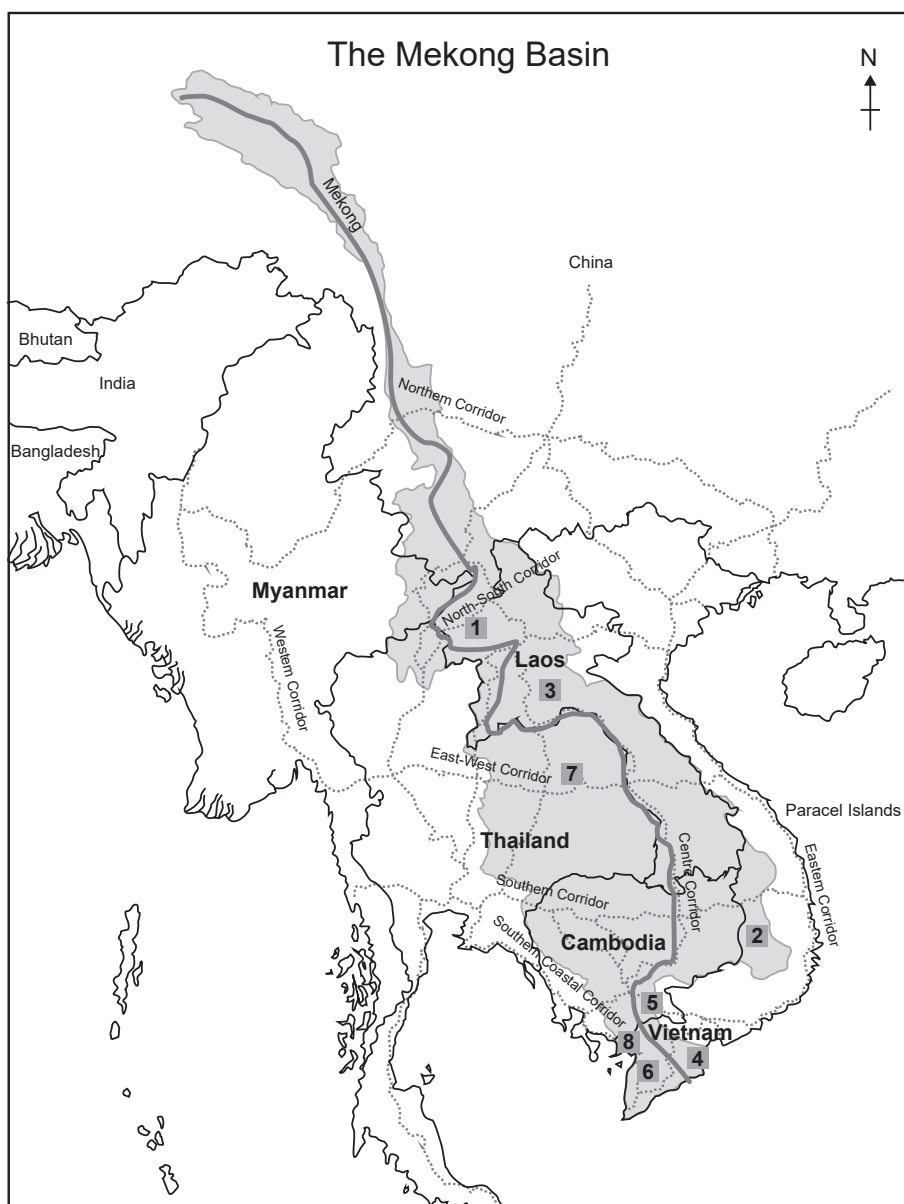
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Preface

The Lower Mekong Public Policy Initiative (LMPPI) is a four-year project, funded by the United States Agency for International Development (USAID). LMPPI is housed at the Fulbright Economics Teaching Program (FETP), a center for public policy teaching, research and policy dialogue in Vietnam, and is jointly managed by FETP (now the Fulbright School of Public Policy and Management at Fulbright University Vietnam) and the Vietnam Program of Harvard Kennedy School's Ash Center for Democratic Governance and Innovation in the United States. LMPPI seeks to generate knowledge, promote learning, and stimulate dialogue on public policies to support environmentally sustainable economic development, increase agricultural productivity, and improve household livelihoods in the five countries of the Lower Mekong Basin: Cambodia, Laos, Myanmar, Thailand and Vietnam.

LMPPI has built an extensive network with research institutions, government agencies, and various stakeholders in the region for cross-disciplinary research on key topics in sustainable development related to climate change, resource competition, and regional economic integration. LMPPI has contributed to capacity building of our research partners throughout the implementation of the research project. Besides, LMPPI personnel also contributed to the teaching and study of policy challenges associated with sustainable development and natural resources management at the Fulbright School. As a result of these efforts, eight research projects were completed during the span of the initiative, plus two dozen master's theses by MPP students at the School. LMPPI research activities are geographically and thematically diverse.

LMPPI researchers and partners have successfully conducted research on sensitive areas such as hydropower in Lao PDR, agricultural policies in Cambodia, and cross-border livelihoods in Thailand, Lao PDR and Vietnam (Map 1). In the Mekong River Delta of Vietnam, the most vulnerable part of the region, we have closely worked with universities, research institutes, and local governments to examine the numerous challenges in agricultural and environmental policies and opportunities for a sustainable future. Empirical findings, situational analyses, and public policy recommendations from these studies are presented in this volume in three parts: the environment, agriculture, and livelihoods.



Key to selected study sites

- 1 Beyond the Battery: Flexible Energy Futures in Laos PDR
- 2 Pricing and Management of Groundwater Irrigation in Vietnam
- 3 Macroeconomic and Environmental Implications of Hydro-Power Development in Lao PDR
- 4 Management of Seed Quality for Sustainable Black-Tiger Shrimp Aquaculture in the Coastal Mekong Delta of Vietnam
- 5 The Implications of Rice Policy Changes in Vietnam for Rice Producers in Southeastern Cambodia
- 6 Evaluation of New Rural Development Program in the Vietnamese Mekong Delta
- 7 Impacts of the East-West Economic Corridor on Local Livelihoods in the Lower Mekong Basin
- 8 Land Use Strategies for Triple Rice Farmers in the Floodplains of the Vietnamese Mekong Delta

Introduction

*Le Viet Phu, Nguyen Van Giap, Le Thi Quynh Tram,
Chu Thai Hoanh and Malcolm McPherson*

The Lower Mekong Basin faces enormous challenges in the twenty-first century. Threats to agricultural production and the environment from unabated exploitation of the Mekong River, against the backdrop of climate change, could potentially disrupt the regional economy and push millions of people into poverty. The environmental challenges arise from excessive demand for surface and groundwater, particularly from intensified rice cultivation, increasing contamination of water and soil and hence fish and agricultural products, and dry-season saltwater intrusion due to hydropower dams and climate change. Additional threats include coastal erosion in the Mekong Delta, the loss of biodiversity, and deteriorating marine ecosystems.

The Environment

Chapter 1, entitled “The Environment-Economic Development Nexus in the Lower Mekong Basin: Hydropower, Climate Change, and Transboundary Water Cooperation” lays out the most significant environmental challenges related to water, food and energy and their combined transboundary impacts in the Lower Mekong Basin (LMB). This study identifies and focuses on *three major areas* of interest which require careful coordination and planning, and appropriate transboundary environmental assessments. **These include: (1) assessment of hydropower development along the Mekong River, including in China, and its implications on downstream livelihoods, along with a robust evaluation of risks and uncertainties; (2) the use and sharing of water, including irrigation and diversions; and (3) the impact of climate change.** The study analyzes opportunities and challenges in each area, and then presents three principles for successful transboundary cooperation.

In Chapter 2, entitled “Beyond the Battery: Power Expansion Alternatives for Economic Resilience and Diversity in Laos,” researchers from the Renewable and Appropriate Energy Laboratory (RAEL) at

the University of California, Berkeley, studied an alternative energy development scenario to replace mainstream hydropower in Lao PDR. The RAEL team built a long-term least cost optimization model to examine using run-of-the-river hydropower, tributary hydropower, solar, wind, and microgrids, respectively, to meet projected future demand. **The authors found that non-hydropower renewables could replace the generation from proposed hydropower stations along the Mekong at lower cost than current plans (in term of less damage to ecosystems and livelihoods).** Following a renewables-based path saves nearly US\$1.8 billion in long-term costs compared to a full-build of all 375 hydropower projects in Laos under planning consideration. These cost savings could simultaneously enable a more diverse and resilient economy.

Supplementing this profound conclusion, Chapter 3, entitled “Hydropower Development in Lao PDR: Macroeconomic and Environmental Implications” suggests that environmental and social costs of hydropower development in Laos are not being properly valued and generally not included in the calculation of these projects’ total costs by the government. Furthermore, building such a large number of dams will have cumulative effects and consequences on the Mekong River system, including in downstream countries. **The team from the National University of Laos recommends using tools such as Strategic Environmental Assessment (SEA) and the System of Environmental-Economic Accounting (SEEA),** which include both quantitative and qualitative information about the economic benefits and environmental and social impacts of development as well as the value of natural capital and associated ecosystem services.

In Chapter 4, entitled “Counting all of the Costs: Choosing the Right Mix of Electricity Sources in Vietnam to 2025,” the authors examined what **alternative energy sources would allow Vietnam to produce enough electricity to satisfy future demand at a reasonable cost.** A “reasonable” cost is one that covers the costs of producing and distributing reliable power—something that has yet to be accomplished. It should also be a given that existing laws regarding pollution from electricity generation should be enforced. Many groups are objecting to new coal plants on the grounds that they will further pollute the air and water with ash, mercury, and acid emissions. Coal is also the heaviest source of carbon dioxide, contributing to global warming, which threatens the Mekong Delta and

many coastal areas of Vietnam, including Ho Chi Minh City. Some are also concerned that rising coal imports will be a burden on the balance of payments and be less reliable than domestic power sources. But are there realistic alternatives to using a lot of coal in the next five to ten years?

In Chapter 5, entitled “The Undervaluation of Ecosystem Services in the Lower Mekong Basin,” it is recognized that **ecosystem services and the natural resources that generate them are systematically undervalued throughout the LMB**. As a result, they are over-exploited and their contributions to growth and human welfare grossly underestimated. Undervaluation of ecosystem services occurs for three reasons. First, markets that value natural resources either do not exist or are seriously distorted. Second, it is highly lucrative for selected groups to continue exploiting natural resources, most of which are public goods. Finally, LMB governments view natural resources as a “cheap” way to foster rapid economic growth. All LMB countries would benefit if they appropriately valued natural resources. Each country would begin using *all* its available resources efficiently and encourage the sustainable management of the remaining stock of natural wealth.

Chapter 6, entitled “Pricing and Management of Groundwater Irrigation in Vietnam,” presents a specific case of ecosystem service provision. The author examines the consequences of overexploiting groundwater for irrigation and household consumption in many parts of Vietnam. Access to groundwater irrigation provides households with an alternative water source rather than relying on state-provided irrigation. The increasing reliance on groundwater for agricultural expansion and household consumption, in the face of periodic water scarcity due to climate change and water diversions in the Upper Mekong, urgently calls for a **sustainable water policy. The author recommends implementing an appropriate irrigation charge for groundwater exploitation as a first step toward better water management in the Mekong Delta.**

Agriculture

In Chapter 7, entitled “Agriculture in the Lower Mekong Basin: Current Trends and Policy Challenges,” the authors examine trends in agriculture across the LMB to identify policies that will induce farmers to raise their productivity and maintain the sector’s dynamism and prosperity. Agriculture in the LMB has grown rapidly over recent decades. Staple

crop yields and the output of horticulture, livestock, and aquaculture have risen sharply. However, these positive changes have also been accompanied by widespread environmental damage and, so far, none of the gains has been adequate to permanently alleviate poverty and eliminate food insecurity. To respond constructively, **LMB governments should re-focus their current policies in ways that assist farmers to sustainably raise their productivity.** Governments will need to spend more on agriculture and rural development and more efficiently allocate this expenditure. At present, too many resources are devoted to “big ticket” capital items such as irrigation, and too few to agricultural R&D and the maintenance of rural social overhead capital. Correcting these distortions will enable agriculture in the region to regain some of its former dynamism, raise rural incomes, reduce food insecurity, and offer “pathways out of poverty.” Implementing these changes under current circumstances will be difficult. Non-agricultural sectors are not expanding rapidly enough to absorb the labor which agriculture would have to release for rural incomes to rise sharply. Moreover, even if governments were to spend more on agriculture and rural development, it will take time for the investments to produce results.

Chapters 8 and 9 present the findings from studies in the Vietnamese Mekong Delta. Chapter 8, “Effects of Seed Quality on Sustainable Black Tiger Shrimp Production in the Vietnamese Mekong Delta”, analyzes the coastal aquaculture sector and its threats. The study was conducted by a team of researchers from Can Tho University, in collaboration with universities and institutes in Tra Vinh and An Giang provinces. Brackish-water shrimps are raised in either a shrimp monoculture system, mostly in saline water areas, or in an integrated cultivation system where fresh and saline water are seasonally available. Shrimp farmers, facing financial constraints, have used seeds not tested for common deadly shrimp pathogens, which affect not only individual aquaculture ponds, but also neighbouring shrimp producers. This study concludes that improving the economic efficiency of shrimp farming **requires a combination of water management, proper stocking density, and appropriate feeding schedules. In particular, PCR testing of shrimp seeds should be made compulsory.** It also proposes a market-based user-pays mechanism to recover the costs of instituting and administering stricter quality controls which will benefit all shrimp producers.

Chapter 9, entitled “Land-Use Strategies for Triple-Rice Farmers in the Floodplains of the Vietnamese Mekong Delta,” investigated the controversial triple-rice cropping policy in Vietnam. Over the past two decades, the intensive triple rice system (TRS) was widely adopted and initially improved local livelihoods. However, TRS has brought many problems. First, it is causing severe land degradation due to the intensive crop cycles without sufficient recovery time, and environmental pollution from the overuse of chemical pesticides and fertilizers. This is also a threat to human health, local biodiversity, and fishery resources. More importantly, TRS is unsustainable in the long term, as it requires high production costs, depresses rice prices, and eventually lowers farmers’ incomes. The study **identifies more sustainable and less damaging farming systems, such as double rice cropping with upland vegetables, aquaculture, or fishing during the fallow season, which may provide better economic outcomes and resilience than TRS.** However, a transition to alternative livelihoods requires developing local markets and providing farming techniques to the farmers. In addition, contract farming and enhancing the rice value chain, integrating ecology and landscapes, communal capacity building, and extension system upgrades, must be considered for sustainable land use.

Chapter 10, entitled “Small-scale Aquaculture and Fisheries Management in the Floodplains of the Lower Mekong Delta, Vietnam,” presents a case study of the combined rice–shrimp system based on *sustainability criteria*. A survey was carried from a sample of 94 households in the floodplains of An Giang and Dong Thap provinces, Vietnam, to determine the status of small-scale aquaculture and fisheries. **The results show that the rice–prawn (*Macrobrachium rosenbergii*) model is most suitable for economic and environmental reasons in the Delta floodplains.** The farmers showed that the dual cultivation system is also most resilient against severe flooding.

In Chapter 11, entitled “The Implications of Rice Policy Changes in Vietnam for Rice Producers in Southeastern Cambodia,” the Cambodian Resource Development Institute studied the livelihoods of rice farmers in the southeastern provinces of Prey Veng, Takeo and Svay Rieng. These provinces are dependent on producing low-value rice varieties (IR504) for export to Vietnam. Rice farming contributes more than half of household income in this region. Vietnam has decided to shift away from

the production of low-value to high-value rice varieties and agricultural cash crops. The shift may have severe impacts on rice-based livelihoods in southeastern Cambodia. Due to limited local rice processing capacity in Cambodia, local millers would be unable to absorb excess unsold paddy if there were a dramatic fall in demand from the Vietnam market. However, the authors found that in the short-term, Vietnamese traders and exporters will continue purchasing paddy rice from Cambodia as long as the demand for low-value rice exists. In the long term, the authors suggest that Cambodia should **develop a more stable market and facilitate farmers to switch from IR504 to medium-duration and aromatic rice varieties**, which require less input, particularly pesticides and chemical fertilizers, and will bring higher earnings.

Livelihoods

In Chapter 12, entitled “The Future of Natural Resource-Dependent Livelihoods in the Lower Mekong Basin,” the authors argue that the livelihoods of natural resource-dependent (NRD) households throughout the LMB have regressed over recent decades. There is little prospect that their circumstances will improve substantially. The environment is deteriorating, and NRD households are being displaced by development strategies which largely benefit non-rural groups. There is increasing competition from outsiders for the natural resources upon which they depend, and their continued poverty and food insecurity prevents them from acquiring the assets which would boost their living standards. Furthermore, none of the LMB governments currently has policies or institutional arrangements that will significantly modify these trends. **Constructive changes would occur, however, if LMB governments were to actively protect the environment, make financial resources available for rural development**, implement the United Nations’ Sustainable Development Goals which emphasize “leaving no one behind” and “reaching the furthest first,” and create mechanisms for the collaborative extension of the Basin’s infrastructure and transboundary management of its natural resources. LMB governments could further improve the situation by providing cash transfers and other support to enable NRD households to relocate from rural areas.

Chapter 13, entitled “Impacts of the New Rural Development Program in the Vietnamese Mekong Delta, 2010–2015,” presents the findings from

an empirical study to evaluate the New Rural Development Program (NRDP) in Vietnam. The program has been implemented since 2010, aiming at upgrading infrastructure and accelerating socioeconomic improvements in rural Vietnam. Despite largely positive government assessments of the program, there are concerns about its long-term sustainability as well as overall costs. Therefore, the authors investigated the factors behind the program's success and evaluated its impact on household living standards. The findings reveal that provinces having strong leadership, abundant financial resources, and closer to urban markets have more NRDP-qualified communes. At the same time, structural transformation has occurred faster in NRDP communes compared to non-NRDP communes. The NRDP has also helped increase household income, total expenditure, food expenditure, housing areas, land areas, and fixed capital accumulation. However, there has been **an increase in institutional centralization in the program, which needs to be addressed**. There should be a greater focus on **local empowerment and local needs during the program's implementation, and a longer-term funding source**.

In Chapter 14, entitled "Impacts of the East-West Economic Corridor on Forest-dependent Livelihoods in Vietnam, Laos and Thailand," the Hue College of Economics, in collaboration with multiple teams from Laos and Thailand, investigated the contributions of the EWEC, which spans 1,450 km across Myanmar, Thailand, Laos, and Vietnam, to local livelihoods, particularly of forest-dependent villagers. The study revealed that significant changes in local livelihoods occur when villagers having access to forest resources such as timber and cash crops take advantage of easier transportation and better market access. Forest-dependent villagers have better access to finance, health care, and education, but are also dealing with more risks and a lack of opportunities for non-farm jobs in this region. The EWEC has also attracted more migrants, thus leading to higher pressure on forest resources. **The authors recommended that the Lower Mekong countries undertake measures to encourage sustainable livelihoods for forest-dependent villages and protect forest resources in this region.**

Chapter 15, entitled "Gender Roles in Different Farming Systems in the Vietnamese Mekong Delta Floodplains," examines how the phenomenon of male labor migration is impacting women who are left to manage

farming households in the Delta. Socioeconomic difficulties, environmental degradation and inadequate infrastructure conditions have made managing agricultural-based livelihoods more difficult. The study then investigated the extent of women's participation in agriculture, the difficulties inherent in different types of farming systems, and interventions for supporting women's needs. Quantitative and qualitative evidence were collected in four districts of An Giang and Dong Thap provinces in Vietnam. **While women's participation in agriculture has been recognized, their contribution to various decision-making processes and living conditions is not well known or acknowledged.** Difficult living conditions and social barriers to their participation in decision-making remain. The implementation of current policies and programs for improving gender equality and gender development also remains inadequate.

Chapter 16, entitled "Implications of Rubber Land Concessions and Local Resource Governance in Cambodia," examines a controversial economic land concession (ELC) policy to promote agricultural industries in Cambodia. This study highlighted how rubber land concessions have changed one local community's livelihood resource access and gender relationships, and identified the roots of this change. Based on a case study of a rubber ELC in Sesan district, Stung Treng province, the authors investigate its impacts on access, resource governance and gender activities in a rural Brao community. The Brao community has opted for off-farm strategies to sustain their livelihoods, following their reduced access to the communal forest. **From a policy perspective, the study urges a greater role of the local government in natural resource governance, beyond its current role as the central government's extension agent, towards more effective and accountable decision-making.**

Conclusions and recommendations

LMPPI's central research theme on the environment, agriculture, and livelihoods has identified key challenges and recommendations in each sector. Addressing these cross-cutting issues requires cooperation on water governance and effective institutional mechanisms for collaboration among domestic stakeholders and between countries in the Lower Mekong Basin.

On energy development, to address environmental challenges relating to hydropower construction and growing energy demand, it is important to have more comprehensive environmental assessments regarding the valuation of ecosystem services provision and the full economic and social costs of hydropower development on a transboundary scale. This should not be limited to impacts on direct users but also indirect users, non-market impacts, and the distribution of impacts across sectors, countries, and affected people (Chapters 1, 3).

It is important to acknowledge that upstream countries such as Lao PDR (and China, though not a LMB country) are positioned to benefit from hydropower development in any situation. As a result, **to limit transboundary adverse impacts** requires LMB countries to compensate for the loss of foregone benefits of non-development. Trade, investment, and economic integration could offer a way to help Lao PDR meet its economic goals without relying on hydropower and resource mining. There are opportunities for the LMB countries to meet their growing energy demand by taking advantage of new renewable energy technologies and grid integration rather than relying on traditional coal power (Chapters 1, 2, 4).

To reduce reliance on coal for power generation, the Government of Vietnam needs to tackle several issues at the same time. First, the industrial sector is excessively inefficient as a result of maintaining low subsidized fossil fuel and electricity prices for too long. Removing implicit subsidies by creating a level playing field for the private sector to compete equally with state-owned enterprises in energy production and distribution will provide incentives for investments in cleaner energy sources and tapping into vast renewable resources, in particular, wind and solar. Second, the government should adopt policies to improve energy efficiency through tax incentives or pricing instruments to encourage the adoption of more energy efficient equipment and appliances. Third, a full accounting of the environmental costs of coal power should penalize plants that are polluting the atmosphere and facilitate a quicker transition to environmentally friendly power sources (Chapter 4).

On resource governance, to raise water productivity and promote efficient use of water, water use charges should be introduced (Chapter 5, 6). **To foster transboundary collaboration** to enhance resource management throughout the LMB will require significant shifts in Vietnam's approach to natural resource exploitation and the recognition,

at the highest policy levels, that Vietnam cannot address issues related to global warming and damming the Mekong alone. Constructive steps would involve the joint publication of relevant data on water flows and water releases, international cooperation to standardize environmental impact assessments, and transparent evaluations and debate on project proposals which affect the whole Basin (Chapters 1, 5).

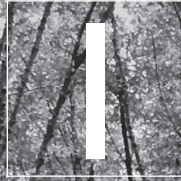
To improve water quality, scaling back triple-rice cropping would reduce the chemical contaminant load which undermines agricultural productivity and aquaculture in the Lower Mekong Delta. To address salinization in the Lower Delta and free up water to provide ecosystem benefits, suitable aquaculture-crop farming and irrigation schemes will boost the dry-season flow of the Mekong through the Lower Delta, keeping the saline intrusion closer to the river mouth (Chapters 8, 9, 10).

On agricultural policy, to boost agricultural productivity, policymakers need to focus on the incentives that encourage farmers to expand their planting of higher value crops and livestock, especially those for which there is expanding demand in urban areas (vegetables, horticulture products, high quality or organic rice, maize and soy for livestock feed, up-scale animal products). This effort will need to be supported by appropriate agricultural R&D, extension and outreach, and improved infrastructure for efficiently packing and transporting higher value produce (Chapter 7). At the same time, **domestic agricultural policy** could have transboundary implications, therefore requiring proper planning of the agricultural sector and development of agricultural value chains to maximize the economic benefit of local production (Chapter 11).

On livelihoods, to address rural poverty and food insecurity, policymakers have several options. One is to spend a higher share of the budget on agricultural R&D to address the challenges facing an ageing and more feminized workforce in the LMB. The second is to remove (or dramatically modify) land-use restrictions so that farmers can maximize the returns from their land. The third would be to encourage farmers to participate in larger-scale activities (using their land as equity in the venture). The fourth is to expand and extend rural infrastructure and upgrade rural social services so that opportunities for raising income and welfare are available for the whole rural population. The fifth option is to provide direct cash transfers to the very poorest rural citizens so that they can move beyond food insecurity (Chapters 12, 13). To ensure the

long-term sustainability of livelihoods, regional governments need to be more proactive in protecting access to resources for disadvantaged communities and encouraging a more gender-balanced approach to economic development (Chapters 14, 15, 16).

None of the policy recommendations will be easy to implement. The current institutional structure prioritizes economic growth at the expense of environmental stewardship. Government policies across the Basin remain focused on urban industrial development and natural resources are seen as the means of promoting activities which increase national income and welfare. The consequence is that agriculture and the environment are seriously stressed. The contributors conclude that appropriate shifts in government policy would significantly relieve those stresses. The challenge for policymakers is to decide whether these constructive actions should be taken immediately or be delayed. Whichever course of action is decided, one thing is clear: delay will not reduce the long-term damage that current policies are inflicting on the agriculture and environment of the Lower Mekong Basin, and hence the future food security, livelihoods, health and well-being of its peoples.



The Environment

1

The Environment–Economic Development Nexus in the Lower Mekong Basin: Hydropower, Climate Change, and Transboundary Water Cooperation

Le Viet Phu

The countries of the Lower Mekong Basin (LMB)—Cambodia, Lao PDR, Thailand and Vietnam—are facing many environmental problems due to their pursuit of resource-intensive development programs in their drive for faster economic growth and higher-income status. It is also critical to identify the linkages between development, natural resource exploitation, and environmental degradation to ensure sustainable and long-term economic growth in the face of projected severe climate change. To take one central example, the socioeconomic benefits from hydropower development in the Upper Mekong and the “potentially irreversible negative impacts” downstream are inseparable (Costanza et al. 2011: 1). In this regard, optimal decision-making should offer both ongoing economic growth and prevent longer-term, even catastrophic, environmental damage in the LMB. Only an approach that adequately addresses the needs of multiple users and provides incentives for long-term transboundary cooperation can form the basis for the efficient, equitable and sustainable use of the Mekong River.

The water-energy-food nexus approach (FAO 2014) has been used to examine the interconnections between different sectors, and diverse water usages/users, and countries along the Mekong River (Smajgl and Ward 2013a; Smajgl et al. 2016). The nexus approach highlights the simultaneous, multiple relationships between the water supply, food production, and energy generation at both national and regional scales (Smajgl and Ward 2013b: 5, fig. 1.2). Although intra-national issues—such as improving water governance in the Vietnamese Mekong Delta (VMD)

to improve flood management and protect rice crops—are also important, the primary concern of this chapter is the transboundary water-food-energy impact of hydropower development on the Mekong mainstream and its tributaries. At the center of the nexus, water governance is supposed to be coordinated with inputs and feedback from all related sectors and countries along the Mekong to ensure that proposed actions in one sector or area take into account their impacts (negative or positive) on other sectors and users through feedback and consultation processes (Smajgl and Ward 2013a, 2013b; Smajgl et al. 2016; FAO 2014; SABMiller and WWF 2014). However, this consultation process does not always produce the best outcome for the LMB, since it adds time-related costs to projects, as in the case of many hydropower projects in Laos, even when correctly implemented (Cronin and Weatherby 2014).

In the LMB, three critical water governance areas (hydropower development, water use, and climate change) are intertwined, involving trade-offs and synergies across multiple sectors and countries. The damming of the Mekong River for hydropower has already changed the mainstream's flow patterns and lowered the volume of nutrient-rich sediment downstream, thus reducing agricultural productivity and affecting capture fisheries which support millions of poor and vulnerable people. On the other hand, hydropower projects may be an important source of national income generation, especially for the resource-rich but least-developed Laos. Hydropower may also supply Thailand and Vietnam with cheaper and less polluting energy instead of relying on traditional coal-fired power plants. However, the long-term implications of the building of individual dams as well as the collective development of hydropower dams on other sectors and on downstream countries must be carefully considered.

Agriculture, to meet increasing domestic demand as well as for export, remains the largest water user in the LMB countries. Agricultural production has increased dramatically over the last few decades, intensified by a shift from largely autarkic economies to export-oriented development (ESCAP 2005; Leinenkugel et al. 2014: 10, fig. 1). Both Cambodia and Laos have plans to significantly extend the areas under dry season irrigation to supplement their relatively under-developed agricultural sectors. Plans to increase dry season irrigation throughout the LMB by up to 50 percent in the next 20 years (from 1.2 to 1.8 million ha

of the total 15 million ha of agricultural land in the LMB) will likely affect dry season water demand, especially in the Vietnamese Mekong Delta, where dry season flows are fully utilised for economic activities, and for preventing salt water intrusion (MRC 2013: 12). Major additional water diversions from the mainstream—a large-scale project to divert water from Lao PDR to northeast Thailand is being studied—may also affect dry season flows to the Delta. With reservoir storage of less than 5 percent of the main annual flow, there will be limited options for redistributing water from the wet to the dry season. Vietnam has already built an extensive network of dikes and irrigation systems in the Delta to support triple rice cropping. The consequences of this intensified farming have been land degradation and environmental pollution from the excessive use of water, fertilizers, and chemicals. Increasing water demand, when the supply is uncertain, has also placed additional pressure on groundwater extraction for aquaculture farming in northeast Thailand as well as in the Delta, contributing to lower water tables, land subsidence, and heavy metal contamination in groundwater aquifers.

The intensification of agriculture and other activities increasing the demand for water in the LMB have not taken into account the impact of a cascade of hydropower dams already built upstream. Recent and ongoing hydropower development presents the most significant transboundary challenge to the region, with 26 hydropower projects (of 10 Mw or greater) under construction on Mekong tributaries, in addition to the dams already built in China. The LMB has about 30 GW of hydropower potential, but only 10 percent has been developed (MRC 2013: 12). The Government of Laos plans for many more dams to be built, including twelve on the mainstream and hundreds on tributaries. While the mainstream dams are run-of-the-river type, those on the tributaries will require significant reservoirs (MRC 2011). Upstream hydropower development in China has also continued unabated. The completion of the cascade on the Upper Mekong (Lancang) River in China will significantly shift seasonal flow patterns and reduce water-borne sediments, with expected serious impacts on agricultural production and fisheries in the LMB.

The LMB is also one of the most vulnerable regions in the world to climate change. In addition to human-made intervention to the Mekong River system's flow regime, climate change is expected to exacerbate flow variations. Climate change could further increase the variability of wet and

dry season flows, the frequency and intensity of extreme events such as droughts, floods, tropical storms, and sea-level rises (ICEM and USAID 2013). This especially affect agricultural production, and add significant uncertainty to the benefits and costs of hydropower.

In Cambodia, the mean annual temperature is projected to increase by between 1.4 and 4.3 °C by the end of the twenty-first century. Annual precipitation may also increase, especially in the wet season. Floods and droughts will increase in frequency, intensity and duration. Rice yields may increase during the wet season, but there may also be soil degradation and the loss of forest ecosystems, and inundation of coastal zones. Similarly, warmer temperatures in Laos may help increase crop yields; however, the increasing frequency and severity of floods and heavy precipitation will cause significant losses of infrastructure and agricultural productivity due to soil erosion (MRC 2009). Projections for Thailand show a longer hot season, with average temperature increases of 1–2 °C by 2050, and 3–4 °C by 2100. Changes in the annual rainfall pattern are also predicted, with a prolonged wet season, as well as extended dry seasons, increasing the risk of both floods and droughts; and there may be more typhoons in some areas of the LMB. The Mekong Delta of Vietnam is most vulnerable to rising sea levels and storm surges due to its low elevation, along with saltwater intrusion and coastal erosion, threatening infrastructure, livelihoods, ecosystems and tourism.

Overall, climate change may aggravate water shortages and drive competition over water resources on a local or regional scale. Adaptation measures such as relying on groundwater during shortages may exacerbate land subsidence and saline intrusion. Some estimates suggest that a 1-meter sea-level rise would affect 10 percent of the population and cause losses equivalent to 10 percent of the GDP due to the inundation of 40,000 sq. km of coastal areas (MRC 2009; Lange and Jensen 2013). Miguel et al. (2004) demonstrated a connection between rainfall shocks, negative economic growth and the propensity for conflict in subsistence economies in Sub-Saharan Africa. The changing flows and flood regime of the Mekong system, especially with upstream development, dams, and water diversions at a time of increasing demand for water for agriculture and industrial development, may further deteriorate water security and push communities toward conflicts.

Prospects for cooperation in the LMB

Hydropower development

While hydropower development remains highly controversial, one study by the Mekong River Commission (MRC) suggests positive economic benefits from the Lancang storage and other tributary dams, provided that they are operated as designed. These benefits range from reducing flood damage during the wet season to preventing saline intrusion in the dry season, contributing directly and indirectly to income and employment in the LMB (MRC 2013: 25). The cumulative adverse impacts in the LMB are the loss of wetlands, reduced flows to Lake Tonle Sap, and the loss of sediments and nutrients to the Delta, harming its capture fisheries, and changing its geomorphology. Addressing these and other related transboundary issues requires the LMB countries and China to cooperate on the operation of the upstream dams, with socio-environmental impact assessments and dam designs that will minimize negative impacts on the downstream countries.

The MRC study suggests a possibility for expanded irrigation and tributary hydropower in the Mekong Basin without significantly changing the river's flow regime. Cambodia's Delta irrigation expansion and a diversion in northeast Thailand could be met by potential increases in dry season releases of new tributary hydropower. However, the benefits will not be equally shared. Blocking fish migration (essential for breeding) and the loss of sediment will have a negative impact on agricultural productivity and capture fisheries, and hence on the livelihoods of the LMB's most vulnerable populations. The proposed additional 30 tributary dams in Lao PDR and Cambodia alone are expected to reduce capture fisheries by 7 percent with current developments and up to 10 percent in the next 20 years (MRC 2013: 19).

The most controversial subject remains overall mainstream dam development. Because the 12 mainstream dams in Laos are run-of-the-river and do not rely on storage for operation, it is expected that their impact on the Mekong River's flow regime would be minimal. Cost-benefit analyses indicate that Laos would be the primary beneficiary, as it strives to become the "Battery of Southeast Asia," with a net present value of up to US\$15 bn in income generated and hundreds of thousands of jobs created. It would also help cut greenhouse gas emissions by

50 Mt/year by 2030 (MRC 2013: 19). The fact is that Lao PDR has been rapidly developing its hydropower sector over the past two decades. In 1993, the total capacity of all hydroelectric plants in Laos was only 206 MW, but as of 2015, this figure is 4,168 MW. Laos plans to produce 10,000 MW of hydroelectricity by 2020, and 75 percent of that power is expected to be exported to Thailand, Vietnam, Singapore, and Malaysia. With a theoretical maximum capacity of 26.5 GW, Laos will have more potential for hydropower to be exploited in the long term (International Hydropower Association 2016).

However, such large-scale hydropower development will have immense socio-environmental impacts. The mainstream dam developments have met with fierce opposition from Cambodia and Vietnam. A recent study by the Vietnam National Mekong Committee suggested that despite insignificant immediate economic losses due to mainstream dams, capture fisheries would be decimated and some important, economically valuable fish species would become extinct (MONRE 2015). Costanza et al. (2011) argues that Laos would gain in all situations involving mainstream dam construction, whereas the other three LMB countries will either gain very little or even face significant losses, depending on the parameters used to discount future costs. Furthermore, with a quarter of the Lao population living below the poverty line in rural or remote areas, the planned expansion of hydropower as a major development strategy will result in the loss of agricultural land, forest, fisheries and traditional livelihoods. Given the huge uncertainties regarding the benefits and costs of constructing and maintaining hydropower dams, and of dam designs to mitigate adverse environmental impacts, it is necessary to take a more cautious approach, including developing a sufficient knowledge base with proper consultation with all stakeholders. However, such assessments do not exclude mainstream hydropower altogether. There is indeed a possibility that *some* further development of hydropower on the Mekong River could be considered, provided all social, environmental and economic analyses and consultation steps are properly followed (Costanza et al. 2011: 3).

Importantly, Weatherby and Eyler (2017) report that an emerging trend in renewable energy could bring about important changes in a way that would help the Mekong countries achieve energy security, improve their trade balances, and promote sustainable development in the region

without relying on traditional coal power. In the coming years, new hydropower projects will have to compete with alternative energy sources, as natural gas is getting cheaper, and solar and wind power technologies more efficient and affordable. In addition, new hydropower projects often face more technical challenges and are located in remote and mountainous areas, so more investment is needed in the transmission system, as well as more costly relocations of affected populations. The transition to a more flexible approach in the LMB combining new renewable energy technologies, improvements in transmission, and better demand-side management may promise greater economic returns while reducing emissions, the need for more dams and hence reduce their negative environmental, ecological, and political fallouts (see Chapter 2, this vol).

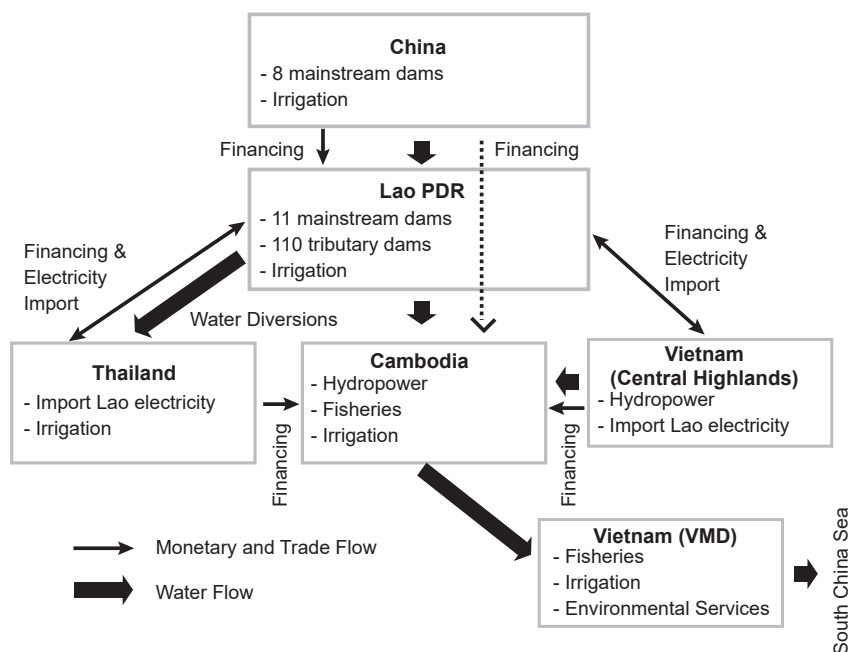
Transboundary cooperation and challenges

No single player is to be blamed for the regional water governance impasse. All the LMB countries (and China) have contributed to the exploitation of the Mekong River without appropriate consideration of the impacts on their neighbors: Thailand is both the primary funder of and customer for Lao PDR's hydroelectricity; Vietnam's construction of hydropower in the Central Highlands has negatively affected Cambodia and its own Mekong Delta; and Cambodia's construction of the Lower Sesan II hydropower plant is expected to severely affect fisheries and the livelihoods of millions of people in that country as well as in the Delta (Cronin and Weatherby 2014). Figure 1.1 shows the flows of water, hydropower finance, beneficiaries, and potential losers of hydropower development in the LMB.

At the center of this diagram, Lao PDR is expected to be the "winner" from these hydropower developments in all situations, while the costs seem to be disproportionately borne by the downstream countries, especially Cambodia and Vietnam (Costanza et al. 2011). Small-scale farmers and those relying on capture fisheries are the most affected. One MRC basin development scenario (BDP2) suggests a cumulative net economic benefit of US\$33.4 bn for a cascade of 11 dams on the Lower Mekong over a 20-year period; however, this value is dependent on the selection of the discount rate used to convert future damages to present value. In extreme cases, the total damage of the dam cascade could be as high as US\$274.4 bn (Costanza et al. 2011). The reason for these

wide-ranging impact forecasts is that transboundary environmental and socioeconomic impact assessments have not been taken seriously, and that the lack of a standard assessment of the economic and environmental impacts of a dam or a cascade of dams results in there being no scientific basis to compare and identify the trade-offs, even at the national level. China's reluctance to share information related to its dams' operations further exacerbates the problem. Moreover, China has been uncooperative with LMB countries on impact assessments and unwilling to share information on hydrological data, river basin and project plans, and the use and development of water resources (Cronin and Weatherby 2014).¹

Figure 1.1: Main players in water use in the Mekong River system



Overcoming fundamental differences over benefits or losses, energy or food, and upstream development or downstream impacts requires a new approach to regional cooperation, adaptation to climate change, and environmental conservation through trade and regional integration. Implementing this approach requires a significant shift away from direct sharing of water under most transboundary river basin management schemes toward the sharing of *benefits* on a regional scale, although this

does not conform to prevailing national priorities and security concerns (Bach et al. 2012). Regional trade and investment could compensate Laos for foregoing the benefits of more hydropower development on the Mekong in order to achieve a better basin-wide outcome (Costanza et al. 2011; ESCAP 2005). To date, three major factors have prevented effective transboundary coordination, including: the uneven distribution of resources, benefits, and potential impacts; the lack of a standard environmental assessment instrument; and despite the MRC's existence, the lack of a mechanism to share information, especially related to China's construction in the upstream areas.

Planning resilience to climate change must also be based on the multiple criteria required in the nexus approach, including water resource use, development status, and trade-offs and synergies across sectors and across borders (SAB Miller and WWF 2014). Transboundary cooperation is becoming more urgent, given the need to collectively address the potential threats of climate change. Climate change is affecting the water-food-energy nexus through multiple channels, by altering the water regime, temperature and precipitation patterns, raising sea levels, and increasing the frequency of extreme weather events. Thus, adaptation must be based on a nexus approach because fixing problems in one area of the LMB might inadvertently cause problems elsewhere; for example, more extensive irrigation to cope with drier conditions upstream will reduce the amount of water available to downstream users (Bach et al. 2012). A transboundary approach to climate change must take into account the impacts on non-contiguous yet interconnected regions and stakeholders with opposing interests. Despite the seriousness of climate change threats, the LMB countries have yet to coordinate their responses, however; this is largely due to the uneven distribution of climate hazards and vulnerabilities, creating different national risk perceptions and degrees of commitment to climate actions (Lange and Jensen 2013).

Conclusion

The LMB countries need a grand strategy to deal with transboundary issues related to the sustainable use of their greatest shared natural resource, the Mekong River. This summary identifies *three major areas* that need a regional water-food-energy nexus approach to achieve the best outcome while minimizing adverse spillovers between sectors and/

or countries sharing the same river system. These include: a harmonious approach to hydropower development that balances the need for economic development by exploiting hydropower potential in the upstream against environmental concerns of the downstream countries; a mechanism to best use and share water for irrigation and agricultural expansion; and a climate change adaptation and mitigation strategy that ensures resilience against unexpected changes of water flows, sea level rises, and extreme weather events. It is understood that any solution would involve trade-offs between sectors and between countries possessing different resource endowments, economic development statuses, and environmental concerns.

This study highlights *three principles for transboundary cooperation* on the environment to succeed. First, it is important to have more comprehensive environmental assessments regarding the valuation of ecosystem services and economic cost of hydropower development on a transboundary scale. This should not be limited to impacts on direct users, but also indirect users, non-market impacts, and the distribution of impacts across sectors, countries, and affected populations. Second, it is important to acknowledge that upstream countries such as Lao PDR (and China, though not a LMB country) are positioned to benefit from hydropower development in any situation. As a result, to limit adverse transboundary impacts the LMB countries will need to compensate for foregoing the benefits of development. Increasing transboundary trade, investment, and economic integration could offer a way to help Lao PDR meet its economic goals without relying so heavily on hydropower and mining resources. There are also opportunities for the LMB countries to meet the growing energy demand by taking advantage of new renewable energy technologies and grid integration rather than relying on traditional coal power. Finally, a long-term solution to the transboundary water issues requires the participation of many stakeholders, including the governments, related sectors, business communities, and the people of the LMB countries and China.

Note

- ¹ This study was written prior to recent developments regarding the Lancang-Mekong Cooperation mechanism.

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2

Beyond the Battery: Power Expansion Alternatives for Economic Resilience and Diversity in Laos

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In the last two decades, Laos has initiated a major hydropower development program. Through new dam construction and revenues from existing dam operations, hydropower has played a key role in driving economic growth of 7–8 percent per annum, while revenues from electricity exports to neighboring countries make up a significant and growing fraction of the country's much-needed foreign exchange at about 30 percent of all exports. The government has negotiated large-scale electricity exports to Thailand (7,000 MW by 2015) and Vietnam (5,000 MW by 2020), and reportedly has plans to do the same with China and Singapore. The Ministry of Energy and Mines (MEM) has publicly committed to quadrupling the country's installed hydropower capacity by 2020 and has floated the possibility of even doubling *that*—an eightfold increase—by 2030 (Reuters 2014). This plan exemplifies Lao PDR's stated commitment to become the “Battery of Southeast Asia” and suggests an intention to exploit much of the country's estimated hydropower potential of 26,000 MW.

While hydropower in Laos is often framed as a comparative advantage, there are numerous costs to making such a plan operational. The social and environmental costs are well known, and include the displacement of rural communities and livelihoods; the loss of fisheries, agricultural land, forests and wildlife locally; and the disruption of fisheries and sediment-based agriculture downstream, including Cambodia's Tonle Sap and Vietnam's Mekong Delta (Costanza et al. 2011; Ziv et al. 2012; Singh 2012; Kondolf et al. 2014; deBuys 2015; *Vientiane*

Times 2015). Equally significant are the high financial costs, which force the Lao government to rely heavily on the private sector. Despite efforts to leverage public sector financing to improve sectoral performance (Porter and Shivakumar 2010), this reliance has substantial impacts at the project scale and on the economy as a whole (Baird and Quastel 2015; MPI 2015). Concessions to foreign investors often mean low prices for Lao electricity, and uncoordinated project development across the rural landscape. This carries a range of actual and opportunity costs, including a deprioritizing of economic complexity, including extending rural electrification in Laos itself. In short, while becoming the “Battery of Southeast Asia” may be one path to development given the currently limited set of options, it represents a difficult trajectory.

In this study, we explore two ways that planners and decision-makers can begin to think beyond the “battery” strategy in its current form, by looking at possibilities for alternative energy technologies with which to meet Lao PDR’s national production commitments, and ways to make rural electrification better serve its population. Our analysis is based on two models: a capacity expansion optimization model, and a spatial planning model for rural electrification. These models are intended to help think through possibilities that could emerge in the near future with global and regional commitments to more sustainable forms of development. As such, they bridge the possible under current conditions to the world of future scenarios that depend on the actions of others, including global powers like China and the United States, global and regional development banks, and a range of private-sector financiers and entrepreneurs. Our goal is to explore the “possibility space” that exists if energy technologies are built under a range of possible conditions. Our first model does this at the national scale in the context of planned electricity exports, while our second looks more closely at rural electrification in central Laos. Both models demonstrate approaches that can be replicated or expanded elsewhere, and are intended here as contributions to ongoing discussions.

After reviewing the history, plans and debates related to the Battery of Southeast Asia model, we present our capacity expansion model. Using six different policy-driven scenarios, we argue that precise and targeted substitution in non-hydro renewable electricity can result in lower investment costs while maintaining similar export revenues.

Moderate integration of technologies such as solar, wind, and biomass is technically and economically viable, especially when the substantial downstream (basin-wide) impacts of large hydropower installations are taken into consideration. This makes strategic substitution of renewables an economically and technically feasible solution.

We then examine the landscape of rural electrification, the possibilities for which would be significantly enhanced by the sorts of alternative energy trajectories examined earlier. Using the case of Region 1 in central Laos, we combine data on electricity demand and costs with geospatial population data and existing grid infrastructure, resource availability, and other socioeconomic considerations to both forecast local electricity demand as the economy grows and propose the most cost-effective option for electrification over a specified period. We show that under high diesel price conditions, combinations of solar-based mini-grid and off-grid solar provide financially viable opportunities for rural electrification. In most cases, these distributed solar-based options cost less than grid expansion and large-scale transmission infrastructure.

Taken together, our results provide models that create an integrated platform for examining the costs and benefits of various energy pathways for Laos, both nationally and locally. This allows us to discuss the implications of an alternative, integrated approach to national and rural development based on the promotion of local and sustainable energy resources.

The “Battery of Southeast Asia”: History, plans, debates

Laos has a long history as an exporter of natural resources, from precolonial through colonial times (O'Donovan 2002; Stuart-Fox 1995). Hydropower, although a modern resource, fits this pattern. Early efforts to develop the country's hydropower potential as a source of nation-building were imagined by foreign planners—many of them American—who were drawn into the region in the late 1950s and early 1960s as part of President Johnson's efforts to create “a non-communist alternative” in Southeast Asia modeled on the Tennessee Valley Authority (TVA) (Black 1962). The first president of Laos, Kaysone Phomvihane, embraced hydropower for national development, but demurred from the grandiose visions of TVA-style mega-projects such as Pa Mong and Sambor, mainstem dams that would have tied Laos and Cambodia into the electricity system of

Thailand, then a key US ally (Sneddon 2015). While Phomvihane was very much a modernist, his vision was more incremental and geared toward domestic energy use rather than a regional grid. As Andrew Wyatt (2004: 135) points out, this approach was founded in “socialist ideologies of self-sufficiency and concerns over external influences that impinged on national sovereignty as a result of an over-reliance on foreign aid.”

The export-oriented approach to hydropower development emerged in the late 1980s and early 1990s, contrasting starkly with this earlier strategy (*ibid.*). Born of the economic turmoil engulfing Laos and its socialist neighbors in the mid-1980s as assistance from the Soviet Union and other Eastern Bloc countries declined, export hydropower emerged as a rare and reliable source of foreign exchange. This was primarily via the Nam Ngum 1 dam. Two decades earlier, during the height of the Second Indochina War, Nam Ngum 1 had been built in the hills north of Vientiane. Funded by the United States and Japan, it had been constructed under the auspices of the Mekong Secretariat, and survived in the middle of a war zone because both sides believed they would prevail. After its completion in 1971, Nam Ngum 1 exported electricity continuously to Thailand, despite the geopolitical vicissitudes of the two countries’ relationship. After 1975, this was seen by the new Lao PDR leadership as a success (*ibid.*: 136). In the late 1980s, as Party leaders embraced foreign investment and an outward-facing economic reorientation to stabilize the economy (Stuart-Fox 1997), Nam Ngum 1’s example fit the new imperatives of generating scarce foreign exchange. As Wyatt notes, the “Battery of Southeast Asia” strategy originated in this reorientation, as the Nam Ngum 1 model, bolstered with “advice from the ADB and World Bank, encouraged the Lao government to commit itself to large-scale hydropower as the backbone of its drive for economic development” (Wyatt 2004: 136–37).

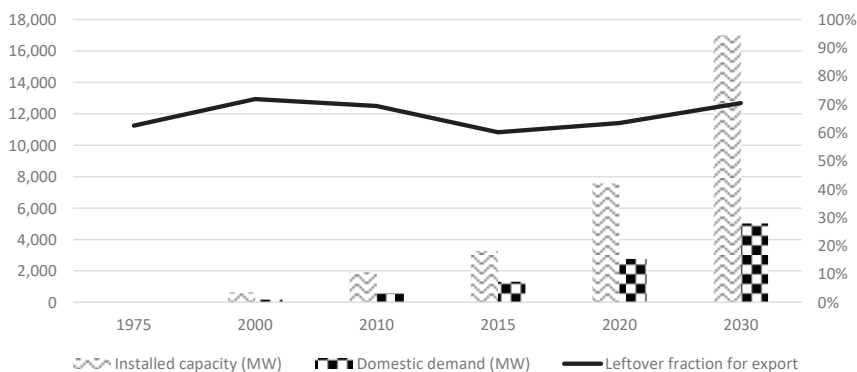
In the last two decades, as export hydropower has become a mainstay of Lao development strategy, it fit with the oft-cited fact that Laos is a poor, mountainous, landlocked country surrounded by wealthier neighbors. The “Battery of Southeast Asia” model reframes this as a comparative advantage, taking the country’s “mountainous landscape and rivers suitable for hydropower development” as a counterweight against the lack of coastal access and other conveniences, and positing that “if used correctly and efficiently, [hydropower] will be a strength and bring income to the country as a clean, inexhaustible energy source”

(MEM n.d.: 1). This appeal is at least twofold. Hydropower has proven to be a relatively reliable source of foreign exchange, at least compared to minerals and commodities such as copper, gold and rubber (CID Harvard 2014; Vongvisouk and Dwyer 2016). Moreover, hydropower is what economists call *rentable*: the monetized value it yields is relatively easily controlled, unlike timber or some agricultural products, which have proven difficult to regulate in a centralized manner (MAF 2005; *Vientiane Times* 2015). As the Lao government has become increasingly vulnerable to under-collected revenues and rising debt loads due to the actions of local authorities (*Vientiane Times* 2014), central-level officials have come to depend increasingly on large hydropower as a source of national revenue.

Plans

Figure 2.1 shows a version of the hydropower development vision presented regularly by ministry officials (Inthavy 2015). It highlights the “takeoff” in hydropower capacity that is widely expected in the next decade and a half, showing capacity more than doubling by 2020 and increasing roughly fivefold by 2030. Such a scenario would leave the fraction of installed capacity available for export at around 60 percent (in 2015) and rising. Other public predictions by government spokespeople make these findings look conservative. The Vice-Minister of Energy and Mines predicted that by 2020, “we’ll have 12,000 MW in operation with two-thirds for the export market,” and speculated, “by 2030, we may

Figure 2.1: MEM’s vision of hydropower development in Lao PDR, 1975–2030 (derived from Inthavy [2015])



double that ... to 24,000 MW, which is nearly all the hydro potential in Laos" (Reuters 2014). The *Nikkei Asian Review* reported in 2015 that "Laos plans to sell 80 percent of the power it generates to neighboring countries" (Kyojuka 2015).

Economic complexity

Laos has approximately 30 GW of potential hydropower capacity, and revenue streams from resource exports such as copper, agriculture and forest products. A central tension expressed in the 2015 Draft Five-year Plan concerns the appropriate rate, manner, and extent of natural resource exploitation. The concern is that broad-based economic growth and development may be inconsistent with overuse or over-dependence on natural resources:

Acceleration of economic growth relies mainly on natural resources. However, management and use of natural resources in many cases is still carried out in an unsustainable, wasteful and not in an environmentally friendly manner. This has resulted in harmful impacts on the local people and has impacted greatly on the environment of the country. Therefore, consideration must be given to future development. If the issue is not tackled urgently and timely [sic], it may lead to the Dutch Disease in the Lao economy. (MPI 2015: 65)

This concern with unbalanced economic growth is reflected in official concerns about Laos having a high-growth but low-development (or "dual") economy in which performance in some sectors fails to catalyze development in others (and especially social sectors). The Lao economy already exhibits a sectoral imbalance, with electricity exports figuring centrally. Although the latest figures from the Lao Ministry of Planning and Investment (MPI) are incomplete, they show nonetheless that electricity is one of the few sectors—and the only large sector—where investment growth was sustained in the wake of the global financial crisis of 2008 (table 2.1). At the same time, however, economic diversity has been decreasing in an economy that was already not very diverse. This is suggested by the table data (bottom row), as well as (more convincingly, given the incompleteness of the data, by fig. 2.2. This shows the rising share of the Lao economy played by natural resource exports, electricity chiefly among them.

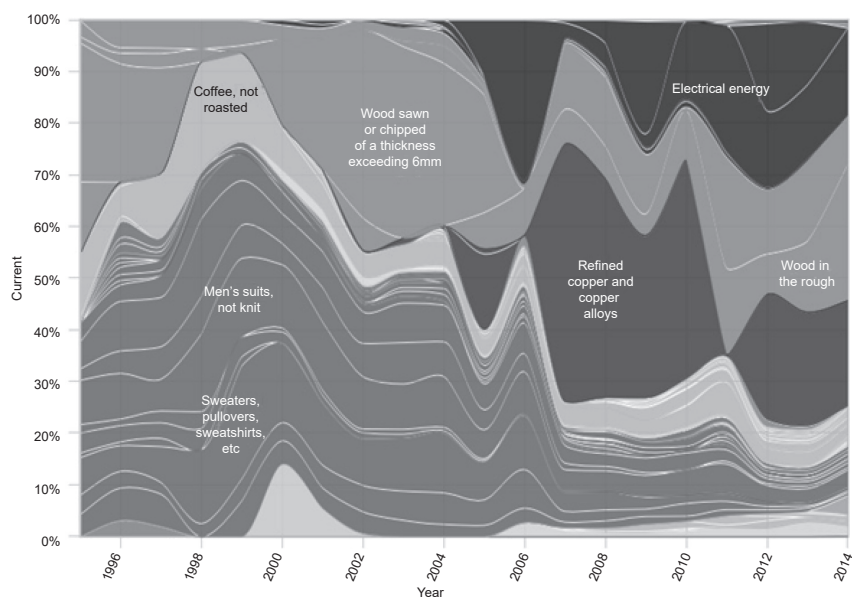
Table 2.1: Changes in total Investment and diversity, Lao PDR, 2005–2015 (US\$ m)

		2005–2010	2011–2015	Change	2015
1	Electricity Generation	\$2,952	\$3,097	5%	\$568
2	Mining	\$3,104	\$2,539	-18%	\$184
3	Agriculture	\$1,732	\$1,048	-40%	\$466
4	Industry & Handicraft	\$1,259	\$614	-51%	\$37
5	Service	\$1,887	\$426	-77%	\$12
6	Construction	\$358	\$357	0%	\$1.4
7	Hotel & Restaurant	\$487	\$187	-62%	\$0.6
8	Banking	\$140	\$140	1%	\$-
9	Trading	\$175	\$58	-67%	\$-
10	Public Health	\$14	\$50	263%	\$-
11	Telecom	\$88	\$46	-48%	\$-
12	Wood Industry	\$211	\$19	-91%	\$-
13	Garment	\$22	\$9	-57%	\$-
14	Consultancies	\$50	\$7	-85%	\$-
15	Education	\$22	\$2	-91%	\$-
	TOTAL	\$12,500	\$8,599	-31%	\$1,268
	<i>Diversity Index</i>	<i>1.97</i>	<i>1.72</i>		<i>1.16</i>

Source: Atlas of Economic Complexity, Center for International Development at Harvard University, <http://www.atlas.cid.harvard.edu> (accessed February 14, 2019)

Building an integrated platform for investment in both power export and rural electrification industries can improve economic diversity, domestic connectivity, and sustainability through mitigating downstream hydropower impacts. The development of industrial sectors beyond extractive industries and raw materials could simultaneously satisfy goals and components of the Ministry of Agriculture or MPI and promote growth. A program of small-scale energy and industrial diversification, with a mix of traditional industrial and forward-looking programs (e.g., ICT-based) provides constructive alternative investments for foreign and domestic partners to pursue. This allows for substitution of some of the largest and most damaging centralized energy projects, including the tributary and mainstem dams identified in Ziv et al. (2012), while sustaining hydropower revenues and enabling a broad-based economy.

Figure 2.2. Lao exports, by percentage of total value, 1995–2014



Source: *The Atlas of Economic Complexity*, Center for International Development at Harvard University, <http://www.atlas.cid.harvard.edu> (last accessed February 14, 2019)

Putting these plans into practice requires a co-evolution of constructive alternative foreign and domestic investment practices in larger grid-connected projects and distributed off-grid and mini-grid networks. Technological diversification could help overcome this challenge and address issues of declining energy security (Tongsopit et al. 2016). Currently, stimulating investment is difficult due to macroeconomic imbalances and a perceived vulnerability to external shocks (IMF 2015). Identifying feasible alternative energy options provides a first step to promote the idea that economic and energy diversity is possible. The next step will be to transfer research outcomes into practice, by encouraging investment that improves economic diversity.

Renewable Electricity Planning Dialogue

Investigating alternative investment pathways is especially critical given concerns about the adverse impact of extensive hydropower development

in Laos on fisheries and ecosystems in the Lower Mekong Basin. A growing body of literature on energy resources in the Mekong Basin is identifying 1) the resource availability of different renewable energy technologies 2) national scale and rural household-scale electrification objectives, and 3) scenarios under which energy transformation can occur. However, there is a disconnect between the body of literature on hydropower impacts from proposed development (Ziv et al. 2012; Costanza et al. 2011, Intrawalan et al. 2015) and the available alternatives or solutions to energy planning challenges. Table 2.2 summarizes the range of energy studies to date, categorized by type of model and scale of analysis. A few studies incorporate both macro-scale energy planning and rural electrification (ADB 2015; NREL 2016). Some provide geospatially explicit resource assessments and others conduct scenario-based plans (Luukkanen et al. 2015a,b; NREL 2016). Most other pathway studies lack the integrated analysis that combines impacts of hydropower development and identifies alternative energy technologies based on resource and cost factors. To our knowledge, this is the first study to integrate both macro-scale energy planning and rural electrification strategies and map out pathways where incremental substitutions in hydropower development could achieve similar revenues and meet rural electrification goals by 2030.

Capacity expansion model

Our model simulates capacity expansion: the optimal building of various electricity generation technologies in Laos under six different planning scenarios. It operates on a 15-year horizon, and incorporates estimates of domestic and export demand projections, data on existing energy infrastructure stocks and resource constraints, up-to-date information on planned hydropower projects scheduled before 2030, local tariffs and international fuel prices (Box 2.1). Our scenarios are based on variations of the Mekong River Commission's Basin Development Plan 2 (BDP2), which is used in several other studies (see table 2.2), including those from which we borrow environmental damage projections. Our scenarios include a base case, which we define as BDP2 plus the three mainstem dams that are currently underway (BDP2 +3), and a Full Build scenario comprising all planned projects up to 2030 (see Box 2.1). We also added four scenarios based on policy support for renewable energy or a carbon price, and constraints on biomass or coal (table 2.3). For each scenario,

Table 2.2: Recent studies and models of the Mekong Basin's energy resources

Study	Type of Model	Macro	Mini-grid
ASEAN Center for Energy (2015). 4th ASEAN Energy Outlook.	Scenario-based pathways/ LEAP, 2035 Vision	Yes	
Huber, M., A. Roger and T. Hamacher. 2015. Optimizing long-term investments for a sustainable development of the ASEAN power system. <i>Energy</i> 88: 180–193.	Hourly transmission, generation, and storage optimization; Spatially explicit	Yes	
International Energy Agency (IEA). 2015. Southeast Asia Energy Outlook.	Scenario-based pathways, energy supply & demand forecast	Yes	
Kumar, S. 2016. Low Carbon Energy Systems and Indicator Framework for Cambodia, Lao PDR and Myanmar.	Indicator-based framework	Yes	
Luukkanen et al. 2015. Long-run energy scenarios for Cambodia and Lao.	Integrated techno-economic and environmental modeling; Scenario analysis	Yes	
Luukkanen et al. 2015. Energy Dependence and Potential for Renewables.	Scenario-based planning, LEAP (Long-range energy alternative planning)/LINDA (Long-range integrated development analysis)	Yes	
MEM. 2016. Electricity demand forecast and supply 2016–2030	Scenario-based pathways	Yes	
Stimson Center. 2016. A call for strategic basin-wide energy planning in Laos.	Integrated resource planning, scenario-based pathways	Yes	
WWF. 2015. Laos Power Sector Vision 2050.	Scenario-based pathways	Yes	
Blum et al. 2015. An analysis of remote electric mini-grids in Laos using the Technological Innovation Systems approach.	Technology diffusion model		Yes
ADB. 2015. Renewable Energy Developments and Potential in the Lao People's Democratic Republic.	Resource potential tool	Yes	Yes
National Renewable Energy Library (NREL). 2016. Geospatial toolkit Lower Mekong: Laos Dynamic Technical Potential.	Geospatial resource tool; Interactive mapping; Analytical model	Yes	Yes
USAID. 2016–2021. Clean Power Asia.	Integrated resource planning	Yes	Yes

our model identified the specific planned projects that would be included (see model). We therefore force investment decisions based on the planned projects of each scenario and then allow the model to select remaining resources for capacity expansion to meet demand, subject to resource availability and least cost. The model calculates the total system costs and revenues over the lifetime of the selected projects up to 2030 based on this optimization. For each scenario, we also ran sensitivity analyses on demand (taking high, medium, and low demand projections from MEM), cost variables and growth rates, expected capacity factors, percentage peak contributions allowable by resource, and fuel and carbon prices.

Our model helps us understand (a) the cost and revenue tradeoffs of different configurations of planned projects; (b) whether and how alternative energy resources would substitute for planned projects to meet demand under a least-cost objective function; and (c) how policy decisions and market conditions may influence the most suitable utility-scale energy generation mix for Laos. Our results and their implications for energy planning are discussed below. The analysis evaluates options on a direct cost basis and a full accounting of environmental and other damages such as population displacement are *not* included in the model outputs.

Table 2.3: BDP2-modified scenarios

Scenario name	Description
BDP2 +3	Dams currently or soon to be in operation with three mainstem dams (Xayaburi, Don Sahong, Pak Beng). This scenario also includes Lao PDR's coal development plans
RPS	BDP2 + 3 with Lao PDR's renewable portfolio target of 30% by 2030
Carbon Price	BDP2 + 3 with a \$40/ton carbon price added
No Biomass	BDP2 + 3 with no biomass capacity
No Coal	BDP2 + 3 with no coal development plans
Full Build	The full MEM portfolio of planned generating projects (375)

Box 2.1: Model inputs

Our model draws on a comprehensive dataset of over 375 projects planned by Électricité du Laos (EDL) before 2030 (EDL, March 2015) that included technology type, project status as of 2015, installed and expected production capacities, expected year of completion, and the nationalities of project developers.

Additional inputs included planned project lifetime (in years), initial capital cost (\$2012/kW), fixed operation and maintenance (O&M) costs (\$/kW), variable O&M costs (\$/kWh), carbon emissions (tCO₂/MWh), fuel costs (\$/MWh), initial efficiency (%), capacity factor (%), and electricity prices (tariffs) (\$/kWh). Where data were not available per project, we used estimates from the literature (see Appendix).

We estimated the costs and revenues generated over the lifetime of each project, incorporating future changes in capital cost and capacity factor, for each scenario. The model attributes costs and benefits to specific countries by percentage of project ownership.

Since our scenarios align directly with BDP2 scenarios, we were able to use others' assessments to include estimates of economic damages to capture fisheries. We focused on these impacts as opposed to other environmental issues, as the reduction of value has been assessed to be an order of magnitude larger than other expected impacts (sedimentation, human displacement, increased reservoir fisheries), both positive and negative (Costanza et al. 2011). In weighing the value of electricity generation against the expected losses in capture fisheries, our model considers the two major sets of quantified impacts from large-scale hydropower to illustrate the scale of tradeoffs involved in each scenario at the country level.

Model results

While we stress that the purpose of this project is not to identify and settle on a single scenario, we find that the least costly path for Lao PDR's targeted electricity exports is a diversified one that includes substantial contributions from solar, wind, and biomass electricity resources. This "BDP2 +3" scenario allows the construction of the Xayaburi, Don Sahong, and Pak Beng dams, guaranteeing future revenues from exported hydroelectricity, but substitutes downstream dams with a mix of non-hydro renewable resources at lower cost. This avoids the projected additional damage to fisheries caused by downstream dams. We also find

nuanced differences in the role of biomass under different scenarios that investigate the introduction of a Renewable Portfolio Standard (RPS), carbon price, and the full-build of all planned hydropower dams.

The “Full Build” scenario takes all planned mainstem and tributary hydropower dams in Laos through 2030 and estimates the investment cost, the levelized cost of energy (LCOE), and generation capacity for each plant and the entire national power system. Given that some dams have yet to be financed, we compare this with our BDP2 +3 scenario. This adds only three mainstem dams—Xayaburi, Don Sahong, and Pak Beng, and the current plans to build coal-powered electricity stations by 2024 (see fig. 2.3). It considers the possibility of targeted substitution of mainstem dams of power for export. In addition to BDP2 + 3, we run a “no coal” scenario which considers the three mainstem dams, but excludes the country’s plan to install almost 1 GW of coal by 2024, as seen in figure 2.4.

The results highlight that a significant wind resource in the southern Laos zone could play an integral part to power exports—all without the major adverse impacts from hydropower development downstream at a similar cost and generation profile. Additionally, we penalize wind with a “transmission” penalty for new transmission interconnections necessary to bring power from a centralized wind facility to export markets in ASEAN.

The opportunity cost of developing hydropower along the Mekong River mainstem itself, especially in downstream areas, is high. The significant wind and biomass resources for power export, combined with distributed solar for household and village-scale electrification, can provide an integrated strategy for power development. The BDP2+3 (figure 2.4) highlights the feasibility of such an option and at lower overall costs even at a 7 percent discount rate. Installations of non-hydro renewables are feasible and could quickly replace large-scale hydropower additions beginning in 2018. Wind and biomass resources are complemented by significant utility-scale solar installations beginning in 2025. We find that wind and solar can comprise large shares of the power mix by 2030, generating similar levels of electricity production, at a lower cost than building all the planned hydropower projects.

Most importantly, we find that coal is not the least-cost energy expansion path for Laos. When the coal plans are not enforced in the model, cheaper options such as biomass, solar and wind are substituted.

Figure 2.3 BDP2+3 installed capacity additions by year

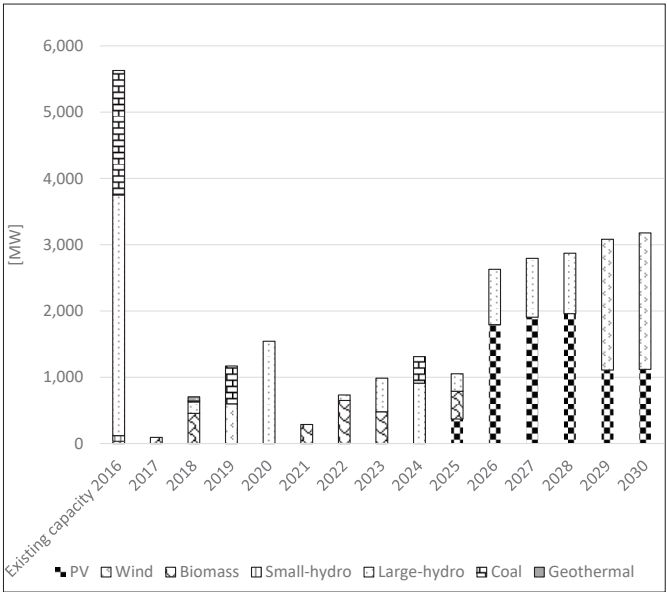


Figure 2.4. "No Coal" installed capacity additions by year

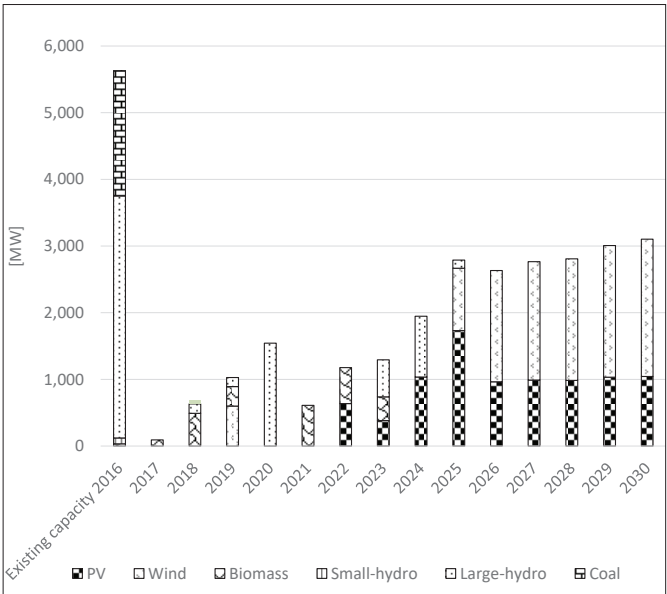


Figure 2.5. Capacity expansion plan for Full Build scenario to 2030

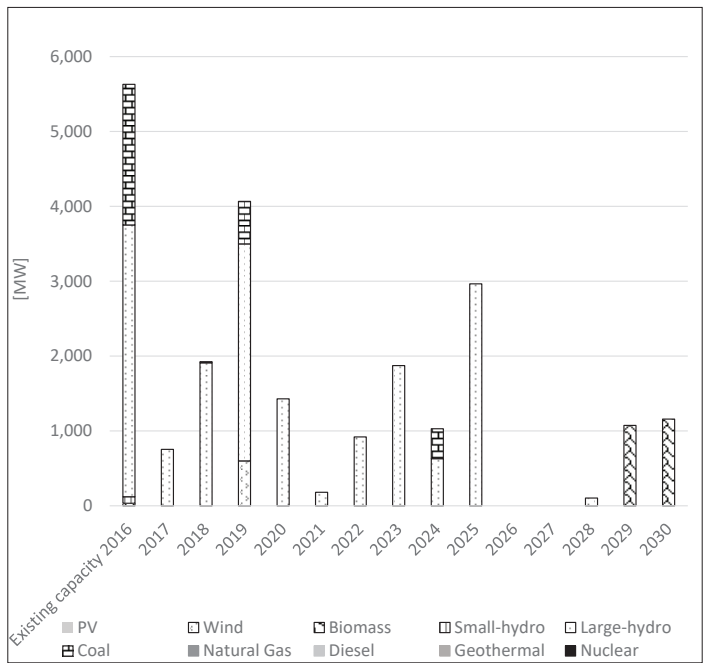
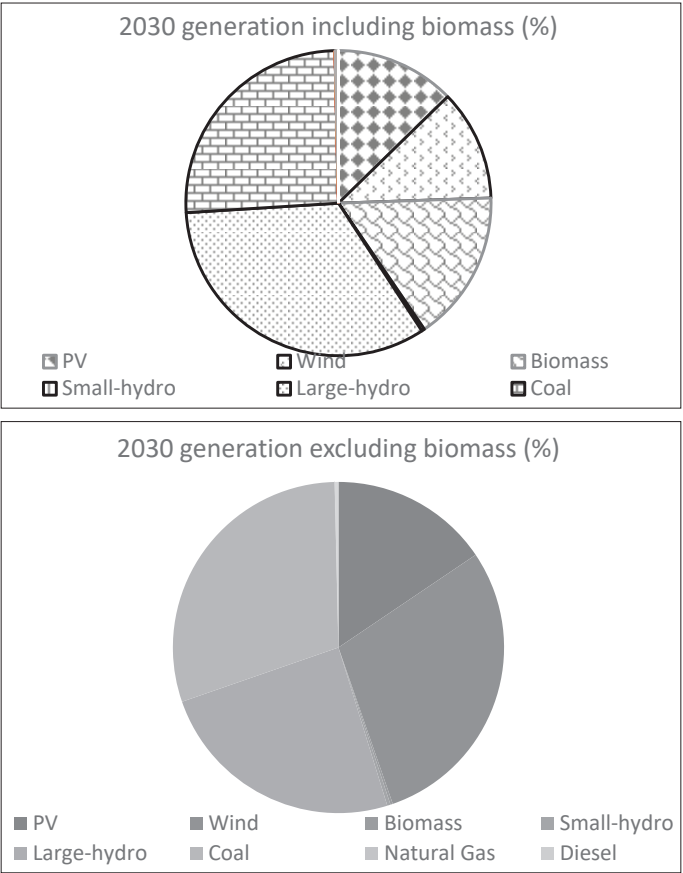


Figure 2.5 describes the Full Build capacity plan that constructs all future planned hydropower projects for export. Wind electricity plays a limited role; however, it could fill the generation gap at a low cost and complement large-scale hydropower facilities. The Full Build scenario would impose significant costs downstream to Cambodian and Vietnamese fisheries. It would also come at a similar cost to developing wind and biomass resources, especially for downstream mainstem dams that could threaten extinction for critically endangered species such as the Irrawaddy Dolphin (*Orcaella brevirostris*), one of the few remaining freshwater dolphins. Migratory fish in this scenario are key not only for the Irrawaddy Dolphin’s diet, but also for communities along the Laos–Cambodia border depending on fish as a major source of protein and their livelihoods (Brownell et al. 2017).

As seen by comparing BDP2+3 with the Full Build, biomass could provide an immediate stopgap to maintain export revenues as solar and wind costs continue to decline. However, by 2024, substantial

Figures 2.6a and 2.6b. The 2030 generation mix for BDP2 +3 with and without biomass utilization



deployments of solar and wind become increasingly competitive against biomass and small hydropower plants. At the same time, as biomass feedstocks remain uncertain and geographically dependent, we add a sensitivity to the model ignoring the possibility of biomass electricity from sources such as bagasse. We find in this case both utility-scale solar PV and the substantial wind resource in the South provide opportunities to export electricity at lower installation costs and faster deployment times than large-scale hydropower dams or coal-fired power plants. Solar and wind could replace biomass in situations where food–fuel tradeoffs loom too large, which is explored in the “No Biomass” scenario (figs. 2.6a and 2.6b).

A modest investment in electricity from biogas could go a long way to reduce short-term operating costs in the power system. One way to mitigate a potential food versus fuel conflict is to utilize bagasse from sugarcane. Bagasse provides a waste resource that could be less controversial than rice straw or other biomass feedstocks (Gheewala et al. 2017). However, air quality remains an issue from outdoor biomass burning. Smog and organic particles can contribute to outdoor air pollution and reduce air quality (Jenjariyakosoln et al. 2014; Hill et al. 2015). Compared to lignite coal, however, there are environmental benefits to this design. The flexibility provided by a system supported by biomass and large-scale hydropower facilitates further integration of solar and wind systems, while reducing the system-level intermittency challenges and balancing export demand.

In addition to the wind resources highlighted in BDP2+3, there are significant solar resources that would play a role for exporting power, taking into account the flexibility of a hydropower-dependent system. Existing domestic hydropower resources provide complementarity to a Southern wind-based development plan. Furthermore, targeting wind resources in the South allows for greater development opportunities and investments in transmission and distribution infrastructure that would bring greater connectivity both domestically and regionally to ASEAN countries.

The cost of solar and wind have decreased substantially such that the cost of BDP2+3 remains between US\$1.4–1.8 billion less compared to the Full Build scenario (see table 2.4). This presents non-hydro renewables with the opportunity to play a significant role in Lao power exports. The larger installed capacity, met by a judicious mix of biomass, wind, and solar. Biomass offers early options. The projected cost reduction potential of solar and wind widen the dividends gap comparing solar and wind with hydropower. Because hydropower costs are not expected to decline to the extent of solar and wind technologies, pushing toward 2030, solar and wind can meet the targeted export goals at substantially less cost (IEA 2015). Large-scale hydropower projects historically have delayed construction timelines and face significant cost-overruns, which are less likely for solar and wind projects that are quickly deployable as incremental investments (Ansar et al. 2014). Furthermore, capacity factors for hydropower plants in Laos have decreased.

This trend may continue, exacerbated by climate change and reduced flows from upstream cascade dams. Modest declines in capacity factor toward 2030 will further widen the cost gap between non-hydro renewables and large-scale hydropower, leaving the possibility for gigawatt-scale capacity of stranded hydropower assets. We accommodate projected future river flows and find that solar, wind, and biomass combinations reduce the risk of lost revenue from declining generation. This finding is significant and would drastically reshape the development plan of power sector investments in Laos to better match regional power needs. Furthermore, it could strengthen capacity and deepen ties with Vietnamese and Thai counterparts, where civil society movements are growing against mainstem hydropower development.

The results of our modeling reveal the extent of food-energy-water nexus challenges facing Lao PDR and the GMS region, with broader lessons for other regions. We address these challenges in terms of three gaps in the current energy landscape in Lao PDR and the GMS, the closing of which will enable globally optimal energy solutions within the Lower Mekong Basin (LMB). A focus on these gaps (discussed below) from private investment and the international donor community could help avoid destabilizing and irreversible ecological damage to the LMB. Of particular importance is a mechanism to harmonize the apparent financial benefits of dam construction, strongly concentrated in Laos and Thailand, with downstream impacts, especially in Vietnam and Cambodia (see table 2.5).

Table 2.4. Summary of relative cost differences across scenarios

Scenarios	Optimization Results	
	Total Cost (NPV, \$m)	Net Difference (\$m) relative to Full Build
BDP2 + 3	\$8,996	\$(1,799)
RPS	\$8,999	\$(1,796)
Carbon Price	\$15,400	\$4,605
No Biomass	\$9,320	\$(1,475)
No coal	\$8,165	\$(2,630)
Full Build	\$10,795	

Table 2.5 Expected fishery impacts and adjusted NPV of hydropower projects in various scenarios to 2030

		BDP2+3	Full Build
NET FISHERIES LOSS	Lao PDR	5%	23%
Annual percentage of migratory fish biomass lost.	Thailand	2%	6%
	Cambodia	6%	49%
	Vietnam	5%	41%
ANNUAL VALUE OF FISHERIES LOST	Lao PDR	\$30,000,000	\$125,000,000
Fish assigned a \$2.5/kg replacement value.	Thailand	\$37,000,000	\$125,000,000
	Cambodia	\$100,000,000	\$740,000,000
	Vietnam	\$44,000,000	\$310,000,000
	Total	\$210,000,000	\$1,300,000,000
NPV OF HYDROPOWER PROJECTS	Lao PDR	\$3,100,000,000	\$1,100,000,000
By investor home nation in hydropower projects located in Laos. Expected annual revenues from hydropower projects, less amortized costs and expected annual fishery loss as above. Fish loss discounted at 3%.	Thailand	\$1,400,000,000	(\$1,200,000,000)
	China	\$36,000,000	(\$2,400,000,000)
	Vietnam	\$260,000,000	(\$350,000,000)
	Other	\$1,700,000,000	\$110,000,000
	TOTAL	\$6,500,000,000	(\$2,700,000,000)

Mobilizing investment to recognize the significant opportunities in wind and biomass sectors will require innovation at multiple scales. Solar can easily provide distributed energy resources in the form of off-grid, mini-grid, and grid-connected facilities. However, we find comparative advantages in prioritizing wind electricity for export and devoting limited centralized land for wind farms, given Lao PDR's resource base and proximity to neighboring countries. We also see opportunities to couple wind with hydropower production and improve grid flexibility across the country (Huang et al. 2019). This will aid Laos in its efforts to develop regional ASEAN-wide power contracts (e.g. one recently signed with Malaysia), and to reduce the costly power imports from Thailand in the southern provinces.

Rural electrification

Physically Lao PDR has the potential to serve as a regional source of energy supply (and perhaps storage) for many decades, but we find in

the model discussed above room for more optimal—i.e., less risky, more resilient, more productive of long-term revenue—pathways of energy development. Yet, despite the potential for megawatt-scale substitutions of renewable energy, attracting investment outside of mining and conventional electricity generation remains an obstacle to developing renewables. Our investigation now explores energy as an opportunity to support development and investment in sectors of the Laos economy other than commercial power generation. We shift attention from large, centralized projects that serve urban centers such as Bangkok, Ho Chi Minh City, or Vientiane, to the far nodes of Lao society. We highlight the emerging competitiveness of distributed, renewable energy-based mini- and micro-grids to meet universal electrification needs, minimize environmental costs, increase supply mix diversity and resilience, and allow for intensified rural development and connectivity.

Why is rural development in Laos important? Today more than 60 percent of Lao PDR's 6.7 million population remains rural. Meanwhile, urban population growth in Laos has slowed from 6.1 percent annually in 2000 to 4.6 percent in 2014 (World Bank 2014). Most of the rural population resides in over 8,600 villages ranging in size from dozens to hundreds of people. These are largely subsistence-oriented communities: an average of 82 percent of households depend on agriculture; this figure is close to 90 percent in the north. There is thus significant potential for developing rural enterprise in Laos.

However, given the current limited road and transmission network in Laos and the challenges of terrain and low population density, the high cost of reaching these individual communities with basic services represents a major challenge. Furthermore, while overall population density has increased over the past two decades, it is still quite low at 29 people per sq. km, roughly equivalent to that of West Virginia in the United States. Even after substantial government efforts to consolidate villages, much of the rural population remains isolated and highly dispersed, often in mountainous terrain, representing a challenge for productive electrification. In fact, despite recent increases in national electrification levels over the past decade, a third of all villages in Laos remain completely un-electrified.¹

Census data show that in urban areas electrification rates are 96 percent, while more than 60 percent of villages without road access remain

unelectrified. Electrification rates are lowest in the Northern region.² The low population density and lack of existing connectivity presents an opportunity to explore grid extension alternatives that may provide faster, cheaper routes to improving local energy access—as well as a group of ancillary services such as internet access and distance education. In fact, the Lao government in recent policy sets out a 99 percent electrification target by 2030 (MPI 2015). Rural electrification under these targets will require significant investment, but transmission and distribution projects not crucial for a specific generation project face obstacles attracting investment.³

In the remainder of this section we examine the following questions:

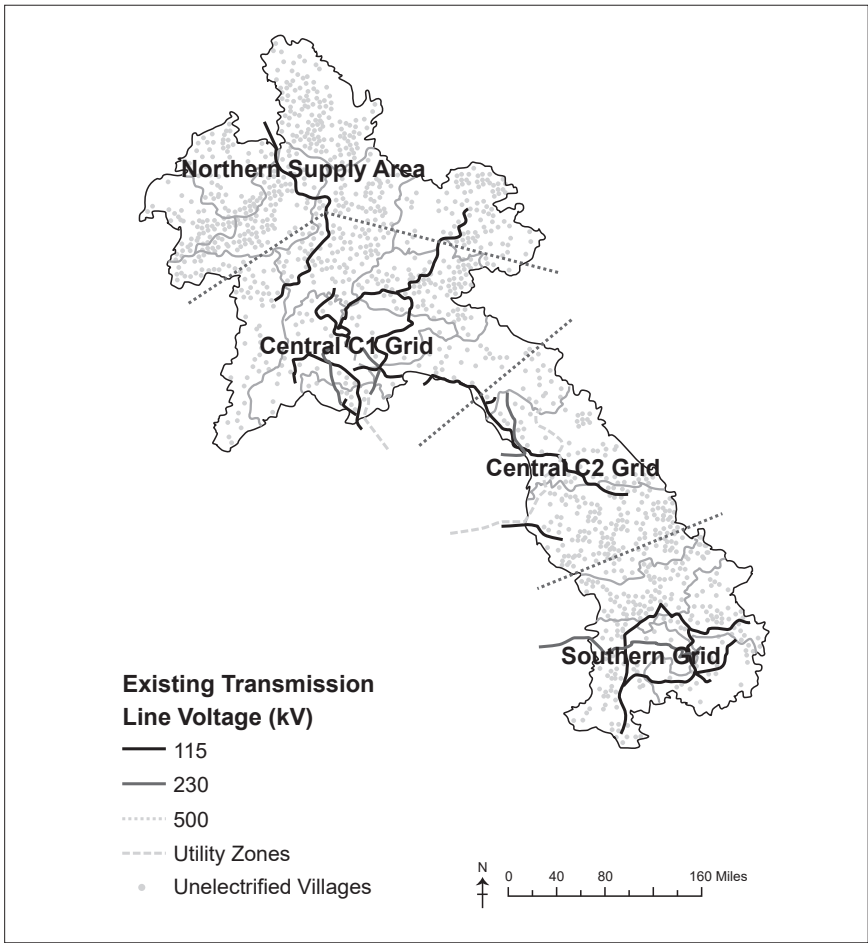
- What mix of off- and on-grid solutions is optimal for Lao PDR's landscape and resources?
- What are the economic impacts of centralized grid expansion versus an off-grid strategy?
- What trade-offs do alternate pathways to energy access represent?

We adopt a simple, commercially available optimization model, Network Planner, for this analysis. This model combines electricity demand, village population, existing grid infrastructure, technology costs, resource availability, and socioeconomic data to both forecast demand and run algorithms to propose the most cost-effective option for electrification over a specified time horizon. The model compares the long-term costs of solar-based off-grid technology, micro-grids, and distribution networks.

We use Network Planner to perform sensitivity analyses on variables such as demand growth, technology cost and various grid extension scenarios in Laos. This complements our previously explained analysis of commercial energy production opportunities and will eventually form an integrated platform for understanding the costs, benefits and implications of Lao PDR's possible energy futures. We run the model by dividing Laos into Zones, which have different resource potential characteristics. We demonstrate results for the Central 1 Zone. There are 635 non-electrified villages in this zone with an average population of 575 people per village. Solar potential is high across the zone (4.8–5.0 kWh/m²/day). While the total agricultural residue available is large for most districts (rice, maize, sugar cane, cassava), the volumes available for localized electricity

production through small-scale gasification are low due to the generally small size of farm holdings and the difficulties of residue collection. Biomass waste represents a major area for future research, as well as an area in which Lao PDR may have advantage as a global research pilot site. Nevertheless, we restrict biomass to utility-scale projects in Laos and do not consider it as a potential resource in our Network Planner modeling.

Figure 2.7 Existing transmission infrastructure and non-electrified villages (Electricité du Laos 2016)



Results

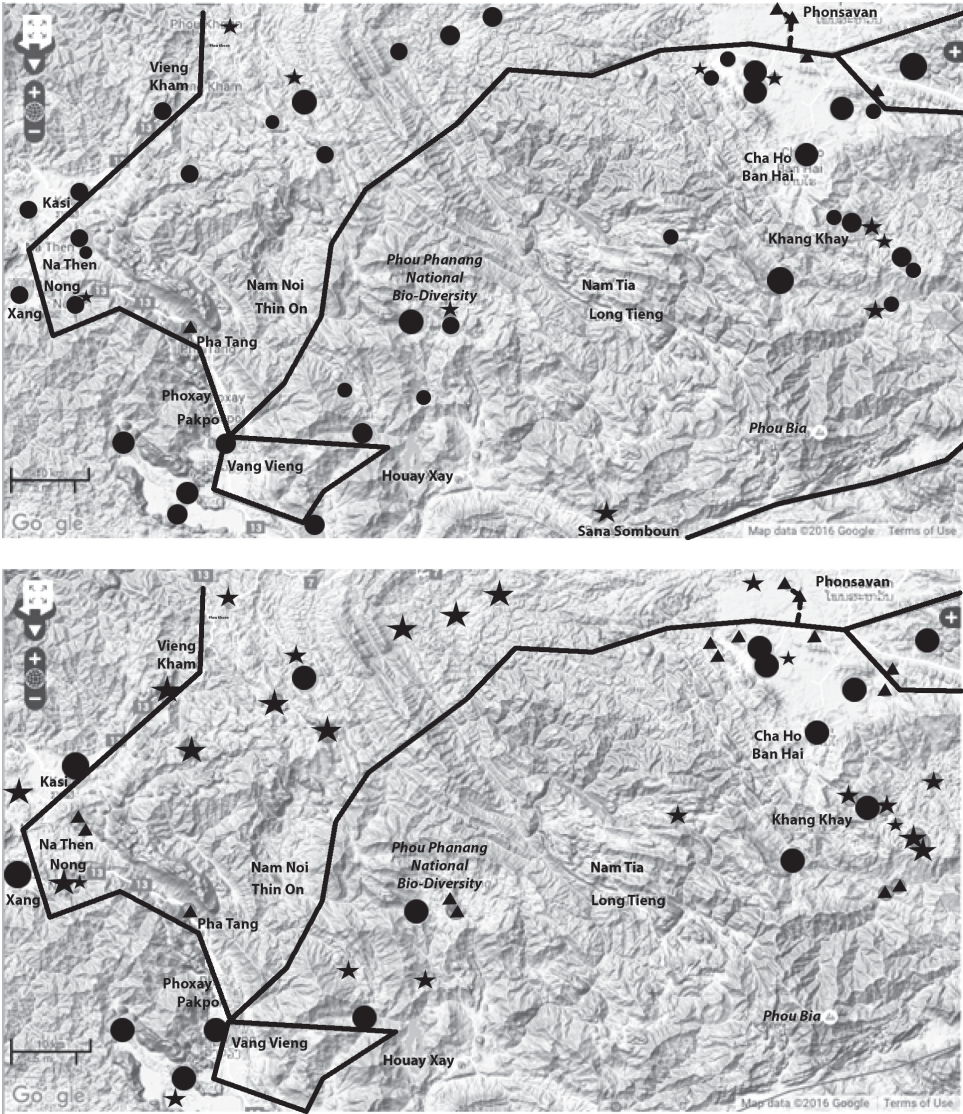
Indicative spatial results of the model are highlighted in fig. 2.8 estimating the mix of villages suggested for grid-connection (triangle), micro-grids (star) and off-grid options (circle). The two views show how the optimal configuration varies when diesel prices change, with the lower map reflecting output from the high-diesel cost scenario. Table A3 in the Appendix shows complete financial results from the model run.

In our model, villages predominantly gain access to electricity through the centralized grid rather than off-grid solar photovoltaic (PV) or small-hydropower systems. In the Central Region more than 70 percent of villages are grid-connected. In the Northern Region only 39 percent of villages have grid access and there is a high percentage of micro-hydro deployment (23 percent of villages). There is also a modest amount of small PV deployed across rural villages in Laos, accounting for as much as 6 percent of the electrification within villages in certain provinces. Increased deployment of micro-hydro and off-grid solar technologies could potentially improve electricity access in isolated communities, especially given the limited reach of the national transmission infrastructure (see fig. 2.7). Building these plants with smart infrastructure can also lead to the flexibility of connecting to the grid if extension occurs after an off-grid project is deployed.

Most village nodes are supplied using a combination of diesel-based and small PV off-grid generation in the top-most map because of 1) comparatively low household electricity demand, 2) low cost of diesel (US\$1.18/liter), and 3) higher cost of microgrid technologies such as solar PV and micro-hydro (US\$6/W and US\$4/W respectively). The initial system cost is US\$129.9 million. The total system cost, which is predominantly fuel cost, is US\$478.9 million, and the LCOE is US \$0.52/kWh, where LCOE is the net present value (NPV) of the unit-cost of electricity over the lifetime of a generating asset. For the average village of about 500 people, the initial system cost is US\$320,000 using off-grid technology, with an average of \$635 per household, while the mini-grid and grid connection options are US\$356 (US\$0.44/kWh) and US\$282 (US\$0.41/kWh) per household, respectively.

When the diesel price is increased to US\$3/liter, however—a scenario well within the realm of possibility given historical experience—there is a major shift from off-grid systems using generators to hybrid solar and

Figure 2.8 Changes in optimal electrification solutions for villages under high diesel costs (bottom map)



diesel-based mini-grids and grid electricity. In this scenario the LCOE for all systems rise, with the LCOE of off-grid technologies at US\$0.78/kWh, mini-grids at \$0.57/kWh, and grid extension, which uses no diesel generation but must now be applied to less favorable villages, rising to (US\$0.44/kWh). It should be noted that these high costs reflect the difficulty of bringing electricity to the most remote areas in Laos, and are on par with prices for rural electrification projects internationally.

Conclusion

Building new capacity to assess opportunities for renewable energy project development is crucial to diversifying the Lao economy and employing a broad-based approach to power sector development planning. This study identifies opportunities to develop non-hydro power renewables and enable more sustainable power export revenues. Planning for an integrated regional energy system in Laos by 2030 requires coordination across rural electrification goals and hydropower developments. We find that lower-cost power generation options exist that could replace generation from proposed hydropower projects and remove alarming downstream impacts from hydropower. Promoting a more sustainable development plan along the Mekong River system requires alternative investments and will enable Laos to pursue electricity generation goals using the vast resources available in the country.

This work allows us to engage with several distinct groups, all of whom have a key potential role in realizing the efficiencies of diversifying Lao PDR's energy portfolio and preserving the most essential services of the Mekong. Expected primary consumers of our modeling work include Lao energy and economic planners and decision-makers, especially those who are concerned about Laos avoiding economic "conditions" such as Dutch Disease and the Dual Economy (the urban-rural divide) (MPI 2015). Our model helps policymakers quantitatively understand the trade-offs facing hydropower project development and identify the various future pathways to enable a more sustainable, resilient electricity system. The models in concert also provide private investors from the United States, China, and Europe with the capability to broker regionally efficient solutions at a national and village scale that also preserve the interests of Cambodia, Vietnam, and Thailand. Non-governmental organizations and international financial institutions in the donor community will

likely be central to providing the incentives and support that enable the various energy pathways proposed. Our work complements advocacy-oriented work on preserving the Mekong River by mapping new energy investment pathways. Our theory of change focuses on building such pathways at a national scale to provide alternative electricity investment options and at a village-scale by identifying opportunities for mini-grid development. Acknowledging the importance of regional neighbors and private investment as well as Lao PDR's policies and plans in any solution is an essential part of alternatives to the status quo.

From both national planning and village-scale rural electrification perspectives, we find significant advantages on the order of US\$1.8 billion by substituting proposed large-scale tributary dams with new wind, solar, and biomass projects. The flexibility of existing hydropower projects could facilitate a transition to more intermittent renewable power that can be used for export. Additionally, building a non-hydro renewables-based export economy can facilitate greater transmission connectivity and a more resilient grid. Lao PDR depends heavily on power imports from Thailand for electricity. Simultaneously, remote communities lack access to grid services or basic lighting. Under infrastructural constraints and medium-to-high diesel prices, solar-based off-grid and mini-grids emerge as cost-effective alternatives to centralized grid expansion. Moreover, a broad-based electricity system plan that incorporates the significant resource availability of utility-scale wind and solar could transform the economy of Laos and promote ASEAN-level electricity market growth—without the negative environmental and social implications of hydropower development.

Fisheries, sedimentation, and water availability are all necessary for regional stability in the Lower Mekong Basin. The Full Build scenario could cause irreversible damage to fisheries, threatening the extinction of critically endangered species including the Irrawaddy Dolphin. Hundreds of millions of villagers rely on fish protein from the Mekong River for daily life. Furthermore, surrounding agricultural activities depend on water availability from the river to provide food in one of the world's key rice-exporting regions. Potentially high costs and damages of mainstem hydropower development could create financial and environmental difficulties that affect future water, energy, and food production. Reduced flows and increased sedimentation on the river will disturb agricultural

productivity and reduce power generation output. Climate change may exacerbate this effect as explored in the capacity expansion model presented in this chapter, given the possibility of declining future capacity factors from hydropower production due to variability, drought, and extreme conditions. These effects are already well-documented by other studies.

We find that reconsidering the most damaging hydropower projects to avoid such significant ecological and economic losses could provide high-yielding investment opportunities within Laos on the order of hundreds of millions of dollars. Mobilizing private investment toward utility-scale non-hydropower renewables is a start. This chapter demonstrates the viability of different options and under changing policy conditions including the external cost of carbon and accounting for possible renewable portfolio standard targets. The model also finds future export value for electricity in the region by building new transmission and generation infrastructure. That would facilitate better regional coordination and improve the economy of Laos without harming neighboring countries and largest trading partners. At the same time, opportunities for solar powered mini-grids are increasing from a financial viability perspective. Poor infrastructure and variable diesel costs contribute to the attractiveness of distributed off-grid options that are based on solar power rather than diesel.

Hydropower will continue to play a significant role in the ASEAN power grid and Laos will likely lead Southeast Asia in developing future energy projects for export. Here, we quantify the economic advantage of replacing the most destructive hydropower projects with non-hydro renewable-based alternatives. We acknowledge that many of the planned hydropower projects may continue, therefore we identify the specific projects that could hinder economic development. Ideally, more sustainable design practices, including true run-of-river schemes and the staggering of cascading dams will alleviate some ecological impacts, including the impact on fish populations. Our study suggests hydropower could play a more complementary role in future power system operations by providing fast-responding flexibility and stability in a more diverse system that utilizes increasing amounts of intermittent solar and wind electricity. Both climate change and Upper Mekong mainstem hydropower development in China could significantly alter water availability

and seasonal timing of power availability. Importantly, we find that combinations of utility-scale solar, wind, and biomass reduce the risk of lost revenue from declining generation in hydropower projects. Therefore, Laos should use existing hydropower to its advantage by providing operational flexibility in the power system and recognize that developing more utility-scale wind and solar PV represent more financially attractive opportunities and reduce investment risk.

Importantly, the scenarios presented here could achieve similar revenue streams and require less capital investment than building all the planned 375 hydropower projects in Laos' pipeline. Additionally, the databases we have made publicly available through the Lower Mekong Public Policy Initiative can help inform policymakers who need to decide on specific projects. There is a great opportunity for Laos to diversify and develop a broad-based inclusive economy that promotes sustainability and resilience. Attracting the investment to achieve this remains a challenge, but presenting data of resource availability and making comparisons in an open-source platform could spur projects that might otherwise not fall under consideration. It will take an alternative and integrated approach, but full access to electricity in Laos can be achieved by 2030, and the economy has the opportunity to lead Southeast Asia as a battery and power generation hub. It will take the concerted effort of civil society, private investors, public planning agencies, and policymakers to decide and create a more resilient and diversified future for Laos.

Appendix I. Socioeconomic and demographic data

To conduct this study for Laos we collected five major categories of data.

- *Geospatial data* – on the location of non-electrified villages from the Laos Decide database, based on the National Agricultural Census 2010/2011. We created digital overlays of the Laos existing grid network using data from the Lao PDR Ministry of Energy and Mines.
- *Socio-economic data* – on interest rates, economic growth rates, population growth rates and elasticity of electricity demand from the World Bank Indicators and the Laos PSDP.
- *Demographic data* – data on village populations, household sizes necessary to project electricity demand are taken directly from the Laos Decide database.

- *Non-residential electricity needs* – data on common institutional facilities (such as health centers and schools) and basic productive processes (such as mills and water pumps), average counts and electricity use were taken from the Laos PSDP and the Socio-economic survey of Laos (Nanthavong 2006).
- *Cost Data* – capital, operations and maintenance costs for off-grid, mini-grid and grid technologies and grid components are taken from various sources. The model requires detailed cost components of the three electrification technologies such as the following: the cost of medium voltage (MV) lines, low voltage (LV) lines, transformers, diesel generators, diesel fuel per litre, solar panels and solar batteries—as well as recurring costs, including operation and maintenance (Kemausuor 2014). Low and medium distribution line and operations costs are taken from International Guidelines (NRECA 2016). The model also requires interest rates to be used to determine the discounted costs for each technology option which will be combined with other cost components in estimating the projected cost of electrification for each technology option based on the projected electricity demands at the end of the planning time horizon. We explore the impact on total system costs of variations in technology cost through sensitivity analysis.

Table A1. Socioeconomic and cost data for Network Planner

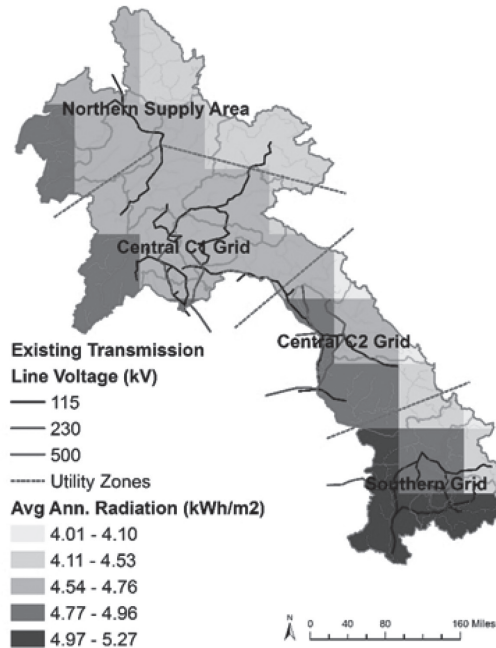
Metric Description	Value(s)	Unit
FINANCE		
Economic growth rate per year	8%	fraction per year
Elasticity of electricity demand	1.2	
Interest rate per year	5%	fraction per year
Time horizon	5	years
DEMOGRAPHICS		
Mean household size (rural)	6.1	person count
Mean household size (urban)	5.7	person count
Mean interhousehold distance	2060	meters
Population growth rate per year (rural)	-0.1%	fraction per year
Population growth rate per year (urban)	4.6%	fraction per year
Urban population threshold	5000	person count

DEMAND (HOUSEHOLD)		
Household unit demand per household per year	100	kilowatt-hours per year
Target household penetration rate	90%	fraction
Peak electrical hours of operation per year	1460	hours per year
DISTRIBUTION		
Low voltage line cost per meter	9.8	dollars per meter
Low voltage line equipment cost per connection	100	dollars per connection
Low voltage line equipment O&M cost as fraction of equipment cost	0.2	
Low voltage line lifetime	20	years
Low voltage line O&M cost per year as fraction of line cost	0.2	
GRID SYSTEM CHARACTERISTICS		
Distribution loss	0.2	fraction
Electricity cost per kilowatt-hour	0.5	dollars per kilowatt-hour
Installation cost per connection	100	dollars per connection
Medium voltage line cost per meter	8,650	dollars per meter
Medium voltage line lifetime	50	years
Medium Voltage O&M cost per year as fraction of line cost	0.02	
Transformer cost per grid system kilowatt	40	dollars per kilowatt
Transformer lifetime	25	years
Transformer O&M cost per year as fraction of transformer cost	0.02	
OFF-GRID SYSTEM CHARACTERISTICS		
Diesel fuel cost per liter	1.18	dollars per liter
Diesel fuel liters consumed per kilowatt-hour	0.5	liters per kilowatt-hour
Diesel generator cost per diesel system kilowatt	600	dollars per kilowatt
Diesel generator hours of operation per year (minimum)	4000	hours per year
Diesel generator installation cost as fraction of generator cost	0.1	
Diesel generator lifetime	20	years
Diesel generator O&M cost per year as fraction of generator cost	0.05	
Peak sun hours per year	2400	hours per year
Photovoltaic balance cost as fraction of panel cost	2	
Photovoltaic balance lifetime	10	years
Photovoltaic battery cost per kilowatt-hour	200	dollars per kilowatt-hour
Photovoltaic battery kilowatt-hours per photovoltaic component kilowatt	8	kilowatt-hours per kilowatt
Photovoltaic battery lifetime	4	years
Photovoltaic component efficiency loss	0.25	fraction
Photovoltaic component O&M cost per year as fraction of component cost	0.02	
Photovoltaic panel cost per photovoltaic component kilowatt	750	dollars per kilowatt
Photovoltaic panel lifetime	20	years

Appendix II. Estimating Population and Demand Growth

In the Network Planner model residential electricity demand is dependent on the village's total population, and increases over time with economic and population growth. We provide the model with spatial data on the size and location of electrified and non-electrified villages, taken from the Laos Population Census 2005. According to this data set there are over 2,700 non-electrified villages in Laos (see Table A2), spread across the Northern, Central and Southern Regions.

Figure A1. Insolation and transmission lines in Laos



The model then projects each village's population forward to the final year of the planning time horizon by applying different population growth rates to rural and urban areas based on the a defined urban-rural threshold of 5,000 people. The model applies the population growth rate every successive year till the planning year, and thus includes provisions allowing for a community to begin with a rural growth rate and transition to an urban growth rate as its population passes the urban-rural threshold (NRECA 2016).

Table A2. Village demographics and sources of electricity by province, 2011

Province/Village type/Land type	Number of villages	Average Number of Households per Village	Average Percent Farming Households	Percent of villages with electricity	Source of electricity (% of villages)					
					Electricity grid	Public generator	Private generator	Hydro generator	Solar cells	Other sources
Northern Region	3,601	90	89%	64%	39%	1%	2%	23%	3%	1%
Phongsaly	541	54	96%	54%	11%	2%	6%	44%	2%	-
Luangnamtha	356	82	90%	58%	47%	2%	1%	7%	5%	1%
Oudomxay	471	102	92%	50%	38%	1%	1%	9%	4%	-
Bolken	283	101	87%	70%	62%	1%	1%	4%	4%	1%
Luangprabang	783	93	81%	64%	46%	2%	2%	13%	2%	2%
Huaphanh	721	63	92%	79%	24%	1%	-	55%	1%	-
Xayabury	446	154	92%	71%	62%	1%	3%	5%	6%	-
Central Region	3,430	146	67%	76%	72%	2%	-	2%	2%	-
Vientiane Capital	490	270	32%	100%	99%	3%	-	-	1%	-
Xiangkhuaung	512	79	90%	58%	45%	-	-	10%	5%	1%
Vientiane Province	506	161	77%	90%	86%	3%	-	-	1%	-
Borikhamway	323	134	81%	86%	76%	2%	-	7%	2%	1%
Khammouane	587	111	79%	79%	75%	1%	1%	1%	3%	1%
Savannakhet	1,012	136	79%	64%	61%	1%	-	-	1%	-
Southern Region	1,631	122	79%	67%	56%	2%	1%	6%	4%	0%
Saravane	605	92	90%	65%	55%	3%	1%	3%	6%	-
Sekong	233	64	86%	58%	24%	3%	-	28%	3%	1%
Champasack	643	164	71%	78%	74%	2%	2%	2%	3%	0%
Attapeu	150	151	84%	41%	37%	1%	1%	1%	1%	2%

Source: Lao Census of Agriculture 2010/11: village component - village type data from Lao Statistics Bureau.

Table A3. Network Planner output data

	Scenario 4975	Scenario 4976	Difference
Unelectrified Nodes	N/A	N/A	N/A
off-grid nodes	409	162	-247
off-grid initial cost	\$129,871,070	\$64,417,325	\$-65,453,745
off-grid recurring cost	\$478,861,865	\$394,006,661	\$-84,855,204
off-grid cost	\$608,732,935	\$458,423,986	\$-150,308,949
off-grid cost levelized	\$0.52 / kWh	\$0.78 / kWh	\$0.26 / kWh
off-grid diesel fuel cost	\$150,700,054.46	\$231,337,592.34	\$80,637,537.88
Mini-grid nodes	173	389	216
Mini-grid initial cost	\$30,813,420	\$102,612,690	\$71,799,270
Mini-grid recurring cost	\$119,379,241	\$385,407,010	\$266,027,768
Mini-grid cost	\$150,192,661	\$488,019,700	\$337,827,038
Mini-grid cost levelized	\$0.44 / kWh	\$0.57 / kWh	\$0.13 / kWh
Mini-grid energy storage cost	\$28,759,975	\$71,907,522.54	\$43,147,547.18
Grid nodes	53	84	31
Grid initial cost	\$7,473,548	\$14,363,61	\$6,890,066
Grid recurring cost	\$34,966,996	\$64,528,007	\$29,561,011
Grid cost	\$42,440,544	\$78,891,621	\$36,451,077
Grid cost levelized	\$0.41 / kWh	\$0.46 / kWh	\$0.05 / kWh
Grid length existing	3,470,542 m	3,470,542 m	0 m
Grid length proposed	66,403 m	90,262 m	23,859 m
	Download	Download	

With population as the basis, the model uses mean household size, taken from the same Population Census and electricity demand per household, taken from the Laos PSDP 2004, to compute residential demand, with additional factors accounting for economic growth and the elasticity of electricity demand also taken directly from the PSDP. The model computes both peak demand (in kW) data and the total electricity demand (in kWh) for each village at the end of the specified time horizon.

Network Planner also uses a series of logistic curves to project non-residential demand from villages through commercial facilities, schools and clinics. Using demand estimates taken from the PSDP as a base year estimate, the model uses a simple logistic curve to predict the growth in electricity demand in the final year. The curve is based on empirical data of how the number of facilities scales with population. This is a useful way of localizing the model to the Laos context.

Network Planner is one of the most accessible off-grid modeling tools available, but has severe limitations. In particular, it is difficult to provide granular detail on resource quality and only a few resources are treated well within this model. Not all of the financial results are consistent

with current experience in rural electrification and off-grid systems. Furthermore, the functions used to determine projections of growth and the relationships between cost and system build out are not editable, so it becomes difficult to make the tool specific to the local context. An extension or rebuild of a Network Planner-type tool could be very useful for use in developing nations such as Laos. Nevertheless, the above results illustrate the potential for such tools to help officials in nations such as Lao PDR weigh the costs and benefits of various rural electrification strategies, and sort out which productive activities might be most favorable in remote areas given their expected electrification solutions.

Appendix III. Shannon-Weaver diversity

Measuring the extent of economic diversity is not a straightforward exercise, and is a relatively new field of inquiry, which draws on both ecological and information theory. Templet (1999) offers one attempt to empirically identify the nature and benefits of economic resilience. This work revolves around Shannon-Weaver diversity, with a familiar equation used across many fields (ecology, information theory, thermodynamics, etc.).

$$H = -\sum_i [p_i \ln p_i] \text{ (eq. 1)}$$

H here represents the diversity of an economic system—with an analogue to Shannon's (1948) original use of the Boltzmann entropy formula to represent *choice* or uncertainty. The p_i here represents the fraction of total energy in a system (or fraction produced by a system)—eg., a nation—flowing through a sector or compartment (Templet 1999: 225).

The intuition of this equation is that H, economic diversity, increases as 1) the number of compartments or sectors increases and 2) the balance (toward a completely uniform distribution) between sectors increases. Shannon (1948) points out that at complete uniformity of n compartments (all at $p_i = 1/n$), H becomes $\log n$. This is the state of maximum entropy, when uncertainty is maximized. The above is one way to measure evolution of a given system: for example, comparing the development of the economies of two states in the US—one resource heavy, with few ancillary services, the other more balanced between extraction and services. Templet (1999) performed such an exercise, also included an

energy throughput term with diversity, and found a strong correlation with growth. The scale of the energy throughput is included as a coefficient in Temple's "Capacity" measure.

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Notes

- ¹ Government of Lao PDR, Lao Decide Info: Informing Decisions for Sustainable Development; <http://www.decide.la/>.
- ² Government of Lao PDR, Laos Power System Development Plan, 2004, Annex 8, Demand Forecast.
- ³ Meeting with government officials, Vientiane, May 25, 2016.

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3

Hydropower Development in Lao PDR: Macroeconomic and Environmental Implications

*Phanhpakit Onphanhdala and
Vatthanamixay Chansomphou*

Lao PDR is heavily dependent on its rich natural resources to improve its economic performance. Industry, mining and electricity accounted for about 28.8 percent of its GDP in 2016, meanwhile the economy as a whole grew at a rate of approximately 7 percent (World Bank 2017). The explosive growth of the energy sector in the late 2000s has contributed in large part to this. Gross national income (GNI) per capita reached US\$1,740 in 2016, making Laos a lower-middle income economy (ADB 2017). Over the past decade, however, the country's inflation rate has averaged 5 percent annually, which implies that the Lao economy has not grown as much as these statistics seem to indicate. Indeed, being resource rich could possibly be seen as a 'curse' that increases economic volatility—for example, when an appreciation of the Lao kip due to electricity and mineral exports makes other exports less competitive in the world market. Fluctuations in energy and mineral prices, especially for copper and gold, could lead to macroeconomic instability, and hold back necessary infrastructural and human resource development.

Unlike minerals, hydropower development, harnessing the country's rivers and mountainous landscape, has been viewed as the key to sustainable economic growth for Laos. Revenues from hydroelectricity generation, including electricity exports and taxes, are expected to support macroeconomic stability and improve fiscal and trade balances. Furthermore, policymakers have argued that revenues from electricity will support wider infrastructure improvement, human resource development, and rural development. However, there are growing concerns regarding the financial, social and environmental costs of the planned extensive

hydropower development for three major reasons. First, the contribution of hydropower dams to the national budget has been relatively small so far, less than 5 percent of revenue in 2014–15. Second, hydropower development often requires the sacrifice of large land areas and the mass relocation of local inhabitants, their homes, farms, assets and livestock, adversely affecting their livelihoods. Finally, dams can sometimes cause rather than prevent flooding downstream in the rainy season as well as droughts in the dry season. Large hydropower dams may also have negative impacts on biodiversity and vital ecosystems necessary for food security.

While some locals might be better off from the infrastructural improvements brought about by a large hydropower development, most will be worse off due to losing their farmland and access to the natural resources that are fundamental to their livelihoods. Despite their projected long-term contribution to economic growth, hydropower projects are costly both financially and environmentally. This chapter examines the interconnections between the aggregate impacts of dam development on the national budget and the environment. It addresses three key areas of hydropower development in Lao PDR: its macroeconomic implications, its environmental impact, and how to maintain plans for the sector for continuing economic growth while minimising its negative effects.

In order to identify the economic and environmental impacts of hydropower in Lao PDR, two major projects, Nam Ngum 2 and Nam Ngiep 1, will be used as case studies. This study is based on reviewing dam feasibility studies, and research literature and other relevant documents rather than interviews with affected villagers. It is still difficult to access data and direct information about these hydropower projects: many official documents related to the building and operation of Lao hydropower dams are not publicly disclosed and using them would be regarded as violating the National Hydropower Policy of Lao PDR (International Rivers 2008).

Table 3.1 shows the categories of power plants, including hydropower dams, in Lao PDR referred to in the Law on Electricity, which was first promulgated in 1997. Dams were categorised according to their regulatory authority, with the largest ones under the National Assembly, the next largest under the Central Government, medium sized-ones under provincial governments, and the smallest under local/district authorities.

The Law on Electricity provides dam investors initial concession terms of up to 30 years, with the possibility of an extension of up to 10 years. Nevertheless, the Law does not specify in what condition and how operational a dam should be when its ownership is transferred back to the state. Moreover, it is important that the Law should emphasize proper compensation, especially to those who are resettled to make way for a dam. In 2008, the Law on Electricity was first revised. It was similar to the previous one in terms of concessions, but each category of dam was enlarged. The Law on Electricity was most recently updated in 2011. The concession term remains 30 years, but the law stipulates there will be no further extension to ensure the dams will be in good operational condition when handed back to the Government of Laos (GOL). The most significant difference when compared to the 2008 version is that even the larger dams must be transferred to operate under local (provincial level) government supervision. This seems to be a sign of decentralization (table 3.1).

Table 3.1: Categories of hydropower/power plants in Lao PDR

Authority	1997 version	2008 version	2011 version
District	≤ 100 KW ^a	≤ 100 KW	≤ 100 KW
Provincial	101 KW–1.9 MW ^b	101 KW–4.9 MW	101 KW–50 MW
Central Govt.	2 MW–50 MW	5 MW–100 MW	50 MW–100 MW
National Assembly	> 50 MW	> 100 MW + 10,000 ha water reservoir	> 100 MW + 10,000 ha water reservoir
Concession terms		30 years	30 years
Extension		≤ 10 years	–

Notes: ^aAuthorized in Special Zone; ^bauthorized by provincial government/municipal authority and Ministry of Industry and Handicraft.

Sources: GOL, Law on Electricity, 1997, 2008 and 2011.

Table 3.2: Hydropower/power plants size

Size	Authority	Installed capacity
Small	EDL and EDL-Gen	≤ 15 MW
Medium		15 – 40 MW
Large	Central Government	> 40 MW

Source: EDL-Gen unpublished documents.

Table 3.2 shows that small and medium-sized power plants with less than 40 MW installed capacity are managed by Électricité du Laos (EDL) and EDL-Generation and all above that are directly under GOL authority. However, there are some exceptions when a large hydropower dam is authorized by EDL and EDL-Generation under central government supervision, for example, the Xayaboury Dam on the Lower Mekong.

The Lao government plans to build many more power plants, especially hydropower, for domestic and international electricity demands. The Ministry of Energy and Mines (MEM 2016) reports that there are 50 hydropower dams under construction, which are expected to be operating by 2020. They will generate over 25,000 GWh of electricity annually. By 2030 the GOL aims to develop approximately 91 hydropower projects all over the country and an additional 246 projects for which memorandums of understanding (MOUs) have already been signed.

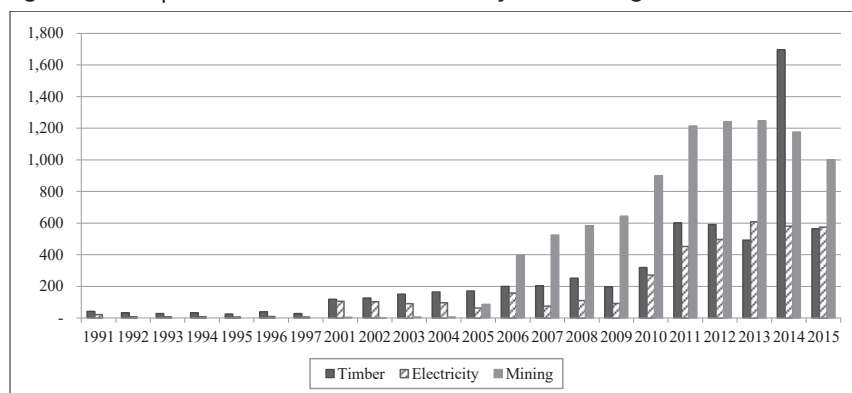
Hydropower dams in Lao PDR

The contribution of hydropower to Lao exports has been quite small and fluctuating, approximately averaged US\$180 million per annum between 1991–2015 (fig. 3.1). During the Asian Financial Crisis, this contribution decreased to US\$6 million in 1997 (from about US\$22 million in 1991). In the 2000s, hydropower exports gradually increased to approximately US\$100 million per annum on average due to the increasing number of hydropower dams and promotion of electricity to its neighbors in the Fifth (2001–2005) and Sixth (2006–2010) National Socio-Economic Development Plans. In 2010, the value of electricity exports doubled to around US\$272 million; this figure has continued rising sharply due to large hydropower projects such as Nam Theun 2, Nam Ngum 2 and the Theun Hinboun Enlargement. Since then, however, despite rising revenues from electricity exports, the sector's overall contribution to GDP has remained minor.

Hydropower revenue

Table 3.3 illustrates government revenue and grants between FY1990/91 and FY2015/16. Overall, revenue growth was clearly positive and rose sharply twice between FY2010/11 and FY2015/16. Tax revenue contributed

Figure 3.1: Export value of timber, electricity and mining, 1991–2015 (US\$m)



Sources: Bourdet (2000), BOL (2016) and Trade Map (2016).

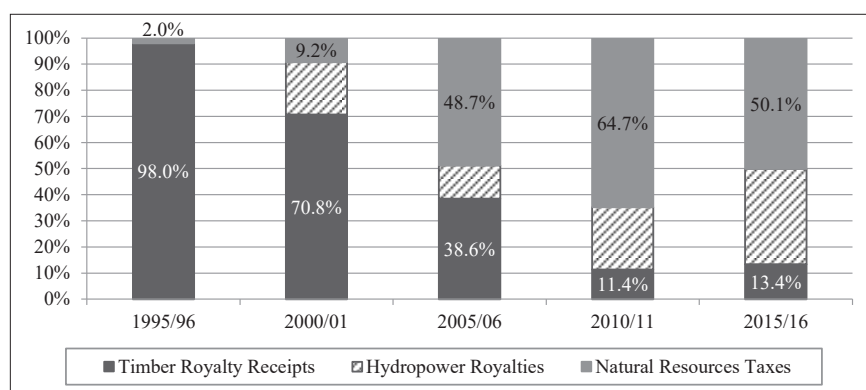
Table 3.3: Government revenue between FY1990/91 and FY2015/16 (US\$ m)

	1990/91	1995/96	2000/01	2005/06	2010/11	2015/16
Revenues and Grants	8.4	27.5	275.1	526.1	1,731.1	2,583.2
Revenues	6.1	21.7	222.3	422.5	1,268.9	2,346.9
Tax Revenues	3.8	17.6	181.0	360.6	1,135.2	1,999.9
<i>Profits Tax</i>	0.8	2.1	22.8	45.4	67.7	215.8
<i>Income Tax</i>	0.0	1.4	17.0	23.2	67.7	196.0
<i>Land Tax</i>	0.2	0.2	1.9	3.0	12.2	12.9
<i>Business Licenses</i>	0.1	0.0	0.0	0.6	0.0	n/a
<i>Minimum Tax</i>	n/a	n/a	n/a	2.2	5.2	n/a
<i>Turnover Tax</i>	0.7	3.4	35.3	87.9	63.6	n/a
<i>VAT</i>	n/a	n/a	n/a	n/a	235.9	557.4
<i>Excise Tax</i>	n/a	1.6	41.3	79.3	242.7	447.3
<i>Import Duties</i>	0.5	4.1	19.9	51.0	120.2	243.8
<i>Export Duties</i>	1.3	0.6	6.3	5.3	14.3	8.5
<i>Registration Fees</i>	n/a	0.2	1.7	2.5	6.9	9.1
<i>Other Fees</i>	0.2	0.7	7.9	16.1	66.4	184.7
<i>Natural Resources Taxes</i>	n/a	0.1	2.6	21.5	65.7	62.4
<i>Timber Royalty Receipts</i>	n/a	3.5	20.2	17.1	11.6	16.7
<i>Hydropower Royalties</i>	n/a	n/a	5.7	5.7	24.3	45.4
Non-Tax Revenues	2.3	4.1	41.3	61.9	133.7	347.0

Sources: BOL, Annual reports (1996–2016).

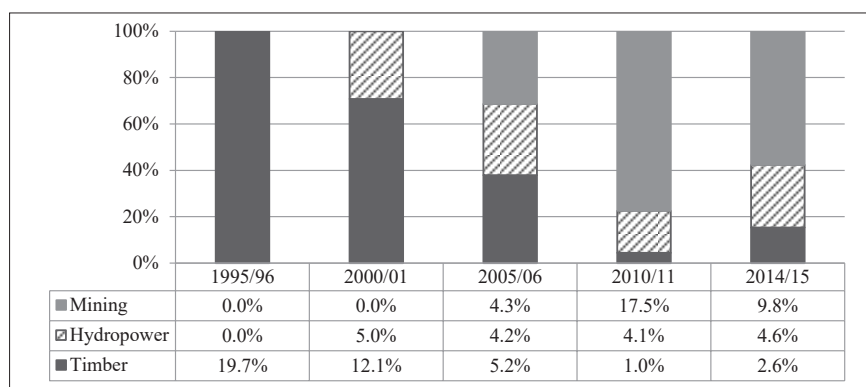
over half of the total income. On average, government revenue has been increasing at the rate of about 30 percent annually since 1991. Notably, natural resource taxes, timber royalties and hydropower royalties are not large elements in the government revenue. Collectively, they accounted for only about 5.3 percent for total revenue (table 3.3).

Figure 3.2: Share of direct tax from timber, electricity and mining, 1995–2016



Sources: BOL, Annual Reports, 1995–2016.

Figure 3.3: Natural resource revenue (direct and indirect tax) as % of government revenue (not including grants), 1995–2015. Based on BOL, Annual Reports (1995–2015), EDL Electricity Statistics (2016), Phu Bia Mining (2016), and MMG (2016).



Figures 3.2 and 3.3 show the distribution of income from natural resources in government revenues. Taxes on hydropower include royalties, profit tax, income tax, import tax, turnover tax and dividend (non-tax) revenue. Compared to mining and timber, however, the proportion of hydropower-derived tax was relatively small and remained constant at around 4 percent. The Lao mining sector was seen as responsible for the volatility in the national budget. The GOL, thus, attempted to develop hydropower with a cumulative investment value of around US\$1,100 million in 2012 (MPI 2013). In FY2014/15, however, the share of revenue from hydropower did not even reach 5 percent, because many hydropower projects have been exempted from tax, leading to large losses of potential revenue.

Table 3.4: Government expenditure between FY2000/01 and FY2015/16 (US\$ m)

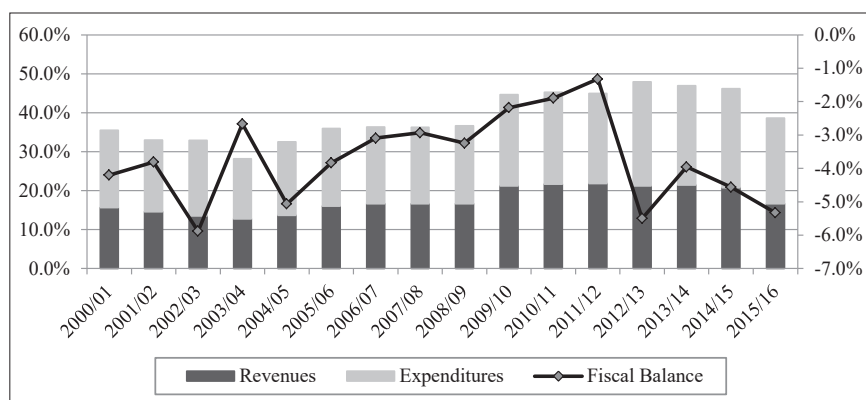
	2000/01	2005/06	2009/10	2010/11	2012/13	2014/15	2015/16
Total Expenditure	724.9	830.0	1,689.6	1,882.3	2,740.5	2,879.9	2,710.6
Current expenditure	283.7	458.5	877.4	985.3	1,767.6	1,750.8	1,770.9
Wages and salaries	13.1%	20.4%	20.1%	19.5%	36.0%	29.5%	n/a
Transfers	11.1%	9.0%	11.6%	12.4%	8.9%	8.4%	n/a
Materials and supplies	10.5%	8.6%	8.9%	9.5%	6.9%	10.1%	n/a
Debt payment	n/a	5.3%	5.0%	4.3%	8.2%	6.2%	n/a
Interest payment	4.3%	4.2%	3.0%	3.0%	4.1%	3.9%	n/a
Others	0.0%	0.0%	3.3%	2.4%	0.4%	0.8%	n/a
Off budget expenditure	0.0%	0.0%	0.0%	1.3%	0.0%	0.0%	n/a
Capital expenditure	478.1	371.5	812.2	897.0	975.2	1,030.1	937.7
Local finances	27.8%	6.1%	12.9%	12.2%	10.1%	11.2%	n/a
Foreign finances	38.2%	38.6%	35.2%	35.5%	25.2%	24.5%	n/a

Sources: BOL, *Annual Reports* (2000–2016).

Table 3.4 illustrates real expenditure between FY2000/01 and FY2015/16. In general, government spending has been rising and there were two significant changes in FY2009/10 and FY2012/13. First, in 2009, the GOL invested heavily on infrastructure improvements for the 25th SEA Games in Vientiane (from about US\$830 million in FY2005/06 to US\$1,690 million in FY2009/10). Second, there was another increase in public spending to US\$2,740 million in FY2012/13, with civil servants receiving monthly allowances of 760,000 kip (around US\$95) and the cost of hosting the Asia-Europe Meeting in late 2012.

With current patterns of revenue and expenditure, the budget will continue to see massive deficits (fig. 3.4). Mining revenues are the major source of economic growth, but are subject to market price volatility, as explained. Therefore, the GOL is opting to develop more hydropower dams to increase revenue and narrow the budget deficit.

Figure 3.4: Fiscal balance as percentage of GDP



Source: BOL, Annual Reports (2000–2016) and World Bank (2016).

Regulating the dams

Tables 3.5 and 3.6 show the potential environmental and social impacts of both storage and run-of-river hydropower schemes, respectively.

Several regulations relating to environmental and livelihood protection have been passed to minimize the potentially adverse effects of hydropower, including the Law on Water and Water Resources (1996), Forestry Law (2007 updated), Land Law (1997, amended in

Table 3.5: Potential environmental impacts of different hydropower schemes

Environmental impacts	Type of plant	
	Storage	R-O-R
Positive		
• Produces no atmospheric pollutants.		✓
• Neither consumes nor pollutes the water used for electricity generation.		✓
• Avoids depleting non-renewable fuel resources (i.e., coal, gas, oil).	✓	✓
• Very few greenhouse gas emissions relative to other large-scale energy options.	✓	✓
• Can create new freshwater ecosystems with increased productivity.	✓	
• Enhances knowledge and improves management of valued species due to study results.	✓	✓
• Can result in increased attention to existing environmental issues in the affected area.	✓	✓
Negative		
• Inundation of terrestrial habitat.	✓	
• Modification of hydrological regimes.	✓	✓
• Modification of aquatic habitats.	✓	✓
• Water quality needs to be monitored/managed.	✓	
• Greenhouse gas emissions can arise under certain conditions in reservoirs.	✓	
• Species activities and populations need to be monitored/managed.	✓	✓
• Barriers for fish migration.	✓	✓
• Sediment composition and transport may need to be monitored/managed	✓	✓
• May open up remaining remote & pristine areas & refuges to human access.	✓	

Notes: R-O-R stands for run of the river. ✓/indicates that the impact could occur/has already occurred, based on the information of previous studies/reports.

Sources: Adapted from Branche (2015) and Norplan (2004).

Table 3.6: Potential social impacts of different hydropower schemes

Social impacts	Type of plant	
	Storage	R-O-R
Positive		
• Leaves water available for other uses.	✓	
• Often provides flood protection.	✓	
• May enhance navigation conditions.	✓	
• Often enhances recreational facilities.	✓	
• Enhances accessibility of the territory and its resources (access roads and ramps, bridges).	✓	✓
• Provides opportunities for construction and operation with a high percentage of local manpower.	✓	✓
• Improves living conditions.	?	?
• Sustains livelihoods (freshwater, food supply).	?	?
Negative		
• May involve resettlement.	✓	✓
• May restrict navigation.	✓	✓
• Local land use patterns will be modified.	✓	✓
• Waterborne disease vectors may occur.	✓	?
• Requires management of competing water uses.	✓	✓
• Effects on impacted peoples' livelihoods need to be addressed, with particular attention to vulnerable social groups.	✓	✓
• Effects on cultural heritage may need to be addressed	✓	✓

Notes: R-O-R stands for run of the river. ✓/indicates that the impact could occur/has already occurred, based on the information of the previous studies/reports. ? implies that the impact is ambiguous.

Sources: The list of impacts is adapted from Branche (2015), Norplan (2004).

2003), Agriculture Law (1998), and Environmental Protection Law (1999, amended in 2012). According to the Environmental Protection Law, and the Decree on Environment and Social Impact Assessment No. 112 (2010), for instance, hydropower projects with an installed capacity of more than 15 MW must produce an Environmental and Social Impact Assessment (ESIA) report and an Environmental Management Plan (EMP). The Law on Electricity (2011) further stipulates that investors in electricity production have an obligation to protect the environment and take into account social considerations. In addition, the Decree on Compensation and Resettlement of People Affected by Development Projects was endorsed in 2005 and the Technical Guideline on Compensation and Resettlement of Development Project was released in 2010.

In 2006, the National Policy on Environmental and Social Sustainability of the Hydropower Sector in Lao PDR was endorsed by the government. The policy capitalized upon the principles of the Nam Theun 2 Hydropower Project, setting them as the standard for ongoing and future projects. Furthermore, the integrated river basin management approach was encouraged to be practiced where multiple projects are planned along a single river (Science Technology and Environment Agency 2006).

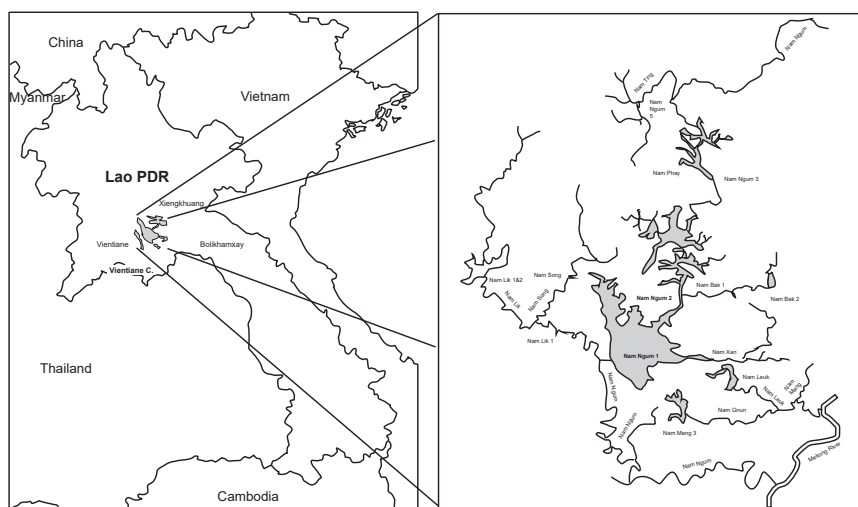
Economic impacts of large-scale hydropower: Nam Ngum 2 and Nam Ngiep 1

Despite the existence of these laws and regulations, both Nam Ngum 2 and Nam Ngiep 1 have been criticized for the lack of adequate compensation for those who were resettled to make way for the dams and hydropower stations. Secondary data were obtained from academic papers, newspaper articles, conference proceedings and assessment reports to examine the economic implications of the dams for local villagers as well as for national revenue.

Nam Ngum 2

Nam Ngum 2 is located within the Nam Ngum river basin, on the Theun River, a tributary of the Mekong River in Vientiane province, Central Laos. This project is approximately 90 km north of Vientiane and 35 km

Figure 3.5: Location of Nam Ngum 2



Sources: Compiled from the Ministry of Energy and Mines (2014) and Environmental Justice Atlas (2015).

upstream of Nam Ngum 1 dam (see fig. 3.5). Commercial operation of this project began in 2013. Thailand is the main shareholder of the project and consumer of its hydropower (see further table 3.7).

Controversy over Nam Ngum 2 focuses on its resettlement and compensation schemes as well as its impact on important fisheries. The dam's catchment and reservoir at full capacity would cause flooding and other adverse impacts on 16 villages nearby, requiring the resettlement of a large number of people. International Rivers (2009) reports that around 6,000 villagers, mainly ethnic minorities, had been resettled 100 km away from their homes. However, 41 households were unwilling to leave (Aphibunyopas 2010), fearing the potential loss of their religious and cultural identity in the ethnic Lao villages where they were supposed to resettle. International Rivers (2009) also reported that Nam Ngum 2 would impact the fishery yields of the Nam Ngum 1 reservoir, a source of food and income for more than 9,000 people.

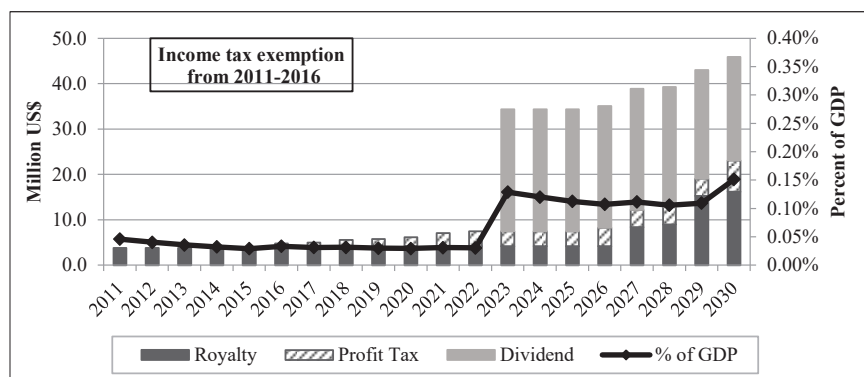
Table 3.7: Key features of Nam Ngum 2

Location	River: Nam Ngum Province: Vientiane
Commercial Operation Date	2011
Concession Term	25 years
Market	Thailand
Installed Capacity	615 MW
Average Annual Energy	2,218 GWh/year
Project Type	Reservoir
Catchment Area	5,640 km ²
Reservoir Area	100 km ²
Reservoir Volume	4,230 million m ³
Height	185 m
Resettlement	Yes
Shareholders	Ch Karnchang Co. Ltd (Thailand) 28.5% EDL-General 25% Ratchburi Electricity Generating Holding Plc (Th) 25% Bangkok Expressway PCL (Th) 12.5% Shlapak Group (US) 4% PT Construction & Irrigation Co. (Laos) 4% TEAM Consulting Engineering 1%

Source: Adapted from PÖYRY 2017.

The resettled villagers were promised compensation for the loss of their rice fields based on size. Sengkhram (2007) reveals that a one-hectare rice paddy, yielding about 2,000 kg of rice per annum, would be compensated with 2 million kip (roughly equal to US\$2,001 at the time of writing) per household per year. The compensation was to be paid for ten years and set as a fixed rate at the beginning. This amount could only buy 274 kg of their staple food, sticky rice, at average market prices (7,312 kip or US\$0.9 per kg) in 2014 (LSB 2015).

Figure 3.6: Projection of Nam Ngum 2 Revenue Contribution to the GOL, 2011 to 2030



Source: Based on World Bank projection in 2014 etc.

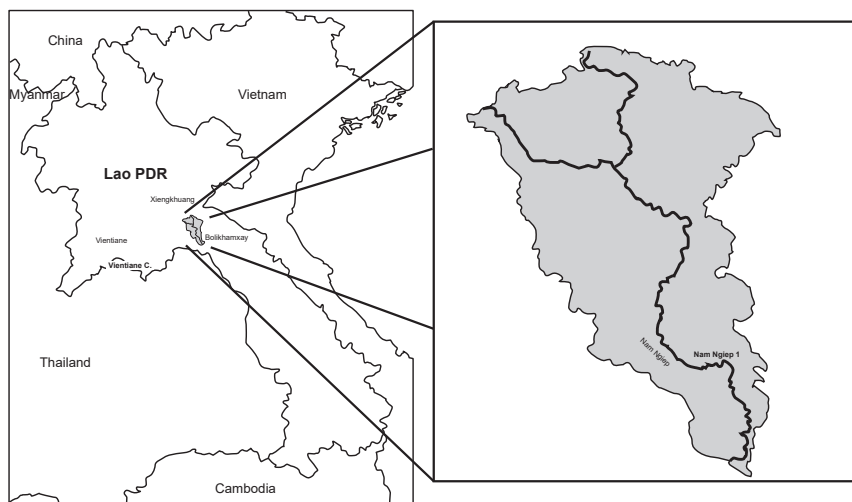
Figure 3.6 demonstrates projected revenue from Nam Ngum 2 between 2011 and 2030. It includes royalty fees, taxes on profits and dividends. Nam Ngum 2 was built at a cost of roughly US\$832 million, largely financed by Thai commercial banks and the Export-Import Bank of Thailand (International Rivers 2009). The project was granted exemption from corporate income tax for five years from the Initial Operating Date. The royalty fee is approximately US\$3.8 million annually and expected to grow more than fourfold by 2030. The largest proportion of hydropower revenues is from dividends. This might imply that the GOL can generate more income by increasing their share of such projects. However, it is worth noting that there is a risk in depending on the hydropower royalty from Nam Ngum 2 as it is very small—projected at less than 0.2 percent of GDP in 2030.

Nam Ngiep 1 hydropower project

Nam Ngiep 1 is located in Bolikhamxay and Xaysomboun provinces, 145 km away from Vientiane, with a total installed capacity of 290 MW (fig. 3.7). The electricity will be mainly exported to Thailand (NNP1 2017). According to the feasibility study conducted by Nippon Koei in 2002, the project would affect 13,000 villagers indirectly and 4,359 villagers directly upstream and downstream of the dam site (Johnston 2012). Those most directly affected by the dam are Hmong. Moving from living in the

highlands to the lowland resettlement site will affect their cultivation and lifestyle as their livelihoods and culture rely on hunting and collecting forest products. Although the resettled Hmong households were promised access to 400 ha of paddy land, 400 ha of land for other crops, and an electricity supply, they are reluctant to relocate to Lao host villages (ibid. 2012).

Figure 3.7: Location of Nam Ngiep 1 Hydropower Project



Source: Authors compiled from NNP1 (2017).

Nam Ngiep 1 is expected to cost approximately US\$900 million, and will be funded mostly by Asian Development Bank (ADB) and Japan Bank of International Cooperation loans (International Rivers 2014). During the 27 years of the concession, this project will be expected to contribute US\$600 million through royalty fees, taxes and dividends to the Lao Holding State Enterprise, with the government as shareholder (NNP1 2017). The GOL will earn around US\$22 million annually in taxes from Nam Ngiep 1.

Figure 3.8 shows projected revenue from Nam Ngiep 1 up to 2030. The pattern of royalties, profit taxes and dividends are similar to those of Nam Ngum 2. The hydropower royalty begins with US\$3.9 million in the first year of commercial operation and hits its peak at around

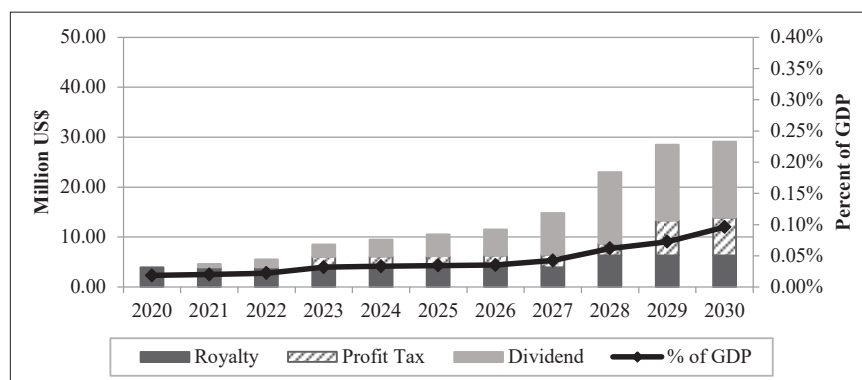
US\$6.3 million per year. The largest proportion of revenue will come from dividends. As a shareholder, the government will receive about US\$0.7 million in 2021 and US\$15.2 million in 2030. Although on average this project will contribute approximately US\$13.6 million a year, it will account for just 0.1 percent of total revenue in 2030.

Table 3.8: Key features of Nam Ngiep 1 project

Location	River: Nam Ngiep Province: Bolikhamxay and Xaysomboun
Commercial Operation Date	2019
Concession Term	27 years
Market	Thailand
Installed Capacity	290 Mw
Average Annual Energy	1,546 Gwh/year
Project Type	Reservoir
Catchment Area	3,725 km ²
Reservoir Area	67 km ²
Reservoir Volume	1.2 billion m ³
Height	167 m
Resettlement	Yes
Shareholders	KPIC Netherland B.V.* 45% EGAT International (Th) 30% Lao Holding State Enterprise 25%

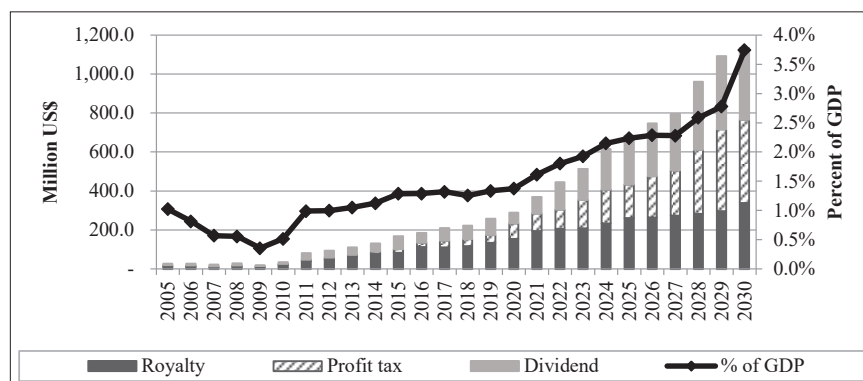
Source: NNP1 (2017).

Figure 3.8: Projection of Nam Ngiep 1's contribution to revenue, 2020–30 (World Bank 2014)



The World Bank's projected revenues from potential dams reveals that the GOL will earn over US\$200 million from this sector in total in 2017; this is projected to reach US\$1,135 million in 2030. Hence, revenues from hydropower in terms of royalties, profit taxes and dividends would appear to sharply rise (see fig. 3.9). Yet, despite more than 90 planned hydropower dams by 2030, it seems that hydropower dams might not be able to narrow the fiscal imbalance due to their relatively small overall contribution. This is due to weak project management and progressively weaker participation of relevant stakeholders in each project: building more dams might not guarantee a stable revenue stream. Put differently, the expected revenue from hydropower does not align with the number of dams being planned. Therefore, further research is needed not only on how many dams should be built, but how to maximise their contribution to the GDP of Laos and minimize their negative impacts.

Figure 3.9: Projections of hydropower royalties in Laos, 2005–2030



Source: World Bank projection in 2014.

Environmental and social impacts

Nam Ngum 2 Hydropower Project

Environmental impacts. Nam Ngum 2 Hydropower Project is located in the Nam Ngum River basin within which six dams have been already constructed and three others are under construction or planned. In fact, many are concerned about the cumulative environmental and social impacts of the various projects in this area, from mining, hydropower,

tree plantations to other types of land use (Lagerqvist et al. 2014). Nam Ngum 2 project is expected to inundate a vast area, change hydrological flows, affect water quality, and change terrestrial and aquatic habitats, and therefore agricultural activities and fisheries. When the construction of Nam Ngum 2 dam started in 2006, many observers were already concerned about its impacts on the water quality and quantity in the nearby Nam Ngum 1 reservoir (on the same stream). The water level in the Nam Ngum 1 reservoir actually dropped when the dam was completed and the reservoir was first filled at the end of 2010. Other downstream impacts include the reduction of fish stocks in the Nam Ngum 1 reservoir, which is a major source of food for more than 9,000 people (International Rivers 2010; cited in Environmental Justice Atlas 2015).

Impacts on communities, land and property. The construction of Nam Ngum 2 has had significant impacts on vast areas and a large number of people. These include 1,099 families from 16 rural villages, the majority of which were Khmu (68 percent), followed by Lao (30 percent), and Hmong (2 percent). The reservoir inundated about 500 ha of paddy fields, 300 ha of orchards, and 80 ha of individually managed pasture land, vegetable gardens, community pasture land, fish ponds, and community forest. In addition, it inundated existing public infrastructure, including 4 km of irrigation, 53.3 km of National Road No. 5,¹ 23 secondary schools, a district hospital, 14 government offices, and 8 temples. The project has also affected residential land and private properties, including hundreds of homes, 71 rice mills, 75 shops, 9 restaurants, 16 blacksmiths, a furniture maker, a sawmill and weaving studio (Syladeth and Guoqing 2016).

Compensation. Of the affected households, 1,053 households were relocated to Phonsavath village, Feuang district, Vientiane province;² where each household received some cash, a newly built two-storey wooden house on a 600 m² block of residential land with a 0.5-ha piece of land for agriculture, while 46 other households chose to take only cash in compensation and resettled elsewhere. Those who lost their paddy fields were given a choice of either farmland-to-farmland compensation or farmland-to-cash at the rate of about \$5,250/ha. As well, those who lost their productive land and plantations received some compensation in

cash. In addition, in the recipient Phonsavath cluster, the infrastructure was improved to support the newcomers: the developer provided a new paved road, electricity, a water supply and other public facilities. During the transitional period, resettled families could enjoy these facilities free of charge (Syladeth and Guoqing 2016).

Livelihood changes and adaptation. Since resettlement, however, some households have found it difficult to adapt to their new lifestyles in a different part of the country. Prior to resettlement, most of the affected people had agrarian livelihoods, as subsistence farmers who earned some income from upland rice, paddy, fruits, vegetables, in addition to raising livestock, fishing, hunting, collecting non-timber forest products (NTFPs), and producing handicrafts for sale. After resettlement, they have had to learn to engage in commodity production, trade and services. In order to improve, or at least restore, the livelihoods of those displaced by Nam Ngum 2, the resettlement project provides short-term and long-term livelihood restoration programs, including activities such as fishing, livestock raising, craft, and other related works. Unfortunately, agricultural land in the resettlement area is limited and parts of it had already been developed for cattle grazing and upland rice farming by local people. Therefore, the location and quality of the 0.5-ha farmlands allocated to the resettled households were not suitable for cultivating rice or vegetables. Some resettled households were granted farmland that is too far away from their new homes, while others found that the soil was of poor quality and needed substantial investment to try to turn it into productive farmland. Only a few households that received higher compensation for their land and livestock could buy productive land in the resettlement area (Lagerqvist et al. 2014). Therefore, many families faced a lack of both agricultural land and capital to invest to improve it, and had to turn to service activities within the resettlement area or elsewhere.

Nam Ngiep 1 Hydropower Project

Environmental impacts. Nam Ngiep 1 Hydropower Project has already had several impacts on the environment. The project caused a loss of 4,000 ha of natural habitat and 3,500 ha of modified habitat (NNPI 2017b). Some parts of the project area contain important and inaccessible forests rich in native flora and fauna; some 35 percent of the project footprint was

deciduous forest. Nam Ngiep 1 is located adjacent to two national parks, Phou Khao Khoay National Biodiversity Conservation Area and Nam Kading National Protected Area. In addition, a number of fauna species and 13 species of plants listed as critically endangered, endangered or vulnerable under the IUCN Red List of Threatened Species are found in the area. Fortunately, most of the project components and inundated areas are on the lower slopes or in the valley, while most of the endangered wildlife are only found up in the mountains due to previous hunting and shifting cultivation (Environmental Resource Management 2014).

Indeed, Nam Ngiep I is anticipated to cause adverse environmental impacts at different stages of its lifetime. During the six-year construction period, temporary fluctuations of water flow were expected in the Nam Ngiep River. The construction will increase soil erosion and increase sediment loads in the area. It could increase traffic, noise, dust and vibration, which would disturb wildlife. The inundation period, lasting three years, will cause the increase of sediment, and eutrophication and proliferation of exotic aquatic weeds. It will also change the downstream water quality and hydrological patterns. Then, during the operation of the dam, there will be a loss of habitat for certain terrestrial and aquatic wildlife species, changes in the river flow during wet and dry seasons, and changes in river morphology downstream and upstream and along tributaries (Nam Ngiep 1 Power Company 2017a).

Impacts on communities, land and property. In early 2014, preparations for the project began. In total 23 villages along Nam Ngiep River are anticipated to be affected by the project directly and indirectly. Among these, 8 villages, located upstream along the river bank, would have to comply with watershed management policies that would affect their use of forest and water resources. Some households of three villages located in the upper part of the reservoir had to give up their productive land and required compensation, while another eight households had to move to a higher elevation as their homes and gardens were to be flooded. In the lower reservoir area, residential and productive lands of four villages, including 384 households, will be inundated; thus, whole villages have had to be relocated. At the dam site itself, the construction and inundation of the re-regulation reservoir required all 33 households to be relocated; they received compensation for the loss of their homes, residential land,

productive land and other assets. Nine more villages, located downstream, are expected to be affected by changing water levels, water quality, water temperature, and the erosion of river banks. Apart from that, 21 households at two host villages had to give up some of their land for the resettlement communities. In addition, some households located along the transmission line and access road had to give up their land and/or other assets, including residential land, paddy fields, upland rice fields, fish ponds, and farm land. In addition, the dam area displaced community managed and reserved forests, protection and unstocked forests, and parts of a buffer zone. Public facilities that were lost include schools, temples, village health centers, cemeteries, and other public land (Nam Ngiep 1 Power Company 2014; Somsoulivong 2017).

Compensation. The compensation offered to affected people varies depending on the types of assets and facilities lost. Upstream communities are supposed to receive support for implementing watershed management programs. Households whose land will be inundated received compensation in cash. Those who had to be relocated could choose to move into the designated resettlement area and receive compensation in kind or choose to resettle elsewhere and receive full compensation in cash. The resettlement program began in early 2015 and was expected to be completed in April 2018. The Houy Soup area in Bolikhan district, Bolikhamxay province, on the opposite bank of the Nam Ngiep River, was chosen as a resettlement area. About 6,000 ha of land was given for new resettled households. Approximately 400 1,000 ha was allocated for residential land, irrigated paddy fields and upland rice fields, pasture land, cash cropping, and commercial tree plantations. Nevertheless, there are concerns over the soil quality in the relocation areas; therefore, the project developer provided soil improvement programs. Affected people also gained public infrastructure, social services, and economic and social development programs, to ensure that their standard of living is at the same level, if not better than it was before the project (Somsoulivong 2017; Nam Ngiep 1 Power Company 2017c). A new road will connect the resettlement villages and the capital of Bolikhamxay. The developers have also pledged to provide the resettled villagers with improved social services and livelihood development assistance (Nam Ngiep 1 Power Company 2014).

Livelihood change and adaptation. Most of those affected are Hmong who still practice shifting cultivation. They grow rice, fruit, and vegetables. They also raise buffaloes and cattle and some of them also hunt and collect NTFPs. Being resettled would force them to change their lifestyle. In fact, prior to the start of the project, people who were told that their villages would be relocated suffered mental and physical stress and other health complications. Some Hmong villagers are concerned about losing important aspects of their culture and identity. The affected people have also complained about the poorer quality of the soils in the Houay Soup area. They think that the land size—6,000 ha for village use with 400 ha for houses—is inadequate for the 438 Hmong households with about 3,000 persons. Unlike the Hmong, the lowland Lao people of the host villages are positive and welcome the project, because they think that it will bring new infrastructure such as a road, electricity and water supply, a health center, school, etc. (Zola 2013). The Houay Soup resettlement site has good quality housing, home gardens and agricultural land, utilities, a clinic, school, market, bus service and roads. The developers have established a demonstration farm, where resettled households can visit to look at livelihood activities in the area (Nam Ngiep 1 Power Company 2017).

Discussion and policy implications

Hydropower dam development brings both benefits and losses to the Lao economy. The Lao government earns revenue from electricity exports and taxes. However, the contribution from hydropower dams is relatively small as a proportion of overall GDP. On the other hand, hydropower development entails major social and financial challenges. Is it worth constructing more dams? Many might conclude that there should not be more hydropower dams built in Laos. Yet the country cannot ignore the need for electricity and economic development, and hydropower dams can provide long-term benefits. Good maintenance will extend the life of the dams.

There are three major points to discuss here. First, domestic investment and shareholding of hydropower dams as well as EDL and EDL-Gen should be expanded. The government has had to allow more foreign investors to invest in the energy sector. Given the current dominance of foreign investors, it is crucial to absorb technological know-how and ensure skills transfer from foreign experts to local partners. This will help

Laos become more independent in terms of technical management and increase the country's participation in hydropower projects and increase income not only in terms of royalty fees and taxes, but also from the export of electricity. Second, Laos has not benefited from taxes on the dams due to the tax exemptions on existing and up-coming hydropower projects. Tax exemptions must be reduced and fiscal administration must be strengthened. In addition, as a first step, it is important to look at renegotiating the electricity price with Thailand. This will help narrow the fiscal deficit.

Finally, it is important to study the environmental, social, and ecological impacts of the hydropower dams. These costs should also be taken into account when evaluating the worth of each project as well as the overall strategy, to ensure that the revenue gained from hydropower is not negated by more substantial or long-term negative impacts and losses.

Environmental and social aspects

Although hydropower is seen as a clean source of energy that can generate significant revenue, it has a significant environmental footprint. It also has adverse social impacts unless the projects are well managed and effectively implemented throughout the construction and life of a dam. Therefore, the enforcement of appropriate legal requirements and guidelines is indispensable. In Lao PDR, the government has pledged to apply the principles of Nam Theun 2 Hydropower Project—including conducting a full ESIA and EMP; identifying affected people and the loss of their assets, resources and livelihoods altered by the hydropower project; funding and implementing effective conservation management; ensuring public involvement in environmental and social assessment; publicly disclosing project consultation reports, impact assessments, mitigation plans, and monitoring reports, and so on—as the standard for other ongoing and planned hydropower projects.

The case studies of Nam Ngum 2 and Nam Ngiep 1 revealed that large land areas are needed for inundation for reservoirs and other main components and infrastructure required for the dams as well as for the transmission of the electricity generated. As such, existing productive land, forest, habitats, flora and fauna, and general biodiversity are often sacrificed as part of a hydropower project. This *environmental cost* is not being properly valued and generally not factored into calculations of a

hydropower project's total cost. Another cost that is difficult to evaluate is the *social cost*, which is incurred mostly due to the displacement of affected people. With adequate assessment methods, good management plans and effective implementation, these two costs could be minimized. But for that to happen, there needs to be considerable investment by the public sector and by the developers. From the analysis, the Nam Ngum 2 project seemed to entail higher environmental and social costs than its Nam Ngiep 1 counterpart, although, as stated in the beginning there is limited information about the environmental and social impacts, management and resettlement plan of this dam.

Finally, apart from looking merely at project-level environmental and social impacts, it is imperative to assess the bigger picture. Hundreds of dams are currently planned for Laos, along with several major investment projects such as mining, and large-scale agricultural and industrial projects. Developing so many natural resource projects will surely have immense and possibly unforeseen interactive or cumulative effects. To evaluate these effects, using tools such as SEA and SEEA is ideal. SEA will provide visual and qualitative information of the economic benefits and environmental and social impacts of the project as a whole, while SEEA will involve direct estimates of the value of natural capital and ecosystem services for Laos. These tools will help project designers, policymakers and researchers gain a clearer idea of the tradeoffs involved in using natural resources to generate transient increases in national income.

Notes

- ¹ At that time, National Road No. 5 was the main connection between Xaysomboun district, Vientiane province and Xieng Khouang province.
- ² After the resettlement, Phonsavath village (in Feuung District, Vientiane Province) was expanded and turned into a village cluster, including 13 new villages.
- ³ <https://namngiep1.com/social-environmental-policy/social-policy/project-area-villages/>.

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4

Counting all of the Costs: Choosing the Right Mix of Electricity Sources in Vietnam to 2025

David Dapice and Le Viet Phu

Vietnam has a proud history of extending grid electricity to almost every village and of increasing the total amount of power by more than 12 percent a year—from 14.7 billion kWh in 1995 to 175 billion kWh in 2016. In the past, most generation came from hydroelectricity, but as the best sites have been developed, the share of hydroelectricity has fallen and is projected to continue falling, even as some new projects are brought on line. Current plans call for most incremental supply to come from a string of coal plants throughout the country, especially since nuclear power plans have been shelved. If natural gas supplies increase, a portion could come from that fuel or from LNG imports—at more expense. Renewable energy does not figure into current supply projections except as a modest source, as its rapid growth rate is from a low base. However, recent developments cast doubts on the current energy plans. Most international banks no longer lend for coal plants (Chinese banks are an exception) and recent declines in renewable energy costs have made it competitive with fossil fuels.

It is a given that Vietnam needs to produce enough electricity to satisfy demand at a reasonable cost. A “reasonable” cost is one that covers the costs of producing and distributing reliable power—something that has yet to be accomplished. It should also be a given that existing laws on pollution should be enforced. Many groups are objecting to new coal plants on the grounds that they will foul the air and water with ash, mercury, and acid emissions. Coal is also the heaviest source of carbon dioxide, contributing to global warming and thus climate change, which threatens the Mekong Delta and many coastal areas, including Ho Chi Minh City. There are also concerns that rising imports of coal will weigh

on the balance of payments and be less reliable than domestic power sources. But are there realistic alternatives to using a lot of coal in the next five to ten years?¹

The state utility, Electricity Vietnam (EVN), has been accused of corruption and of investing billions of dollars in questionable assets unrelated to its core functions. However, it also faces having to sell electricity at a regulated price well below the cost of production and delivery. This burden has not allowed the utility leeway to engage in looking at alternative pathways to deal with energy policy. Paying customers to save money by buying more efficient equipment (and thus delay capacity additions), finding ways to use renewable energy with its existing fleet, and developing a “smart grid” are all at early stages of introduction. Yet the rapid decline in the cost of renewable energy, the possible access to low-cost finance for “green” investments, and the introduction of consumer–producer agreements for voluntary demand curtailment provide many more alternatives than relying on coal, and at potentially lower long-run costs, pollution and public resistance.

To look at the best path forward for Vietnam’s energy policy, a number of other questions must be answered: How rapidly will *or could* demand for power grow? What will interest rates be? Will the cost of generating plants go up or down, and by how much? What will the cost of each fuel be? Will carbon emissions or other pollutants begin to enter into investment decisions?

This chapter will examine these questions. It will begin by looking at demand projections and investments in efficiency—getting more output per kilowatt hour (kWh) used. It will then try to estimate the costs of building and running various types of generating plants in Vietnam over time. It will also use various costs of carbon to see if including these both as a source of global warming *and* as an indicator of local pollution changes the calculation. Changes in the domestic supply of gas will also influence the set of potential solutions, as will the declining costs of solar electricity and battery storage. In all of this it is the system or mix of investments that need to work, not any single investment.

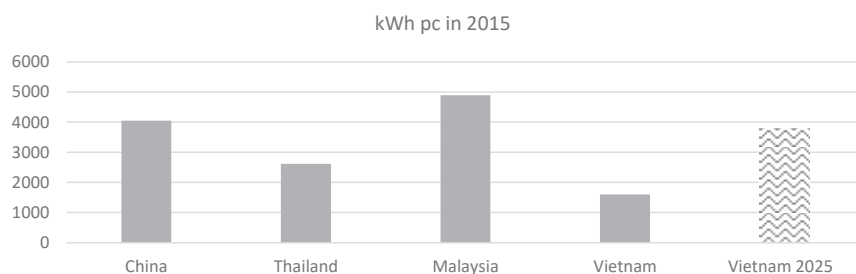
This study concludes that there are various ways to economically and environmentally satisfy the rising future demand for electricity in Vietnam, and the country does not need to rely on coal as much as planned. Exactly which mix will be chosen is partly a decision for

engineers and utility managers—but it will also partly be a political decision about how much to listen to citizens’ increasing concerns about pollution, as well as how much to rely on imported as opposed to local sources of energy. If global concern over carbon emissions grows, it is possible that Vietnam, and other developing nations, would need to tax its emissions in the next decade. That would decisively make coal uncompetitive against the alternatives.

Demand growth

In Vietnam, the demand for and supply of electricity has grown just over 12 percent a year in the last two decades, but more recent growth (2010–16) has been in the 11 percent range. There has been a tendency to project future growth in the same range, though some sources project even higher demand growth.² Yet Vietnam reached electricity consumption of 1,700 kWh per capita in 2016, taking it into a range when electricity demand often slows. Figure 4.1 compares Vietnam’s electricity consumption per capita in 2015 with that of China, Thailand and Malaysia, along with a projection for Vietnam for 2025.

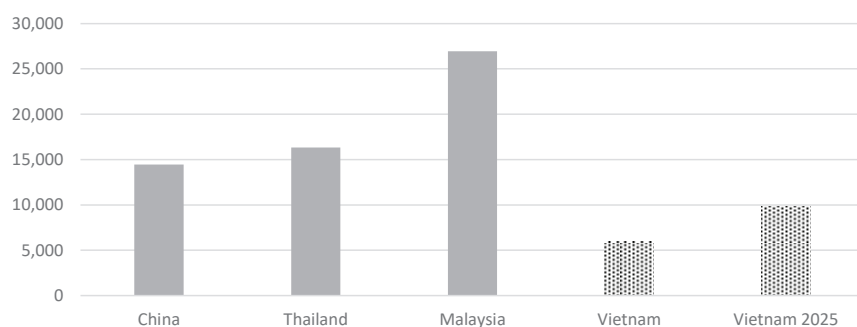
Figure 4.1 Electricity consumption in kWh per capita in 2015, and Vietnam projections for 2025 (World Bank 2019)



If Vietnam’s population plausibly grows at the rate of 0.9 percent a year from 2015 to 2025 and its electricity supply and demand grows by 10 percent a year, its per capita consumption of electricity would be 3,780 kWh per capita by 2025 (fig. 4.1). This is well above Thailand’s current consumption and approaches China’s current per capita consumption. China’s current GDP per capita is more than twice that of Vietnam,

however: Is it likely that Vietnam would consume as much power as China now does? Figure 4.2 shows the 2015 estimates of GDP per capita at comparable (PPP) international prices, plus the 2025 projection for Vietnam with real GDP growth of 6 percent a year and population growth of 0.9 percent a year from 2015 to 2025. This 6 percent GDP growth rate is somewhat lower than targets but equal to 2010–2016 trends.

Figure 4.2 GDP per capita in 2015, selected nations, and Vietnam in 2025



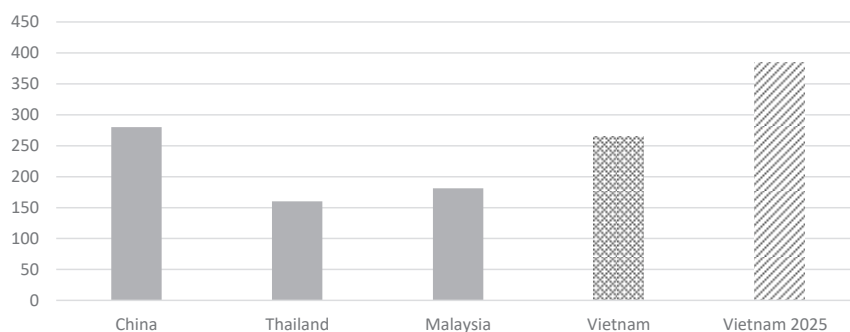
Source: World Bank data, except projection for Vietnam at 6% GDP growth and 0.9% population growth.

Figure 4.2 shows that Vietnam's GDP per capita is growing fairly quickly but still, in 2025, it would be well short of 2015 real GDP per capita in China and Thailand.³ Is it reasonable to think that Vietnam will be more energy-intensive per unit of GDP than China? Vietnam has a more moderate climate, less heavy industry, is less urbanized and is already well connected. There will not be a spurt of demand due to new households being connected. In addition, historically electricity in Vietnam was relatively low priced, so energy efficiency had not been an urgent matter. There is much low hanging fruit—i.e. good opportunities to reduce electricity use through improving efficiency—especially if efforts are made to promote (and provide loans for) efficient capital equipment that would pay for itself.

In short, it *may* be that the projections of electricity demand growing at roughly 10 percent a year to 2025 are too high, and that demand growth will moderate if prices reflect the actual costs of production and delivery, while efforts are made to promote efficient electricity use. China has found its electricity demand slowing drastically (to less than 5 percent a

year) in recent years and greatly overbuilt its generation capacity because it too projected past patterns of growth into the future. Figure 4.3 shows the energy intensity of GDP—the ratio of electricity consumption per capita per \$1,000 of PPP GDP per capita, underlining the questionable implications of such rapid demand growth for Vietnam. This third graph projects an unlikely energy intensity for Vietnam if electricity demand grows at 10 percent to 2025, as many project.⁴

Figure 4.3 kWh pc per \$1000 of per capita GDP in 2015, selected nations, and projected for Vietnam to 2025. Source: ADB and World Bank GDP and electricity consumption data, both per capita in 2015. Vietnam is projected from 2014 at 10% electricity demand and 6% GDP growth, with 0.9% annual population growth. GDP is PPP - GDP using international prices.



It takes four to six years to build a coal plant, and only two to three years to build a natural gas plant and even less time to put in place wind or solar power.⁵ If there is uncertainty about future demand growth for electricity, it makes sense to tailor its supply more closely to actual growth rather than try to peer too far ahead. This argument only works if the costs of the various options are fairly close. The next section investigates the likely costs of each type in purely financial terms. Later refinements will ask about the impact of including environmental costs.

Energy efficiency, price reform and electricity demand

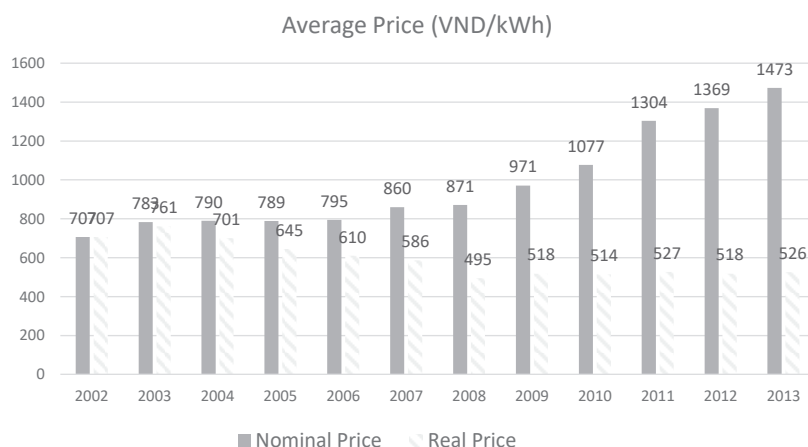
Vietnam is extremely inefficient in term of energy consumption. Pursuing rapid economic growth relying on intensive energy use (in many key sectors such as cement, steel, fertilizers and construction), Vietnam has seen the industrial sector gradually becoming the largest consumer of electricity with over 54 percent of the total generation, while residential

and services consumption lagged behind at about a third of the total demand (FPTS 2015). The increasing energy dependency is indicative of a serious structural problem with economic growth in Vietnam. The electricity elasticity of GDP (growth rate of electricity consumption/growth rate of GDP) is one of the highest in the world, reaching 1.8 to 2 during the last decade, which is higher than that of China (1.3 in 2010) and is much higher than that of India (less than 0.8) (Le 2017a). In 2015, industrial production consumed over 54 percent of the total electricity supply, but generated only 38 percent of GDP. While other sectors, such as trade and services consumed less than 5 percent of the country's electricity to produce more than 40 percent of GDP, and agriculture, forestry and fisheries consumed 1.5 percent of electricity but produced 18 percent of GDP. The low price of electricity is a primary factor behind the inefficiency. It is important to note that the real price of electricity has been decreasing, despite several attempts to raise the retail price during the past decades. The effective price in Vietnam is much lower than most countries in the region, even in most developed countries. Meanwhile, coal prices in this period have increased by 40 percent, causing customers to shift from fossil fuels to using more electricity (UNDP 2014).

The inefficient use of energy may remain in the long term, depending on whether the Government of Vietnam continues to maintain a retail price below the long-run marginal cost of production. There are policies to change this situation.

The current average retail electricity price is about 7.5 cents/kWh, among the lowest in Southeast Asia and the world. The average price (in cents/kWh) is about 11 in Malaysia, 30 in the Philippines, 8.75 in Indonesia, 8–12 in India, and is much higher in developed countries such as Australia (22–47) and Germany (31). These indicate a potential for using pricing instruments to reduce excessive consumption as a result of a low retail price. In this context, better understanding the property of the electricity demand is critical to devising the optimal pricing policies. A probable high price elasticity of residential electricity demand in Vietnam relative to that in other comparable developing countries such as China or India might carry significant implications for demand projection (Le 2017a).

Figure 4.4 Average prices of electricity



The country currently has about 22 million households using electricity of all kinds, accounting for 29 percent of the country's total electricity production. However, due to a currently low level of electricity consumption per capita, it is expected that residential demand will continue to rise substantially in the coming decades. More than 45 percent of households use less than 100 kWh/month; while fewer than 10 percent of the population consume more than 300 kWh/month (Vietnam Electricity 2015). This opens up the potential for using pricing instruments to regulate electricity use behavior. Appropriate electricity pricing policies combining a higher rate at the higher consumption level while maintaining a lifeline for small users can have a large impact on residential electricity consumption, while limiting the negative impact on poor households.

Reports have found that the energy saving potential in Vietnam is very high, up to 30 percent of total energy consumption (GIZ 2017). Lighting now accounts for 35 percent of the total power consumption of the country, while this figure in the world is only 15–17 percent (Vietnam Electricity 2015). Therefore, much can be achieved with the transition to modern lighting equipment such as LED light bulbs. In the building sector, potential power savings from air conditioning and auxiliary equipment (water pumps, blowers), lighting systems, office equipment, elevators, can be very large, from 10 to 40 percent (GIZ 2017). Some sectors might even see much higher efficiency, such as in the cement industry,

where a potential saving of up to 50 percent could be realized. However, with the currently low electricity price, many of these potential savings have not materialized. Furthermore, a majority of Vietnamese enterprises are small to medium companies with limited resources for the large capital investments required to replace older inefficient equipment.

Energy price reforms are needed to unlock the potential of energy efficiency. Low energy prices, as a result of fuel subsidies, are reducing the incentives for consumers and industries to invest in more energy-efficient appliances and equipment. As a consequence of rising energy consumption and high energy prices, subsidies have become a major financial burden on the government. The International Energy Agency (IEA) calculates that implicit subsidies in various forms, mostly to state-owned enterprises in energy production and electricity generation, amount to \$2.86bn out of the total fossil-fuel consumption subsidy of \$3.45bn in 2012 (UNDP 2014). Removing this subsidy will help bring the cost of production closer to the actual cost of generation. The cost of producing electricity from renewables may be lower than the cost of producing from coal as early as 2022. Only targeted subsidies should be retained where they can be justified as serving social welfare objectives.

Potential for leapfrogging in energy use

Technological innovation creates opportunities for leapfrogging in energy systems. This refers to the use of modern technologies in emerging economies that were not available to industrialized countries at a comparable period of development. Leapfrogging may occur in areas such as energy transformation, the carbon intensity of energy generation, and the energy intensity of economic growth (van Benthem 2015, cited in Fetter 2017: 103). Despite limited evidence to suggest that developing economies in the late twentieth and early twenty-first centuries are experiencing growth with lower energy use or energy intensity than in the past, researchers have documented leapfrogging in the adoption of solar electricity generation technologies in rural areas, ethanol production in Brazil, and biomass stoves in China, adoption of energy-efficient appliances and fuel-efficient vehicles (Fetter 2017: 103). Will these phenomena happen again in the future, which allows for a lower-energy-intensive economic growth eventually?

The historical development has conceptualized an environmental Kuznets curve. In the period of industrialization, the growth rate of electricity is often higher than the rate of economic growth due to the development of energy-intensive heavy industries. When the process of basic industrialization is complete, the economic structure shifts toward services and light manufacturing, together with the adoption of more efficient technologies, then the elasticity of electricity to GDP is expected to be lower. This has happened, for example, in the OECD countries.⁶ The electricity demand in 2014 decreased marginally as compared to 2007, whilst economic growth in the OECD reached 6.3 percent in the same period. Furthermore, the peak electricity use per unit of GDP appears to be shifting over time. The level of GDP per capita corresponding to the global average peak was about \$2,000 per capita in 2002, growing to \$8,000 per capita in 2009 in real terms (Bloomberg New Energy Finance, 2015, cited in Vitina et al. 2017). If the pattern holds, it is expected that Vietnam's electricity demand will rise for at least a couple of decades from now, until the GDP per capita has reached an upper-middle income status. The GDP per capita in Vietnam in 2015 was estimated at \$2,111 (World Bank 2017), equivalent to \$1,910 in 2009 real terms.

So by how much is consumption expected to grow? And are there possibilities that a quicker transition to renewables, economic restructuring, and technological developments, may allow for less energy-intensive economic growth? In that case, there are opportunities to divert from coal to less polluting energy sources while still meeting the rising demand. These questions are at the center of various government-published Power Development Plans (PDPs). Previous PDPs projected a high annual growth rate of more than 10 percent, but recent adjustments appeared to have scaled back the growth trajectory as emerging technologies and economic developments unfold. For example, after the passage of the revised PDP7 in 2016, the projected demand was lowered by about 18 percent, which is very significant. However, independent researchers have suggested that a reduction of up to 34 percent is possible. The underlying cause of this is that the selection of GDP growth rates is not appropriate, far higher than reality. Specifically, the GDP growth rate selected for the period from 2010 to 2015 was between 7.5–8 percent, but in fact only reached from 6–6.5 percent, which led to critical adjustments to the latest PDP, allowing for less coal. With the reduction in electricity

demand forecasts and improved power efficiency, Vietnam could afford to take 5,000 MW of nuclear power off-grid and 30,000 to 40,000 MW of new coal-fired power plants. At the same time, a large share of renewable energy is to be developed. This will lead to a reduction in the burden on capital expenditure (a potential saving of up to \$45–50bn from investing in building new coal power plants), operating costs, and a significant reduction in the impacts of pollution on the environment, including on health, agriculture, and climate change (GreenID projection, in Tam 2017).

Another venue for improved efficiency is power loss in transmissions which remains at more than 8.6 percent of the total generation, among the highest in the world. Compared to countries at a similar level of development, Vietnam has seen minimal progress in improving the efficiency of its national grid. Admittedly, solving the problem of reducing power loss is not easy when the main power source is concentrated in the north, while the main consumption center is in the south. Moving toward distributed energy such as solar and wind, coupled with smart-grid management, the transmission loss could be reduced as these resources are readily available where needed. A long-term projection where 81 percent of electricity is produced from renewables in 2050 has a much lower total discounted system cost than the business as usual, coal-based scenario by a lopsided margin, \$341bn versus \$415bn (WWF 2016). Despite the high upfront cost, savings on fuel more than compensate for extra investment. Maturing technologies in real-time monitoring and control, automated dispatch operations, and high-quality forecast for solar and wind energy are critical to the operation of such a system. Furthermore, regional electricity integration might allow Vietnam to take advantage of vast renewable energy sources in Lao PDR and southern China.

Costs of alternative generating options

The cost of a kilowatt hour of electricity depends on fixed costs and variable costs. Fixed costs depend on the capital intensity (usually measured per kilowatt or per megawatt) of the generating plant and the financing costs, along with some fixed maintenance costs. Variable costs are mainly fuel costs plus some minor variable maintenance costs. It is usual for more capital-intensive generating options to have higher fixed costs and lower variable costs. Nuclear and hydroelectric plants and wind or solar are relatively expensive to build, but have low running costs once

built.⁷ Coal is fairly expensive to build, but relatively cheap to operate, though maintenance costs are high. Natural gas combined-cycle turbines are cheap to build, but gas as a fuel is often more expensive. Single-cycle gas turbines are very cheap to install, but have the highest operating costs, so they are often used as “peaker” plants and operate only a few hours a month during periods of very high demand. Appendix I shows current and projected sources of electricity generation capacity by type of fuel or renewable.

Coal

A huge proposed coal plant in Long An has a published cost of \$1,800 per kW. The plant is expected to operate 6,300 hours per year and use 1 ton of coal for 2,700 kWh.⁸ If we assume 6 percent loan costs and a 16-year period to repay the loans, the annual repayment cost would be \$180 per kilowatt of capacity. Fixed maintenance would be \$42 per kW of capacity.⁹ Coal costs are (late 2016) about \$90 cif, or \$210 for fuel for the year for 6,300 kWh—which is 3.33 cents per kWh. In total, and counting minor variable maintenance costs, the total cost is 7 cents per kWh.

In comparing coal with gas or renewable projects, it is important to consider the different time needed to bring each type of generation on-line. A coal plant planned in 2017 and begun in 2018 may not be on-line until 2023. But a solar plant planned in 2022 could easily be up and running in 2023, assuming connections were available. Thus the comparison should be the *projected* cost of solar in 2022 with the current cost of coal plants, rather than the current solar compared to the current coal. Given that utility scale solar costs in the United States fell 20 percent from 2015 to 2016 and solar capital cost declines of 6–10 percent a year are likely, the analysis should be using much lower solar capital costs than today’s if the power is available at the same time as the coal.

The seven cent cost *assumes* that the plant will meet existing environmental laws, though reports suggest that this cannot be certified. Extra costs of pollution equipment and operating costs may have to be added to those estimated here if the proposed plant is going to meet current legal requirements. Even then, burning millions of tons of coal a year has health and economic implications due to the heavy metals, ash and acid pollutants released. In addition, incremental coal demand will come from imports as coal reserves in Vietnam are either not available or

not competitive with imported coal, beyond current production levels. In addition, the 6 percent capital cost may prove optimistic if few loans are available for coal power plants. Finally, coal plants last for many decades and if global agreements place a tax on carbon, it would be difficult if most of Vietnam's new capacity was a heavy carbon polluter.

Natural gas

A generic combined-cycle natural gas plant costs \$1,000 per kW and has fixed maintenance costs of \$10 per kW. The plant can extract 150 kWh from one million British Thermal Unit (BTU) of gas. Piped gas from an offshore field should cost about \$7 per million BTU at wholesale while imported liquified natural gas (LNG) would cost \$10 per million BTU at current prices. Retail prices of gas can be taken at \$10 per million BTU. Using the same 6 percent and 15-year financing, the fixed costs are \$113 a year per kW of capacity and variable costs would be 4.7 cents per kWh for piped gas and 6.7 cents per kWh for LNG. Adding fixed and variable costs and assuming 6,300 hours per year, *the gas will cost 8.5 cents per kWh*. Gas generators can cycle up or down much more quickly than coal and thus can work better combined with renewable energy. Gas generators also take less time to install. The main problem is if there is enough gas available from domestic sources. If not, it is possible to import LNG, but this is more costly. As the "Blue Whale" field near Quang Nam comes online in the 2022–24 period, it should be able to supply up to 7,300 MW of electricity capacity. If new fields are found, more gas-fired units could be built at lower cost with less pollution, though fields can take five to seven years to bring into production from initial exploration.

Gas-fired electricity is sometimes also produced by single-stage turbines. These cost less to install per kW of capacity (about \$680 compared to \$1,000–\$1,100 per kW for combined cycle gas), but are less efficient and use more gas per kWh produced. Since gas is a relatively expensive fuel, it only makes sense to use single-stage gas generators as a backup. If a backup plant were used 700 hours a year, the price of electricity would exceed 20 cents per kWh, counting both fixed and variable costs.

Solar

Renewable (solar and wind) energy sources are not very important in Vietnam's current energy mix. This is understandable because they have not historically been competitive with gas and coal, or with hydropower. Renewables have tended to be capital-intensive and only produce power when the sun is shining and the wind is blowing. EVN has not invested in sophisticated grid management systems that would integrate these variable sources easily, though this becomes an issue mainly when solar/wind is 20 percent or more of total consumption. However, extremely rapid declines in solar costs have driven the cost of utility scale solar energy to below \$1,500 per kW of capacity in the US in 2016 and costs of \$1,000 per kW in 2020 are anticipated (NREL 2016).¹⁰ Costs in Vietnam have been reported even lower than \$1,000 per kW in 2016, though these are not confirmed.¹¹

Solar energy should be comparatively cheaper in Vietnam since it tends to be further south than the continental United States and receives more sunlight. In addition, very low-cost loans are available from the US Export-Import Bank—about 3.5 percent a year for fifteen years. Further substantial declines in equipment costs are anticipated into the 2020s as scale and technology cut costs. What would a kWh of solar energy cost? To answer that, a site has to be selected with the number of hours of sunlight. The number of hours of sunlight in south-central Vietnam tend to average 5 per day, after deducting for clouds. This combination of low investment costs, low interest rates, and high solar levels combine to produce competitive electricity costs. A solar plant at \$1,000 per kW and 3.5 percent interest rates financed over 15 years or an \$800 per kW solar plant financed at 6 percent over fifteen years would both produce power costing less than five cents per kWh.¹² This suggests the feed-in tariff (officially offered price) of 9.35 cent per kWh for solar is fully adequate if moderate cost loans can be accessed (Kenning 2017).¹³ Indeed, switching, as India has done, to an auction system for solar electricity supply might elicit bids much lower than the current feed-in tariff. India has received one solar supply bid of four cents per kWh (Anand 2017).

While all generating options are paid off in 15 years given the financing assumption, solar (like hydro and wind) is essentially free after 15 years of payments while coal and gas continue to incur fuel costs and higher maintenance costs. A calculation looking at the costs over

the lifetimes of the projects would show even more of an advantage for renewable energy.

As pointed out previously, the falling cost of solar energy combined with the short time needed from planning to delivery (one year) allows a different calculation in competition with current coal plants. It is likely that in 2020 the total costs of solar will be close to or below \$1,000 per kW of capacity, implying a cost per kWh of less than five cents for power being delivered in the same year as a coal plant starting now, even with a 6 percent cost of capital. When total solar costs fall below \$1,000 (and they may already be this low), arranging bids for electricity supply rather than feed-in-tariffs may be one way for EVN to lower the costs of electricity.

The other aspect of solar is that it is likely to combine well with hydroelectricity, which is plentiful in Vietnam. When the sun is shining, there is often little rain and reduced hydro capability. When it is raining (as during the monsoon), solar is not needed as much. High solar output during the dry season would allow reservoirs to save water during the day and supply more power at night. While detailed studies are needed to ensure this combination would work well during cloudy dry season days, it is promising enough to warrant careful follow-up. Solar installations are guaranteed to last 25–30 years and will still work at 90 percent of their installed efficiency after 25 years. Finally, installation of a utility-scale solar project can be done in one year, responding as needed to demand growth.

Wind

Wind-powered electricity in Vietnam is very site-specific. It would work best as part of a grid that can adapt to changing wind supply quickly, as hydro and natural gas can but not coal. As sizes of wind turbines have grown and costs come down to below \$2,000 per kW, the unsubsidized cost of wind power in good sites has fallen to 4–5 cents per kWh in the US. If similar sites are available in Vietnam, it should be possible to use wind capacity competitively as part of the mix of generating capacity. The World Bank has drawn a wind map of Vietnam and identified southern coastal areas as being favorable for hundreds of thousands of megawatts of potential power (VietnamNet 2016). If wind is given the same 9.35 cent price as solar, it should be able to expand considerably and quickly. (Prices paid to wind were 7.8 cents per kWh in 2016 and are likely to increase further in 2017.) Similar to solar energy, wind energy can be

installed in a year, responding to demand as it develops. Once a higher feed-in tariff is approved, many wind projects should move forward, though the same rules should apply to wind as to solar if bidding replaces feed-in tariffs.

Hydroelectricity

Hydropower has played a major role in the supply of Vietnam's electricity in the past and even now is still the largest source of capacity (roughly 45 percent), but it supplied only 36 percent of actual generation in 2016, slightly less than coal (37 percent). Projections are for hydroelectric capacity to grow from about 17,000 MW now to 24,000–25,000 MW by 2025, though by then it should account for only 25–30 percent of total generating capacity. Hydroelectricity produces at maximum capacity when there is sufficient water flow (and demand), but the output is reduced during the dry season. Generally speaking, hydroelectric plants produce 3,700–4,000 hours per year at their full rated capacity while coal plants often produce more than 6,000 hours.

Hydroelectricity has very low maintenance costs and no fuel costs, so virtually the only cost of production is the capital cost of the project and a few people to operate the unit. After the unit is paid off, the cost of production is very low. The reason why more hydroelectric plants are not built is that only certain sites are suitable and environmental costs can offset some of the advantages—displacing people, destroying farmland due to the reservoir and downstream flooding, fish kills and other costs. On the other hand, it emits no pollution, can help to control floods, and provide fish supplies from its reservoirs.

Hydroelectricity is spread throughout Vietnam. It accounts for over 50 percent of northern capacity, 44 percent of capacity in the central regions and nearly a third in the southern part of the country. (Gas accounts for half of capacity in the south, while coal accounts for about half of capacity in the center and north.) This means that each region has backup capacity which is not coal, and that can be mixed with wind or solar.

In addition, hydropower can add solar panels floating on the reservoir or located nearby. This makes connections and a stable mix of power from both solar and hydro easier. Pumped storage units are also being introduced. A reservoir below the dam catches “used” water, which is pumped back to the higher reservoir during periods of surplus power.

This allows more hydroelectricity to be produced during peak periods of demand. The cost of peak electricity from pumped storage is less than from rarely used peaker plants. However, pumped storage is limited to only a few favorable locations.

Transmission

Transmission of power from one part of Vietnam to another occurs on high voltage transmission lines. If there is a drought in one area, power from other surplus areas can help maintain supplies. This transmission capacity could be utilized and improved if renewable sources in the southern half of the country became significant. Alternatively, gas pipelines could fuel gas-fired plants in the northern half of the country as an alternative, if supplies were adequate. This depends on the sources of offshore gas and demand onshore for them where the gas comes ashore. Again as the share of renewable energy grows, increasing investments in transmission lines will be needed to utilize all sources effectively.

In addition to the transmission of power, a smart grid can sense when supplies are not sufficient and make adjustments so that brownouts and blackouts are avoided. This can include reducing supplies to consumers that agree to short interruptions to supply (reduced air conditioning for an hour) or who are able to bring other sources online. If battery storage becomes cheaper and widespread, the smart grid could also use that source. In addition, if renewable sources provide fluctuating power, the smart grid can adjust to use this power without disrupting overall supply by electronically regulating both other supplies and demand.

Costs of carbon and other pollutants

Emissions from coal power plants contain high concentrations of pollutants such as fine particulate matter (PM) and heavy metal oxides, of which particulate matter of 2.5 micrometers or less (PM_{2.5}) is of the greatest health concern as it is capable of penetrating into the alveoli. Long-term exposure causes chronic diseases and premature deaths from chronic obstructive pulmonary disease, stroke, ischemic heart disease, and lung cancer. A recent study by a Harvard research group has predicted that PM_{2.5} will be the leading cause of death by 2030 in Vietnam and regional countries (Kopplitz et al. 2017). Other flue gases, such as ozone,

react with other molecules in the air under sunlight to form toxic fog. The inhalation of this type of fog will gradually cause chest pain, asthma, coughing and shortness of breath. Sulfur dioxide and carbon dioxide emissions in the atmosphere cause acid rain, adversely affecting vegetation and crop development and other physical structures. In addition, thermal power consumes a huge amount of water for cooling. The heated water will be discharged directly into the environment, in addition to air and solid waste pollution, causing extremely serious damage to the livelihoods of millions of local people who are dependent on agriculture and the aquatic system for food. Coal-fired plants also emit the largest amount of greenhouse gases and contribute to climate change—the Mekong River Delta is one of the most vulnerable regions in the world to rising sea levels, tropical cyclones, and widely fluctuating river flows.

Ash from coal power plants is another prominent threat. At present, coal power plants emit 16 million tons of ash a year. By 2030, the amount of fly ash discharged annually is 38 million tons. Plans to convert fly ashes to building materials have been largely symbolic. From now to 2030, Vietnam needs 5 sq km of land every year to store coal ash. Ash contains a high concentration of heavy metals such as cadmium, lead, mercury, and arsenic. Many disposal sites are not well waterproofed, allowing toxic substances to leach into groundwater aquifers and endangering the livelihoods and health of the people living around them.

Converting these environmental risks to their health impact and economic costs will allow a comparison between the different energy development strategies. The same study by Harvard University points out that coal-fired thermal power was responsible for 4,300 premature deaths in Vietnam in 2011. The number of deaths is projected to increase to nearly 20,000 by 2030 if all of the coal power plants in PDP7 are fully operational (Koplit et al. 2017). After the PDP7 revision in early 2016 allows for a lower demand projection and reduces 20,000 MW of coal power, the number of deaths by 2030 is lowered to 15,700. Note that the number of deaths is not solely from the increased use of coal, as other causes might exacerbate health effects, such as a growing population and rapid migration to a few densely-populated cities, leading to higher levels of exposure to toxic pollutants.

In monetary terms, the economic cost of coal power varies, depending on a number of factors and assumptions regarding the parameters used to

derive the damage function. A case in point, examining the feasibility of converting coal-to-gas as the power source at Dung Quat Power Plant, the coal-fired power has environmental externalities three times greater than gas power, and is economically unfeasible. Taking into account the cost of all health consequences of coal power, including premature mortality, non-lethal effects, the opportunity cost of treatment, and so forth, the estimated external cost is approximately US 3c/kWh (Phuong 2016). Health costs are expected to increase over time together with income and environmental awareness. This figure is comparable to those used by the US energy sector (Cropper 2015). Another study even suggests that every kWh of coal-fired electricity incurs a medical expense of up to US 17c/kWh for the full cost of coal's lifecycle (Meyer 2015).

The costs of carbon pollution are harder to estimate since the main impact is on global warming. Rising sea levels and weather/temperature issues are major threats to Vietnam, but the country, by itself, is not going to have a major impact on global temperature levels. However, there may be a global compact that essentially negotiates a carbon cost for all fossil fuel users. This tax, if it occurs, would be paid to the national government but would show up as an extra financial charge on each coal plant. A metric ton of thermal coal produces about 2.5 tons of carbon dioxide when burned, so the question becomes, what is a reasonable estimate of the cost of carbon dioxide? No one knows, but there are many estimates. One recent and plausible estimate by a well-known expert put it at \$31 per ton of CO₂ (2010 prices) or \$35 now (Nordhaus 2017). If this were the amount negotiated, it would cost coal producers in Vietnam about \$4.2 billion in 2016 rising to \$10.5 billion by 2025. This would add *4.6 cents per kWh to the cost of coal-fired electricity*. Of course, there may be no such carbon agreement or if there is one, it might be for a lower initial amount. But applying even half of this estimate to the cost of coal plants would make them uncompetitive. Natural gas would also be hit, but to a much less extent. A million BTU of gas generates 53 kg of carbon dioxide and creates 150–160 kWh of power. So it would take 2900 kWh of gas-fired electricity to generate a ton of carbon dioxide, or 1 to 1.2 cents per kWh with a cost of \$35 per ton.

Of course, these calculations are hypothetical, depending heavily on assumptions about the parameters used in damage assessments, such as the willingness to pay, WTP (or the value of statistical lives, VSL), and

forgone outputs. The point is that, if carefully calculated, coal is clearly a lot more expensive than other low-emission sources, regardless of which set of parameters is used. Taking a precautionary approach, it is entirely justifiable to use a higher damage number so as to avoid apparent and irreversible damages should emerging cleaner technologies become more affordable in the future. Even without considering the cost of carbon to climate change, the health costs already justify non-coal power. Adding carbon costs further makes coal less affordable. So, with a proper environmental accounting, coal power is already not the least-cost option for electricity in Vietnam.

Political costs of coal

In part because of the experience of China, many local and community groups are aware that coal may create dirty air and water in the areas around large coal-fired electricity plants. They often try to deter such investments by normal political means and also by using social media or demonstrations. It is up to the Party and Government to decide if such objections should carry much weight, but if there are cleaner and more or less equally competitive alternatives, it is not clear why a coal-intensive expansion path should be preferred. If indeed pollution is severe, then land values in the area of the coal plant are likely to plummet and this could reduce the ability of local governments to pay for services or investments. That too, may add to the reluctance to support “dirty” energy investments.

Another issue is if only Chinese banks will lend for coal plants, that likely means that reliance on China will increase in general—it will be necessary to use Chinese capital equipment, spares, and rely on them to fulfill promises regarding pollution. This may not be a preferred path. China has excess capacity in coal generating plants and is willing to finance them to lessen unemployment. There are also indications that Japan is willing to finance coal plants for similar reasons.

Finally, if demand does slow and Vietnam found it had invested billions of dollars in idle coal plants (as has China), there would also be political costs to having imposed an unnecessary burden on society through either higher electricity bills or lower spending in other vital areas.

Conclusions

This survey argues several things:

1. Demand projections are uncertain and could be too high if Vietnam follows ASEAN experience with respect to electricity intensity. *Vietnam can and should gradually raise electricity prices to cover the costs of new power plants and promote efficient energy use so demand is reduced to levels more typical of other similar nations.*
2. The industrial sector is excessively inefficient as a result of maintaining subsidized fossil fuels and low electricity costs for too long. *Removing implicit subsidies for fossil fuels by creating a level playing field for the private sector to compete equally with state-owned enterprises in energy production and distribution will provide incentives for investments in cleaner energy sources and tapping into vast renewable resources such as wind and solar.*
3. Coal plants take longer to bring on line, so are riskier compared to alternatives if demand does slow. Since private power plants usually require government or EVN promises to buy coal power for many years in advance, they could become a burden. *Limiting take or pay contracts to a limited number of years would put more risk on the investor, but would reduce investment, especially now that most international banks do not favor financing coal plants.*
4. China has followed a coal-centric strategy and generated considerable costs in pollution, excess capacity of electric generation, and costs of mining. *Serious effort should be made to reflect the costs of coal pollution in coal-fired electricity prices. The same is true for gas, but is much less significant.*
5. Electricity from renewable energy, pipeline gas and even LNG are competitive with coal, in some cases without considering pollution and carbon costs, but certainly if these are included. *Considering the falling costs of wind and solar and their shorter completion periods both reduces risks and reflects rapid cost reductions in their capital costs. They are or will be competitive in the cost of generating electricity, even with similar financing costs as fossil fuels. Allowing bids for electricity from independent generators rather than feed-in tariffs might help to lower costs.*
6. Coal will have to be imported on the margin. Domestically supplied power may be preferred. *After fifteen years of repayments, renewable*

energy is essentially free and coal and gas continue to incur fuel and higher maintenance costs. Life cycle costs show renewable energy to be cheaper.

7. *There are rising domestic and international political costs to coal that may need to be considered. A transition to more renewable energy will require more investment in “smart grids” that manage demand and in fossil fuel types (mainly gas) that can easily respond to fluctuations in renewable supplies. This is an additional cost, but it is modest compared to the costs of coal pollution.*

Appendix I: Current and projected types of generating capacity

Table A4.1 Current and projected types of generating capacity ('000 MW)

Energy source	Share of Capacity (%)			Installed Capacity			Growth/Year (%)	Output (billion kWh)		
	2016	2020	2025	2016	2020	2025		2016–2025	2015	2020
Coal	33	43	49	12.7	26.0	47.6	15.8	59	134	228
Gas	20	15	16	7.7	9.0	15.0	7.7	41	45	79
Hydro	44	37	26	17.0	21.6	24.6	4.2	56	80	85
Other	3	5	9	0.1	3.4	9.3	65.0	3	13	23
Total	100	100	100	37.5	60.0	96.5	9.9	159	272	415

Notes: “Other” includes wind, solar and small hydro and a small and declining share of diesel-fired generators. Capacity is taken as of January 1, 2016 but December 31 in 2020 and 2025.

Sources: Capacity and output are taken from midpoints of VCBS (2016).

Appendix II: Actual and projected electricity supplies

Table A4.2: Actual and projected electricity supplies (2000–2016 is actual)

	Generation in billion kWh	Annual Growth from previous period	Sources
Data from 2000–2016			
2000	26.7		
2005	52.1	14.2%	
2010	91.7	12.0%	
2015	158.0	11.6%	
2016	175.4	11.1%	
Projections			
	320	16.2%	World Bank “Smart Grid” document, 2016
2020	265–278	10.9%–12.2%	VCBS, <i>Vietnam Power Industry 2016</i>
	265	10.9%	ADB, 12/2015, <i>Vietnam Energy Road Map</i>
2025	400–431	8.6%–9.2%	VCBS
	400	8.6%	ADB (9.7% a year from 2015 to 2025)
	572–632	7.5%–8.0%	VCBS (8.0% and 8.6% from 2020–2030)
2030	572	7.5%	ADB (8.0% a year from 2020–2030)
	690	8.0%	World Bank, “Smart Grid” document (2020–2030 growth)

If the lowest projections are correct, the 2030 output would be 572 billion kWh in 2030. That would raise the output of electricity in 2030 to nearly 5600 kWh per capita and consumption would be about 5200 kWh per capita. That electricity consumption is double Thailand’s current per capita use and more than the United Kingdom in 2014! The higher growth estimate puts output per capita at 6700 kWh and consumption at 6300 kWh per capita, getting Vietnam close to France’s 2014 per capita use. Yet even with a 6 percent annual GDP growth rate, the 2030 PPP GDP per capita would be \$13,000—less than China or Thailand in 2015, and less than a third of the UK’s current GDP per capita! If electricity prices reflect costs of production and distribution, it is hard to imagine how Vietnam

would reach such high levels of consumption at such a relatively low level of GDP per capita.

It is noteworthy that after China reached 3,300 kWh per capita, its electricity growth rate fell to about 5 percent a year (2011–16). It is unlikely that Vietnam will surpass China in its per capita power consumption unless it keeps electricity prices below costs and also ignores energy efficiency investments. China's GDP per capita is far higher than Vietnam's and it is nearly twice as urbanized. It has a much higher fraction of heavy industry and more need for electric cooling and heating, with its location and continental climate. It is not certain how fast electricity demand in Vietnam will grow, but it is dangerous to draw straight lines.

The 10 percent annual growth from 2015 to 2025 is consistent with ADB projections in 2015, but that projected amount may be higher than what is realized. If, for example, Vietnam reached the 2014 Thai per capita level of 2566 kWh by 2025. In that case, consumption would be about 256 billion kWh and production would be about 7 percent higher or 274 billion kWh rather than the projected 400 billion kWh. (Vietnam even then would be poorer and less urban than Thailand in 2014 with a similar climate and industrial structure.) That would imply only a 5 percent annual electricity growth rate from 2016 to 2025! The point is not that growth will be 5 percent or 10 percent, but that it is hard to tell for sure. If China's electricity growth fell to less than 5 percent a year after 2011, the same could happen or be caused by Vietnam by 2020 or after 2020.

The following data show PPP GDP per capita, urbanization, industry as a share of GDP and prices per kWh. In all countries, virtually all households are connected. Data are World Bank for 2015, except prices which are from various sources. Projections are 6 percent GDP and 10 percent electricity growth.

The policy question for Vietnam is if it can grow rapidly with a lower energy intensity than it is projecting—closer to those of the richer ASEAN or other developing economies. If it raises prices to allow private generating investments and helps producers reduce electricity use per unit of output with information on efficiency and loans for improved equipment, it is likely to slow the rate of electricity demand growth below the 11 percent projected for the rest of this decade and the 8–9 percent for 2020–2025. By reducing the rate of demand growth, Vietnam would not

need to invest so much in energy and could redirect more funds into other areas such as infrastructure or education.

Table A4.3: PPP GDP per capita, urbanization, industry as a share of GDP and prices per kWh

Variable	China	Thailand	Malaysia	Vietnam	Vietnam 2025
PPP GDP pc	\$14,450	\$16,340	\$27,000	\$6035	\$9925
Urban %	56%	50%	75%	34%	40%
Industry%	43%	37%	37%	37%	37%
US cents per kWh	12–16	9–12	9–13	7–8	?
2014 Electricity pc	3927	2566	4646	1430	3780
Electricity use/GDP pc	.27	.16	.17	.24	.38

Notes: Vietnam 2025 takes electricity demand from 2016 actual levels, growing at 9% per capita per year, or 10%. Urbanization rate is projected growing at 0.6% a year, its historic growth rate. Industry/GDP has not shown any trend growth recently.

If it is uncertain that the rapid growth of electricity demand will continue, it makes sense to build just a little ahead of need rather than bet on continued rapid expansion. If it takes four to six years to build a coal plant, it is necessary to commit to a highly uncertain expected demand. The cost of coal without adjusting for carbon and other pollution costs is roughly on par with other sources. If the completed coal plant is not needed, its effective cost rises since it either goes underutilized or EVN is forced to close its own plants if there is a “take or pay” contract with a private producer. If pollution costs are considered, then the argument in favor of other sources of power becomes overwhelming.

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Notes

- ¹ The time needed to bring a plant online varies from 4–6 years for coal plants to 2–3 years for combined cycle natural gas, and less than 2 years for wind and solar photovoltaic. Nuclear power plants normally take 6–10 years, but some Chinese nuclear plants are apparently built more quickly and cost much less than other models.
- ² The ADB (2015), World Bank (2014) and Vietcom Bank (Duc Dam 2016) mostly project about 10–12% annual growth from 2015 to 2025—faster up to 2020 and slower to 2025. The ADB's 2015–2025 projection is for 9.7%/ year. However, a World Bank study (2016) put estimated 2020 demand at 320 billion kWh and 2030 at 690 billion! This suggests a 16% annual growth from 2015 to 2020, then 8% a year to 2030. Electricity per capita by 2030 would exceed 6,000 kWh—more than Denmark or the United Kingdom—an unlikely outcome. See also Appendix II.
- ³ GDP per capita is not the only determinant of electricity demand. The price of electricity, urbanization, climate and industrial structure are also important. Thailand has a similar climate, much higher urbanization (50% vs 34% for Vietnam) and higher electricity prices. They have similar shares of industry/GDP. Yet 2025 projections are for Vietnam's per capita electricity to be more than double that of Thailand's in 2015, even though GDP per capita will be much lower, even with fairly rapid growth.
- ⁴ The 'Made in Vietnam Energy Plan' (ECA 2016) also argues that electricity intensity in Vietnam is high and there is potential for sensibly reducing demand. The argument here is similar, but relies on the need for prices to reflect costs and the high economic returns to using efficient machinery, appliances and structures. This chapter takes an agnostic stance towards energy imports, but is sympathetic to the risk reduction implicit in renewable energy—avoiding potential carbon taxes and pollution costs, as well as fluctuating exchange rates and coal prices. In short, similar conclusions but different reasoning.
- ⁵ Again, the question of nuclear power is a complicated one. It is unclear if a nuclear plant could be operating by 2025, even if it were started in 2018. Close monitoring of China's experience and of developing nuclear technology in other countries is needed to decide if the balance of risks and benefits favors large and long-to-market-investments and dealing with later problems of nuclear waste disposal. Nuclear energy is not covered in this chapter.
- ⁶ For a list of the OECD countries, see <https://www.oecd.org/about/members-and-partners/>.
- ⁷ Wind and solar are not very expensive per kW of capacity, but are more costly if calculated as investment per expected kW-hours of production. Unlike fossil fuel plants, they only produce when the wind is blowing and the sun is shining, which is 1,400–1,800 hours/year for solar in southern Vietnam and 2,000–3,600 hours per year for wind, depending on the site of the wind project and the size and efficiency of the turbine.
- ⁸ Australian thermal coal has 23.8 million BTU per metric ton. An efficient coal plant will need 8,800 BTU per kW-hour. The 2,800,000 kW Long An plant would

burn 6.5 million tons of coal per year. If only 1% of the coal is heavy metals or other toxins, that would add 65,000 tons a year to the area.

- ⁹ Maintenance costs are taken from estimates of new US plants (EIA 2018).
- ¹⁰ NREL's data show cost of a 100 MW facility including hardware, land, and installation and grid connections has fallen from \$3.82 a watt in 2010 to \$1.42 a watt in 2016.
- ¹¹ Personal communication from Hai Nguyen. This excludes land and may refer only to solar hardware.
- ¹² Middle Eastern solar bids came in at 2–3 cents per kWh (Dipaola 2016). There was also a bid in Chile for less than 3 cents and these are all unsubsidized. Solar panels that track the sun are only slightly more costly, but get higher output than fixed panels. Wind costs in the US without subsidies are now estimated at 4–5 cents per kWh (Brew 2017).
- ¹³ It is the weighted cost of capital, which includes interest rates on loans plus the return to equity, which is higher, which determines the total cost of solar repayments and thus the cost of solar electricity.
- ¹⁴ It is likely that backup generation will be needed unless more contracts to allow reduced power to consumers for brief periods are negotiated. Another possibility is to increase wind power, which is less correlated with sunlight.
- ¹⁵ The main component is monetizing health impacts, or the number of premature deaths, in economic values. There are two approaches: one relying on the loss of potential income of an average working person due to an early death (the forgone output), and another by measuring the willingness to pay to avoid an early death. For example, if a person earning \$2,500 a year loses 30 years of productive life, assuming wage rises at 3% a year, and a discount rate of 6%, the present value of the forgone output is approximately \$52,000. The WTP is a subjective welfare concept and often not well documented in developing countries, therefore a benefit transfer approach could be used. Using a VSL of \$5–10m in the US as the baseline, the VSL in Vietnam is between \$241,000–304,000 (Le 2017b). Other authors have used vastly different values, from as low as \$58,000–98,000 in China in 2000 (Wang and He 2014) to as high as \$1m in Phuong (2017).
- ¹⁶ While this paper focuses on Asian economies, even richer, highly urban economies in Latin America have much lower than projected (for Vietnam) electricity use. Brazil, at \$15,400 GDP per capita, uses 2600 kWh per capita, and Argentina, with \$20,000 GDP, uses 3052 kWh per capita. Even with 7% real GDP growth, Vietnam would not reach \$11,000 GDP per capita by 2025. The 10% electricity demand growth for Vietnam, not the highest, reaches nearly 4,000 kWh per capita by 2025. There is no question that unsubsidized power and modest efficiency measures would reduce projected demand growth.

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5

The Undervaluation of Ecosystem Services in the Lower Mekong Basin

Malcolm McPherson and Le Thi Quynh Tram

Ecosystem services and the natural resources that generate them are systematically undervalued throughout the Lower Mekong Basin (LMB). As a result, they are over-exploited, and their contributions to growth and human welfare grossly underestimated. This chapter examines why and suggests how policymakers can constructively respond. The first section sets the context by defining key terms and describing how LMB governments view the contribution of natural resources to national development. This is followed by a discussion of procedures for valuing ecosystem services and natural resources, then an examination of the policy implications of appropriately valuing ecosystem services in national decision-making.¹

Background: Definitions and context

Ecosystem, ecological, or environmental services are defined as the “good things nature does” (Daily 1997: 3) or the “benefits of nature to households, communities, and economies” (FAO 2016: 6). In 2005, the United Nations’ Millennium Ecosystem Assessment (MEA) identified more than two dozen services that ecosystems provide.² Most are public goods and many are joint products.³ A forest, for example, simultaneously produces lumber and wood pulp, provides animal habitats, is biodiverse, recycles nutrients, removes toxins, moderates water flow, sequesters carbon, prevents erosion, harbors pollinators, protects watersheds, replenishes aquifers, sustains livelihood activities (food, fiber, fuel, shelter), and generates landscape and other “amenities.” These multi-dimensional, multi-layered, and multi-period interconnections are typical of ecosystems, making it difficult to disentangle their structure from their function, particularly the services they provide.

Economic analysis of what we now identify as ecosystem services began in the mid-eighteenth century with the Physiocrats (meaning “the power of nature”). For them, agriculture was the only productive economic activity, and the main source of national wealth was land. By the mid-twentieth century, few economists paid attention to land and natural resources. Their use was largely “a consequence of growth and not as a factor of production.”⁴ This interpretation is no longer tenable. Economic growth and human development cannot be sustained without the efficient use of ecosystem services and prudent management of natural resources.

This shift in perspective challenges LMB governments, all of which have based their development strategies on the exploitation of natural resources. A balance is needed between transforming resources to support growth and preserving them to sustain development. Striking that balance raises three issues: who decides on the appropriate balance; who gains and who loses from the decision; and who compensates whom for any losses, and how? Thus far, the incentives within the LMB encourage the continued transformation and often destruction of natural resources to boost economic growth. With few exceptions, the politically influential and well-connected decide, and compensation is rarely paid.

This path is well worn, both internationally and throughout the LMB. The rapid economic growth in Vietnam following *doi moi*, the post-war recovery in Cambodia, New Economic Mechanism in Lao PDR, and the period when Thailand was emerging as the “Fifth Tiger,” generated unprecedented increases in *measured* material benefits for key population groups. However, this growth has seriously depleted the stock of natural resources and degraded the environment.

Natural resource-driven economic growth has been easy to promote, since most natural resources are public goods and therefore “cheap” to exploit. Each LMB country has dammed rivers, cleared forests, drained wetlands, polluted the atmosphere, over-pumped aquifers, denuded highlands, over-fished lakes and rivers, destroyed biodiversity, fragmented habitats, and contaminated soil and water. At minimum cost to themselves, private and state-owned entities have pushed the adverse effects (erosion, pollution, contamination, and depletion) onto their neighbors, the nation, and the region as a whole. By externalizing significant shares of their operating costs, enterprises and individuals have lowered the market prices of the goods and services they produced.

This behavior reflects two fundamental mistakes. One is to assume that a low price is a low cost.⁵ The other is that the *transitory* increases in income derived from the *permanent* conversion of the limited supply of natural resources can be sustained.⁶

Valuing ecosystem services

Promoting sustainable resource use requires management practices and institutional arrangements that appropriately value all economic resources, including natural wealth.

Macro Resource Valuation: All countries have transformed natural resources and used ecosystem services to promote economic growth and human development. Throughout history, humans have significantly raised their standards of living by applying their skills and knowledge to transform the *existing* stocks and flows of natural resources into useful goods and services (Johnson 2000). With few exceptions, the social costs of transforming natural resources have been ignored or assumed to be zero. This has been a monumental mistake.

Recognizing this, agencies such as the World Bank, United Nations, OECD, and several national statistical offices began estimating the value of natural wealth. A common approach is capital theory, which treats wealth as a stock of capital “that yields a stream of income over time,” with “income” being “the product of capital” (Johnson 1964: 223). Two values emerge. One is natural wealth, i.e., the capitalized value of the services, and the other the value of the services themselves.

World Bank researchers estimated natural wealth to derive from total national wealth, which they identified as *the* determinant of “sustainable development.”⁷ Their initial, partial estimates revealed that natural assets comprised roughly 10 percent of the aggregate worldwide wealth (Dixon and Hamilton 1996: 16).

These initial estimates highlighted significant biases and omissions in the Standard National Accounts (SNA). These Accounts provide detailed estimates of services yielded by human and produced capital (specifically, wages and profits), but grossly understate the contribution from natural resources. “Established markets” internalize (i.e., measure as income or earnings) only a small fraction of the contribution of natural resources and their services to national income and welfare. This point is supported by

LMB data, where conventional estimates of GDP include the value added associated with minerals, energy, lumber, wild fish catch, ecotourism, and recreation, but little else.

Other scholars directly estimated the “ecological benefits” generated by natural resources. Using 1994 data for 16 ecosystem services, Robert Costanza and his associates estimated that worldwide benefits ranged from US\$16 to US\$54 trillion (in 1994 PPP prices), with an average of US\$33 trillion (Costanza et al. 2014). This was 1.8 times the corresponding world GDP of US\$18 trillion. Based on a broader list of services, more extensive survey data, and a revised valuation method they calculated that for 2011, the annual flow of ecological services (measured in 2007 PPP terms) was US\$124.8 trillion. This was 1.7 times the 2011 world GDP of US\$75.2 trillion.

A third approach, spearheaded by the United Nations with support from the World Bank and OECD, simultaneously estimates the value of natural capital and its service flow. This approach, the System of Environmental-Economic Accounting (SEEA),⁸ now guides national accounting exercises in many countries. Australia was an earlier adopter. The estimated value of natural capital was A\$2.5 trillion in 2004 and A\$4.8 trillion in 2013. Respectively, these stocks were 2.9 and 3.2 times the conventional estimates of GDP (ABS 2012: 42–49, and esp. table 4.7).

These estimates need to be carefully interpreted. They are based on imputation procedures such as willingness to pay, benefit transfer, and resource rents, which at best are indirectly related to values in established markets. Though caution is warranted, it does not invalidate the estimates. They show that by any measure, the contributions of natural wealth and ecosystem services to national wealth and well-being are large.

Micro Valuation: No LMB government has adopted the SEEA, although some tentative explorations have been made.⁹ Nevertheless, through ad hoc ways, each country has partially valued some of their natural resources. Examples include environmental regulations, mechanisms to combat global warming and Climate Change, incentives to encourage “green growth,” and Payment for Ecosystem Service (PES) schemes.¹⁰

To protect the environment, LMB countries have created national parks, biodiversity reserves, wilderness areas, conservation reserves, and green zones. Regulations control pollution, prohibit the use of toxic substances,

and mitigate damage. Programs to reforest denuded areas, restore mangroves, encourage recycling, reduce contamination, and prevent the dumping of industrial and other effluents exist. International agreements often provide guidelines for these actions. All LMB countries have signed the Paris Framework Convention on Climate Change (2015), and each is committed to achieving the Sustainable Development Goals, several of which involve improving environmental management (UNDG 2015).

Through their environmental laws, LMB governments have adopted the principle of the “polluter pays.” International efforts in this area are being institutionalized through “carbon taxes,” which tax and/or regulate carbon emissions, and “cap-and-trade” schemes, whereby high emitters purchase emission permits from low emitters. LMB governments have yet to move in this direction.

Market-based responses have been used as well. The declining stock of natural resources has increased its private and social value. “Amenity value” premiums have been increasing for locations with clean air and panoramic views, low levels of pollution, and reduced congestion. These market pressures (often reinforced by regulations) have significantly altered both private and public incentives.

Interest in PES schemes has increased. Those who own, or control natural resources are paid to manage them in ways that contribute to the broader public good. The payments compensate in whole or part for market, regulatory, or other distortions that undervalue natural resources. Common programs relate to watershed services, soil conservation, habitat preservation, carbon sequestration, wetland protection, biodiversity, and landscapes.

Vietnam has made the most progress in this area. Beginning in the 1990s, the Government of Vietnam paid specific groups to reforest denuded uplands, manage fragile or unique forest areas, and preserve watersheds. From 1993 to 1998, Program 327 replanted 5 million ha of degraded forest. Program 661, which extended the initiative until 2010, replanted an additional 14.3 million ha. Participating households were reimbursed for the replanting costs, paid an annual per hectare fee, and given title to the land they agreed to protect. The program was also used to preserve existing forests, for example, the Ba Vi National Park.

In 2008, Vietnam piloted PES schemes in two provinces, namely Lam Dong and Son La. In Lam Dong, the direct beneficiaries of forest services

(hydropower generators, water supply companies, and ecotourism operators) paid fees based on their output or gross turnover. The program's success was limited for several reasons, however. Incentives were weak. Insecure land tenure made it difficult to identify which households should be paid. The households' short-term livelihood activities conflicted with the government's long-term conservation goals. Voluntary compliance did not work. Government compulsion is needed to ensure payments are made. These difficulties could have been resolved, but the scheme unraveled due to "elite capture." The fees collected were diverted from the household members who protected the natural resources. This was not surprising, since all market and quasi-market activities reflect specific social and political settings and power dynamics.

Other LMB countries have considered PES schemes. Lao PDR adapted the necessary administrative procedures to introduce PES but did not act on it (ADB 2015: 44). In Cambodia, a recent study noted: "As Cambodia further embraces a green economic growth pathway, ecosystem service valuation can play a role in ensuring that the flow of goods and services that nature provides will be protected, restored and managed to enhance livelihoods" (Talberth 2015: 23). The operative word is "can," as thus far, there have been few PES-type incentives. Moreover, Cambodia's development strategy continues to rely on exploiting its natural resources. Activities to preserve, restore, and manage natural resources are of second-order significance.¹¹

Efforts in Thailand have concentrated on fostering cooperation among various government entities to ensure that the value of ecosystem services is included in planning exercises. The introduction of PES schemes is still being examined.¹²

Policy implications

The systematic and persistent undervaluation of the contribution of natural resources and ecosystem services to national welfare and well-being across the LMB has several policy implications.

First, undervaluation results in massive and continuing environmental damage. There is no *economic* incentive for people to modify their behavior. Without substantial increases in the private costs of exploiting natural resources, the damage will intensify. Second, valuation techniques that ignore or only partially account for ecosystem services significantly

inflate the contribution of measured factor inputs.¹³ By not considering the future permanent reductions in social productivity due to the loss of ecosystem services, a large number of natural resource-based projects seem viable.¹⁴ Third, the socially efficient rates of substitution and complementarity among productive inputs—human, produced, and natural capital—are misstated. This emphasizes the inefficient use of all national resources.

Fourth, when ecological services are improperly valued, decision-makers have little advance warning of the effects of looming thresholds or “tipping points.” Examples from the LMB include coastal damage when mangrove barriers are destroyed, contaminated irrigation water due to the excessive use of herbicides and pesticides, or land subsidence through excessive groundwater extraction. By the time the damage becomes apparent, remedies are expensive and time-consuming. In some cases, the damage is irreversible. These outcomes could be diminished (or avoided) if decisions regarding resource use were guided by “option values,” “safe minimum standards,” and/or the “precautionary principle” (UNESCO 2005).

Fifth, undervaluing ecological services has adverse distributional effects. Those who benefit from particular activities gain a “free ride” by transferring at minimal or often no cost the adverse effects to other groups or the nation as a whole.

Finally, by measuring the value of *all* factors that contribute to national income and welfare, policymakers will be better prepared to manage the biophysical, geo-hydrological, and socioeconomic system as an integrated whole. At a minimum, policymakers would be made aware of the high social costs of the current patterns of uncoordinated natural resource use throughout the LMB and the potential gains of arrangements that efficiently manage local and transboundary resources.

Conclusion

Ecosystem services and the natural resources that generate them are grossly undervalued across the LMB for three reasons. Markets that value natural resources either do not exist or are seriously distorted. It is too lucrative for selected groups to continue exploiting natural resources, most of which are public goods. LMB governments still view natural resources as a “cheap” way to stimulate rapid economic growth.

A reality check is overdue. National and social development programs can no longer presume that the LMB's natural resources and ecosystem services are a low cost (or costless) means of augmenting the production of marketed goods and services. As a biophysical entity, the Basin is an exhaustible resource that is being rapidly and *permanently* degraded by current government policies.

LMB countries will benefit by appropriately valuing natural resources and using these values in national decision-making. Appropriate valuations will provide the incentives for each country to use *all* its available resources efficiently and equitably. The incentives will encourage the sustainable management of the stock of natural wealth and their associated services. Furthermore, improved management will enhance environmental resilience, lessen the risk of climate hazards on human well-being, and increase the social amenity derived from natural resources. Removing the biases in resource valuation will strengthen the foundation for sustained *inclusive* growth. Equity will improve by reducing the number of natural resource-dependent households and communities arbitrarily displaced by national "development" projects. Finally, appropriate valuation of natural resources will highlight the need for all LMB countries to devise and strengthen mechanisms related to transboundary resource governance.

LMB governments could promote the needed adjustments by modifying their current policies and strategies. The following actions will be helpful. First, government officials should move beyond the idea that the exploitation of natural resources facilitates economic growth. Natural resources are co-equal factors of production; however, unlike the stocks of human and produced capital, they are declining. Second, governments should adopt a wealth-based system of national accounting and project and program appraisal. This would fully and consistently account for the contribution of *all* factors of production to national development. Third, any taxes, subsidies, and regulations that reduce the market or imputed price of ecosystem services below their social cost must be removed. Fourth, governments should modify institutional arrangements that impede schemes that protect and conserve natural resources. Fifth, all governments should fully and adequately fund the agencies responsible for monitoring, protecting, and preserving natural resources. This will reduce, if not prevent, their continued contamination, destruction, and degradation.

None of these changes will be easy. Those who benefit from the present circumstances will resist. Time is needed to devise mechanisms and upgrade capacities to manage local and transboundary ecosystems. However, this is the bad news. The better news is that since the current distorted resource valuations are largely the result of LMB government policies, they can be remedied. Such remedies will realign the incentives facing individuals, firms, and governments to efficiently and equitably manage and preserve natural resources and their associated ecosystem services.

Notes

- ¹ A fully-referenced copy of this chapter is available upon request from the authors.
- ² The list comprises crops, livestock, capture fisheries, aquaculture, wild foods, timber, cotton, hemp, silk, genetic resources, biochemicals, natural medicines, pharmaceuticals, fresh water, air quality regulation, climate regulation (global, local, and regional), water regulation, erosion control, water purification, waste treatment, disease regulation, pest regulation, pollination, natural hazard regulation, cultural services—such as spiritual, religious, esthetic values, and recreation—and ecotourism (MEA 2005, table 1: 7). The MEA grouped the services into four: supporting, provisioning, regulating, and cultural. Recent studies use only three: provisioning, regulatory, and cultural (ABS 2012: 7).
- ³ Public goods are open access and non-rival, meaning that one person's does not impinge on that of any other.
- ⁴ Ayres and Warr (2002: 5–12) noted: "This simplistic assumption is built into virtually all textbooks and most of the large-scale models used for policy guidance by governments." The history of ignoring the contribution of natural resources and ecosystem services dates back at least to Adam Smith (1776, 1937: 144–174).
- ⁵ The *price* of a good (or service) is the amount paid for it based on a willing buyer/willing seller. Its cost is the social value of the real resources used in its production.
- ⁶ The Asian Development Bank warned: "The existing development approach is unsustainable, causing losses in natural capital that threaten future prosperity" (ADB 2015: 3).
- ⁷ National wealth is the sum of human, natural, and produced assets (Dixon and Hamilton 1996: 15).
- ⁸ "The SEEA is an accounting framework that records as completely as possible the stocks and flows relevant to the analysis of environmental and economic issues" (ABS 2012: 5).
- ⁹ Exploratory efforts are being made, especially by Vietnam through the ADB-supported GMS Core Environment Program.

- ¹⁰ The Asian Development Bank website “Payments for Forest Environmental Services in Viet Nam (2014–2017)” noted: “Since 2011, ...the ...PFES scheme... has mobilized hundreds of thousands of households to protect and manage more than 5 million hectares of forest land. More than US\$230 million has been disbursed to participating households in 40 provinces so far.” A generous estimate suggests that this amount represents approximately US\$6 per hectare per year.
- ¹¹ Tonle Sap, for example, is both highly polluted and over-fished (Forsyth 2015).
- ¹² Janekarnkij and Polpanich (2014) advocate paying local residents for the watershed protection services they were already voluntarily providing.
- ¹³ Stiglitz et al. (2009: 7) stress this point: “What we measure affects what we do; and if our measurements are flawed, decisions may be distorted. Choices between promoting GDP and protecting the environment may be false choices once environmental degradation is appropriately included in our measurement of economic performance.”
- ¹⁴ A deeper problem is involved. With the supply of natural capital and ecosystem services systematically declining relative to produced and human capital, social valuation exercises have failed to anticipate the rising opportunity costs of natural capital. One approach that counteracts this bias is to value natural resources at “replacement cost,” i.e., the cost using current technology and knowledge to replace (or reconstitute) lost/degraded ecosystem services.

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6

Pricing and Management of Groundwater Irrigation in Vietnam

Le Viet Phu

Around the world, water is exploited and used for a variety of purposes, from industrial to agricultural to daily domestic consumption. In Vietnam, the largest user of water is agriculture, which accounts for over four-fifths of the country's total surface water exploitation. In the twenty-first century, pressure on water resources has been increasing as hydropower development in the Mekong upstream massively reduces the flow of water into Vietnam, while climate change is causing rising temperatures, shorter rainy seasons, and earlier dry seasons. Meanwhile, population growth, urbanization and economic development are driving up water demand across all sectors, yet water use remains largely inefficient.

Water shortages are increasingly common in parts of Vietnam. A large area of farmland in the Red River Delta in the north has been suffering from severe irrigation water shortfalls, and even fertile land has had to be abandoned. To irrigate important crops, such as maize, beans and potatoes, farmers have to install long pipelines to access water from rivers or ponds or drill groundwater wells. In 2015–16, the Central Highlands faced such a prolonged drought that coffee growers began cutting down their coffee trees. The increasing demand for groundwater may be linked to climate change and water use in the upstream basin of the Mekong River. In addition, the Vietnamese Mekong Delta (VMD) has been experiencing longer dry seasons, later rains, and changing rainfall patterns. With its flat and low-lying terrain, the VMD is experiencing severe salt water intrusion. During a recent drought, salinity concentration and intrusion reached record levels, worsened by upstream Mekong countries retaining or diverting water for agriculture. Meanwhile, surface water is increasingly polluted by the over-use of agrochemicals in intensive agriculture and aquaculture and contaminants from industrial and domestic wastewater.

Against this background, the demand for groundwater keeps rising in Vietnam due to limited alternatives. Because there is no clean water alternative, water consumers have turned to groundwater. It is estimated that by 2020 the daily water demand will exceed the sustainable groundwater extraction rate from all aquifers. Water demand depends on many factors, including topographic constraints (saline intrusion, duration and intensity), type of agricultural system, availability of alternative water sources (surface, rainwater, storage, pipe), and socioeconomic factors. The Division for Water Resources Planning and Investigation for the South of Vietnam (DWRPIS) reports that groundwater demand has been increasing at approximately 10 percent per year. The total demand for groundwater for all uses is projected to reach around 5 million m³ in 2020. However, the total estimated daily safe groundwater reserve is only 4.5 million m³, or 88 percent of the projected demand in 2020 (DWRPIS 2008). This projection applies to the total volume of groundwater from all aquifer layers, without assessing the exploitation costs and technology barriers. Between 1993 and 2010, the water head of each aquifer fell from 3 to 7 m (DWRPIS 2013). The forecast shows that current demand patterns are rapidly leading to the general over-exploitation of groundwater.

The situation in the VMD is even more alarming. The VMD is located south of the economic powerhouse of Ho Chi Minh City, covering an area of 40,600 km² in 13 provinces and home to 18 million people, 75 percent of whom live in rural areas. The area produces more than half the country's rice output, 90 percent of which is destined for export, and 70 percent of its aquaculture production. Groundwater is a common source of fresh water for drinking for millions of households, for agricultural irrigation in the dry season, and for diluting saline water for shrimp aquaculture. It is also used for industrial purposes. Most economic activities in the VMD depend on the transformation or use of natural resources, particularly water. The 2013 report highlighted that almost 2 million m³ of groundwater is being extracted every day from more than 500,000 boreholes, with domestic use and aquaculture each accounting for almost 40 percent, and industries the remainder.

While groundwater accounts for a mere 2 percent of the total water use in the VMD, it contributes more than 60 percent of the total water used for domestic purposes. Over the past decade, it has become evident that land subsidence is causally linked to the over-extraction of groundwater.

Erban et al. (2014) estimated an average subsidence rate of 1.6 cm per year. If groundwater pumping continues at the current rate, the Delta will subside by 88 cm by 2050. This subsidence, in addition to an anticipated 25–30 cm rise in the sea level due to global warming (Vu et al. 2018), will exacerbate the depth and duration of the annual floods and the degree of economic damage caused.

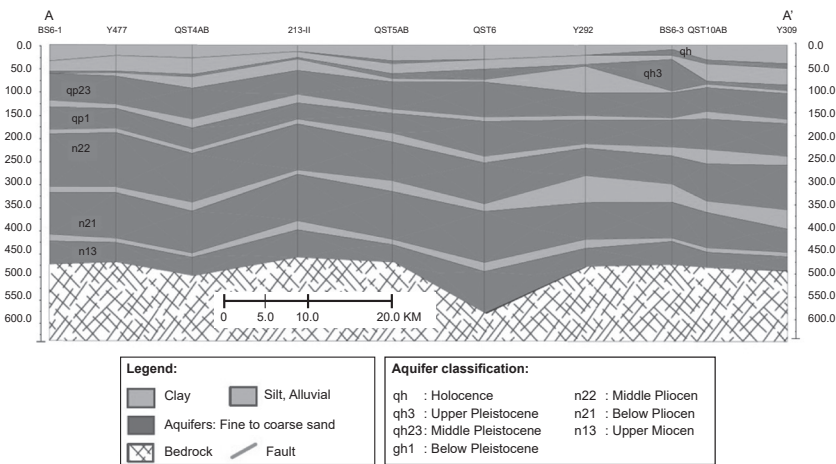
Types of groundwater users

Groundwater aquifers are often classified based on their depth to the water table (see fig. 6.1). Shallow aquifers, from the Holocene to the Pleistocene, have been over-extracted. Deeper aquifers (the Pliocene and Miocene) and the bedrock aquifers have not been studied extensively. Based on the depth of the bore well, extraction volume, purpose of usage, and bore ownership, groundwater users are further classified into four main types. The largest and best documented users are drilling wells operated by Urban Water Supply and Sanitation companies. These wells are concentrated mainly in the cities, providing water to densely populated areas. They are usually deep wells at the Pliocene layer with large flow volumes, and well-monitored. The second type of users are wells drilled by factories that require relatively large volumes of water. These wells too are often concentrated in urban centers and industrial zones. A third category of wells is managed locally by Rural Clean Water and Environmental Sanitation Centers to supply water to household clusters. These wells are sufficient for small to medium volume water users. The fourth category consists of small drilled wells, self-managed and exploited by rural households for domestic purposes. Small rural wells are often located outside the range of the central water stations: they are of shallow to medium depth with small flow volumes, mainly serving family needs and household production (see fig. 6.2).

Value of groundwater in agriculture

The purpose of this study is to determine the monetary value of groundwater in agricultural production in Vietnam. Given the prevalence of household usage as well as the absence of monitoring to limit extraction, this study focuses on households who use groundwater for agricultural production. The study aims to evaluate access to groundwater

Figure 6.1: Cross-section of groundwater aquifer in the Bassac River



Source: An et al. 2014

6.2 Different groundwater irrigation systems in Vietnam

A. Large central groundwater pumping and processing station in Ca Mau province



Source: LMPPI

B. Bore well (left) and dug well (right) for coffee plantations in Cu M'gar, Central Highlands



Source: LMPPI

C. Central groundwater station for a local commune in the Central Highlands



Source: LMPPI

and its use for agricultural proposes. We limit the scope of the study to the direct economic value to household level agricultural activities, which account for half of the total extracted water volume in some VMD provinces, such as Ca Mau and Dong Thap. Large users, e.g. urban and communal water supply stations extracting from deeper wells are better monitored, and thus do not pose significant long-term environmental issues.

We employed several methods, including a production approach, a hedonic valuation approach—i.e. indirect measurement of groundwater as an input in economic activities, which affect the value of production of irrigated land and thus, the market value of land—and comparing farms with and without access to groundwater, to answer these questions: What is the equivalent monetary value of groundwater as an input in agricultural production? What is the aggregate value of groundwater to the local and regional economy?

Answering these questions will help formulate solutions to broader questions of water sustainability: Can the administration and management of groundwater in Vietnam be improved to reduce over-extraction, and can groundwater extraction be kept at sustainable levels? For the longer term, given water shortage scenarios, what types of water governance of all hydrological sources (surface and groundwater) will ensure an adequate water supply for all purposes (agriculture, urban, industrial, and household use) in Vietnam that is efficiently and equitably managed?

Water value and measurements

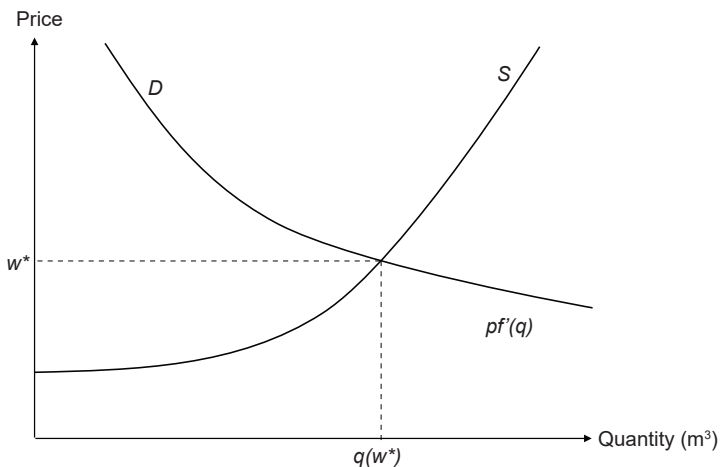
It is important to define which value we are attempting to measure. Water is normally not traded as a commodity, but as an input to the production of an output such as a crop or a real estate asset. Therefore, the value of water must be identified indirectly through other markets. Water, as a critical input in the ecosystem, also carries non-use values that are unrelated to the production of any economic goods. We first briefly discuss methods of water evaluation, their corresponding measurements, and why they matter.

First, the total value of water is different from the marginal value of the last unit of water used in the production of an output. The marginal value is the added value of using an additional unit of water (volumetric), while the total value of water is the contribution of water as an input,

along with other inputs such as feed, fertilizers, labor and capital. An economic efficiency assumption requires that water is used up until the marginal value is equal across alternative uses. The total value, measured as the area below the marginal benefit curve, could be much higher than the unit price of the last unit of water used in the production of an output, for example, rice.

If water is abundant, and therefore, the cost of supply is essentially zero, the marginal benefit could be extremely small or even zero. In fig. 6.3, the total value of water is the area under the downward sloping demand curve $pf'(q)$ up to the quantity consumed $q(w^*)$. The marginal value of water, if water is efficiently allocated, is equal to the marginal cost w^* , at quantity $q(w^*)$. Under the assumption that farmers are well informed and the market is in equilibrium, the marginal values of product of all inputs are equal, across inputs and production systems. Therefore, it is not necessary to examine every production system which uses water as an input in order to identify the marginal value of water.

Figure 6.3: Total value and marginal value of water



Second, the short-run and long-run values of water are different. In the short run, when productive capital and some inputs are fixed, water demand is expected to be more inelastic, and thus has a higher willingness-to-pay (WTP) than in the long run. In the long run, water users could shift to more efficient production technology which will allow them to be less dependent on any single source of inputs, including water.

The fixed cost of a water supply system is usually enormous, while the cost per unit of water supplied is very small. Young and Loomis (2014) discussed the appropriate treatment of water and suggested that water should be evaluated as a fixed input in agricultural production and a variable input in industrial production. However, ignoring the time dimension or nature of inputs can seriously lead to underestimation of the cost of production and overestimation of the value of water.

Third, at-site and at-source values of water are different. The at-site value of water is calculated at the place of use, while the at-source value of water is calculated at the location where the water is obtained. Costs associated with pumping, transportation, and storage could be much higher than the economic value of water at the point of use, and therefore, the economic value of water of similar quality at the point of use may differ widely from the value at the source (*ibid.*). This is especially true for a groundwater irrigation system because the establishment cost is a significant obstacle for farm owners. At-source economic values of water could be negligible, but the cost of extraction could be prohibitively high.

Fourth, water value could be measured per period or as capitalized value into an asset. For agriculture, the annual value of water is the value of water as an input for a year (or cropping seasons within a calendar year) per unit of land. The capitalized value of water is the value of ownership of water access attached to a piece of land. Both values are directly related via a discount rate. If farm owners have perfect information and there is no uncertainty over the future value of water, then discounting the stream of water value over an infinite time horizon generates the capitalized value of water.

Five, water has both use and non-use value. The use value of water, either consumptive or non-consumptive (also called in-stream) use, is derived from the production of an output; thus, an economic value could be assigned to each unit of input. Non-use (or passive-use) value could be an existence value of water, which may merely reflect the notion that water is preserved. The non-use value is not tied to the actual consumption of water. It could be the value of ecosystem services attached to water sources (runoffs, fauna and flora, saline prevention, land subsidence, etc.), because the existence of most if not all ecosystems is solely determined by having access to some sources of water, such as rainfall, an irrigation canal, reservoirs, or groundwater. Therefore,

focusing solely on the use value of water might understate the total economic value of water, which includes both use and non-use values. However, non-market values are often subjective and often not well measured.

In some cases, certain sources of water such as groundwater are not primarily used, especially when canal or rainwater is readily available, due to both the quality and cost of extraction. However, groundwater proves to be critically important, and even considered a backstop resource, during an extended period of drought. In such an extreme condition, the value of the backstop is not well defined. This study aims to measure the value of groundwater as a *regular* input in a typical production system, in the absence of such uncertainty.

Valuation methods

Water is considered an input in production, but one that is most often not traded or priced explicitly. Therefore, the value of agricultural water supply must be measured in terms of its contribution to the total value of a crop. Farmlands that have better access to water, all else being equal, will have a higher productivity. Comparing farmlands with similar characteristics (demographics, soil characteristics, climate conditions, and input intensity) but with differing degrees of access to water, it is possible to attribute production value to water use. Depending on the concept of use (at the margin, the total contribution, or as substitution for other sources), the measured values of irrigation water, and of groundwater, vary significantly in the literature.

The accounting approach (also called the residual valuation method) identifies the total value of water as the residual value to the total production value after subtracting all accountable costs of other inputs. In a static equilibrium with a small decision-maker (thus no market power to influence price), the product exhaustion theorem indicates that the value of the marginal product and the price of that input equal, $VMP_i = P_i$. While this approach appears easy to implement, the requirement for very detailed household interviews to identify every aspect of production, including the type of outputs and inputs, volume of use, price for each output and input, including those supplied by each household and thus do not have a market price. Ensuring data collection that entails all necessary inputs (both quantitative and qualitative) and values of

non-market inputs, skills and expertise will be challenging. Missing, unobserved or under-valued inputs can greatly affect the calculated value of water in the residual value approach, making this method less appealing in practice. Studies using the residual method to estimate irrigation water value in mostly developing countries include Berbel et al. (2011), Kiprop et al. (2015), Syaukat et al. (2014), MacGregor et al. (2000), Kumar et al. (2004), Hussain et al. (2009), and Lange and Hassan (2006).

Alternatively, water used for agriculture can be valued in a production function that links the transformation of inputs into an output. Farmers will choose the optimal level of inputs such that the net revenue (the revenue from crop sales less the cost of inputs) is maximized. Assuming farmers use the same technology and are fully efficient, the relative price of inputs is then equal to the marginal value of the product (crop) at its optimal level of production. Farms with better access to water are expected to have higher productivity, in the same way as access to roads or other infrastructure helps lower costs and thus raise profits. Econometric studies often use a translog production function, which assumes a constant elasticity of substitution between inputs; however, a flexible translog function may also be used.

In the absence of farm output data, a hedonic valuation approach relies on land characteristics to predict the contribution of water access to the total value. A more productive farm often sells for more than a less productive one, assuming all other characteristics being similar. The hedonic regression approach estimates farmland values based on observable farm characteristics, then infer the contribution of water access to the total land value. Studies using the production or the hedonic valuation approach include Brozovic and Islam (2010), Swanepoel et al. (2015), Torrell et al. (1990), Mukherjee and Schwabe (2014), Faux and Perry (1999), and Stage and Williams (2003).

An advantage of the hedonic valuation is that water value is identified through the real estate price, with a perfect market assumption (which is certainly subject to further debate). Farmers are assumed to automatically switch to the most profitable production system in the long term by choosing the most efficient production method (thus equating marginal benefit of water use across crops or land use choice). Thus, the value of water is the same across all types of production or land use. This removes a potential issue facing other methods such as the residual valuation

technique in which input values are priced differently according to each farming system's income stream.

These approaches will only help identify the market value of water. None of the above methods is able to estimate the non-market value of water. Non-market values are values that may not be reflected in transactions. Water has many non-market values, including the value of scarcity which drives up future extraction costs, land subsidence, as a buffer stock for surface water supply. The WTP approach can identify the value of water scarcity or via hypothetical market interviews with water users.

Table 6.1: Value of groundwater irrigation in other countries

Study	Country	Method	Capitalized Value	Annualized Value
Brozovic and Islam (2010)	US	Hedonic, Matching	\$712–723/acre ^a	\$41–48/acre
Swanepoel et al. (2015)	US	Hedonic	\$1574/acre	\$16–25/acre-foot ^b
Torrell et al. (1990)	US	Hedonic	\$610/acre in NM 1980	
MacGregor et al. (2000)	Namibia	Residual Value	N\$0.03 (financial) – 0.64 (economic)/m ³	

Notes: ^a 1 imperial acre = 4,046.86 m²; ^b an acre-foot volume equals to a field of one acre filled to a depth of 1 foot.

Farmland production and water valuation

We model crop yields or farm outputs as a function of variable inputs, land characteristics, household demographics, and other control variables, assuming a physical transformation process taking place in an efficient manner:

$$\log(Y)=f(\text{Inputs, Land, Labor, Climate, Others})$$

where $f(.)$ describes a functional relation between inputs and outputs. Output can be measured as yields (total production per acreage planted or harvested), or values of output (yield multiplied by unit price, assuming small farmers and a competitive market). Inputs can be either observable or unobservable. We assume $f(.)$ a linear combination of inputs and the

logarithm of output, making the interpretation of estimated coefficients as a percentage change in output. A set of location fixed effects could be included to control for unobserved factors that do not change over time such as climate (temperature, precipitation), local conditions (road, infrastructure), and other socio-economic factors.

$$\log(Y_i) = \beta_0 + \beta_1 * D_{IRRI\ i} + \sum_j X_i^j * \beta_j + \varepsilon_i$$

Irrigation can be considered as an input to the production or as a property of the farmland. Farms having access to any source of water, either government-built canals, a stream/river, or groundwater, may be more productive than those without any type of irrigation. Since we do not observe the amount of water withdrawal, the value of having irrigation is interpreted as the value of having access to water per unit of agricultural land (one acre or hectare), regardless of the withdrawal amount or water quality. Farmers may decide to pump as much as allowed to maximize the value of crops grown on their land. This interpretation of the value of water is aligned with Young and Loomis (2014), that is, water should be considered a fixed input in agricultural production.

Closely related to the production approach, the Ricardian hedonic valuation estimates the farmland value as a function of its attributes, among which having access to irrigation is an explanatory variable. If the land market is perfectly competitive, and farm owners have complete information about their land, the value of farmland is defined by its potential production possibility and profitability. More profitable farmlands are likely to have a higher market value. Observing the market price of farmland transactions and its determinants, a regression model can be used to identify how irrigation capitalizes in farmland value by raising the price of irrigated farms as compared to that of non-irrigated farms.

Data sources and empirical findings

In Vietnam, necessary information on groundwater—e.g. the location of water pumps, well depths, and water characteristics—is generally not available. To estimate the value of groundwater to household farming, we relied on a combination of econometric methods which allow us to identify the value of irrigation water in general, and then compare farms with and without access to groundwater to separate the impact of having groundwater on farming (fig. 6.4). The Vietnam Access to Resources Household Survey (VARHS) data is the only large-scale household database that collects information pertaining to production practice and irrigation systems used in farming. The VARHS 2014 survey has a sample of 3,648 households in 12 provinces from north to south across Vietnam (fig. 6.5). We identified parcel-level information about outputs, inputs, type of irrigation, and household characteristics, totaling 16,343 farm plots. The number and share of plots with each irrigation type are shown in fig. 6.6. In addition, we conducted two field surveys in the Central Highlands and in Ca Mau province of the Lower Mekong Delta to validate the model results. Both surveyed locations are heavily dependent on groundwater for coffee plantations or as the primary source of water for all economic and daily uses.

Figure 6.4: The structure of a with-and-without analysis

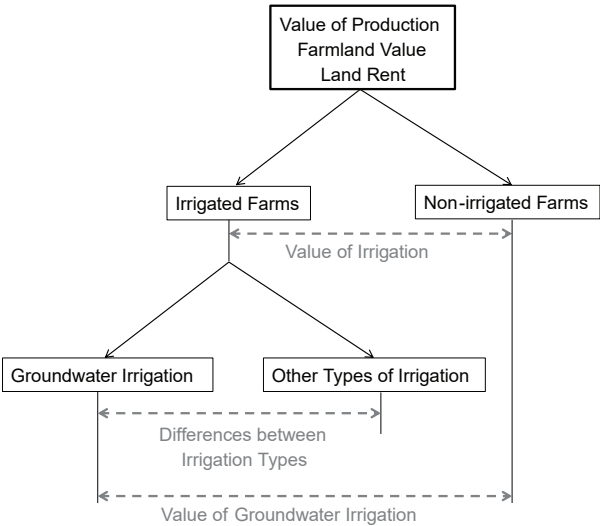
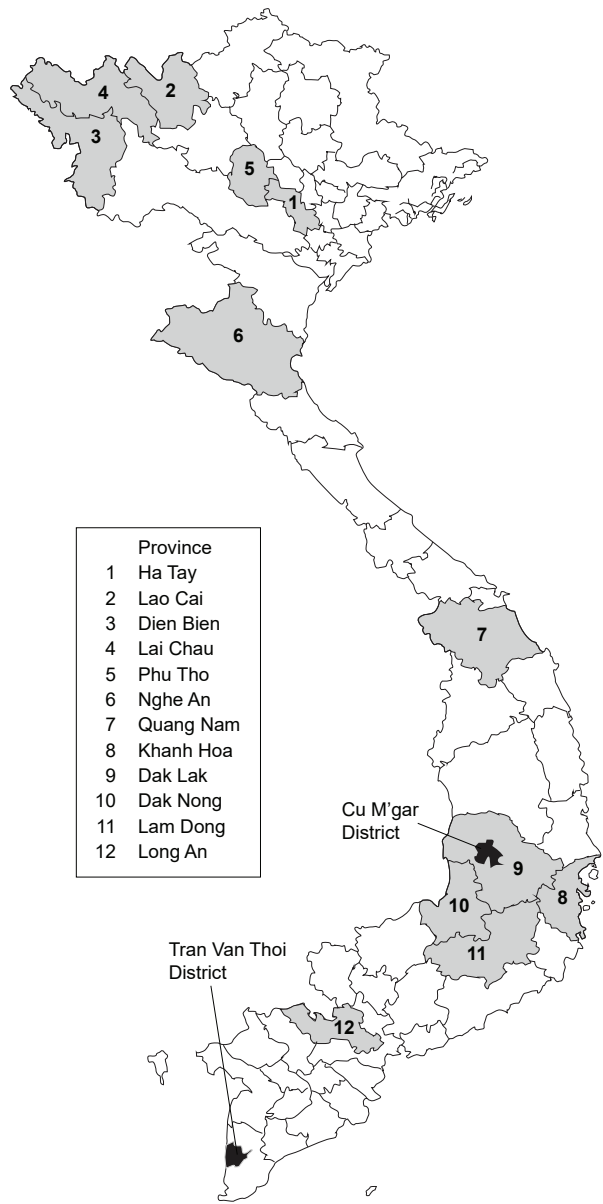
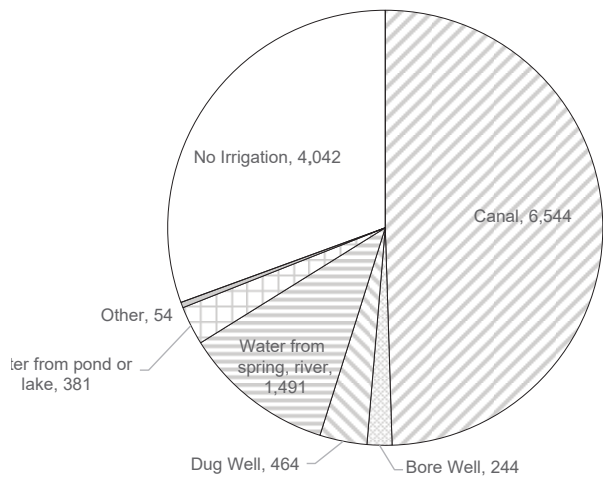


Figure 6.5: The location of 12 VARHS provinces, and field surveys in Cu M'gar district, Dak Lak province, and Tran Van Thoi district, Ca Mau province



Source: LMPPI

Figure 6.6: Number of farm plots by irrigation type



The hedonic valuation suggests the at-source value of groundwater irrigation at VND6.32 million/ha/year, which is similar to the result of VND5.55 m/ha/year from the model of land rent. Groundwater for coffee plantations even carries a higher value, VND9.10 m/ha/year. Using the production approach, we compared the value of alternative irrigation types, whether a farm has access to a main canal or groundwater irrigation. We found no significant difference in the impact of different types of irrigation on farmland values. Furthermore, we identified the upper limit of the value of irrigation of approximately VND20 m/ha/year for rice fields. The econometric modeling and estimates are detailed in Le (2018). The results are summarized in table 6.2.

Table 6.2: Value of irrigation and groundwater irrigation by different methods (VNDm/ha/yr; US\$1 = VND21,388)

Method	Irrigation		Groundwater Irrigation
	Rice Farms	Maize Farms	
Production method	15.20	8.32	
Hedonic valuation	20.25		6.32
Coffee			9.10
Land rent model			5.55

Groundwater management: The way forward

Understanding the policy context is critical in devising an appropriate response. Viewed in this way, the over-exploitation of groundwater is a consequence of Vietnam's overall approach to water governance. There are several negative elements. First, the administrative arrangements for managing water (both surface and groundwater) are dispersed and uncoordinated. There are ten separate ministries, a National Commission, and potentially other agencies with direct (and often overlapping) responsibilities for water management. There is no overall mechanism for harmonizing policy and action. Second, there has been serious and extended public under-investment in water resources throughout the country. Irrigation and flood control have received the bulk of this limited allocation. Thousands of kilometers of canals and dikes have been constructed to deliver water to farms, cities, urban users and to modify the effects of flooding. Literally nothing of any consequence, however, has been spent on drainage and the control of water pollution. For much of the Mekong Delta, water is supplied and drained through the same system. This has profound implications for water quality which, in turn, accentuates the rate of groundwater extraction, especially in the Lower Delta region.

A third negative element is that farmers and other water users have been given access to water at minimal and often no fees. The public sector has subsidized water supply charges and the expansion of the irrigation system. With all public funds for agriculture limited (barely 5 percent of the national budget), the principal costs most farmers have borne have been implicit. Primarily, these have been poor water service, inadequate drainage, and increasingly contaminated water. While farmers and other water users have been subject to these rising implicit costs (especially related to seasonal access to water and its quality), the increasing scarcity of good quality water has not been reflected in explicit water charges.

On the positive side, farmers and other water users have been enterprising in finding new and more productive uses for water. As noted above, the decline in wild-capture fisheries stimulated the expansion of aquaculture. Increasing saltwater intrusion in the Delta led rice farmers to shift to shrimp–rice rotations. More recently, water has been diverted to higher value activities such as livestock, fruit and vegetable farming. And, as water upstream becomes more contaminated, Vietnamese producers are increasingly relying on groundwater.

The Government of Vietnam, like many others around the world, is caught in a situation of having inappropriately fixed the price of a socially vital resource. With no explicit charges on the volume of water consumed, households, farmers and industrialists have had no incentive to economize on its use. This did not matter when there was a general surplus of water. But that is no longer the case.

Since the Government of Vietnam can no longer guarantee that water will be available in unlimited quantities to all users (the implication of setting a zero price), it now faces two problems. The first is make the case that water is now scarce in ways that farmers and other water users will accept (i.e., without prompting adverse reactions or resistance) and that remaining supplies have to be managed more efficiently. The second is to begin introducing controls and/or fees on water use so that economic agents across the whole economy will modify their behavior with respect to water as a resource. This will not be easy: overcoming ingrained patterns of lavish water use will require a major shift in economic behavior and attitudes.

Fundamentally, direct government action is the only option. While not acting is also a possible public policy response, it will lead to an intensification of existing behavior, especially the continued over-extraction of groundwater and increasingly severe water rationing. Since a water market already exists in the sale of treated drinking water (a reflection of weaknesses in the public provision of safe access to potable water and lack of trust households have in public water supplies), many Vietnamese are already used to paying for water. Moreover, since many Vietnamese, especially the poor, do not have access to adequate supplies of clean water for household or other use, they are already used to the rising implicit costs of water (reflected in health hazards, water-borne diseases, and/or the increased time and travel inputs to obtain safe water). In this respect, the "general public" already understands the problems posed by the increasing scarcity of good quality water well ahead of government action.

Even if the economic value of groundwater is high, it does not necessarily mean that a full fee should be collected. Groundwater is renewable if extraction is limited to an allowable level. Therefore, a fee should be collected to reduce excessive use or to recover the full cost of operation and maintenance of the irrigation system. However, the

fee should be low enough so as not to affect those who are dependent on subsistence agricultural production but sufficient to aid other agricultural policies to reduce overall extraction. Evidence shows how the use of market incentives can change consumer behavior with respect to groundwater. Households who have to purchase their water from the groundwater supply unit (GSU) consume less than half that of those with private wells (Danh 2008).

From an economic perspective, the Government of Vietnam has not charged fees for the volume of water used in agriculture. This implicit long-standing subsidy to millions of farmers for decades makes the application of market tools to groundwater politically difficult. Administratively, the government lacks adequate data and means for determining patterns of water use. There are laws and regulations on groundwater user fees for commercial purposes, but they are not fully applied in practice. To apply market-based tools in ways that change water users' behavior requires a strategic implementation plan, supported by a suitable monitoring and enforcement system. Developing these will take time and involve experimentation. The Government of Vietnam will need assistance in devising these tools and guidance in managing the adjustment process. International experience should be carefully examined and adapted to the local institutional structure.

Finally, management of groundwater should be framed in the context of overall water governance. As with surface water, groundwater is both an inter-provincial and transboundary (Mekong Basin) resource. Water governance for the VMD should take into account the drivers of groundwater exploitation, problems created by the lack of intra-basin collaboration in managing and sharing of water (upstream hydropower development and water diversion), user demand, seasonal variations, factors affecting water quality, and the intensifying effects of climate change.

Conclusion

This study estimates the value of irrigation water and groundwater used in agricultural production in Vietnam. Production function and hedonic valuations were applied to estimate the value of having access to water resources to agricultural output, farmland value, and land rent. We showed that farms irrigated by groundwater are clearly more valuable than non-irrigated farms by about 32 percent or VND126.4 million per

hectare, on average. Converting this number to an annualized value, groundwater irrigation adds VND6.32 million/ha/year to farm income. In coffee plantations, this value may be as high as VND9.10 million/ha/year. We further established that the upper limit of the value of groundwater irrigation is approximately VND20 million per hectare of irrigated land per year, assuming that all water sources are indistinguishable. These estimates are higher than in other studies conducted for Vietnam. This study shows that groundwater contributes a large percentage of value to agriculture in Vietnam, at least VND1,200 billion per year, yet it remains neither accounted for nor properly monitored to avoid potential depletion.

These high estimates of the value of groundwater indicate significant policy issues. Irrigation water has not been efficiently and equitably managed in Vietnam. Coupled with the increasing reliance on groundwater for agricultural expansion and household consumption, climate change and water diversions in the Upper Mekong Basin, the urgency of a sustainable water policy is warranted. Implementing an appropriate irrigation charge is a first step toward achieving this objective.

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2

Agriculture

7

Agriculture in the Lower Mekong Basin: Current Trends and Policy Challenges

Malcolm McPherson and Le Thi Quynh Tram

This chapter examines trends in agriculture—which encompasses crops, livestock, aquaculture, horticulture and fisheries—across the Lower Mekong Basin (LMB) to identify the adjustments needed for the sector to remain dynamic, productive and profitable. We analyze agriculture's contribution to the regional economy, society, and environment to identify how the sector has been changing, and will have to continue changing over coming decades, to support economic, social and human development. These dimensions have been widely studied in a variety of contexts (e.g. Duong et al. 2003; World Bank 2007, 2016; Johnston et al. 2010; ADB 2013).

The principal challenge for agriculture in the LMB is to continue producing high-quality food and fiber in quantities that sustain national economic growth and development while simultaneously leaving the environment and ecological systems unimpaired. By meeting these goals, the sector will generate productive employment and increase incomes to levels that sustainably alleviate poverty, eliminate food insecurity, and raise rural living standards.

Despite rapidly increasing output over recent decades, LMB agriculture has not met these goals. Moreover, with current institutional arrangements, policies, and governance, it cannot meet them. Fundamental structural changes at all levels—individual, household, community, regional, national, and international (especially transboundary)—are required. The anticipated negative impacts of climate change add to the urgency.

The next section describes the key features of agriculture in the LMB. This is followed by an examination of issues affecting the sector's prospects: policy-induced resource misallocation, increasing

environmental stress, adverse labor force dynamics, and ineffectual management of transboundary resources. We then review how policymakers might constructively respond to these challenges.

Agriculture in the Lower Mekong Basin

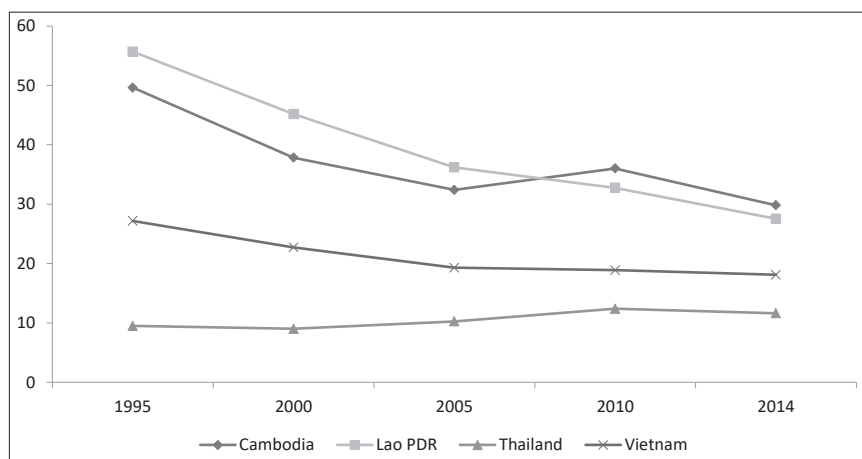
Agriculture is fundamental to livelihoods and welfare throughout the LMB. By raising rural incomes, supplying increasing amounts of food, feed, fuel and fiber, boosting export revenue, and broadening the national tax base, agriculture is already a major contributor to national development. All LMB governments seek to create modern, urban-industrial, and globally integrated economies; agriculture has been critical in providing a foundation for that effort.

Agriculture is the major source of employment and livelihoods in the region, dominating land use, water demand,¹ stimulating trade, and strengthening the balance of payments. This performance is reflected in conventional benchmarks. Productivity has improved since the late twentieth century: agricultural incomes have risen; both the volume and variety of agricultural exports have increased; and social indicators such as absolute poverty and food deprivation have declined. To illustrate, between 1995 to 2013, food production increased by 193 percent in Cambodia, 194 percent in Lao PDR, 118 percent in Vietnam, and 60 percent in Thailand.² Lower, but still impressive, increases were recorded for livestock production. Productivity per worker in agriculture, measured in constant US dollars, rose steadily from 1995 to 2015, although the gains have been small, both in absolute terms and relative to urban incomes.³ Pressure on the land base, measured as arable land per capita, is high. This accentuates rural poverty and compounds the difficulties resource-dependent households face as they seek to enhance their livelihoods. Figure 7.1 traces the contribution of agriculture to GDP in the LMB.

Despite these impressive outcomes, the standards of living of large numbers of farmers, fishers and their dependents have not risen significantly. Many individuals and households engaged in agriculture are poor, suffer from food insecurity and marginalization, and lack the assets (especially skills and knowledge) to sustainably raise their incomes and welfare.

There are several reasons for the lack of improvement in their living standards. Agriculture and rural development receive minimal

Figure 7.1: Agricultural value-added in the Lower Mekong Basin, 1995–2014 (% GDP)



Notes: Data for 2015 are Cambodia 15%; Lao PDR 28%; Thailand 9%; and Vietnam 19%.

Sources: World Bank and OECD national accounts data, online.

official support. Environmental stress is intensifying, in part, through the unwillingness (or inability) of LMB governments to enforce their own environmental laws. There has been a rapid ageing of the farming population as youth abandon the rural areas. Transboundary resource management is weak at best, increasing the stress on each country's ecosystems; the widely anticipated adverse effects of climate change will only worsen this trend.

The future of agriculture

The future trajectory of agriculture in this region will largely depend upon how policymakers respond. Four issues will need to be addressed: policy-induced resource misallocation; intensifying environmental stress; adverse labor force dynamics; and the institutional incapacity to manage local and transboundary development issues.

Policy-induced resource misallocation

In principle, this matter should be the easiest to remedy. Through dozens of action plans, strategies and policy statements, all LMB governments have reaffirmed their commitments to the United Nations' Sustainable

Development Goals, achieving broad-based, inclusive economic growth, sustaining the environment, and promoting human development (United Nations 2015).

Yet, there is ample evidence that these commitments have not been met. Resources vital to environmental sustainability, agricultural productivity, and enhanced livelihoods are systematically undervalued. This encourages their neglect or misuse. Examples include the waste of public goods such as ecological services, the under-funding of agricultural research and development (R&D), and the misallocation of key productive resources due to distorted pricing.

Correctly valuing ecological services, such as those derived from water, would improve efficiency and equity. Charges for water that fully reflect its scarcity would reduce its use, conserve complementary resources such as fuel and electricity, and “free up” water for those who currently lack access. It would also increase the dry season flow in the Mekong River and through wetlands to sustain critical bio-physical processes such as the dilution of effluents, flushing of acid sulfate soils, maintenance of marine ecosystems, and countering saltwater intrusion. Reducing the current use of water would improve equity. At present, dry season water is rationed on a first-come, first-served basis. This arrangement gives an automatic advantage to non-coastal communities and leads to excessive extraction of groundwater. There are many examples—coastal residents have to travel further inland to obtain non-saline water, crops are damaged by saline intrusion, communities are threatened by coastal erosion, and marshes and mangroves are disappearing (Gillet 2011; Nguyen 2013; Gia 2014).

Another policy distortion which should be corrected is the budget allocation for agriculture and rural development. Budget policy is *not* what a government announces, but what it chooses to tax and the activities it finances. Farmers in every LMB country would benefit if the respective governments were to heed the principles of “optimal public finance” in their budget allocation or, at least in assessing how their budgets perform. That exercise would show that rural incomes and welfare across the LMB would rise significantly if additional funds were allocated to agriculture and rural development.⁴

Numerous other resources are inappropriately valued because of artificially inflated transactions costs. The high cost of marketing and

distribution services (evident in weak or disrupted value chains) primarily results from government interference that enables state-owned enterprises to maintain monopoly positions and other concessions (such as access to subsidized credit).

Intensifying environmental stress

Lao PDR and Cambodia have been criticized for developing the hydropower potential of the Mekong River. This argument is misguided since these countries have a comparative advantage in hydropower. If efficiently and equitably developed, hydropower would electrify each country, generate export revenue, and stimulate national growth and development. Nonetheless, there will be costs. The hydro dams will permanently diminish the capacity of the Mekong and its watersheds to generate the ecological services, such as erosion control, carbon sequestration, biodiversity protection, aquifer recharge, transport, and toxin flushing among others, which sustain agriculture and support rural livelihoods and have been seriously undervalued (Janekarnkij and Polpanich 2014; Hall and Manorum 2015). Appropriate valuation would reveal the high social costs of “development” projects which destroy or degrade them (Le and McPherson 2017).

Improving methods of valuation help focus attention on ecosystem resilience and “tipping points”. Both are subject to uncertainty although theory offers a guide. The “precautionary principle” reminds policymakers that, when investment involves irreversible resource transformation, the “safety-first” notion of keeping options open has both social and private value. According to the “precautionary principle,” when human activities involve the possibility of unacceptable harm, measures should be taken to avoid or diminish that prospect (UNESCO 2005, Box 2). “Safety-first” principles set limits on the probability that failure will result in calamity (such as the complete loss of wealth).

As described in greater detail elsewhere, these shifts in valuation and improved decision-making will need to be supplemented by the implementation, without fear or favor, of the LMB’s existing environmental laws. Each country has state-of-the-art law but it is, at best, weakly enforced (Le and McPherson 2017).

Adverse demographic trends

The incomes and productivity of workers in agriculture and non-agriculture differ by wide margins across the LMB. Agricultural growth, though positive, has been significantly lower than growth in non-agriculture. Employment creation in non-agricultural activities does not absorb the large numbers of laborers who wish to leave agriculture. Older workers and others with few skills have low reservation wages and, thus, no incentive to move. The young and better-educated wish to leave, but the lack of non-agricultural jobs “locks” many of them in rural areas.

These outcomes keep agricultural productivity low. Older, less educated workers (especially women) have fewer incentives to adopt productivity-enhancing techniques. Adoption requires additional learning and offers low net rewards, especially when risks are allowed for. Yet, even if older workers wish to upgrade their techniques, viable options are limited. With so few resources being spent on agricultural R&D, the technical problems faced by older workers and women are not being researched and remedied. Younger, better-educated workers who would prefer to move to urban, non-agricultural jobs have little motivation to hone their agricultural skills.

Ineffective institutional mechanisms

Responsibility for natural resource management is fragmented and largely dysfunctional in all the LMB countries. Water governance is an example. In Thailand, there are more than thirty official entities involved in managing water.⁵ No country has an agency which specifically handles matters related to the Mekong and its tributaries, or monitors and regulates water quality, or allocates water.⁶

These deficiencies have serious consequences. There are no coherent national development strategies that promotes the efficient use of water, appropriately values the ecological services derived from water, and/or effectively incorporates these values into national investment programs. This limits each country’s capacity to raise water productivity and the activities which water complements. There are few arrangements to respond to the concerns of the poor and marginalized who depend on water-based activities, or to protect them from the adverse consequences of national plans to develop water and other natural resources.

A further institutional gap is the lack of regional economic integration. Formal intra-regional trade within the LMB is minimal. This contrasts sharply with the large informal/illegal trafficking in timber, drugs, humans, semi-precious stones, counterfeit goods, and animal parts. These informal flows have filled a vacuum left by official inattention.

Recommendations for policymakers

Agriculture throughout the LMB could have a sustainable, productive future. That, however, will require major changes in the sector and the sociopolitical setting within which agricultural policies are formulated and implemented. The following policy recommendations suggest how that might be done.

One: LMB governments should actively facilitate the transfer of labor out of agriculture. Institutional arrangements will have to be strengthened or created. Laws and regulations related to land tenure should be revised to enable farmers to sell, lease, contract out, loan, or otherwise transfer their ownership or use-rights to land. Complementary changes in regulations on finance, water management, input supply, mechanization, and product marketing should also be made. Agricultural R&D should be reoriented to help *all* farmers (young and old, female and male) by focusing on environmentally suitable, productivity-improving technologies.

Two: Integrate urban and rural development strategies so that LMB countries move beyond their current practice of developing the urban areas at the expense of rural areas.⁷ It will also enable the labor which is leaving agriculture to be more easily absorbed into non-farming occupations.⁸

Three: Raise the productivity of all resources used in agriculture through multiple mutually reinforcing activities. Improve macroeconomic governance to ensure low inflation, a competitive exchange rate, and open markets. Provide farmers with training and access to information to increase their agricultural capabilities. This will help them adapt to shifting supply and demand conditions, modify their production techniques, and mechanize their operations. Promote the broad-based expansion of social services to upgrade rural health and education as a means of further reducing poverty and food insecurity.

Four: These initiatives should be supported by substantial increases in public sector investment in rural infrastructure (roads, bridges, ports, drainage, and storage facilities) and other social overhead capital. Public investment of this nature would help “crowd in” private investment in agriculture and rural areas.

Five: Reduce the rate of environmental degradation by enforcing existing regulations. In all their development projects, LMB governments should fully and fairly value *all* resources (including ecological services) used. Requiring full valuation will not block development. Rather, it will reduce waste and resource dissipation, thereby improving equity and the quality of growth.

Six: Create and/or strengthen transboundary organizations to manage and maintain the LMB’s natural resources. A constructive start would be Basin-wide cooperation to effectively manage the region’s biodiversity and efficiently share limited resources, such as dry season water. Region-wide collective monitoring and reporting rates of natural resource depletion should begin immediately.

Seven: Devise and implement a collaborative plan to upgrade and extend infrastructure throughout the LMB. Providing quality electrification to the rural areas and creating an LMB power pool are long overdue (Chang and Li 2012). A task force comprising all LMB Ministries of Planning should jointly plan the expansion of infrastructure—roads, bridges, ports, airports, pipelines, rail links, and so on—to facilitate the movement of goods and people throughout the Basin.⁹

Eight: Devise Basin-wide mechanisms to monitor and respond to climate change. Regional collaboration in agricultural R&D would deal with the effects of pests, diseases, and weather-related stresses in crops and livestock to help farmers, livestock producers, and fishers adapt. The impact of the Basin’s ageing and increasingly feminized agricultural labor force should be understood and constructively addressed (FAO 2010; IFAD 2014; Henley 2015).

Conclusion

Under existing institutional arrangements and governance structures, agriculture within the LMB does not have a sustainable future. This is despite major progress over recent decades in staple crop production, horticulture, livestock raising, and aquaculture. Though significant and

important, these advances have seriously degraded the environment. Moreover, the gains made have been well below those needed to alleviate poverty and eliminate food insecurity. Many producers and workers who lack the assets (especially skills and knowledge) to enhance their livelihoods have been marginalized or displaced. Furthermore, large numbers of farmers cannot generate the resources to respond effectively to future challenges, including climate change.

Agriculture and the environment are on unsustainable trajectories in large part because local and regional institutions cannot halt (or even reverse) environmental pollution, livelihood impairment, and ecosystem damage. With few exceptions, local plans to “develop” the LMB’s resources—by building dams, expanding irrigation schemes, and extending transport networks—do not include the transboundary collaboration required to efficiently manage the Basin’s ecosystems.

At present, agricultural output across the LMB is being maintained through high inputs of fertilizer, herbicides and pesticides combined with *permanent* reductions in the limited stock of natural capital.

The main task confronting agriculture over the coming decades will be to help farmers sustainably raise their productivity. Currently, too many national resources are being diverted from rural areas, exacerbating the longstanding existing deficiencies in rural social services and infrastructure. Furthermore, within agriculture, too much of the limited budget allocated to agriculture is spent on irrigation and other “big ticket” items, with too little devoted to agricultural R&D and efficiently operating and maintaining existing facilities. Until these imbalances are remedied, agriculture and the rural areas will have few of the capacities that enable the rural population to eliminate food insecurity and craft pathways out of poverty.

Potential solutions should focus on raising the productivity and incomes of those who remain in farming. They will require a two-pronged strategy. One is to create conditions which encourage major increases in public and private investment in agriculture and related rural industries. The other is for the public sector to support large-scale migration of farmers and rural workers out of rural areas. Together, these actions will provide a managed transition for agriculture which avoids continuing bio-physical degradation, steadily improves productivity, and raises the living standards for those who derive their livelihoods from the LMB’s natural resources.

Notes

- ¹ Agriculture accounts for 94% of fresh water withdrawals in Cambodia; 82% in Lao PDR; 91% in Thailand; and 87% in Vietnam (USAID 2006: table 3).
- ² World Bank, World Development Indicators online, <http://datatopics.worldbank.org/world-development-indicators/table/3.3> (accessed October 14, 2016).
- ³ For the period 1995 to 2015, agricultural value-added per worker increased by 40% in Cambodia, 39% in Lao PDR, 72% in Thailand, and 64% in Vietnam. These small increases relative to overall real per capita income growth led to a sharp increase in the absolute rural–urban earnings gap. For Thailand in 2015, it was \$10,560 and in Vietnam it was \$3,500. In relative terms, the gaps were 3.6 and 2.3 (Le and McPherson 2015).
- ⁴ World Bank metadata series (www.wdi.worldbank.org/vnm-Country_en_excel_v2, accessed October 14, 2017) illustrate the point. From 2005 to 2015, the annual growth in agriculture was 3.4%, and for the whole economy 6.4%. Growth of non-agriculture was 7.2%. During the same interval, the average investment in agriculture was 11% of sectoral output while for non-agriculture it was 33.5%. Thus, on average, capital used in agriculture has been 44% ($= 4.65/3.24$) more efficient in generating growth than in non-agriculture. Vietnam's agricultural income, national output, exports and welfare and human development would be significantly higher for those who depend on agriculture if some investment now spent on non-agricultural activities were shifted to agriculture.
- ⁵ See FAO's Information System on Water and Agriculture, AQUASTAT, <http://www.fao.org/nr/water/aquastat/main/index.stm>. Country reports describe "institutions" and "water management." The 2012 report for Lao PDR noted that there are ten separate committees and departments under four ministries and the Prime Minister's Office responsible for "water management, policies and legislation related to water use in agriculture." The 2011 report for Vietnam lists nine ministries, the Prime Minister's Office, and the National Water Resources Council as having jurisdiction over water. There are parallel agencies at the provincial and district levels which handle implementation. The 2011 report on Thailand noted "there are 31 ministerial departments under 10 ministries, one independent agency and six national committees that are involved in water resources development." It continued: "most laws related to water management are outdated." In 2011, Cambodia had four ministries and four separate units and departments responsible for water.
- ⁶ National Mekong River Commissions or their equivalent are consultative mechanisms. In Vietnam, it is part of the Ministry of Natural Resources and Environment (MONRE) which, as noted above, is one of more than ten agencies responsible for water governance.
- ⁷ Even with all the attention LMB government devote to urban development, most metropolitan authorities cannot manage effectively urban sprawl, provide effective drainage and flood mitigation, ease traffic congestion, control pollution, or deliver potable water to their citizens (Gall 2015; World Bank/MPI 2016).

- ⁸ Coxhead et al. (2010: 73) discuss synergies between rural and urban development. They noted: “Nonfarm growth helps resolve the problem of too many workers ‘trapped’ in agriculture and rural areas, with low-productivity, low-wage occupations, for want of a better alternative.”
- ⁹ Cooperation could be extended to reduce illegal activities which undermine the environment, e.g. timber smuggling (Saunders 2014).

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8

Effects of Seed Quality on Sustainable Black Tiger Shrimp Production in the Vietnamese Mekong Delta

Le Canh Dung and Vo Van Tuan

In coastal areas of the Vietnamese Mekong Delta (VMD), approximately 1.8 million ha is currently intruded by saline water, accounting for 45 percent of the delta in the dry season (Tri 2012). In this saline area, brackish-water shrimp, mainly black tiger shrimp (*Penaeus monodon*) and more recently white leg shrimp (*Penaeus vannamei*), is the second-most valuable agricultural product after rice, earning US\$3.95 billion, slightly more than 50 percent of the value of Vietnam's total aquaculture exports (MARD 2015). In 2014 more than 80 percent of the national shrimp production (MARD 2015) was from this area. Brackish-water shrimp aquaculture is predicted to increase in the context of rising sea levels as well as a reduction in fresh water discharges from the Mekong River due to upstream hydropower and irrigation development. This study assesses the effects of seed quality on the economic efficiency of black tiger shrimp farming and proposes a market-based mechanism for improving the supply of high quality shrimp seeds in the coastal VMD.

Brackish-water shrimp is raised in either shrimp monoculture systems (SMS), mostly in the saline water areas, or in integrated cultivation systems where fresh and saline water are seasonally available, such as the rice–shrimp system (RSS), forest–shrimp system, and shrimp cultivation integrated with other aquatic species. Shrimp cultivation is classified into extensive, improved-extensive, semi-intensive and intensive shrimp farming systems. These systems are characterized by shrimp species, stock density, feeding patterns and applications of agro-chemicals. In recent years, there has been an observable increase in the stocking density of shrimp seeds in both SMS and RSS.

Shrimp cultivation in the VMD faces various risks and difficulties, however, such as water shortages and worsening water and shrimp seed quality (Khai 2007; Oanh and Phuong 2012; Long and Chin 2012). Recent outbreaks of shrimp disease have been devastating for many farmers (Dung et al. 2010). This study argues that improving the sustainability and profitability of shrimp farming requires a combination of good water management, healthy seeds, proper stocking density, and appropriate feeding schedules. We specifically examine the costs and benefits of using high quality shrimp seeds in the improved-extensive aquaculture of black tiger shrimp, widely practiced in the VMD. The study's findings are used to propose a mechanism for improving shrimp seed quality management throughout the Delta.

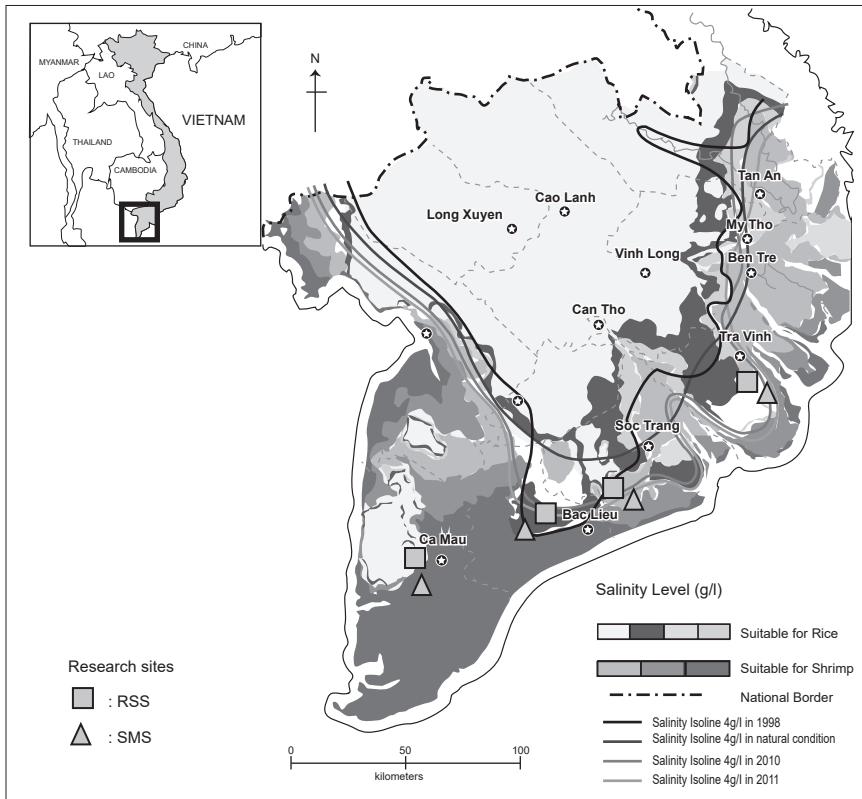
Methods and materials

Figure 8.1 shows the location of eight communes in Ca Mau, Bac Lieu, Soc Trang and Tra Vinh (henceforth, the CBST) provinces practicing improved-extensive SMS or RSS selected as representative study sites for the VMD.¹ In order to identify risks in shrimp cultivation and their cause, this study used interviews, desk studies, key informant panels (KIPs), and focus group discussions (FGDs), followed by quantitative analysis using data obtained from a structured household survey.

A problem tree analysis was initially conducted to identify core problems and reasons for the low economic efficiency of shrimp farming, based on information obtained through KIPs and FGDs, with various stakeholders including shrimp farmers, shrimp seed producers and local staff and managers.² This exploratory research helped identify major problems and their causes, which were later measured and verified by quantitative analysis using data collected from a structured questionnaire-based household survey using stratified and probability proportional to the sampling size of 121 SMS households and 195 RSS households.

A function of multiple log-linear regression was employed to examine the marginal effects of 13 related input factors on shrimp farming profits. These factors consist of three categories: managerial capacity (age of household head, shrimp farming experience), farming techniques (field/pond size, stocking density, seed population, water intake, shrimp seed quality), and production cost and farm-gate price (feed price, electricity,

Figure 8.1: Location of representative case study communes with two shrimp production systems in the VMD



Source of base map: Land Resource Department, Can Tho University, 2016

antibiotics, farm-gate price). We applied production cost variables rather than input price in the estimates, since the inputs used in shrimp farming (e.g feed types and antibiotics) are not the same across farms. We found that the quality of the shrimp seeds was the most significant factor affecting outcomes. Seed quality was defined using a dummy variable that received either a value of 0 or 1 corresponding to shrimp seeds not tested with PCR (polymerase chain reaction) or tested with PCR before stocking, respectively.³ The log-linear function is written as follows:

$$Y = \alpha + \beta_n \text{Log}(X_n) + \delta_n D_n + \varepsilon$$

In which:

Y : profit (VND million /ha)

α : a constant

X_n : a vector of independent variables. Independent variables are defined as follows:

X_1 : age of household head (year)

X_2 : farming experience of household head (year)

X_3 : size of shrimp field (pond) (ha)

X_4 : stocking density (seed/m²)

X_5 : seed population (seed/ha)

X_6 : cost of feed (VND million /ha)

X_7 : cost of electricity (VND million /ha)

X_8 : cost of antibiotics (VND million /ha)

X_9 : number of in-take time (time/crop)

X_{10} : price of harvested shrimp (VND1,000 /kg)

β_n : marginal effect corresponding X_n variable

D_n : dummy variables (0, 1). Dummy variables are defined as follows:

D_1 : Education level of household head (0: illiterate and primary;
1: secondary and upper)

D_2 : System of cultivation (0=SMS; 1=RSS)

D_3 : Test PCR (0=no; 1=yes)

δ_n : marginal effect corresponding to D_n variable

ε : error

The log-linear regression function was estimated using the Ordinary Least Square (OLS) method and ANOVA F test at $\alpha=0.05$ to test a fitness of the function with a null hypothesis H_0 such that the $H_0: \beta_1 = \beta_2 = \dots = \beta_i = 0$ is rejected as $F > F_\alpha$ and otherwise accepted. Additionally, a T-test is separately applied to test a H_0 of which the $H_0: \beta_i = 0$ for coefficient of each independent variable is rejected as the $t > t_{\alpha/2}$ at $\alpha = 0.05$ and otherwise, accepted H_0 .

Main findings

Development of brackish-water shrimp farming in the VMD

Shrimp cultivation in the coastal VMD developed in the early 1990s and went through different stages (see table 8.1). Eight provinces in the VMD produce brackish-water shrimp, of which CBST accounts for a major proportion (fig. 8.2). Between 1995 and 2014, the compound annual growth rates of shrimp farming areas and shrimp production was 10.4 percent and 39.9 percent, respectively.⁴ These values indicate that shrimp farming has shifted into an intensive mode, characterized by faster seasonal rotations and increased stocking density, along with the replacement of black tiger shrimp in some areas by white leg shrimp, especially after the early 2000s when the brackish aquaculture policy was enacted in the coastal VMD.⁵ The intensification of shrimp aquaculture requires the use of more expensive inputs (e.g. shrimp seeds, water, agro-chemicals, feed and energy), and has therefore mainly been adopted by wealthier farmers.

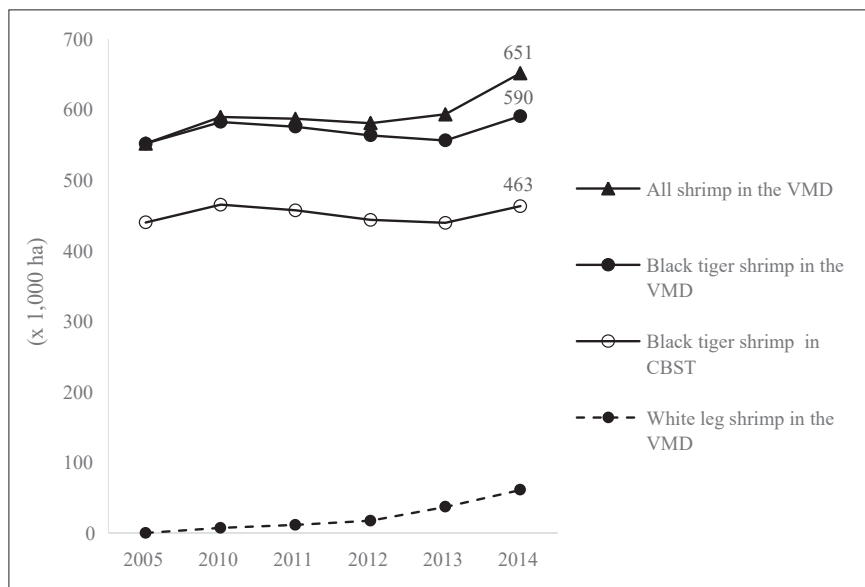
Table 8.1: Historical timeline of shrimp farming in coastal areas of the VMD

Years	Major farming activities
Before 1990s	Traditional rice production in the rainy season and natural aquatic resource exploitation in both rainy and dry seasons
Before 2000	Expansion of rice monoculture areas supported by saline water control and fresh-water irrigation projects
After 2000	Expansion of rotational rice-shrimp systems after changes in land use policy that allowed brackish water aquaculture development rather than trying to expand freshwater-based farming systems in coastal areas
2010s	Conversion from rice-shrimp systems into shrimp monoculture in many areas; Increased shrimp stocking density and harvesting patterns in Bac Lieu and Ca Mau provinces
2012	Black tiger shrimp partly replaced by white leg shrimp
2003-2015	Severe damage to shrimp production by both diseases and price variation in many years, e.g. 2003, 2007, 2012, 2015

Source: Synthesis of KIP(s) & FGD(s) with local stakeholders in CBST provinces, 2015.

The improved-extensive farming of black tiger shrimp accounts for 61 percent of brackish water shrimp cultivation area, including 29 percent of SMS and 32 percent of RSS. Therefore, the risks associated with the improved-extensive black tiger shrimp model have had a negative impact on the livelihoods of a large number of households in the CBST.

Figure 8.2: Shrimp farming areas in the coastal VMD including CBST provinces

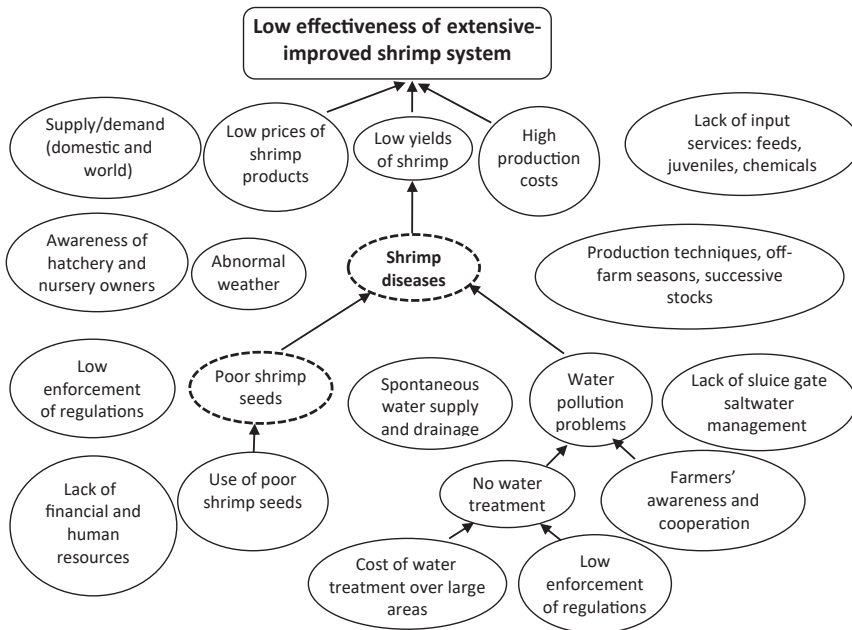


Source: MARD 2015

Factors for low efficiency of shrimp farming

This study investigated many interrelated reasons for shrimp production failures (fig. 8.3), of which shrimp seed quality was identified as a major cause of serious diseases (Oanh and Phuong 2012). This problem results from weak administrative control of shrimp seed quality, unsound physical assets of seed suppliers resulting in more or less unquarantined seed being released, and lack of knowledge as well as poor choices on the part of shrimp farmers. In addition, water pollution in shrimp farming areas require robust shrimp seeds which have a higher tolerance for poorer water conditions.

Figure 8.3: Poor quality shrimp seeds as major factor for low shrimp yield in extensive-improved shrimp farming



Technical and economic factors in shrimp farming

The analysis focused on farm resources and the impacts of inputs, especially shrimp seed quality, on shrimp farming.

Farm resources

Given an average family size of 4.4 members in the surveyed households, with an average of 2.8, or 63 percent of the household engaged in shrimp farming. This is similar across both SMS and RSS. The household head typically manages and directly implements the shrimp operation: the age of the household head therefore more or less affects his/her managerial capacity. In the survey, the average age of the household head was 54 years old. The household head's educational level (table 8.2) helped to indicate managerial capacity in terms of avoiding risks and achieving higher efficiency in shrimp production. In this survey, most household heads had at least primary to secondary education. Only 1.9 percent of household heads in the survey were illiterate. With these educational

levels, household heads are expected to learn shrimp farming techniques easily.

Table 8.2: Major demographic characteristics of shrimp farmers by system

Farm resources (Mean \pm S.E)	SMS (n=126)	RSS (n=195)	Total (n=316)
Household size (person)	4.5 \pm 0.1	4.4 \pm 0.1	4.4 \pm 0.1 ^{ns}
Main labour (person)	2.6 \pm 0.1	2.8 \pm 0.1	2.8 \pm 0.1 ^{ns}
Age of household head (year)	54.1 \pm 1.2	54.0 \pm 1.2	54.0 \pm 0.7 ^{ns}
Educational level of household head (%)	100	100	100
+ illiterate	4.1	0.5	1.9
+ primary	45.5	35.9	39.6
+ secondary	33.9	50.3	44.0
+ high school	14.0	11.8	12.7
+ college/university	2.5	1.5	1.9
Pearson Chi-Square Tests with Sig. value = 0.017			

Note: ^{ns} indicates the means are not statistically significant at $\alpha=0.05$ by t-test.

The average shrimp farm size in the survey was 2.1 ha, with little difference between SMS and RSS (table 8.3). This average farm size was larger than that for other forms of agriculture such as monoculture rice, vegetables and fruit trees per household in the Mekong Delta because shrimp farms are located in coastal zones with a lower population density. The area of shrimp or rice–shrimp plots was approximately 2.0 ha, accounting for 96 percent of the total household land (table 8.3). This high proportion indicates that almost all farm land was devoted to shrimp culture in order to exploit saline water intrusions in the area.

Table 8.3: Farm size and field area of rice/shrimp by production system (mean \pm S.E)

Major characteristics	SMS (n=126)	RSS (n=195)	Total (n=316)
Farm size (ha)	2.3 \pm .2 (100%)	2.0 \pm 0.1 (100%)	2.1 \pm 0.1* (100%)
Rice/shrimp field area (ha)	2.3 \pm 0.1 (97.3%)	1.9 \pm 0.1 (95.0%)	2.0 \pm 0.1** (96%)
Number of plots	1.7 \pm 0.1	2.1 \pm 0.1	1.9 \pm 0.1***

Note: *, **, *** indicates the means are statistically significantly different at $\alpha=0.1$, 0.05, and 0.01 by t-test, respectively.

The average number of shrimp farming plots in the surveyed households is 1.9, which is higher for the RSS (2.1) compared to SMS (1.7). The number of shrimp farming plots is shaped by natural conditions—for e.g., in rice-growing areas with access to fresh water, there were smaller or fewer shrimp ponds. Some farms had more plots as a strategy for dealing with the risk of disease outbreaks, in the hope that the disease would not occur in all plots.

Effects of shrimp seed quality on yields and profits

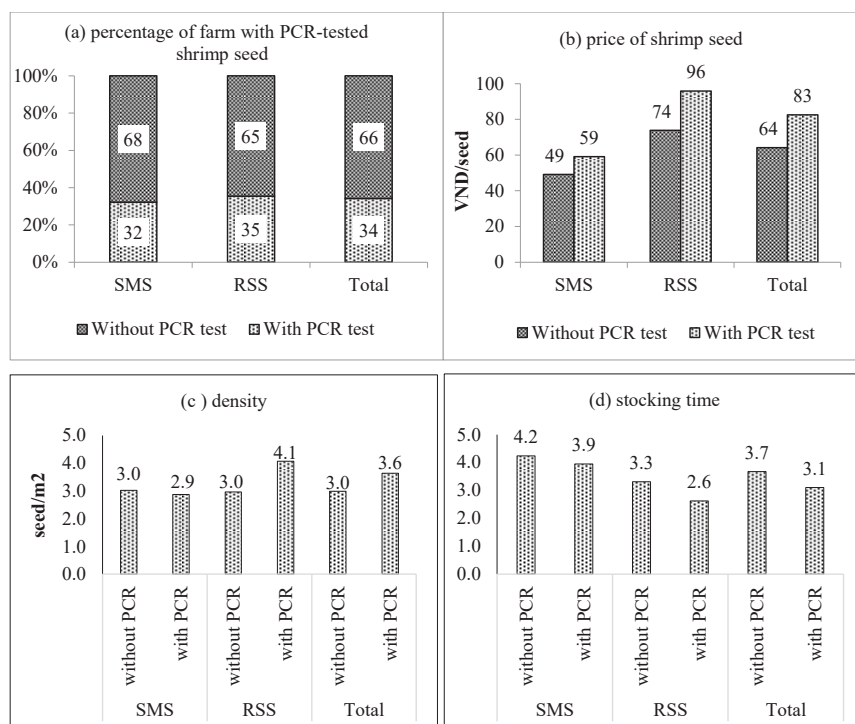
Seed quality is considered the most important input in shrimp farming. Stocking density of shrimp in the improved-extensive system was approximately 100,000 seeds per ha and re-stocking is done three to four times per year. In general, stocking times were determined by farming seasons. However, stocking patterns also depend on individual farmers' experience and on the availability of seawater, and other factors such as pollution from waste water discharged by neighboring farms.

Shrimp seed quality is indicated by the trademark of the hatchery, and the infrastructure and prestige of the seed producers. Reputable producers, however, do not always produce good quality seeds, unless the shrimp seeds were tested for PCR. On the other hand, shrimp producers, particularly improved-extensive shrimp farming, normally prefer buying cheaper shrimp seeds—thus producers choose not to conduct PCR tests on their seed. In contrast, only shrimp farmers who are aware of the importance of shrimp seed quality want their shrimp seeds tested before purchase. In other words, shrimp farmers themselves have to bear the PCR test cost if they want to avoid the risk of shrimp diseases. As a result, only 34 percent of shrimp farmers in our study stocked PCR-free shrimp seeds. The percentages of PCR-tested shrimp seeds are similar in both SMS and RSS models (fig. 8.4a).

Shrimp seeds that are certified free from disease cost more than untested seeds, about VND10 per seed and VND22 per per seed of SMS and RSS, respectively (fig. 8.4b).⁶ The price of shrimp seeds used for RSS is higher than that for SMS because RSS requires bigger and stronger shrimp seeds to better survive in changeable water conditions, such as seasonal changes in fresh and saline water. The higher price of shrimp seeds with disease-free certificates is not because of its quality, but because of the lower prices paid to shrimp seeds detected with disease by PCR

tests. Shrimp producers have a right to reject shrimp seeds, without any compensation, if PCR tests indicate disease. Hence, shrimp seeds with diseases must be sold at lower prices to farmers who were willing to accept a higher risk of poor quality shrimp seeds. PCR tests for shrimp seeds before stocking plays only a minor role in reducing the potential risk of major shrimp diseases; it is not an absolute guarantee of a disease-free shrimp growing cycle of three to four months in ponds and fields, where there are many potential risks to the shrimp. Hence, it is interesting to examine the probability of risk reflected by the marginal effect of seed quality on shrimp farming profits between shrimp seed quality categories identified by PCR tests.

Figure 8.4: Use of shrimp seeds in SMS and RSS



The total volume of seeds stocked per hectare is around 10,000 seeds, equivalent to 3–3.6 seed per m² x 3.1 to 3.7 stocking times, depending on system and seed quality (figs. 8.4c and 8.4d). In general, the SMS model

uses lower shrimp seed density but more frequent stocking than RSS, possibly due to the higher number of harvests. In terms of seed quality, lower stocking density and stocking times of seeds with PRC test (except seed density of RSS) indicated that farmers believed that using seeds with PRC tests could reduce the mortality rate of shrimp.

As shown in figure 8.5a, seed quality is an important factor influencing shrimp yields. In the same shrimp cultivation system (SMS or RSS), shrimp yields from seeds with and without PCR testing were significantly different. There were significant differences in profits between farming using seeds with and without PCR testing (fig. 8.5b). This figure also shows higher profits from SMS compared with RSS due to the higher price of inputs of the former as seen in fig. 8.6.

Figure 8.5: Effect of shrimp seed quality on yield and profit

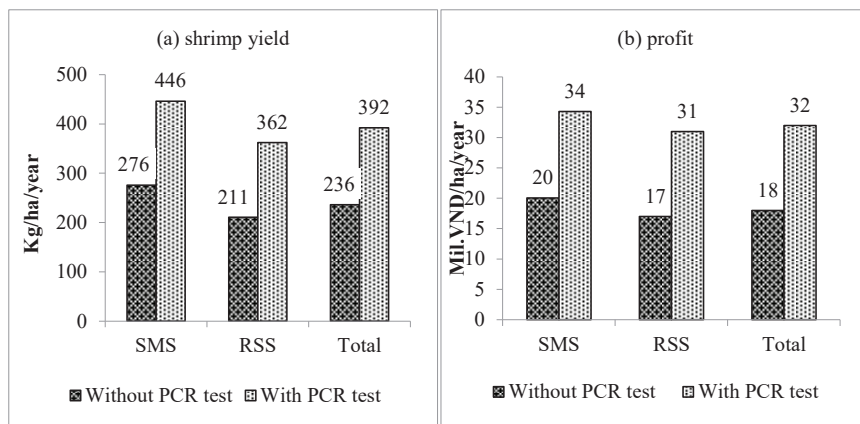
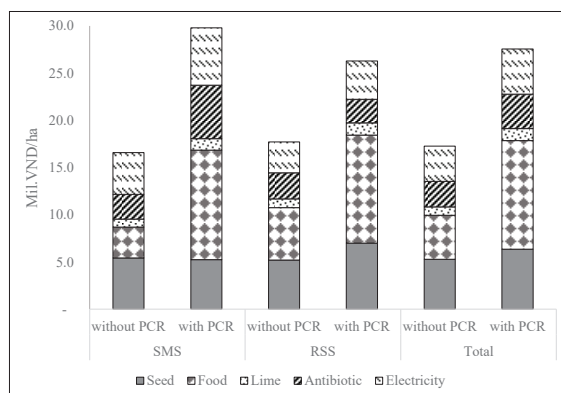


Figure 8.6 presents the variable costs of SMS and RSS for two seed types—with and without PCR testing. In each system, there was a significant difference in total variable costs due to the impacts of partial costs, particularly shrimp seeds. Both seed types were slightly different, about VND1 million per ha per year, depending on seed density, stocking times and price. PCR-tested seeds lead to longer shrimp life spans and therefore required more inputs such as feed and energy, which meant higher total variable costs (fig. 8.6). However, using tested seeds translated into higher yields and profits (fig. 8.5).

Figure 8.6: Variable costs by system and type of seeds



The differences in profitability between both types of shrimp seeds was verified by a t-test (table 8.4). In the SMS, significant differences of revenue between both types were reflected by the benefit–cost ratios (BCR) of 2.7 and 1.5 for types of with and without PCR testing, respectively. In RSS, there were significant differences for almost all financial indicators between both types, but the BCR is lower, only 1.3 and 1.2 for types with and without PCR testing, respectively. In general, PCR-tested shrimp seeds were shown to be more efficient in both systems. However, higher standard variations than the means of all indicators shown in table 8.4 could be a reason why shrimp farmers have not fully shifted to PCR tested-seeds because losses due to diseases may still occur with tested seeds.

Table 8.4: Financial analysis by system and PCR testing (VMD/m/ha; mean \pm S.E)

Indicator	SMS			RSS			Total		
	Without PCR	With PCR	Sig.	Without PCR	With PCR	Sig.	Without PCR	With PCR	Sig.
Cost	17.8 \pm 2.3	31.4 \pm 10.9	*	26.1 \pm 1.8	37.1 \pm 3.5	***	22.8 \pm 1.4	35.0 \pm 4.5	***
Revenue	37.8 \pm 5.3	65.7 \pm 15.9	**	43.4 \pm 2.3	68.2 \pm 6.9	***	41.2 \pm 2.5	67.3 \pm 7.2	***
Profit	20.1 \pm 3.8	34.3 \pm 9.7	ns	17.3 \pm 2.6	31.1 \pm 5.2	***	18.4 \pm 2.2	32.2 \pm 4.8	***
BCR	1.5 \pm 0.2	2.7 \pm 0.5	**	1.2 \pm 0.1	1.3 \pm 0.2	ns	1.3 \pm 0.1	1.8 \pm 0.2	*

Note: *, **, ***, and ^{ns} indicates the means are statistically significantly different at $\alpha=0.1$, 0.05, 0.01 and not significantly at $\alpha = 0.05$ by t-test, respectively.

The impact of input factors, especially shrimp seed quality, on shrimp farming profits was verified by a linear-log multiple variable regression. Table 8.5 indicates that shrimp seed quality associates positively with shrimp farming profits. The marginal effects of shrimp seed quality indicate that farming profits with PCR-tested seed increased VND12.96 mil/ha/year compared to the profits of farms using non-PCR-tested seeds. An increase of 1 percent of the selling price (equivalent to VND1,000 per kg from the current price of VND100,000 per kg) translates to an increase in profits of VND0.48 million per ha. Feed costs also positively affect the profitability of shrimp cultivation. However, the number of water intake times into shrimp fields negatively affects profits, since using water from shared canals might increase the risk of shrimp diseases. Surface water quality in shared canals in an area could be more polluted due to “the tragedy of the commons”—in this case, the release of pollutants in non-compliance with water management regulations.

Supply and demand for shrimp seeds in the Mekong Delta

Meanwhile, the rapid increase in shrimp culture areas, stocking density, and partial shift from black tiger shrimp (BTS) to white leg shrimp (WLS) have all increased the demand for seeds. At present, shrimp seeds are supplied by both local hatcheries and hatcheries and distributed by a variety of small and large from Central Vietnam and many distributors (fig. 8.7). The increase in the number of suppliers has improved farmers’ access to seed; however, it is difficult to enforce regulations and manage standards. Therefore, poor quality shrimp seeds exist (fig. 8.7), which, in turn, has negatively influenced profitability.

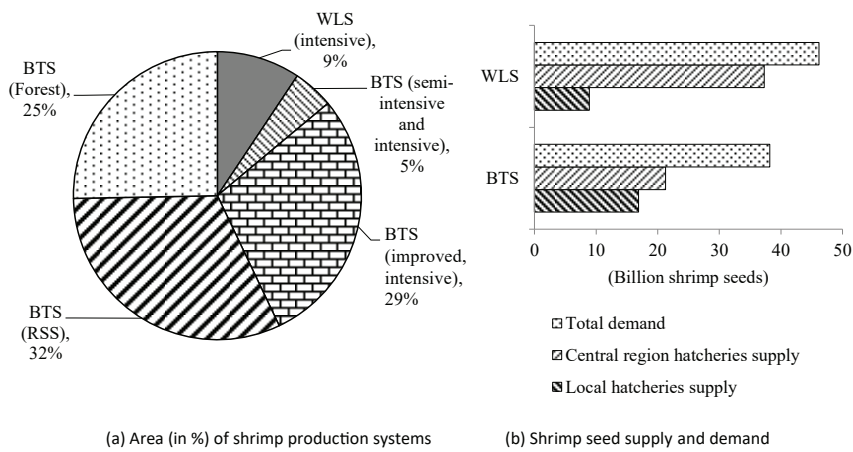
Shrimp diseases, mainly white spot syndrome virus and yellow head virus, have been a serious threat to shrimp production and the sustainable development of shrimp farming in the VMD (Oanh and Phuong 2012). These outbreaks of diseases have been accentuated by climatic variations, increased water pollution and shrimp seed quality. Poor seed quality is a primary cause of shrimp diseases. Fig. 8.8 indicates that infected seeds were available in the market and used by growers if they were not destroyed. Wider PCR testing would contribute to the identification of infected seed before stocking and reduce the transmission of disease. However, many seed producers and farmers resist PCR tests or buying tested seeds to keep their costs low.

Table 8.5: Effect of household characteristics and cultivation factors on shrimp farming profits

Variables	Variable definition	Unstandardized coefficients		Unstandardized coefficients Beta	t	Sig.
		B	Std. error			
CONT.	Constant	-308,223	118,829		-2,594	,011
Log(AGE)	Age of household head (yr)	17,634	13,266	,114	1,329	,186
EDU	Education of head (0;1)	7,775	5,482	,118	1,418	,159
Log(EXP)	Experience of farming (yr)	,982	9,881	,008	,099	,921
Log(AREA)	Area of field (ha)	-3,762	5,438	-,060	-,692	,490
Log(DENS)	Seed density (seed/m2)	1,893	9,495	,032	,199	,842
Log(SEED)	Seed population (seed/ha)	3,462	8,508	,061	,407	,685
Log(FEED)	Feeding cost (mil.vnd/ha)	10,567	6,461	,171	1,636	,104
Log(POWER)	Electricity cost (mil.vnd/ha)	5,948	3,914	,130	1,520	,131
Log(BIOTIC)	Antibiotic cost (mil.vnd/ha)	2,772	2,986	,075	,928	,355
Log(WATER)	Number of intake time	-43,829	18,591	-,187	-2,358	,020
Log(PRICE)	Price (1,000 vnd/kg)	48,681	11,516	,338	4,227	,000
System	(0=SMS; 1=RSS)	-7,753	6,176	-,118	-1,255	,212
PCR	PRC test of seeds (0=without; 1=with)	12,963	5,806	,177	2,233	,027

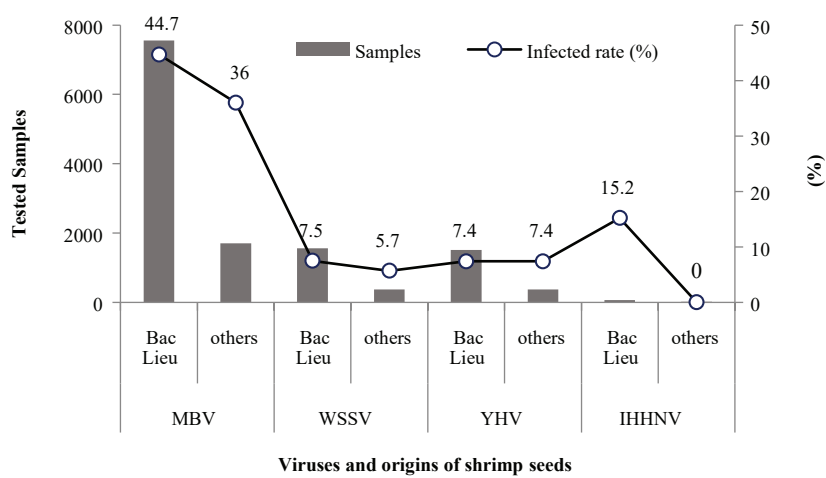
Dependent variable: profit; F=4.256; Sig. Value = 0.000; R=0.561; R²= 0.315; R² adjusted=0.240

Figure 8.7: Seed demand in various shrimp production systems in the coastal VMD in 2014



Source: Departments of Agricultural and Rural Development of coastal provinces in the VMD

Figure 8.8: Infection rates of shrimp seeds detected by PCR testing in Bac Lieu province



Notes: MBV: Monodon Baculovirus; WSSV: White Spot Syndrome Virus; YHV: Yellow Head Virus; IHNV: Infectious hypodermal and hematopoietic necrosis virus

Source: Bac Lieu Fishery Department, DARD, 2015.

Measures for controlling shrimp seed quality

Regulations on shrimp seed production

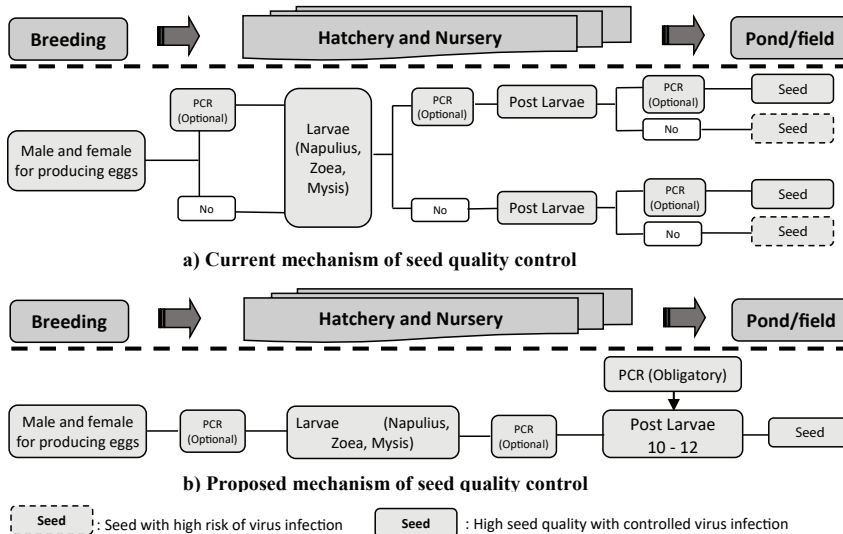
The authorities have recognized these problems and steps have been taken to regulate shrimp seed quality at different levels. At the national level, the Fishery Law (17/2003/QH11), Ordinance on Livestock Breeds (16/2004/PL-UBTVQH11), and Ordinance on Veterinary (18/2004/PL-UBTVQH 11) are legal frameworks for shrimp seed management. These laws have created a foundation for detailed regulations (e.g. Circulars) for related institutions, in particular the Ministry of Agriculture and Rural Development (MARD) and its sub-institutions. The Circular on Fishery Seed Management (6/2013/TT-BNNPTNT) has detailed regulations on fishery seed management. The Circular states clearly that mature shrimp seeds for markets must be quarantined in order to eliminate risky shrimp seeds.

These regulations stipulate standardized facilities at local hatcheries and nurseries, PCR testing at the nursery stage, and well-regulated shrimp seed distribution procedures. However, enforcement has been limited due to the lack of human and financial resources. Proposed solutions for shrimp seed quality improvement include: the enforcement of standardized infrastructure for shrimp seed producers; increasing checks and monitoring of shrimp seed quality to eliminate infected shrimp seeds; and improving PCR testing to control shrimp seed quality.

Mechanism for improving shrimp seed quality

While the current regulations require obligatory PCR tests, there is weak implementation due to a shortage of human and financial resources. A proposed solution is obligatory PCR testing within the post-larval stages 10 to 12 (see fig. 8.9) at hatcheries regardless of prior optional PCR tests. PCR testing at these stages helps to detect infected seeds before their release into shrimp ponds. The costs of maintaining local institutions to conduct this stricter quality control, including staff salaries and dedicated facilities, will be derived from the higher price of tested shrimp seed paid by farmers, based on a perceived willingness-to-pay (WTP). In addition, this will enable the enforcement of related regulations associated with male and female shrimp for producing eggs and standardizing nurseries and hatcheries (Circular 45 of MARD 45/2010/TT-BNNPTNT).

Figure 8.9: Mechanism of shrimp seed quality control for higher economic efficiency



Clearly, the proposed shrimp seed quality control requires a stable financial source. Our research indicates that funding for seed quality management could be collected by shrimp seed providers when selling seeds to shrimp farmers and when transferring the seeds to shrimp seed management authorities.

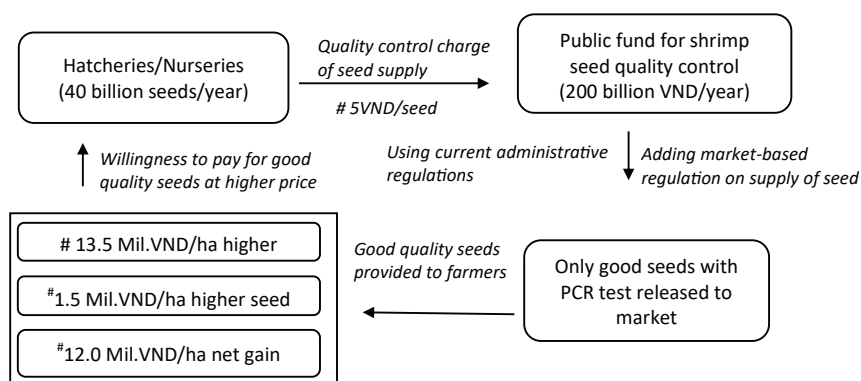
Creation of a public fund for shrimp seed quality management

Shrimp seed producers are supposed to comply with Decree No. 59/2005/NĐ-CP. However, shrimp seed quality seems to have been ineffectively monitored. As a result, infected or low-grade shrimp seeds were allowed in the market. Thus far, it has been difficult to enforce the existing mechanism. A market-based mechanism should be established in order to enable better shrimp seed quality control as well as a healthier shrimp seed market. Shrimp producers who pay slightly higher shrimp seed prices in order to contribute to a proposed public fund will in turn gain much higher profits due to lower risks and better yields.

Our analysis shows that the use of PCR-tested shrimp seeds earned producers an extra VND12.9 million/ha/year (table 8.5), given additional

seed costs of approximately VND1.5 million/ha/year (fig. 8.6). This implies that shrimp farmers who pay for tested seeds had extra net sales of VND12.9 million/ha/year; therefore, it is expected that they are willing to pay an additional cost for higher quality seeds. The proposed mechanism requires a stable fund based on the additional cost paid by shrimp farmers when they buy higher quality seeds, that is, a public fund for shrimp seed quality management, to be created and used for seed control and distribution.

Figure 8.10: Structure of a public fund for shrimp seed quality management



If shrimp seed producers contribute VND5 per seed (about 7 percent of the current average seed price) to this public fund, approximately VND200 billion per year⁷ can be mobilized for effective shrimp seed management in the VMD. This amount, nearly VND25 billion a year, allocated to the eight coastal provinces, will be sufficient to cover annual seed management operations. Public services covered by this fund would include the improvement of basic infrastructure for PCR testing, staff salaries and other related activities. In fact, local governments have tried to look for financial support to compensate for losses due to diseased shrimp seeds. Of course, before this fund is set up, the proposal should be discussed by all stakeholders involved, including farmers, shrimp seed providers, and local and national authorities.

Existing attempts at regulating shrimp seed quality, and hence, output and profits have failed due to information asymmetry and poor implementation due to a lack of financial and human resources. Shrimp

farmers have to save their livelihoods. The spread of shrimp disease could affect the aquatic ecosystem and lead to bigger social and economic losses. This study argues, therefore, that a public fund for better shrimp seeds production is a necessity. We estimate that the shift to only PCR tested seeds will bring in an additional VND4,642 billion per year from shrimp farming in the VMD,⁸ a substantial achievement for the local economy. However, given the additional cost for shrimp farmers, an information and awareness campaign should be implemented to convince them of the need for this additional cost.

Conclusion and recommendation

In the coastal VMD, black tiger shrimp farming has significantly contributed to rural livelihoods as well as local economies. Nonetheless, shrimp growers face severe risks and several constraints, particularly risky shrimp seeds, i.e. seeds not tested for PCR. Disease-prone shrimp seeds have a significant impact not only on the black tiger shrimp output at the household level, but also shrimp production in neighboring communities due to the risk of contamination. Despite the existence of regulations, poor enforcement has limited shrimp seed management; risky, weak or disease-prone shrimp seeds have been readily available and popular because they are cheaper. Relevant shrimp seed management laws need to be enforced in order to control seed quality as well as eliminate the risky seeds that are endangering the livelihoods of shrimp farmers in the coastal VMD.

One barrier to improved management is financial: stocking only PCR-tested shrimp seeds raise production costs, however. Our study proposes measures for risk reduction as well as improving shrimp cultivation efficiency and yields by eliminating the distribution of disease-prone seeds. The obligatory PCR test within the post-larval 10 to 12 stages, together with the enforcement of seed quality control should be implemented. The costs for the strict quality verification should be shared by shrimp farmers when buying tested seeds from seed suppliers. A public fund of about VND4,642 billion a year for shrimp seed quality management is proposed. This fund would be more than sufficient to support the administration of enforcing quality control on seed producers before they sell the seeds. Overall, this study strongly recommends that a market-based mechanism for controlling shrimp seed quality should replace the current ineffective mechanism.

Notes

- ¹ These communes are My Hoa and My Long Nam in Tra Vinh province, Hoa Tu 1 and Ngoc To in Soc Trang province, Phuoc Long and Phong Thanh Tay A in Bac Lieu province, and Thoi Binh and Ho Thi Ky in Ca Mau province.
- ² Local staff and managers are from provincial, district and commune people's committees, the Department of Agriculture and Rural Development, Center of Agricultural Extension, Division of Veterinary, Division of Aquaculture, Division of Water Resource Management
- ³ The PCR technique can detect important shrimp seed pathogens such as white-spot syndrome virus (WSSV), yellow-head virus (YHV), hepatopancreatic parvovirus (HPV), monodon baculovirus (MBV) and infectious hypodermal and haemotopoietic parvovirus (IHHNV).
- ⁴ General Statistics Office of Viet Nam, Statistica Data: Agriculture, Forestry and Fishing for 1995–2014.
- ⁵ Decision No. 224/1999/QĐ-TTg of Prime Minister issued on 1999 on Aquaculture Development in the period of 1999 and 2010 in the coastal Vietnamese Mekong Delta.
- ⁶ The exchange rate in 2015 was US\$1 for VND22,450.
- ⁷ 40 billion seeds * VND5/seed = VND200 billion.
- ⁸ 590,000 ha of BTS * 61% of BTS cultivated at improved-extensive system * VND12.9 million /ha of net gain = VND4,642,138 billion/year.

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9

Land-Use Strategies for Triple-Rice Farmers in the Vietnamese Mekong Delta

Nguyen Hong Tin and Dang Kieu Nhan

The Vietnamese Mekong Delta (VMD) is the “rice bowl” of Vietnam. Annually, it produces 25–30 million tons of rice, amounting to 70 percent of the country’s total production and more than 90 percent of its exported rice (GSO 2014; 2015; 2016). Rice farming and related services remain the mainstay of livelihoods for more than half the rural households in the Delta.

The VMD can be further divided into three sub-hydrological regions, each facing specific ecological threats: the Upper Delta (dealing with increased seasonal fluvial floods and enhancing the water retention capacity through adapted land and water use such as flood-based farming systems); Middle Delta (coping with dry season freshwater shortages and drought as well as securing freshwater supply); and the Coastal Delta (coping with brackish water and salinity intrusions and aiming for sustainable coastal protection (SRV and GoN 2013). In terms of agriculture, the Delta has six zones, including the floodplains, the middle Tien and Hau rivers, Long Xuyen Quadrangle, Hau River West, the river mouth and coastal zone, and Ca Mau Peninsula zones. The floodplain areas (FPAs) are located mainly in the Upper Delta, which consists of An Giang, Dong Thap and several parts of Long An and Tien Giang provinces. Being upstream, this area plays an important role in monitoring and controlling floods throughout the Delta.

Before the 1990s, farming in the FPAs commonly consisted of two annual rice crops rotated with some aquaculture and fishing. In the 1990s, a national rice policy to address food security concerns, and efforts to develop infrastructure, transportation and flood control resulted in the building of an extensive system of dikes. The Ministry of Agriculture and Development (MARD) has promoted intensive rice cultivation in the FPAs

since the early 2000s, specifically, the triple rice system (TRS). In the first few years of its implementation, TRS proved highly beneficial to farmers and other actors (i.e. collectors, traders, millers, and others providing related services) in the rice value chain. However, TRS has led to several major problems since the early years, including:

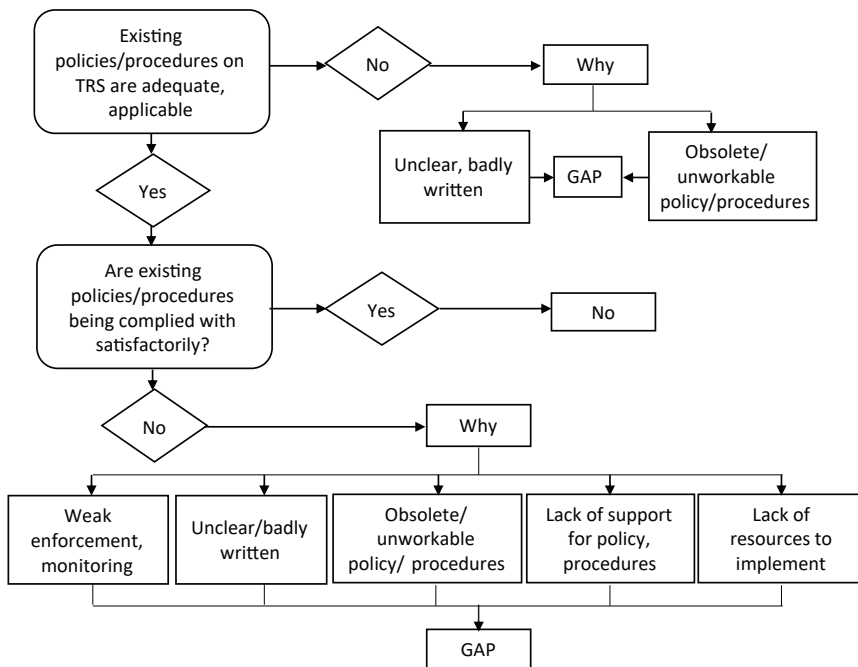
- declining soil fertility due to faster rice cropping cycles, without replenishing the soil or allowing sufficient time for fallow periods between cycles;
- environmental pollution due to the overuse of pesticides and inorganic fertilizers as well as more waste and polluted water carrying these chemicals flushing into canals and rivers;
- declining biodiversity, including of fisheries;
- unsustainable and inefficient rice economy: production costs have increased while rice yields and prices have not; and
- a negative impact on human health due to the overuse of fertilizers and pesticides.

Several studies as well as feedback from VMD farmers point to an urgent need to practice more diverse and sustainable farming systems rather than monocultural intensive ones such as TRS. This chapter identifies the gaps in existing TRS policies in the FPAs and recommends agricultural diversification to improve overall livelihoods as well as avert further environmental damage in the area.

Conceptual framework

This chapter uses the policy analysis framework (Patton et al. 2012) to identify gaps and feedback in existing TRS policies. The gaps and feedback were identified through a review and synthesis of relevant literature, and analysis of primary data collected through surveys. Gaps were identified using indicators such as adequate, applicable and satisfactory features of existing policies in practice (fig. 9.2). In other words, the gaps are considered both in terms of process (correct practice) and outcomes (achieve desired objectives). Findings from the identified gaps, the reasons for these gaps, and desirable alternatives for dealing with gaps will be analyzed and reflected in the recommendations.

Figure 9.1: Flowchart for identifying policy gaps



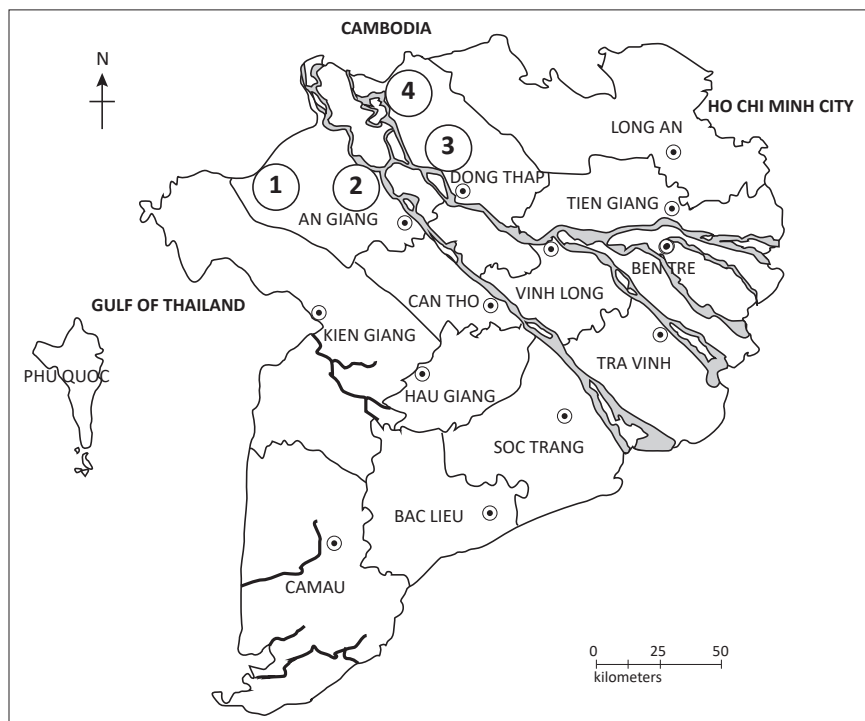
Data

A literature review about rice farming in the FPAs was supplemented by a survey to collect primary data for in-depth analysis and further discussion. The survey consisted of household interviews and focus group discussions.

Survey sites

The study was conducted in four districts: Tri Ton, Chau Phu in An Giang province, and Hong Ngu and Thanh Binh in Dong Thap province (fig. 9.1). The study sites are considered representative of the Delta's flood agro-ecology and all need good floodplain governance; in all four districts alternative flood-based farming systems like floating rice rotated with upland crops, high-yielding rice rotated with upland crops or aquaculture of fish can be considered. The study results there can be generalized for the surrounding districts in An Giang, Dong Thap, Long An, Tien Giang and Kien Giang provinces.

Figure 9.2: Survey sites in the VMD: (1) Tri Ton district, (2) Chau Phu district (An Giang), (3) Thanh Binh district and (4) Hong Ngu district (Dong Thap)



Data collection and analysis

In each district, two representative communes were selected, covering not only the commonly practiced double or triple rice cropping, but also optional or potential farming systems. A total of 477 households practicing the seven livelihood groups were selected: double rice cropping, triple rice cropping, double or triple rice rotated (or mixed) with upland crops, double rice rotated with fish or prawn aquaculture, floating rice rotated with upland crops, fisheries, and farm services (i.e. off-farm wage labor, agro-chemical business, or farm machine services) (see table 9.1).

Table 9.1: The sampling size of selected household groups by district

Districts	2 rice	3 rice	Rice-UC	Rice-fish	Floating rice-UC	Fisheries	Farm-services	Total
Tri Ton	23	25	2	0	20	24	16	110
Chau Phu	25	25	20	0	0	25	15	110
Thanh Binh	25	25	20	0	40	18	14	142
Hong Ngu	28	25	0	20	0	24	18	115
Total	101	100	42	20	60	91	63	477

The structured interviews of the household head or a key household member was carried out using a questionnaire. The information collected consisted of: household profile, livelihood assets, technical and socioeconomic aspects of livelihood activities (farm, off-farm and non-farm), perceptions of key livelihood determinants, and intended changes to livelihood activities under projected scenarios.

Enterprise financial analysis was applied to evaluate the economic viability of household livelihood activities. Gross incomes, total costs, gross margins and benefit-cost ratios were calculated for each activity. Family labor inputs were considered as opportunity costs. In addition, seven groups (each group included farmers) corresponding to the farming systems practiced were invited for the focus group discussions.

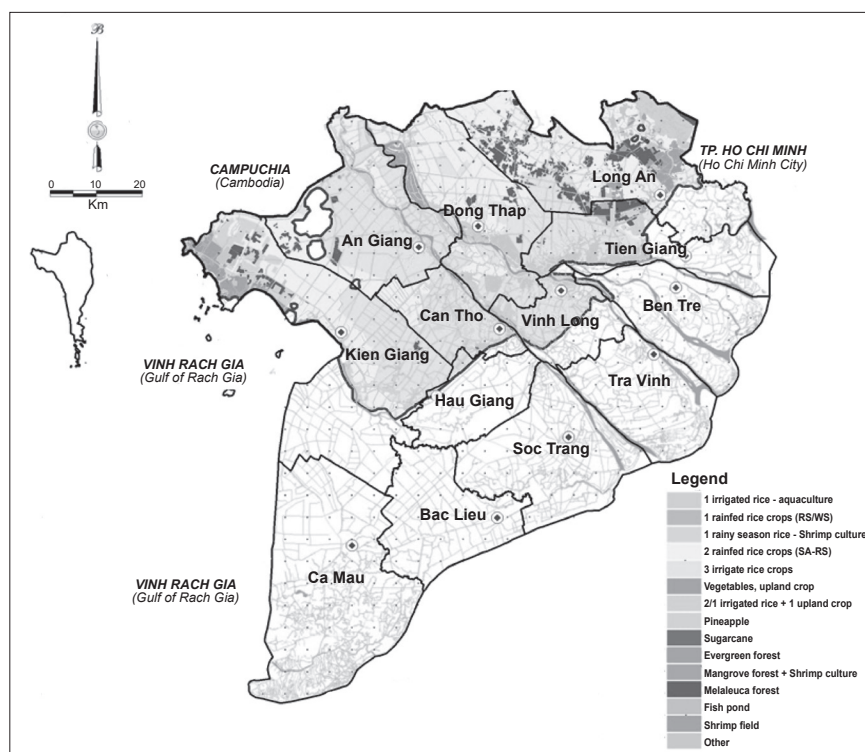
Results and analysis

Land use

The FPAs in the VMD cover mainly seven provinces of An Giang, Dong Thap, Tien Giang, Long An, Can Tho, Hau Giang and Vinh Long. In these areas, the predominant farming systems are intensive rice cropping (triple rice, double rice), mono-upland cropping, integrated rice-upland cropping or rice farming combined with fishing, aquaculture, fruit growing and Melaleuca-forestry systems (fig. 9.3; Nguyen 2016). Soil characteristics and water conditions, particularly the extent of the seasonal flood pulse, determine land use types and livelihood activities, including cropping systems and the crop calendar. Floods can devastate a rice crop, reducing yields and changing the crop cycle. However, in the VMD floods also bring much benefit to farmers, such as replenishing natural fish stocks,

providing alluvial deposits which act as a natural fertilizer, and flush toxicity, particularly in areas with acid sulfate soils (Nguyen 2012). In high flood years, fishing and exploiting natural resources such as wild vegetables are key livelihood opportunities for local people. Rice crops are delayed and the third rice crop can be replaced by aquaculture of freshwater shrimp, fish and crab. In contrast, in low flood years, farmers can start their rice crop earlier at the end of the floods, while other activities such as fishing or harvesting wild vegetables are limited.

Figure 9.3: Land use in flood plain areas of Vietnamese Mekong Delta



Source: Compiled by the authors, 2017

Rice-based farming systems remain the norm in the FPAs and with increasing areas under intensive cultivation under the current plans till 2020, and projected to continue to 2030. According to the Decision No. 639/QĐ-BNN-KH (MARD 2014) land used for TRS in the whole VMD is expected to total 4 million ha in 2020 and 3.8 to 3.9 million ha in 2030. In

particular, TRS was planned to be expanded in the FPAs, with the third crop to eventually cover 47,000 ha in Dong Thap and 129,000 ha in An Giang respectively (Decision No. 401/QĐ-BNN-TT; MARD 2015). This is a controversial plan because these agriculture-restructuring programs aim to reduce the area of land under rice cultivation and replace it with higher added-value and financially lucrative crops. Moreover, local authorities and rice farmers themselves wish to convert rice land to other uses with higher value because rice farming does not bring them much income.

Rice farming systems in the FPAs

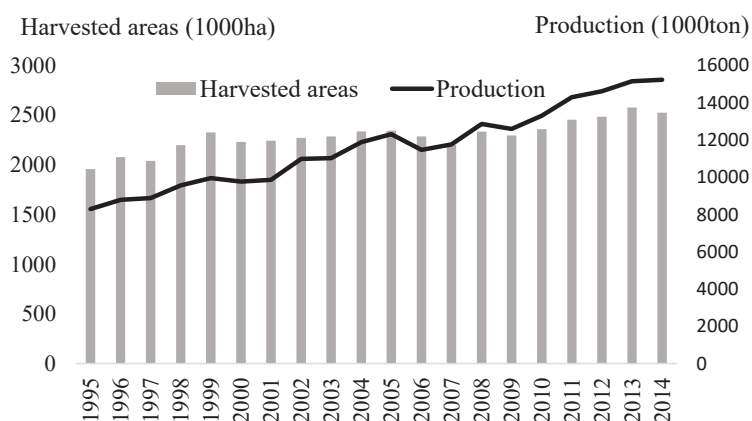
Overall, rice production in the FPAs since the mid-1990s may be divided into three phases: first, conversion from traditional to modern farming by using high-yielding rice varieties with shorter growing cycles and adopting inorganic fertilizers and pesticides use; second, intensification to increase production by increasing inputs and crop seasons; and third adaptive farming by using new techniques such as alternative wetting and drying of the land, integrated pest management (IPM), and related engineering technologies (such as rice growing in combination with flowers to attract natural enemies like spiders, bees to limit insect density).

The key intervention in rice production has been the full dike systems developed since the 1990s that allowed for the quick expansion of TRS. When rice fields are completely protected from floods farmers are able to apply intensification methods and water management for improving production (Huynh 2007; Ha and Duong 2014). As a consequence, the rice harvested area and production of about 2 million ha and 8 million tons in 1995 were increased up to approximately 2.6 million ha and 14 million tons in 2013, respectively (fig. 9.4).

There are six rice-based systems in the FPAs:

- *Double rice-extensive aquaculture (2R-EA) system*: practiced in areas with low dikes. The first and second rice crops are from December to March and from April to July, respectively (fig. 9.5). Farmers usually practice extensive aquaculture with fish and prawns in entire rice fields between the two rice crops to earn more income;
- *Triple rice system (TRS)*: applied in areas with high dikes. The three rice crops are Winter-Spring (WS, November to following March), Summer-Autumn (SA, April to July), and Autumn-Winter (AW, August to October);

Figure 9.4: Rice harvested area and production of provinces in the FPAs



Source: GSO 2015; compiled by the Authors

- *Double rice rotated with upland crops/vegetables (2RU)*: practiced in areas at higher elevation in areas with a full dike system. This system is preferred where there are vegetable processing factories nearby, for example, in Cho Moi district, An Giang province. Upland crops rotated with rice include green beans, corn, okra, chilis, cucumbers, tomatoes, and leafy vegetables;
- *Mixed rice-upland crop (MRU) system*: practiced in areas with “low dike-August dike” and “low-dike-Full dike,”² where the topography is undulating. Farmers grow rice and vegetables at the same time in different plots, according to the elevation of their fields, soil type, irrigation capability, labor availability, and most importantly, market demand;
- *Rice-fish/prawns + intensive aquaculture (2RIA) system*: farmers practice the 2R system. However, farmers do not use all their rice land for fish/prawn aquaculture. Suitable areas remain under intensive rice cultivation;
- *Floating rice rotated with upland crop (FU) system*: practiced only in low-lying areas without dike protection, mainly in Tri Ton and Cho Moi districts, An Giang province, and Thanh Binh district in Dong Thap province. Profits from floating rice are small compared with those from upland crops but the rice straw is retained for mulching, conserving

soil moisture and adding organic matter, thereby returning valuable nutrients to the soil. Chemical fertilizers and pesticides are not used for floating rice.

Figure 9.5: The calendar of six cropping systems in An Giang and Dong Thap provinces

Cropping system	1	2	3	4	5	6	7	8	9	10	11	12	
2R-EA	WS rice			SA rice				Aquaculture					
3R	WS rice			SA rice				AS rice					
2RU	WS rice			SA upland				AS rice					
	WS rice			SA rice				AS rice					
MRU	WS rice			SA rice									
	WS Uplands			SA uplands				AS uplands					
	WS uplands			SA upland									
	WS rice			SA rice				Intensive aquaculture					
2RIA		AS upland						Floating rice					
		SA uplands		AS uplands 2			Floating rice						
FU													

Drivers of TRS in the VMD

Local and regional scales

The development of water management systems for flood control, irrigation, drainage and salinity protection in the VMD has been the key intervention to increase rice production for domestic needs since the country's reunification in 1975 (Biggs et al. 2009). Prime Ministerial

Decision No. 99/ TTg in 1996 allocated 15,500 billion VND between 1996 to 2000 for further infrastructure development, mainly for flood control, improved drainage and irrigation, of which local inhabitants contributed 8,400 billion VND.³ Up to 2012, there were 105,200 km⁴ of dikes in the Delta provinces. Dike and sluice systems in the FPAs have multiple functions to control water and protect fields as well as to mark settlements and act as roads (Truong 2014). The improved infrastructure has enabled the rapid expansion of TRS in the FPAs. Many rice farmers can now adopt or change from two to three rice crops a year.

As mentioned earlier, domestic food security and rice export policies in the 1990s were the most important drivers in the development of rice farming. In the last three decades, many programs and projects to increase rice yields have resulted in an enlargement of harvest areas, about 700,000 ha, through multiple crop seasons and the conversion of fallow land to rice fields. Further, several decisions on food security, agricultural and rice land use planning, dike system development⁵ encouraged double rice and triple rice cropping in the FPAs. However, in the land-use plan (up to 2020) prepared by the Ministry of Agriculture and Rural Development (MARD), the harvested area of rice is maintained at current levels, but yield and production are expected to increase through intensification.

Along with central government policies, local authorities in An Giang and Dong Thap provinces also have implemented programs, such as training on cultivating the third rice crop. In some places with full dike systems in the FPAs, the third rice crop has been an effective way to improve rice farmers' income.

The removal of import restrictions in 1991 allowed prices of chemical fertilizers, pesticides and other inputs for rice cultivation such as DAP, NPK fertilizers to drop by 50 percent. This decision resulted in a shift from traditional organic and manure-based fertilizers to imported chemical fertilizers (World Bank 2004). Cheaper inputs encouraged and allowed most farmers to plant new high-yielding rice varieties needing less time to grow and ripen since traditional rice varieties could not adapt to chemical fertilizers. These high-yielding varieties of rice allow farmers to practice TRS.

Farm scale

Under rice intensification policies, most rice farmers have aimed to increase their yields rather than optimize their inputs for better profit. This trend explains why rice production has continued to increase even as profit margins have fallen. Influenced by government campaigns, farmers were proud of achieving high yields in their communities. With rice surpluses in recent years, however, they have gradually begun to focus on increasing their profits rather than just increasing their yields.

Another reason pushing farmers in the FPAs to TRS is the lack of alternative livelihood opportunities. About 70–80 percent of farming income comes from rice (LMPPI 2017). Without the third rice crop, farmers have more than three months of leisure without any income. Moreover, mechanization during some stages of the growing cycle such as land preparation and harvesting has reduced the labor needs in rice farming while other seasonal employment opportunities for farmers remain limited. Even if other crops such as vegetables and upland crops such as onions, chilis, soybeans, and corn are grown in the fallow season, there are marketing constraints. While rice may be sold immediately after the harvest or stored to be sold later at a negotiated price, facilities for storing more perishable produce such as vegetables are lacking, and end up mainly for household consumption or the local market. Ultimately, shifting from single or double rice crops to TRS reflects the current options available to the farmers to use their fallow time to earn additional income.

Last but not least, the expansion of TRS has been driven by rice intensification programs for rice farmers run by some 17,200 extension officers and experts during the last three decades. Rice farmers have been trained to be confident and familiar with intensive rice cultivation techniques. In addition, now that farmers have invested heavily in the new machines and facilities that enable intensive rice cropping, most are reluctant to switch to other or more diversified systems.

Challenges for TRS

Rice intensification has clearly contributed to improving farmer livelihoods and the socioeconomic development of the VMD floodplains. However, farmers practicing TRS are facing many new problems and challenges, as well as land degradation, environmental pollution (water, soil, and air), and decreasing economic efficiency and sustainability.

Impacts on livelihoods

TRS has improved rice farmers' incomes and generated jobs for other actors in the rice value chain (collectors, middlemen, traders, wholesalers and retailers). These include the provision of services such as land preparation, transplanting, weeding, pesticide and fertilizer application, harvesting and processing in addition to agro-inputs trading, transportation, and rice trading. All these represent TRS's positive contributions to rural development. Yet, several scientists and other experts suggest stopping TRS and converting rice land to other crops or introducing upland crops and vegetables instead of rice to sustain soil fertility. Unfortunately, official data and formal studies of the problems involved in TRS are limited. In fact, local authorities, technical experts and rice farmers in the floodplains have agreed to stop implementing TRS (LMPPI 2017). The problem is determining which crops could replace rice and how to convert the rice lands under TRS to other farming systems.

Until 2010–2011, the second rice harvest earned higher profits than the third (Phan et al. 2011). However, in more recent years (2013–2015), due to climate change impacts on rice yields and production costs reflected in market price fluctuations, the second and third rice-cropping seasons achieved the same financial efficiency (Nguyen et al. 2015). Another recent study by the Lower Mekong Public Policy Initiative (LMPPI 2017) recognized that rice farmers want to drop the second rice season (Summer–Autumn) of the year instead of the third season (Autumn–Winter). This is because the rice selling price in the third season was higher than the second one, and farmers easily sell their rice after the harvest. Moreover, dropping the third season, farmers can continue earning a living through other natural resources or aquaculture because the third season falls during the flood season. In contrast, farmers would have difficulty looking for other income-generating activities if they drop the second season.

Currently, TRS has higher financial efficiency and contributes more to household income compared to other rice-based farming systems. On average, rice farming in An Giang and Dong Thap provinces provides VND55 and VND58 mil./ha/year, respectively. Triple rice farmers in An Giang and Dong Thap earn VND47 and VND41 mil. per household per year, and rice comprises a large proportion of household income (tables 9.2, 9.3a, 9.3b). In the FPAs, rice-upland crops, rice-intensive aquaculture

and floating rice-upland crop systems could provide higher returns. However, farmers who practice these mixed systems are still in a minority. This is because the market for non-rice products is limited. In other words, TRS can remain a key contributor to local livelihoods, at least at present in the FPAs.

Table 9.2: Financial indicators of rice-based farming systems in An Giang and Dong Thap provinces

Unit: (million VND/ha/yr)

Cropping systems	Materials	Labor	Rental machines	Total costs	Gross revenue	Net revenue	BCR
An Giang							
2R	22±6.6 ^b	11±4.4 ^b	5.3±2.1 ^b	33±9.3 ^b	72±13.2 ^b	39±15 ^b	2.4±0.8 ^b ^c
3R	33±9.6 ^a	17±7.8 ^a	9.5±4.7 ^a	50±13 ^a	105±19.4 ^a	55±20 ^a	2.2±0.6 ^c
2RU	20±5.9 ^b	8.1±5.2 ^b	7.5±5.5 ^a	28±9.0 ^b	79±8.5 ^b	51±11 ^a	3.0±0.8 ^{ab}
FU	2.5±0.9 ^c	2.7±1.6 ^c	2.4±2.7 ^c	5.2±2.0 ^c	15±8.9 ^c	9.2±9.4 ^c	3.4±2.9 ^a
Dong Thap							
2R	22±7.1 ^c	7.7±3.4 ^b	6.0±2.0 ^c	30±9.0 ^c	75±12 ^b	45±15 ^b	2.8±1.1 ^{ab}
3R	32±8.0 ^b	12±9.2 ^a	12±3.5 ^a	43±14 ^b	102±17 ^a	58±21 ^a	2.5±0.7 ^{ab}
MRU	40±9.4 ^a	14±7.2 ^a	9.6±4.1 ^b	54±12 ^a	95±24 ^a	41±24 ^b	1.8±0.6 ^c
FR	23±8.9 ^c	5.0±2.3 ^b	4.2±1.2 ^d	28±9.5 ^c	76±11 ^b	48±14 ^b	3.0±1.0 ^a
FU	3.2±1.8 ^d	5.2±2.8 ^b	3.5±1.6 ^d	8.5±3.2 ^d	16±7.9 ^c	7.9±9.0 ^c	2.3±1.6 ^{bc}

Notes: The same letters after the mean values in the same column for each number are not significant differences at $\alpha=5\%$; Labor cost consists of family and hired labor

Source: LMPPI, 2017.

Table 9.3a: Income sources of rice-based farmers in An Giang province

Farm income sources	Farming systems in An Giang province (mil. VND/household/year)				
	2 Rice	3 Rice	Rice-UC	FR-UC	Fishery
Rice systems	37±3.5 ^a	47±3.1 ^a	36.1±4 ^a	5.2±1.3 ^b	3.3±1.8 ^b
Upland crops	0.1±0.1 ^a	0 ^a	24.7±5.8 ^b	29.2±5.6 ^b	0 ^a
Aquaculture	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a
Livestock	0.5±0.4 ^a	0 ^a	1.4±1.4 ^a	0 ^a	0 ^a
Total	37.6±3.6 ^b	47±3.1 ^b	62.4±7.5 ^c	34.5±5.5 ^b	3.3±1.8 ^a
Total HH income	58.2±5.1 ^a	63.7±9.8 ^a	91.2±10.7 ^a	41.9±6.6 ^a	50.2±7.1 ^a
Income/capita	13.5±1.4 ^a	15.7±2.5 ^a	19.3±2.1 ^a	10.6±1.6 ^a	13.1±1.9 ^a
Income/labor	17.9±1.7 ^a	25.1±4.9 ^a	34.4±2.8 ^a	14.7±2.6 ^a	16.8±2.5 ^a
Rice profit/HH profit (%)	95.4	97.2	65.0	20.3	34.3

Notes: UC-upland crops, FR-floating rice, HH-household

Source: LMPPI, 2017

Table 9.3b: Income sources of rice-based farmers in Dong Thap province

Farm income sources	Farming systems in Dong Thap province (mil. VND/household/year)					
	2 Rice	3 Rice	Rice-UC	Rice-Fish	FR-UC	Fishery
Rice systems	40.6±2.9 ^b	41.6±3 ^b	44.6±34.2 ^b	48.7±17.1 ^b	-3.8±2 ^a	8.7±2.5 ^a
Upland crops	0 ^a	2.8±2.1 ^a	52.6±19.6 ^b	0 ^a	152.9±16.9 ^c	0 ^a
Aquaculture	1.6±1 ^a	0 ^a	0 ^a	145.3±110.8 ^b	0 ^a	3.5±3.5 ^a
Livestock	2.8±1.9 ^a	0 ^a	5.7±5.3 ^a	0.4±0.4 ^a	0.5±0.5 ^a	0 ^a
Total	44.9±4.9 ^{ab}	44.4±3.3 ^{ab}	103.9±41.5 ^{bc}	194.4±109.8 ^c	149.7±16.9 ^c	12.3±4.9 ^a
Total HH income	55.4±4.8 ^{ab}	56.7±4.9 ^{ab}	124.3±41.6 ^{abc}	203.6±104.5 ^{cd}	155.4±16.3 ^{bc}	42.8±6.2 ^a
Income/capita	14.9 ±1.7 ^a	15.2±1.5 ^a	25.6±7.7 ^a	51.4±27.9 ^b	36.9±4.2 ^{ab}	11.8±1.8 ^a
Income/labor	18.9±2.1 ^a	19.2±1.7 ^a	34.3±10.9 ^{ab}	58.5±28.4 ^{bc}	49.0±6.2 ^b	14.4±1.9 ^a
Rice profit/HH profit (%)	88.4	92.2	39.0	62.3	-1.0	31.0

Notes: UC-upland crops, FR-floating rice, HH-household

Source: LMPPI, 2017

Soil degradation

The problem remains that TRS within the full dike irrigation areas have led to soil degradation and a decline in yields (Guong et al. 2010); consecutive rice cropping with the conventional practice of anaerobic decomposition of rice residues can increase Nitrogen binding to lignin-derived phenols, which can result in limited Nitrogen mineralization in soils (Schmidt et al. 2004; Olk et al. 2009). Soil degradation due to TRS was identified in the Cho Moi district (An Giang province), which is surrounded by a full dike system (Guong et al. 2010). The degradation is worse under monoculture rice cultivation compared to land rotated with upland crops. The deterioration in soil quality could also be caused by a reduction in the organic matter due to the accumulation of phenolic compounds that have resulted in less available Nitrogen in the soil (Olk et al. 2007). Moreover, in the TRS, tillage is carried out partly or fully while the soil is under water, causing much leaching of valuable minerals and nutrients. In the long term, the topsoil layer becomes hard and dense quickly, whereas mineralization occurs slowly, which limits the development of rice root systems (Thao 2002; Ve 1999), thereby having a negative impact on rice yields (Tien 2005).

Other studies (Phuong et al. 2009; Linh et al. 2016) have also found that TRS resulted in soil structure degradation, declining soil fertility and increased toxicity. The closed dike systems stop natural flooding, and the land is not given time to recover its fertility. Riceland became degraded just a few years after closed dikes and triple cropping were adopted. Nitrogen (N), Phosphorus (P), and Potassium (K) decreased significantly after the introduction of intensive rice cultivation; in particular, one study shows that the P in soils decreased up to 25 percent after 11 years of TRS (Tuyen 2013). To illustrate this process, one ton of rice requires 17–30 kg of K (Dobermann et al. 1996); therefore, TRS with 20.1–21.6 t/ha/yr consumed 350–650 kg K/ha/yr from the soil. The K is supplemented in soils at the rate of approximately 180–220 kg/ha/yr (LMPPI 2017). In terms of toxicity cleaning, replenishing rice fields with alluvia, and flushing out acid sulfates and other toxic substances, also does not take place. This has led farmers to increase their use of artificial fertilizers since the introduction of the full dikes (Nha 2004).

Environmental pollution

Overall, it is clear that TRS causes environmental problems in many ways: soil and water pollution due to the use of inorganic fertilizers and pesticides; solid waste generation; and air pollution due to rice stubble and rice straw burning. The overuse and indiscriminate use of pesticides is one of the most important, direct causes of water and soil pollution in rice farming. Rice is susceptible to attacks from insects, fungi, bacteria, viruses, rodents, and other pests. To protect rice, farmers use pesticides, remnants of which are adsorbed by water and soil particles, which then contaminate the rice through its roots. As such, adverse impacts from pesticide residues on surface water systems, especially on non-target organisms, are inevitable (Sebesvari et al. 2012). Some pesticides are quite stable and their biodegradation may take weeks, and even months.⁶

Soil pollution is defined as the buildup in soil of persistent toxic compounds, chemicals, salts, and radioactive materials, which have adverse effects on plant growth and animal health that directly interacted and settled on the polluted soils. There are different ways that soils can become polluted, including the percolation of contaminated water into soil and excess application of pesticides and fertilizers. In rural farming areas, soil pollution is often associated with the indiscriminate use of fertilizers and pesticides (USAGIC 2008).

The overuse and low efficiency of fertilizers are the main causes of soil fertility losses (Ha 2006). Such degradation may be imperceptible but, cumulatively, fertilizers can seriously pollute water bodies, soils, and the environment. High rates of N fertilization can lead to soil acidification. This process occurs when the ammonium in N fertilizers undergoes nitrification to form nitrate and that nitrate leaches into the soil. However, ammonium-based fertilizers can also contribute directly to acidification in the absence of nitrate leaching (Crews and Peoples 2004). Over time, excessive applications of N can lead to soil acidification. Highly acidic soils are inefficient at transferring nutrients from the soil to plants, causing crop yields to remain below their potential (IDH 2013).

TRS farming practices

The need to keep cultivating the same land continuously in TRS has generated unsustainable and harmful practices. Among these,

- partial land preparation can accelerate soil degradation leading to increasing reliance on fertilizers;
- consecutive rice cycles mine nutrients from the soil, encouraging more fertilizer use. Meanwhile, continuous cropping can lead to higher pesticide use by disrupting the ability of farmers to take advantage of the natural pest balance; and
- many of the new TRS rice varieties require high inputs (fertilizer, pesticides, and water), which negatively impacts soil conditions, water quality and quantity, and biodiversity; furthermore, new rice varieties can threaten the natural genetic diversity of crops.

Furthermore, on average, 1 ha of rice farming will produce 12.8 kg of solid waste, including plastic (75.8 percent), glass and metal (21.9 percent), nylon (1.7 percent), and paper (0.6 percent) (Nga et al. 2013). Fertilizer and pesticide packaging are major sources of this waste, and constitute about 10 percent of the volume of agricultural inputs. Most farmers do not practice safe handling and storage of pesticides and fertilizers, and the wastes generated from packaging materials is poorly managed. More than 70 percent of farmers in the VMD, dumped the used chemical fertilizer and pesticide bottles, bags, and so on into canals or in the rice fields. Approximately 90 percent of farmers said that they washed their sprayers after use in the rice fields, canals, ponds, or rivers, thus polluting the water, impacting fishery resources and biodiversity (Toan et al. 2013). Some of the packaging is burned and the smoke released from burning pollutes the air and is a public health hazard. Residues from pesticides and fertilizers are contaminating rainwater and irrigated water going to rivers and canals, which ends up causing soil and water pollution, killing fish and other aquatic fauna.

Another threat to health is the uncontrolled rice-straw and stubble burning. Up to 98.2 percent of rice farmers in the VMD burn the straw after the Winter–Spring season, 89.7 percent burned them after the Summer–Autumn season, and 54.1 percent burned them after the Autumn–Winter season (Nam et al. 2014). The burning of rice residues has been a common practice to eliminate waste after harvesting because it is a cheap and quick way to prepare land for the next crop under TRS. This practice directly contributes to air pollution and human health problems. Burning these residues emits gases, such as sulfur dioxide (SO₂), nitrogen

oxides (NO_x), carbon dioxide (CO_2), carbon monoxide (CO), black carbon (BC), organic carbon (OC), methane (CH_4), volatile organic compounds (VOC), non-methane hydrocarbons (NMHCs), ozone (O_3), aerosols, and so on, which affect the global atmospheric chemistry and climate change.

Health problems

Nitrates, pesticide residues, and other toxic chemicals in rice farming can cause serious health problems if people are exposed to them for a long period. Rice farmers may be particularly at risk, as they are frequently exposed to agricultural chemicals. Pesticides and other agrochemicals are also destructive to fish and other aquatic fauna that are important food sources for the low-income populations in the FPAs.

The health impacts of pesticides used in TRS vary depending on the intensity and duration of exposure. Humans may be directly exposed to pesticides when breathing and touching chemicals while spraying, or indirectly by drinking contaminated water and consuming food products that include rice containing pesticide residues (Özdemir et al. 2011; Toan et al. 2013; Wilbers et al. 2013, 2014). Contamination can cause headaches, irritation, breathlessness, vomiting, and so on, and cancer or other forms of tumors in serious cases (Dasgupta et al. 2005). The most vulnerable groups are youth and people who are poor or have limited education because they are often in charge of pesticide application in TRS (through so-called agricultural service groups).

Unsafe application of pesticides are a cause of worker accidents and food poisoning among consumers (Propsom 2010; Hoi et al. 2013). A study conducted in the VMD in 2015 found frightening results, with pesticide residues detected in the blood of farmers (Dasgupta et al. 2005). A survey conducted by the MDI in 2013–2014, in An Giang province, also found that women suffered from more skin problems and headaches during rice re-transplanting and weeding, right after pesticide spraying (Nguyen 2017).

The pollution of drinking-water sources with agrochemicals in the TRS regions is a major threat to human health. This is a serious problem because most rural people in the FPAs use surface water from rivers and canals as their main source of drinking water. Normally, after getting water from the river, rural villagers keep it in jars for a few days to let solid particles settle down before boiling it for drinking. This treatment, of course, cannot remove dissolved and nonvolatile chemical

pollutants in the water. Furthermore, pesticide and fertilizer residues used in rice-farming activities are among the main contributors to groundwater pollution. Pesticides used in rice fields are a serious hazard to groundwater extracted from wells (Lamers et al. 2011).

The unsafe pesticide handling, improper occupational protection, and poor awareness of pesticide toxicology among TRS farmers have also been reported to have negative consequences on human health (Berg et al. 2001; Toan et al. 2013). The consumption of rice grown under such conditions causes pesticide residues to enter human and animal biological systems, with potential adverse effects.

Biodiversity and fisheries decline

In TRS, pesticides leaching into water systems can also lead to negative impacts on the quantity and diversity of insects and wildlife near rice paddies (Ghosh and Bhat 1998). While pesticide filtration into soil and water harms animal and human health, it also causes a loss of fisheries resources and biodiversity in terrestrial and aquatic ecosystems (Cagauan 1995; Cong et al. 2008). Efficiency rates of pesticide applications are even lower than those of fertilizers. Some studies have estimated that less than 0.1 percent of pesticides applied to crops actually reach the intended pests (Arias-Estevez et al. 2008). The remainder accumulates in soils, where it may filter into groundwater or surface water and prove toxic to microorganisms, aquatic animals, and humans. The accumulation of pesticides in soils can harm arthropods, earthworms, fungi, bacteria, protozoa, and other organisms that contribute to the functions and structure of soils.

Pesticide use in TRS has been associated with negative effects on fish populations in Vietnam's rice-fish production systems (Kleimick and Lichtenberg 2008). Studies of physiological changes in fish revealed long-lasting effects of organophosphate pesticides on fish health in Vietnam (Cong et al. 2008). When pesticides are used in rice fields, their residues are not just confined to those rice fields. The water discharges and overflows from the rice fields will contaminate the surrounding soil and water. Prolonged misuse of pesticides, herbicides, and fertilizers over the years has caused a tremendous reduction in inland fisheries elsewhere (Moulton 1973; Abdullah et al. 1997), and this may be happening in the VMD.

Pesticide pollution from TRS can have direct negative effects on local aquatic environments, preventing the growth of or destroying the structure of aquatic ecosystems (Margni et al. 2002). Indirectly, it also affects organisms that reach these polluted water sources, such as migratory fish and aquatic birds, and beneficial soil microorganisms that support insects and plants (Agrawal et al. 2010), even in areas downstream from where the chemicals were applied. Pesticide contamination can cause a loss in value of water resources, particularly surface water in rural areas (Minh and Gopalakrishnan 2003), where surface water is used for irrigation, personal hygiene, washing, and especially drinking and cooking.

Unsustainable economic efficiency

TRS may be economically inefficient in the long term, because of increasing input costs (the overuse of pesticides and fertilizers) without corresponding increases in rice yields and prices.

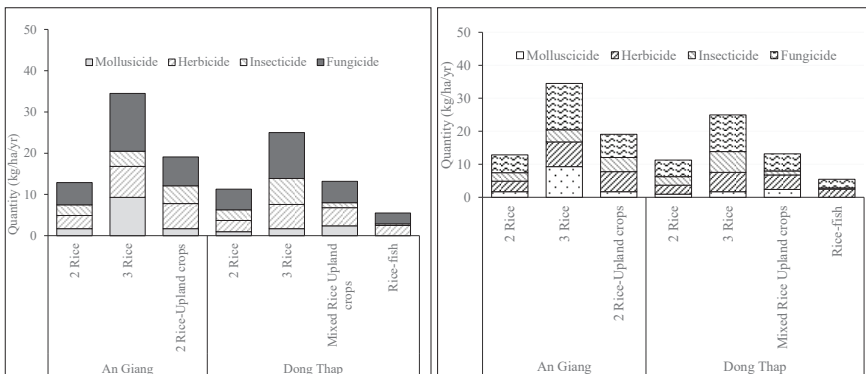
Most triple rice farmers apply fertilizers well above the recommended rates. For instance, in An Giang province, they apply up to 20–30 percent more fertilizer than recommended; the excess was 28 kg N, 15 kg P_2O_5 , and 18 kg K_2O per ha per crop. It is estimated that every year, approximately 140,000 tons of N, 82,000 tons of P, and 66,000 tons of K are wasted due to over-fertilization of rice fields in the VMD. From an economic perspective, this is equivalent to US\$150 million wasted per year from over-fertilization in rice cultivation alone. Furthermore, as demonstrated, over-fertilization has high environmental costs, which, in turn, negatively affect the competitiveness of Vietnam's rice on the world market.

Similarly, up to 50–80 percent of rice farmers used pesticides at levels higher than those recommended (Nga et al. 2013) because they thought that a higher dosage would be more effective. According to our calculations, every year, approximately 1,790 ai (active ingredient) tons⁷ of molluscicides, 210 ai tons of herbicides, 1,224 ai tons of insecticides, and 4,245 ai tons of fungicides are wasted from excessive/unnecessary use in rice production in the VMD. An estimated US\$400 million is wasted annually on excess pesticides.

Increased agricultural input costs also arise from having to maintain intensive growing and harvesting cycles. Notably, inorganic fertilizers

and pesticides comprise 50 percent of the total cost of TRS (Nguyen et al. 2015). This explains why TRS has higher production costs compared to other rice systems and why the costs have increased. Figure 9.6 presents pesticide quantities applied under various rice systems in An Giang and Dong Thap provinces. Among the three rice systems in An Giang (double rice, TRS, double rice-upland crops) and four systems in Dong Thap (double rice, TRS, mixed rice-upland crops, and rice-fish), TRS used the most pesticides, especially fungicides. A study carried out by MDI (2015) reveals that pesticide use in TRS has risen sharply. Between 2011 and 2014, the total pesticide quantity used for TRS per hectare nearly doubled in Kien Giang (table 9.4). Along with pesticides, the volume of seeds and inorganic fertilizer used for TRS also increased significantly. Within three years (2011 to 2014), the volume of seeds, net nitrogen, potassium, and phosphorus applied per hectare in a year increased by 90, 85, 21, and 71 kg, respectively (table 9.5).

Figure 9.6: Pesticide quantity applied under various rice systems in An Giang and Dong Thap provinces



Source: LMPPI, 2017

Table 9.4: Applied pesticides under TRS between 2011–2014 in An Giang and Kien Giang provinces

	2011			2014		
	WS	SA	AW	WS	SA	AW
<i>Phu Tan, An Giang</i>						
Molluscicide	450.2	389.1	409.5	421.7	583.6	321.3
Herbicide	743.7	735.6	619.9	500.8	664.5	570.4
Insecticide	383.0	395.4	180.6	597.9	325.9	334.3
Fungicide	639.4	803.6	1,075.2	1,034.5	830.2	838.3
Stimulant	249.8	278.2	249.7	203.4	462.1	248.7
Total	2,199.8	2,306.5	2,285.2	2,555.0	2,404.2	2,064.3
<i>Tan Hiep, Kien Giang</i>						
Molluscicide	416.2	267.3	248.1	462.4	894.8	586.5
Herbicide	353.8	514.4	399.1	803.3	747.7	1,028.5
Insecticide	128.1	174.9	115.9	490.1	288.1	310.5
Fungicide	499.8	701.2	642.6	955.5	868.5	823.1
Stimulant	83.7	154.5	95.0	162.5	185.2	102.1
Total	1,397.9	1,657.8	1,405.7	2,711.3	2,799.2	2,748.6

Notes: WS: Winter-Spring, SA: Summer-Autumn, AW: Autumn-Winter

Source: MDI 2015

Table 9.5: Applied inputs under TRS between 2011–2014 in An Giang province

Applied inputs (kg/ha/yr)	2011	2014	Changed value
Seed quantity	607.4	697.5	90.1
Net N	449.5	534.4	84.9
K ₂ O	164.5	185.4	20.9
P ₂ O ₅	196.2	267.2	71

Source: MDI 2015

The decreasing efficiency of TRS could also be due to declining yields. TRS has lower rice yields compared to other rice-based systems during the same cropping season. The difference is seen clearly in the Winter-Spring season because this crop is cultivated right after the previous harvest. As proof, an earlier LMPPI study in An Giang and Dong Thap provinces (table 9.6; LMPPI 2017) indicated that the rice yields under TRS were lower than double rice, combined rice-upland crops, and rice-fish systems.

In the Winter–Spring season, TRS in Dong Thap (7.4 ton/ha) is lower than in An Giang (8.4 ton/ha). This could be because TRS has been practiced for a longer period in Dong Thap than in An Giang.

Table 9.6: Rice yields in different farming systems in An Giang and Dong Thap provinces

Farming systems	Cropping seasons		
	Winter-Spring	Summer-Autumn	Autumn-Winter
<i>An Giang</i>			
2 Rice	8.7±1.7	6.8±1.3	-
3 Rice	8.1±0.9	6.7±1.1	6.8±1.5
2 Rice-Upland crops	8.6±1.1	-	7.4±1.4
<i>Dong Thap</i>			
2 Rice	8.4±1.5	6.8±1.2	-
3 Rice	7.4±1.1	6.7±1.6	6.9±1.8
Mixed Rice-Upland crops	7.5±1.1	6.8±1.7	6.3±1.6
Rice-Fish	8.8±1.1	7.4±1.2	-

Source: LMPPI 2017

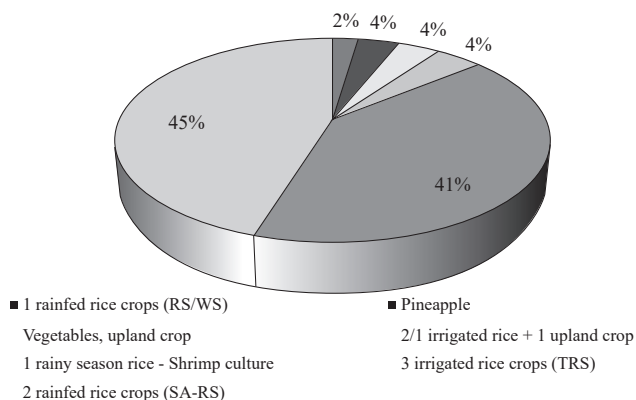
Alternative farming systems

In the FPAs, the different types of agriculture are based on various combinations of three main components: crops, fish, and livestock. Of these, TRS (510,074 ha) combined with the double rice (562,543 ha) system comprised more than 85 percent of the total cultivated area (fig. 9.7). The remaining planted areas were allocated for vegetables, upland crops, single rice cropping, and other less common systems.

Taking into account climate change, upstream hydropower development and agricultural restructuring, land use plans for 2020 and projection to 2030 in the VMD as a whole indicate 1.7 million ha allocated for rice cultivation, 0.185 to 0.2 million ha for rice-upland crops, and 0.24 to 0.3 million ha for rice-aquaculture (MARD 2014). In the FPAs, however, there are plans to reduce the area under rice cultivation by 10 to 15 percent, given the lower returns from rice, and to convert these areas to other use such as growing upland crops, vegetables, and other profitable crops. Under the agricultural restructuring program,⁸ rice

farmers are encouraged to grow upland crops, vegetables and legumes such as peanuts, soybeans, sesame, maize, as well as practice aquaculture alternately with rice, with the aim of reducing areas under TRS. Hence farmers in the VMD do have many other alternatives to TRS.

Figure 9.7: Farming systems distribution by planted areas in the FPAs



In reality, however, the choice to follow or continue to follow a farming system depends on related economic, social, environmental and technical aspects. Economic aspects consist of production costs, market accessibility, and the net benefits for farmers; social aspects include job opportunities, food security and community relationships; environmental issues include challenges to soils, water and other natural resources; technical aspects include how farmers can adapt to the new system, and their familiarity with its farming requirements. When selecting an agricultural system, farmers match these aspects with their resources and local conditions. Thus TRS is still practiced because its requirements have been adopted. Currently, farmers have the experience and skills to cultivate rice, and the infrastructure required for TRS such as dikes, pump stations, and other agricultural services is in place. The most important point is market accessibility, consumption channels and the risks associated with new crops. In case of a drop in the selling price of rice, farmers can store and use the rice for livestock raising. Despite the low earnings from TRS, farmers still find that it generates more sustainable income in comparison to switching to vegetables, upland crops or aquaculture.

Table 9.7: Farmer scoring in terms of the current efficiency of farming systems at the HH level

No	Farming systems	Economic	Social	Environmental	Technical	Overall scores
1	3 rice	3.5	5	4.5	6	19
2	2 rice-upland crops	7	5	7	7	26
3	2 rice-fishery	4	6	7.5	6.5	24
4	2 rice-aquaculture	6.5	4.5	5	8	24
5	Mono-aquaculture	10	2	2	2	16
6	Floating rice-upland crops	5	5	5	5	20
7	Aquaculture by cropping seasons	5	6	8	4	23
8	Small scale livestock	6	10	10	4	30

Note: Scores range from 1 to 10, with 10 being the highest (extremely important to farmer livelihoods)

Source: LMPPI, 2017

The survey results in table 9.7 show the points scored in the eight common farming systems in the VMD using efficiency indicators in four fields: economic, social, environmental, and technical, which were considered by farmers, local authorities and extension workers. The study shows that TRS has lower overall scores compared to other rice-based systems, particularly economic and environmental aspects. This means that TRS is facing problems and therefore, rice farmers should consider alternatives to intensive rice-based farming. Critically, rice farmers reflect that they want to stop practicing TRS, to convert to other promising alternatives such as double rice cropping combined with aquaculture, fishing or upland crops. But present conditions such as linkages in product consumption, farming techniques, infrastructure (especially internal dikes), and ponds are not ready for alternative use. Overall, rice-based agriculture remains the mainstay of farming livelihoods. However, besides TRS, rice-upland crops, rice-fisheries and rice-aquaculture systems are alternatives and opportunities. Moreover, to improve income and livelihoods, rice farmers can practice monocultural aquaculture, floating rice-upland crops, aquaculture by cropping season, and small-scale livestock raising.

In the FPAs, natural conditions impact on the development of all farming systems. Flood regimes are of primary concern because they directly influence the yield and income from various cropping systems. This study offered three scenarios on flood regimes: normal, low, and high, to understand farmers' selections. The results in table 9.8 indicate that under normal and low flood conditions, farmers agreed to enlarge TRS, monocultural aquaculture and livestock practices, while the remaining systems are stabilized or decreased. In contrast, under high flood conditions, farmers want to decrease TRS, rice-upland crops, and livestock. These changes seem to be adaptive strategies for farmers to mitigate the impacts of poor returns on TRS. To decide future farming practices, farmers carefully considered their existing livelihood resources, including land, access to credit/finance, farming skills, and supportive local and central government policies. The market for agricultural products is extremely important, of course, because it determines the profitability of a chosen farming systems and the returns from inputs and investment made by farmers.

Table 9.8: Future potential farming systems to be practiced in the FPAs

No	Farming systems	Normal, low flood	High flood	Sectors required for sustainable development
1	3 rice (full dike areas)	↗	=, ↘	Environmental, social, economic
2	2 rice-upland crops	=, ↘	↘	Economic, technical, social
3	2 rice-fishery	=, ↘	↗	Social, economic, environmental
4	2 rice-aquaculture	=, ↘	↗	Environmental, social, technical
5.1	Monocultural aquaculture	↗	↗ =	Economic, environmental, social
5.2	Floating rice-upland crops	=, ↘	↗	Technical, economic, social
5.3	Aquaculture by cropping seasons	=	↗	Economic, technical, environmental
5.4	Small scale livestock (pig, poultry, cattle)	↗	↘	Social, environmental, economic

Notes: Farming systems proposed by farmers, local authorities and extension workers; =stabilized, ↗-increased, ↘-decreased

Source: LMPPI 2017

Farmers, local technical experts, and authorities gave feedback that TRS has contributed a lot to farming livelihoods. However, while the system was suitable in the past, now it needs to be modified to adapt to changing conditions. On top of that, problems such as the degradation and pollution of soils, water, land use efficiency (natural utilization efficiency), climate change, the impact of hydropower development in upstream areas, and requirements for ensuring livelihoods and income for farmers, need to be taken into account for agricultural land use planning in the FPAs. Farmers want to use their lands to improve their livelihoods: if the land use plans do not benefit them, they will not follow the plans. This explains why macro-level land use planning may have different outcomes in actual practice.

Policymakers and local officials need to take into consideration all the needs and priorities of farmers in the FPAs when planning land use and implementing agricultural policy (see Box 9.1). Otherwise, the farmers will spontaneously shift to other land use types that they think will be better for their livelihoods.

Box 9.1: Farmers' needs

Economic and infrastructure requirements

- Contract farming, production in line with the value chain
- Job generation during flood season
- Credit services provision
- Improvement of electricity, roads, pump systems
- August dike system development to control early floods

Social, capacity building, and institutional building

- Farmer capacity building in new farming practices
- Strong local security management (theft prevention)
- Farming procedure, legal responsibility among farmers and agricultural product buyers

Environmental & resource management

- Limit, reduce and manage pesticide and fertilizer use during rice season
- Apply GAP standards, new farming technologies
- Provide sufficient agricultural solid and fresh waste management
- Allow short natural flooding to replenish alluvial soil
- Apply more organic fertilizers
- Improve acid sulfate soils

Technical support and information access

- Technologies for harvesting, pre-processing, storing, and processing (rice, upland crop, fishery products) should be made accessible to farmers
- Early warning systems (market fluctuations, extreme weather alerts) should be established
- Strong pest management
- Improve seed quality and farming techniques

In sum, instead of practicing monocultural TRS or intensive rice farming, mixed forms of agriculture should be substituted for the sustainable improvement of rural livelihoods. However, existing conditions in the FPAs need to be improved before farmers can make the switch to more varied systems. Such improvements will ensure that farmers are able to adapt well to the new chosen system.

Implications and policy recommendations

Agricultural policy must be flexible and aim at sustainability under actual conditions. Rice land should not be used only for intensive rice farming. Farmers should be allowed to rotate vegetables or upland crops, fish and aquaculture on their rice land. Wherever applicable, nitrogen-fixing legumes, such as mung beans and groundnuts could be alternated to improve land fertility.

Policies that prioritize a third crop and food security should be carefully considered and the benefits and drawbacks to farmers should be weighed over increased rice production. MARD's land-use plan for 2020 (MARD 2014) includes a harvested area for rice that is relatively flat, but yields and production volumes are expected to increase further. This indicates greater intensification is expected for rice cultivation. It also implies that more fertilizer, pesticides, and other inputs will be needed and used to sustain yields and production volumes. If there is no effective solution to address fertilizer and pesticide residues or agricultural waste, the pollution problems will continue to worsen.

It is important to determine suitable flood and farm management to improve soil fertility. Management should include flood control and the adjusting of the cropping season to optimize the benefits of floods, such as alluvial deposits and flushing the toxicity of rice fields. The existing policy of planting eight crops every three years can be replaced by promoting aquaculture or fishing in the third season.

A system of contract farming and a value chain approach should be used. These apply not only to rice but also to upland crops and fishery products. In recent years, programs that support linkages between farmer organizations and agribusinesses have been widely piloted and are relatively successful at improving farming practices and value chain efficiency while reducing the adverse environmental impacts of intensive monocultural farming. For instance, in the VMD, the Good Agricultural Practice Certification (VietGAP), One Must Do, Five Reductions (1M5R), and the Large Model Field (LMF) programs in rice production have been successfully tested with the active engagement of private sector companies (such as Loc Troi Co. and others). Good examples exist at the local level. The key challenge now is to create an enabling legal environment and incentives to scale it up.

Ecological and landscape approaches are also important. These approaches have been increasingly recognized as effective ways of improving the sustainability of rice-based systems. IPM and ecological engineering techniques in rice farming are, in fact, based on the principles of ecological balance to control pests. However, these measures are only effective when small farms cooperate with others to protect the whole ecosystem, rather than as individual farms. Perhaps this is the best approach to achieving the dual goal of ensuring the long-term sustainability of the agricultural sector while effectively protecting the natural environment.

Public-private partnerships (PPPs) are another important strategy. At the time of writing, the government has paid special attention to promoting PPPs in which the government provides public goods to leverage private sector investments to improve commodity value chains. For example, the Loc Troi and Gentraco corporations have applied the Sustainable Rice Platform (SRP) standards within the context of applying the “large field” model in the VMD. To support these partnerships, the government has also financed public infrastructure to improve production efficiency and market access for farmer organizations and agribusinesses. There have been several good PPP models in the agricultural sector. The key constraint in scaling them up is the availability of public funds to meet demand.

Agricultural extension networks should be enhanced at the grassroots level. Regardless of the approach, farmer awareness and know-how

are preconditions for successful implementation and adoption of new techniques and types of farming. Therefore, establishing and maintaining a strong and capable extension force at local levels (in hamlets and communes) is critical. Local extension networks already exist in the VMD, and they have contributed to the successful development of agriculture in recent decades. They can again be the pioneers helping farmers to move away from unsustainable practices.

Agricultural and vocational capacity building for farmers is also important. To encourage farmers to turn to more diverse and alternative systems, farmers need to update their skills to adapt to new systems as well as to generate better jobs during the flood season.

On-farm technical approaches for locally adapted sustainable farming practices are available for farmers. Packages designed for rice farming (3R3G, 1M5R, VietGAP, GlobalG.A.P., SRP, and so on) have been piloted extensively in the VMD over the past decade. Farmers adopting 1M5R techniques were able to not only obtain higher yields and better-quality rice but also save approximately 30 percent on input costs (by reducing fertilizer, pesticides, and water use) as well as cut greenhouse gas emissions by 60 percent. However, to accelerate farmer adoption of these improved technologies, the government needs to pay greater attention to enhancing farmer awareness, facilitating the establishment of farmer organizations, and attracting and engaging the private sector through contract farming.

To reduce disease and pest risk resulting from monoculture, integrated farming systems have been widely developed and spontaneously adopted by farmers in many places. Examples include crop rotation, and rice-fish farming systems. A benefit of such systems is that they help diversify income sources and reduce pesticide needs. From a technical perspective, no major issues are foreseen. However, to help them become more sustainable in the long term, coordinated planning, improved public services, and market development to support efficient and sustainable diversification is needed.

Finally, in any agricultural land use planning, market demands on products, impacts of climate change and development of hydropower dams in upstream areas, soil and water pollution, degradation need to be considered carefully.

Conclusion

Rice-based farming systems are key land-use types in the floodplains of the Vietnamese Mekong Delta. Of these, the intensive TRS has become the most widespread, due to regional and farm-scale incentives. Policies driving rice production volume increases and the development of the full dike system have driven extensive use of imported agricultural inputs (seeds, fertilizers, pesticides) and changed farmer behavior. Since its introduction TRS has undoubtedly made a significant contribution to livelihoods in the FPAs, including job creation and income improvements for many actors in the rice value chain.

TRS has also caused widespread problems, however. Most concerns are related to land degradation due to the crop intensification and environmental pollution because of overused pesticides as well as fertilizers. This is also a threat to human health and has resulted in declining biodiversity and fishery resources. Critically, TRS is proving to be economically inefficient and unsustainable in the long term, with high production costs, low selling prices and consequently an unstable source of income for farmers.

Fortunately, farmers in this area have access to alternative farming systems. Double rice rotated with upland crops, aquaculture, and fishing are options, as are livestock raising, mono or seasonal aquaculture. However, to convert from TRS to the abovementioned systems, policy support and other requirements must be considered. Most importantly, it is critical to develop consumer markets for non-rice produce and products and to support farmers to adopt better and more sustainable farming techniques.

Based on the existing literature as well as on the ground surveys and analysis, this study offers recommendations for adapting current land-use policy for rice farmers. The existing goals of production increases, food security, rice land sustainability, and flood control need to be carefully evaluated and flexibly applied to the actual conditions of FPAs. Approaches such as contract farming and improving the rice value chain, working with the flood plain ecology increasing biodiversity, as well as public-private partnerships, community-capacity building and extension system upgrades, must be considered in order to improve land-use strategies and livelihoods for rice farmers in the FPAs.

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Notes

- ¹ See e.g. Decision No: 899/QĐ-TTg dated June 10, 2013, on approving the project “Agricultural restructuring towards raising added values and sustainable development.”
- ² An August dike is a temporary dike used to protect from early floods in August; a full dike means an area of land completely covered by a dike.
- ³ This money was collected in kind such as farmers offering their land for building works, irrigation systems, labor, and other material.
- ⁴ Data from Vietnamese Water Resource Directorate, presented on the website of the National Committee Large Dams and Water Resources Development (VNCOLD) (accessed June 29, 2017).
- ⁵ See Decree No. 12/2006/NĐ-CP issued 23/01/2006, Resolution No. 63/NQ-CP issued 23/12/2009, Decision No. 639/QĐ-BNN-KH issued 2014, Decision No. 124/QĐ-TTg issued 02/02/2012, Decision No. 101/QĐ-BNN-TT issued 15/01/2015.
- ⁶ The following material is largely based on an earlier study (Nguyen 2017).
- ⁷ Active ingredients (ai) are the chemicals in pesticide products that kill, control, or repel pests. Other ingredients may do a variety of jobs, like attracting the pest, spreading the active ingredients around, and/or reducing drift (Pesticide Product = Active Ingredient(s) + Other/Inert Ingredient(s)). For example, the active ingredients in an herbicide are the ingredient(s) that kill weeds. Often, the active ingredients make up a small portion of the whole product.
- ⁸ The aims of this plan are to improve the quality, competitive advantage, efficiency, and sustainability of the agricultural sector and its products through increasing value addition to commodities, improving value chains, and protecting the environment (Prime Minister’s Office QĐ 899/QĐ-TTg 2013).

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10

Small-scale Aquaculture and Fisheries Management in the Floodplain Areas of the Lower Mekong Delta, Vietnam

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Small-scale aquaculture in the Mekong Delta often takes place in combination with rice farming or raising livestock. Aquaculture in this case is combined with other farming activities in order to make optimal use of natural resources and seasonal conditions. There are three main types of integrated aquaculture in the Mekong Delta: fish aquaculture integrated with livestock raising, rice-shrimp culture, and rice-fish culture.

Many studies have shown the benefits of agricultural diversification. One study recommends cultivating two rice crops annually followed by rice-shrimp aquaculture during the monsoonal floods (Nam 2011). Phillips (2002) estimated that only 88,000 ha in the Mekong Delta was being used for such as rice-fish farming; there is great potential to increase fish production from this type of system. Using a conservative estimate of 100 kg/ha/year, the potential yield of fish from rice-fish culture may exceed 1 million tons per year. In addition, Berg et al. (2012) show that the rice-fish model had significant higher benefits (VND43.6 million/ha/year) compared to other models. The authors also suggest that current farming systems should be reorganized to encourage agricultural diversification, reduce risks, and enhance the ecosystem. Pham (2011) concurs that instead of a third rice crop, there are some successful integrated models such as the rice-fish, rice-fish-duck and special fish-duck farming that can be productive during the annual floods. In these models, rice remains the main income earner while fish is the ideal addition to the productivity and livelihoods of rural households. One drawback of the full dike system introduced in the early 2000s has been that, although they have protected the fields and enabled intensification of rice farming, rice yields

have reduced gradually, while chemical pesticide and fertilizer use have increased to unhealthy and unsustainable levels (see chap. 9).

Total yields from inland fisheries in Vietnam have reduced by 10 to 13 percent annually from 241,300 tons (2000) to 195,400 tons (2013) (GSO 2015). This pattern of reduced fish yields was observable in the Mekong Delta, the largest source of inland fish in the country. The reduction in fish yields is caused by overfishing and shrinking habitats due to agricultural and aquaculture development leading to water pollution as well as habitat degradation and loss (Sverdup-Jensen 2002). Although seen as an insignificant part of the total fisheries sector, inland fisheries play an essential role in the diet and livelihoods of a vast number households, particularly landless ones (Loc et al. 2007). In addition, inland fisheries also provide an important protein source and seasonal jobs for local people (Vu and Ngwenya 2008). Moreover, the floodplains of the Delta are highly productive and critical breeding grounds for fish and other aquatic animals. During the flood season, most fish species take advantage of the floodplains for feeding, breeding and rearing, and constitute an important natural resource for millions of Delta residents. Indeed Coates (2002) noted that the inland fisheries of Southeast Asia are crucial to the region's food security.

Small-scale aquaculture and fisheries production, together with rice, forms the basis for food security of the entire rural population of the Lower Mekong Delta. Hence, the integration of small-scale aquaculture and fisheries with rice cultivation in the floodplain areas is likely to become more important to the future of this region.

Materials and methods

This study of small-scale aquaculture in the floodplain areas was conducted in the hamlets of Tri Ton and Chau Phu in An Giang province, and Hong Ngu and Thanh Binh in Dong Thap province. The study sites were considered representative for considering flood-based farming systems that included small-scale prawn aquaculture and fishing. Interviewed households were randomly selected using two criteria: livelihood activities of the household, and proportional wealth with regard to these livelihoods, as ranked by key local informants using a list of households in the hamlets. A total of 94 selected households from all four hamlets practiced double-rice cropping rotated with prawn aquaculture

(20 households) or fishing (74 households). For the surveys, enumerators directly interviewed the household head or key household member. Information was collected on household profiles, livelihood assets, technical and socioeconomic aspects of livelihood activities, perceptions of key livelihood determinants, and intended changes to livelihood activities under hypothetical scenarios. Enterprise financial analysis was applied to evaluate the economic viability of these livelihood activities; this included calculating the gross income, total costs, gross margin and the benefit-cost ratio for each activity.

Small-scale aquaculture and fisheries in the floodplains

Status of rice-prawn aquaculture model

Annual floods and well-developed irrigation systems have enabled An Giang and Dong Thap provinces to develop their agriculture and aquaculture sectors. In terms of aquaculture, flooding creates the conditions for the unique integrated model of raising giant freshwater prawns (*Macrobrachium rosenbergii*) and cultivating rice. For example, although 2012 was a weak flood year, Dong Thap province still harvested roughly 1,291 ha of giant freshwater prawns, accounting for nearly 59 percent of the provincial target. This integrated prawn-rice model has been proven effective for the Winter-Spring crop and generates incomes and improves water quality due to the reduced use of chemicals and fertilizers.

Rice-prawn aquaculture in the survey areas ranged from 1 ha to 15.5 ha, drawing on 33 percent of the canal areas in each household. The canals are 5 to 7 m wide and 1.4 to 1.8 m deep. In the Summer-Autumn crop, freshwater prawns can be cultured due to deep flooding, creating an abundant natural food source. Before stocking prawn seeds into the newly harvested rice-fields, they are reared in separate ponds from one to one-and-a-half months. The farmers start to culture the seeds in April or May and harvest the prawns in October or November. The prawn seed sizes varied from 1.2 to 1.5 cm, with an average stocking density of 37 ind./m². The high density may cause low survival rates, water contamination and decrease profits since the seeds account for much of the aquaculture costs. Water is obtained directly from surrounding irrigation systems, with 71 percent of households not using a filter mesh or sedimentation pond. Water was exchanged every four to seven days.

All the households in the survey used industrial feed for the prawns, but 44 percent of them supplemented this with raw feed in order to reduce costs. The industrial feed was usually used in the first and second month of the culture period. During the flood season, farmers took advantage of the availability and abundance of other types of prawn feed such as trash fish, crabs and snails. Feeding took place two to four times per day.

Status of small-scale fisheries

Of the 74 fisheries households, 41 households were engaging in primary fishing and 33 households in secondary fishing. Various kinds of fishing gear were employed during the flood season including: gillnets, casting nets and lift nets, used by 51 percent of households (62), traps 21 percent (18 households), longlines 5 percent (4 households), fence (seine) net 2 percent (2 households) and others 6 percent (5 households).

Fishing was undertaken all year round with the main season during the July to November floods. Primary fishing households regard the fishing season as their main chance for increasing their income. Secondary fishing households fish as a part-time activity. Primary fishing households used the flooded rice fields as their main fishing grounds (59 percent) while the secondary fishing households mainly fished in nearby rivers (46 percent). Some households fished in both types of grounds.

Rice-prawn model: Yields and socioeconomic aspects

Rice-prawn model

The study found that 67 percent of households harvested prawns once at the end of the rice cropping season, while 33 percent selectively harvested several times in the last two months of the crop cycle. The average size of the prawns was about 30 to 40 ind./kg with an average price of VND143,700 per kg. The average yield was 2,711 kg/household, which was approximately 2,647 kg/ha. In households with less than 1 hectare, the average yield was 5,414 kg/household (1,460 kg/ha) which was higher than in the households that had larger culture areas (more than 1 ha) (990kg/household or 3,402kg/ha). The rice-prawn yields reported in the case study areas were higher than that of other agricultural models as reported by Phuong et al. (2002), with yields of 750 to 800 kg/ha. The results of the

present study also show the potential viability of the rice-prawn model in other floodplain areas.

The lowest yield in the last five years was 2,377 kg/ha, which was almost the same as that in 2015 (2,647 kg/ha). This was due to the fact that the flood levels of 2015 were the lowest, which affected the natural feed and water quality. In that year only 78 percent of prawn aquaculture households (14) obtained a profit whereas 22 percent suffered a loss.

The results showed that prawn yields for households with more than 1 ha in 2015 (2,647 kg/ha) were similar with the lowest yield of the previous five years (2,774 kg/ha); however, this finding was not clear for households with less than 1 ha; because in this system, farmers can manage their small farms and are less dependent on flood levels (table 10.1). Tran (2004) studied the rice-prawn model in Can Tho and reported that the gross margin from this model was VND40.8 million per ha/crop. Meanwhile, Dang's (2016) study of the rice-prawn model in An Giang province showed that the gross margin of this system from 2013 to 2015 ranged from VND57.1 to 77.0 million ha/crop, in which the highest one in 2014 with VND77 million per ha/crop. The author indicated that the rice-prawn model was a sustainable one for An Giang province; however, in order to improve the gross margin for farmers, the areas suitable for rice-prawn farming should be clearly determined.

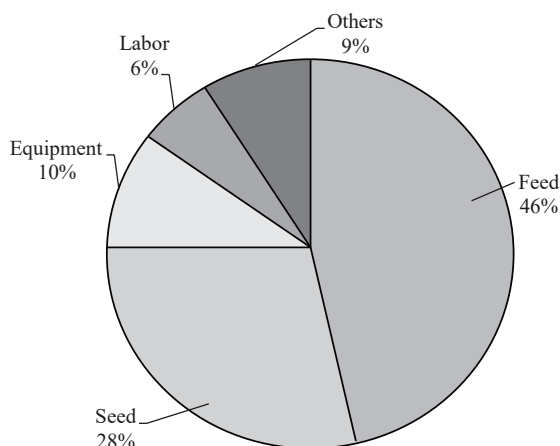
Table 10.1: Economic aspects of the rice-prawn model (VND m/HH/ha)

Indicators	Households with more than 1 ha				Households with less than 1 ha			
	Total cost	Gross Income	Gross margin	Benefit-cost ratio	Total cost	Gross Income	Gross margin	Benefit-cost ratio
Water surface area	181,775	235,498	53,723	23%	436,583	560,458	123,875	22%
Total area	101,892	120,873	18,982	16%	69,448	84,215	14,767	18%

The factors affecting gross margins in the rice-prawn system were the high cost of feed, outdated aquaculture techniques, low level or late floods and non-selective harvesting. Feed accounted for 46 percent of total costs, following by seed (28 percent), equipment (10 percent) and labor (6 percent). Labor expenses were relatively low since the work was mostly done by the family (fig. 10.1). Ly (2005) and Lam (2006) also reported that

feed and seed accounted for 48 to 55 percent and 25 to 37 percent of the total cost of the rice-prawn system.

Figure 10.1: Cost structure of rice-prawn model



Asked which farming model they would like to adopt or continue with in the future, 8 households (44 percent) chose the rice-prawn system, followed closely by dual-crop rice farming (39 percent) and others such as triple-crop rice farming and intensive aquaculture (6 percent). Although the rice-prawn model was not very profitable in 2015, many households in the study believed that it is a suitable model for the future (fig. 10.2). The reasons given for their choice of potential models were higher profits (23 percent), less fertilizer use (21 percent), less chemical use (12 percent), creating jobs for family members (12 percent), lower risk (12 percent), and other factors, including environmental considerations and social accounting (2 percent). The study found that the main factors that will affect the rice-prawn system in future include: the rising cost of feed and disease control; rising cost of prawn seed; environmental threats (especially low floods and poor water quality); and unsustainable prices (fig. 10.3).

Figure 10.2: Potential farming system models by household

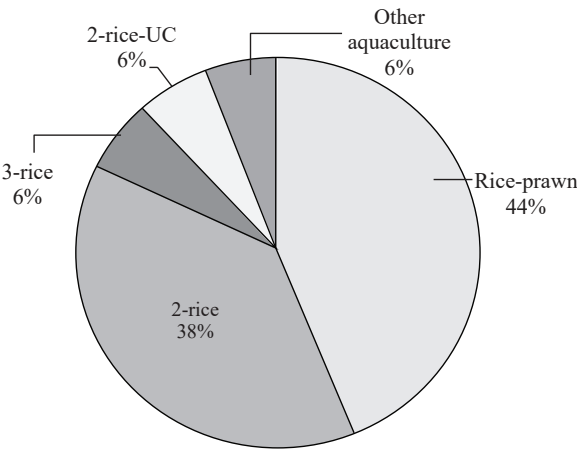
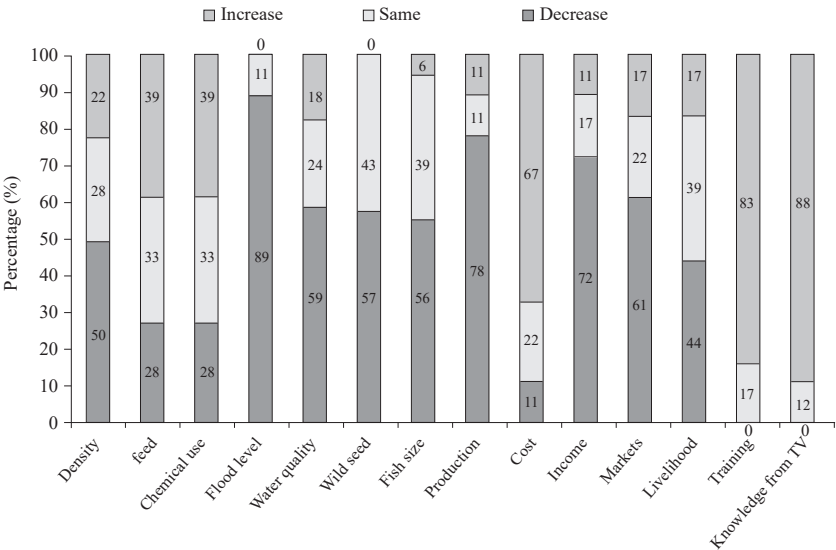


Figure 10.3: Changes associated with rice-based aquaculture as perceived by households



In the interviews, rice-prawn farming households indicated that the advantages of this model are:

- after a cycle of prawn farming, the following rice crop will be naturally fertilized by sediment from the prawns;
- prawn culture after rice farming benefits by the lower cost of pond preparation;
- a decrease of prawn disease, and socioeconomic and environmental sustainability due to reduced use of fertilizer and chemicals;
- maintaining rich soil and fisheries resources;
- the unpolluted environment of rice-prawn farming will help enhance health of farmers and families; and
- it creates more jobs for family members.

However, they also pointed out some challenges of the model, such as:

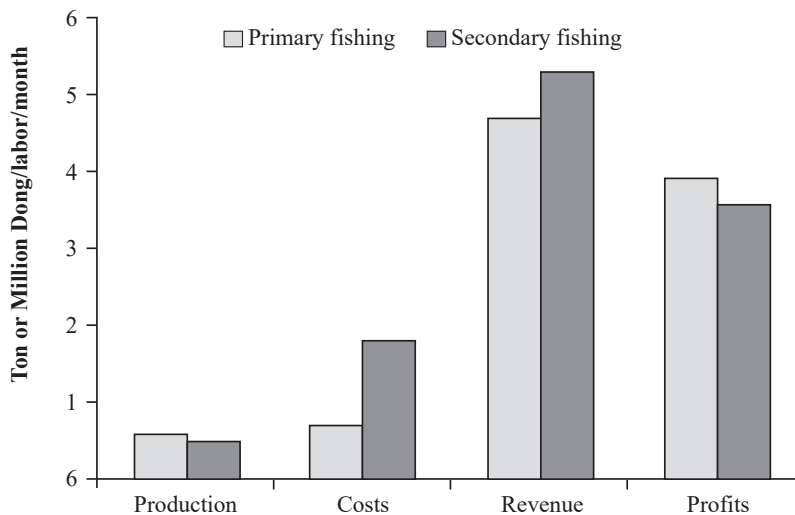
- aquaculture techniques are rarely applied properly;
- a lack of co-operation among farmers and stakeholders;
- insufficient water supply and poor prawn-seed management; and
- uncertainties due to climate change.

Some potential solutions to these challenges were suggested, such as technical training for farmers engaging in aquaculture, establishing cooperatives among the farmers and stakeholders, re-planning for rice development, and improving the management and quality of prawn-seeds (see chap. 8).

Fisheries: Yields and socioeconomic aspects

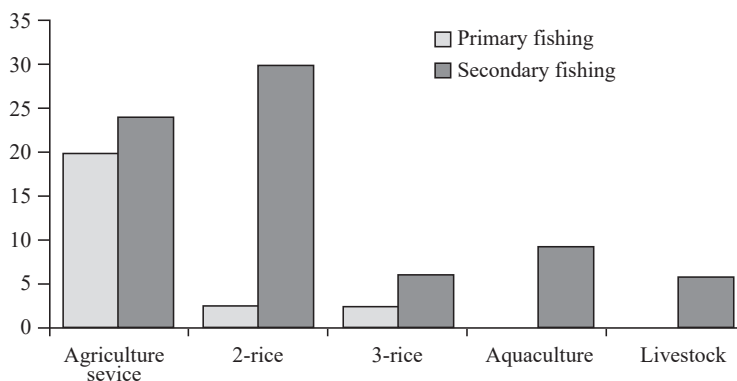
The results showed that primary fishing households spend an average of 187 days on fishing while secondary fishing households spend 134 days. The labor costs of the primary fishing households was lower than those of the secondary fishing household with VND0.75 million per month and VND1.74 million per month, respectively. The yields in the primary fishing households (0.69 tons/labor/month) were higher than those of the secondary fishing household (0.52 tons/labor/month). Therefore, the income from inland fisheries for primary fishing households was VND5.38 million per month compared to VND4.69 million per month for the secondary fishing households (fig. 10.4).

Figure 10.4: Production, investment costs and income of inland fisheries



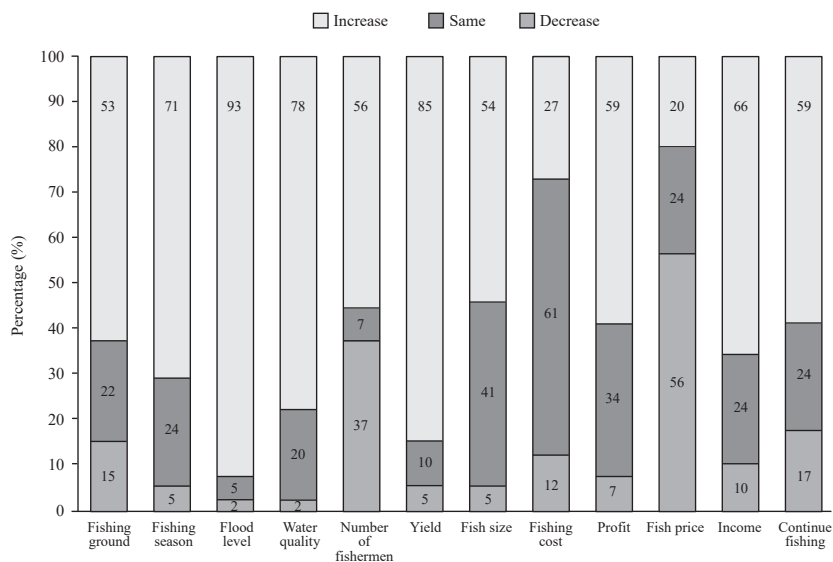
Apart from fishing, 46 percent of households engage in the other income-generating activities. Primary fishing households were also engaged in double-crop rice farming, triple-crop rice farming or other agricultural services. Secondary fishing households also work in double-crop rice farming, triple-crop rice farming, agricultural services, aquaculture and livestock raising (fig. 10.5).

Figure 10.5: Labor costs for fisheries by household (days/HH/month)



For the potential models for future, 53 percent of primary fishing households prioritized double-crop rice farming, 22 percent selected triple-crop rice farming, 11 percent chose rice-fish, 3 percent chose the double-rice and cereal model, 3 percent chose floating rice and 8 percent looked to other forms of livelihoods. Among the secondary fishing households, double-crop rice farming was the most popular choice, at 28 percent, followed by triple-crop rice farming (24 percent), crop rotation (16 percent), rice-fish (8 percent) and others (16 percent). Their reasons for choosing the above models included perceptions of high income potential (37 percent), job creation for family members (23 percent), livelihood for poor families (10 percent), protection of fisheries resources (6 percent), reduced fertilizer use (2 percent) and reduced water pollution (1 percent). The household respondents also indicated what changes they expected in fisheries resources, including a worsening environment, such as lower flood water levels, poorer water quality, and further reductions in the quality and quantity of fisheries resources (fig. 10.6).

Figure 10.6: Changes in fisheries resources as perceived by fishing households



Conclusion

The rice-prawn model is one of the most productive and suitable economic farming models in the floodplain areas of the Vietnamese Mekong Delta. Our findings suggest that this farming model should be encouraged in order to decrease the areas under triple-crop rice farming. Seasonal floods still play an important role in the sustainable development of small-scale aquaculture and inland fisheries in floodplain areas of the Mekong Delta. The floodplain areas should not only be used for rice farming, but also for small-scale aquaculture and fisheries development—this could help to decrease the large areas currently under triple-crop rice farming and create environmentally and economically sustainable pathways for agricultural livelihoods in the Delta.

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3

Livelihoods



11

The Implications of Vietnamese Rice Policy Changes for Rice Producers in Southeastern Cambodia

Ear Sothy and Sim Sokcheng

Thailand, Vietnam and Cambodia are well known as rice producing and exporting nations. In 2015, Thailand was the second-largest rice exporter in the world, exporting around 9.8 million tons (US\$4.5 billion), followed by Vietnam, which exported about 6.6 million tons (US\$2.8 billion) (UN Comtrade 2017). Thailand exports mainly high quality, aromatic rice, while Vietnam exports mostly non-aromatic or low-quality rice. Rice is Cambodia's staple food and its principal crop. Rice farming constitutes the major source of livelihood for 85 percent of rural households, contributing about 4.5 percent of Cambodia's GDP and 20 percent of its total household income. In Cambodia, income from all food crops accounts for 20.1 percent of total household income; more than 50 percent of this is from rice alone. Agricultural income has increased since the early 2000s due to improved yields and higher prices. There has been a rapid reduction in the national poverty rate, from 59 percent of the population in 2004 to 24 percent in 2011. Along with job growth and development in other sectors, rice farming was directly responsible for half of the reduction in the national poverty rate. This success, however, could quickly be reversed by the slightest income shock. It has been estimated that an average loss of just US\$0.30 in daily income would push 3 million Cambodians back into poverty, doubling the current poverty rate to about 40 percent.

Despite these successes and its economic potential, Cambodia's rice sector, in particular in terms of processing/milling, marketing and export, remains controversial. The country produced around 9.3 million metric tons of (unmilled) paddy rice in 2014, including both aromatic and non-aromatic varieties (table 11.1), or approximately 5 million tons of milled rice. The domestic market is estimated to require 2.7 million tons of milled

rice per year. In 2015 Cambodia *officially* exported around 0.54 million tons of milled rice to the European Union and other Asian countries (UN Comtrade 2017). The remaining 2.05 million tons of (unmilled or wet) paddy rice was estimated to have been exported through *informal or unofficial* channels to Thailand and Vietnam. The greater part of this paddy rice, not less than 2 million tons per year, was exported to Vietnam, which processes and re-exports it. In particular, farmers along the border in the southeastern provinces (Takeo, Prey Veng and Svay Rieng) sold their dry-season paddy rice to the Vietnam market through Vietnamese or Cambodian merchants. Given their place in this rice value chain, Vietnamese traders are better able to determine market demand and prices for paddy rice grown by Cambodian farmers, constituting a source of livelihood uncertainty for the latter.

Table 11.1: Rice balance in Cambodia, 2015

Items	Volume (tons)
Production (paddy)	9,324,170
Paddy saved for seeds	684,500
Available (Paddy)	8,639,670
Available (milled equivalent)	4,751,819
Total domestic consumption (milled)	2,703,447
Rural consumption (milled)	2,241,229
Domestic urban market (milled)	186,846
Inter-provincial trade (milled)	275,372
Milled export	538,000
Total used milled	3,241,447
Unofficial exports (milled equivalent)	1,510,371
Total exports (milled equivalent)	2,048,371
Unofficial exports (paddy equivalent)	2,746,130

Sources: Adapted from Frédéric Lançon (CIRAD) 2016; figures based on MAFF 2015.

Given the large volume of unofficially traded rice into Vietnam, the recent shift in Vietnam's official rice policy from high-yield, low-quality (non-aromatic) rice varieties to lower-yield but high-quality (aromatic and sticky) rice is expected to impact Cambodian rice farmers. Vietnam's rice export structure has changed significantly in recent years. The shift

towards aromatic rice, constituting 14 percent of Vietnam's rice exports in 2013, is likely to continue as the Ministry of Agriculture and Rural Development (MARD) has indicated that Vietnam should focus more on high-value rice for export. According to Dwight and Quan (2014), the export of Vietnamese aromatic jasmine rice grew 66 percent between 2012 (nearly 600,000 tons) and 2013 (more than 900,602 tons). Moreover, Vietnam's rice market has shifted from Africa to Asia, particularly China. Hence, it is expected that the production and export of Vietnam's low-quality rice, including imported Cambodian rice, will fall. It is then likely that Vietnam's rice traders and/or exporters would demand more high-value rice and reduce their purchase of low-quality of rice both from Vietnamese and Cambodian farmers.

A dramatic drop in Vietnam's demand for low-quality rice will have a significantly negative effect on the incomes of Cambodian rice producers unless the latter shift to different rice varieties or to other forms of agriculture. We need to understand the region's rapidly changing rice policy and market landscape and provide useful information for policymakers seeking appropriate ways to support local rice producers.

This study aims to assess the implications of rice policy changes in Vietnam for Cambodian rice policy as well as its impact on rice producers in the southeast. The major objectives of this study are: to explore the effects of rice policy changes in Vietnam on rice production and rural incomes in Cambodia in the eastern and southern areas bordering Vietnam; to assess the potential for changing rice farming techniques in response to changes in market demand; and to suggest policy options to help rice farmers avoid income shocks.

Methodology

The study was conducted in July 2016 and employed both qualitative and quantitative approaches to interview actors in the rice value chain. Three types of research tools were designed and employed to obtain different types of information (see table 11.2).

Three policy research institutes in Cambodia and Vietnam—the Cambodian Development Resource Institute (CDRI) and Center for Policy Studies (CPS) in Phnom Penh and An Giang University (AGU) in Vietnam—collaborated in the data collection and analysis. Data in Cambodia were collected by CDRI and CPS. CDRI conducted the

Table 11.2: Analytical frameworks and research tools

Approach	Research Tool	Stakeholders	Expected Output
Quantitative	Quantitative questionnaire	Rice farmers in southeastern Cambodia	Data on farm products and household characteristics, such as cost of production, income and farming practices.
Qualitative	Key Informant Interviews (KII)		Cost-benefit analysis of rice cultivars.
		Cambodia: Policymakers Rice traders Rice millers Rice exporters	Information about the demand and supply and import and export of rice. Perceptions about the demand shock from Vietnam.
		Vietnam: Policymakers Rice traders Rice millers Rice exporters	Reactions and suggestions about Vietnam's rice policy and rice production in south-eastern Cambodia.
	Focus Group Discussion (FGD)	Rice farmers in southeastern Cambodia	Difficulties in rice growing, their reactions and alternatives if there is a demand shock from Vietnam.

interviews with stakeholders in the lower part of the rice value chain, employing both qualitative methods (KIIs and FGDs) and quantitative questionnaires (a household survey), while CPS was responsible for the KII interviews in the upper part of the rice value chain. Data in Vietnam were collected by AGU and CDRI. AGU conducted KII interviews with the Vietnamese private sector while CDRI did the same with the Vietnamese public sector and relevant think-tanks.

Key findings from qualitative approach

Vietnam's agriculture and rice policy

Agriculture has played a remarkable role in Vietnam's economic growth in recent decades. Rice is a significant part of this. About 70 percent of rural households (9 million households), are engaged in rice farming and it is the major source of rural income. Aiming to feed more than 50 million people in 1980s, and about 93 million people in 2016, Vietnamese rice policy prioritized increasing rice output with high-yield varieties. A

major focus of this was investment in full dikes and irrigation systems to enable more intensive rice cropping. Vietnam became one of the world's leading rice exporters. However, for various reasons, Vietnam's rice production growth rate and yields have stagnated in recent years. Natural resource exhaustion, environmental pollution, low domestic competitiveness, changes in international and domestic market demand, rapid industrialization and urbanization, and climate change are challenging Vietnam to restructure its agricultural policy (Dang 2014; see also chapters 9 and 9, this volume).

Interviews with several policymakers in Vietnam consistently indicated that the Vietnamese government intends to shift from lower-value to higher-value rice varieties and other cash crops. Respondents expressed that growing high-yield but low-value paddy cannot improve the livelihoods of farmers and will also harm the environment. Vietnamese rice farmers earn very small margins, while traders and exporters earned much higher profit margins in the rice value chain. Farm-gate prices for paddy rice are too low for farmers to earn profits. Additionally, Vietnamese respondents commented that despite exporting a huge volume of rice to international markets, profit margins in the rice sector are smaller in comparison to those for other agricultural products. Respondents also observed that the international rice market is highly competitive, and exporters—even a large rice exporter like Vietnam—does not have much bargaining power. Exporting rice is also complicated and costly. Some countries, such as the Philippines, require foreign companies to bid for rice export rights to their countries, which lowers rice export prices to almost the break-even price.

In brief, both KII interviews and group discussions with policymakers and researchers consistently agreed that Vietnam should not continue with the intensive production of low-value rice. There is a need to shift away from low-value paddy to high-value paddy or to other high-value cash crops, given rising world market demand for the latter. However, respondents were concerned about the time needed to raise farmers' awareness and the resources required to implement the shift in policy. Tran and Nguyen (2015) point out that uneven awareness of the policies among farmers limits the implementation of crop restructuring policies. There are insufficient funds to support this rice policy shift, especially for infrastructure and irrigation system restructuring. More importantly, the

market for replacement crops is not stable and cannot absorb a sudden big increase in output at present. Similarly, a discussion with Dr Dang Kim Son indicated that it is sometimes difficult to change farmers' ideas and behavior, especially when they have been growing low-quality rice for a long time and the market and networks are already in place. Therefore, more time and resources are required to change existing rice value chains so that rice production and rice markets can be shifted at the same pace.

Case study of Vietnamese rice farmers in An Giang province

KII interviews with Vietnamese rice farmers were conducted by An Giang University in An Giang province employing semi-structured questionnaires. An Giang province is a leading producer of high-yielding rice varieties in the Mekong Delta. Before the 1980s, farmers mostly produced one crop of traditional floating rice during the rainy season (May to December), and rotated this with beans and sesame during the dry season from December to May. After 1985, farmers in An Giang province adopted short-term high-yielding rice varieties and shifted to a two-crop rice farming system. The first crop was called "winter-spring", being produced from November to February, and the second rice crop was called "summer-autumn", from May to August. From August to November, farmers allowed fields to be flooded to receive fertile sediments from the Mekong River. From the 1990s, more farmers shifted to double cropping, and some farmers started to shift to three crops of rice after 2000. Now, more than two-thirds (165,000 ha of rice land) of An Giang province has been converted to the three-crops or the triple rice system.

Before 2010, most farmers used traditional seed storage methods to save their own seed. However, in recent years, rice farmers have tended to buy and use certified seeds from seed companies. Four of the five farmers interviewed in An Giang province were not using the IR504 variety; instead they planted DS1, IR6976, OM6976 and other IRs.

Among the five farmers, only one was cultivating IR504 in a small plot of 1.5 ha. The total cost involved in growing this variety per ha was around VND11,945,000 (US\$529). Harvesting was the highest proportion (17 percent) of total costs, followed by land preparation (16 percent), fertilizer and pesticides (14 percent) and labor for applying the pesticides and fertilizer (11.6 percent). The yield for IR504 is 9.3 tons per ha, but

prices are low, around US\$0.22 per kg. The four households who have been growing non-IR504 varieties estimate that the total costs of one rice harvest ranges from US\$500 to US\$1,100 per ha. Yields range from 6.7 to 8.0 tons per ha, but rice selling prices are US\$0.22–0.29 per kg. Thus, while non-IR504 varieties provide lower yields compared to IR504 variety, they sell for higher prices, so may bring more income for rice farmers.

The farmers interviewed described different ways of selling their rice. Half had a written contract with traders or companies before they started growing the rice, while the other half did not have an official contract. In the latter case, traders and farmers agree verbally to buy and sell paddy just before the harvest. Noticeably, those who have a written contract are satisfied with the rice selling price, while those who have no contract tend to cooperate with neighboring farmers to negotiate selling prices with the traders. But the rice farmers who did not have contracts were not satisfied with the prices they obtained.

Case study of Vietnamese rice traders and exporters

The team from An Giang University conducted three KIIs with Vietnamese rice traders and three rice exporters. One of the rice traders used to trade with Cambodian rice farmers. In the past he entered Cambodia to purchase paddy in person; now he purchased rice from Cambodia via local agents, whom he paid US\$0.09 per 100 kg of paddy. The rice milling company owner described his experience as follows. The price varies with the type of rice and time of the year. He has to compete with Thai traders in Cambodia, who pay higher prices to Cambodian rice farmers. However, Vietnamese traders have the geographical advantage of being closer to the border, while Thai traders cannot penetrate into remote areas. The quality of IR504 from Cambodia is lower than Vietnam's. Husks are thicker, so there is less milled rice; for example, the milling rate is 0.78 for Vietnamese IR504 and 0.72 for Cambodian IR504. In addition, Cambodia's transportation infrastructure is poor and institutional arrangements and procedures at the border are inefficient. In some cases, rice traders have to use informal channels to import rice from Cambodia. Vietnamese traders, however, must buy rice via Cambodian middlemen.

Of the three rice exporting companies, two (Phat Tai and Quang Phat) purchased and exported both IR504 and high-quality rice, while Loc Troi purchased and exported only high-quality rice. In order to ensure

rice quality, Loc Troi purchased paddy mainly from the Mekong Delta and has invested in facilities to check the origin of the rice and farming procedures, control chemical residues and avoid mixing rice varieties. Loc Troi exported milled rice mainly to Hong Kong (70.7 percent of its total) and China (13.4 percent). Singapore, Europe and the United States shared around 15 percent of the company's exports. Phat Tai and Quang Phat exported 90 percent of their rice to China; the other 10 percent was shipped to Africa, Malaysia and the Philippines. The share of IR504 in the companies' total exports was around 55 percent. Both companies reported that they prefer to export high-quality rice because it provides a higher margin. They want to export rice to the United States and Europe, but they also want to keep their existing markets in China and Africa. They mentioned that Vietnam still has a large potential market for and thus an incentive to keep producing low-quality rice. There remains a huge demand for low-quality rice in China, where it is mainly used for making rice flour, while African countries import lower-quality rice for consumption.

All three rice export companies agreed that the market for high-value rice is more profitable than those for low-quality rice. However, some countries preferred high-quality rice while others preferred the low-quality. Exporters need to be flexible to respond to customers' needs. So far, Vietnam has not prioritized a specific rice variety, which allowed markets to determine their production. Loc Troi suggested that the Vietnamese government must have a clear strategy for rice, not only for producers and farmers, but also for other actors in the rice value chain. More importantly, Vietnam should have a rice trademark in international markets. The government should support companies to develop and promote a Vietnamese rice trademark. Quang Phat predicted that markets for IR504 will remain stable for the next few years, but this also depended on the climate and rice production in other exporting countries such as India (the world's largest exporter) as well as the global market. The company will continue buying IR504, but in quantities dependent on demand. Quang Phat also suggested that bank interest rates should be reduced to help keep their rice exporting business viable.

Cambodian agriculture sector and rice policy

Rice production in southeastern Cambodia

In Cambodia, there are two major seasons: dry and wet. In the past, due to the lack of irrigation, Cambodian farmers could only grow rice during the wet season, leaving the land fallow in the dry season. The wet season lasts from June to December, the dry season from mid-December to April. Recently, irrigation systems have been improved, and farmers can grow rice in both the wet and dry seasons. New rice varieties have been planted in both seasons. Varieties can be categorized based on crop duration: short-term (less than 90 days), medium-term (90–150 days) and long-term (more than 150 days). Second, rice can be grouped as aromatic (high value¹) and non-aromatic (low value) varieties. In general, aromatic varieties require a longer growing period than non-aromatic rice varieties. Normally, aromatic rice varieties are medium-term or long-term varieties, while non-aromatic rice varieties are short-term varieties.

Various rice varieties are grown in southeastern Cambodia in both seasons. Because of weather and soil conditions, farmers in this region grow aromatic rice in the wet season and non-aromatic rice in the dry season. Thus, in most cases, “wet season rice” refers to aromatic rice and “dry season rice” refers to non-aromatic rice. However, due to changing demands, an increasing number of farmers are shifting to grow non-aromatic rice (mostly IR varieties) in the wet season. Based on FGDs in three provinces, farmers grow dry-season rice or IR varieties for commercial purposes or for selling to markets; while farmers tend to grow wet-season rice for family consumption only. A few farmers sell a small proportion of their wet-season rice to markets. Farmers mainly grow short-term IR504 varieties in the dry season, and this variety requires a heavy use of inputs such as chemical fertilizers and pesticides, which farmers have to apply themselves. Farmers have to spray pesticides (as detailed in the next section) every three to four days as reported in FGDs.

The FGDs also revealed that IR504 varieties are a lot more labor-intensive and costly, but farmers in the surveyed provinces prefer to grow this variety, even in the wet season, for several reasons. First, the yield is very high (around 5 tons per ha) compared to other varieties (around 2.5 tons per ha). Second, the demand for IR504 varieties is more stable than for other varieties. Despite slight seasonal price fluctuations there is

always demand for IR540 from Vietnamese rice traders. Farmers reported that despite its low price, the high yields for IR504 provide farmers with better income. Third, Cambodian farmers grow rice, IR504, by borrowing money for fertilizers and pesticides from the merchants, and promising to sell the harvested paddy to the Vietnamese merchant to repay their debts. Vietnamese traders charge an interest rate of up to 2 percent per month. Most of the fertilizers and pesticides used in southeastern Cambodia are also imported from Vietnam. Rice farmers in Takeo, Prey Veng, and Svay Rieng reported that they earned very little profit. Some farmers stated that they grow rice just for family consumption, and because they inherited rice growing skills from their ancestors. Besides growing rice, farmers can get jobs in the construction sector, factory work or as taxi drivers, or migrate to Phnom Penh or abroad for paid work. Others work in the logging or fisheries sectors.

Rice farmers in the southeastern provinces declared that their livelihoods would be severely affected if Vietnam traders stopped purchasing their rice because there are no replacement markets. Yet, they would continue growing rice at least for family consumption. Alternatively, they could migrate to work in factories or get other farm jobs in villages such as raising livestock. Notably, local farmers reported that, given current soil conditions, they could switch to aromatic rice if Vietnamese traders stop purchasing non-aromatic rice, because there are secure markets for aromatic rice. “We can switch and adapt our production to any rice varieties as long as there is a secure market,” said many farmers during the FGDs.

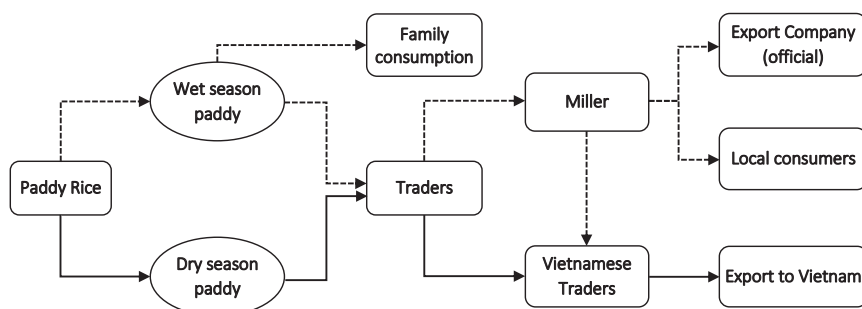
Demand for rice in Southeastern Cambodia

Figure 11.1 illustrates the flow of paddy and rice in southeastern Cambodia, from harvest to consumption or export. Although the flow is similar to the normal rice value chain, there are some specific characteristics that we learnt from field surveys. Wet season rice produced in the southeast is traded mainly to local rice millers and after milling, the rice is either exported to countries other than Vietnam and Thailand (e.g. in the EU) or sold for domestic consumption. Vietnamese rice traders also purchased wet-season rice (mostly unmilled), but relatively less compared to dry-season rice. To ease trading and reduce the costs of paddy collection, Vietnamese rice traders normally purchase it through

Cambodian rice traders. In some cases, especially along the border, Vietnamese traders enter Cambodia and purchase paddy directly from Cambodian rice farmers.

Vietnamese rice traders prefer to purchase paddy wet rather than dry, which means Cambodian farmers can sell their paddy immediately after harvesting. Rice traders also reported that drying paddy in the sun is not reliable and can reduce rice quality and affect its storage quality. Processing facilities in Vietnam (drying and milling) are more advanced and cheaper than in Cambodia due to cheaper electricity and better infrastructure in Vietnam. In addition, Cambodian farmers have started harvesting rice using machines. Cambodian rice farmers can no longer dry their paddy in the sun, because harvesting machines take just one or two days to cover all the fields. Thus, there is not enough time or space for sun-drying. Therefore, both Vietnamese rice traders and Cambodian rice farmers prefer to trade the unprocessed wet paddy.

Figure 11.1: The flow of paddy rice in southeastern provinces of Cambodia



Interviews with rice traders and rice millers show that the end markets for the dry-season variety is in Vietnam. Vietnamese rice traders determine the price of IR504 in three surveyed Cambodian provinces. Vietnamese rice traders offer a price to Cambodian rice traders. Then Cambodian rice traders offer a lower price to Cambodian rice farmers in their village. There are only a few rice traders in each village, hence rice prices are the same. "They collude with each other to determine rice price," said a farmer during a focus group discussion. Some farmers said that they would be happy if more Vietnamese traders entered their villages to collect and buy paddy directly. This could increase competition among

rice traders. There is no rice cooperative or farmer association in the study villages to help farmers with their negotiations. Farmers sold their paddy individually, after some discussion with their neighbours.

In November 2016, however, local rice traders reported that their numbers had been increasing in recent years, making business more competitive, and lowering their profit margin. The price of IR504 is around US\$0.17–0.20 per kg, while it is about US\$0.20–0.25 per kg for aromatic rice varieties. Rice traders claimed that their trade volume (particularly of IR504) with Vietnamese rice traders has been increasing yearly. Moreover, it is worth noting that the profit margins for the traders for IR504 and aromatic rice are similar. The markets for IR504 varieties are larger and more convenient as reported by local rice traders. Local rice traders also mentioned challenges in paddy trading, such as bans on transporting the rice to Vietnam by Cambodian border authorities, bad roads, informal fees and climate change. Local rice traders indicated that Vietnamese rice traders come to purchase Cambodian paddy for three reasons. First, Cambodian rice is cheaper than Vietnam's, hence they have higher profit margins after subtracting all the related costs. Second, Cambodian paddy, particularly IR504, uses less chemical fertilizer and pesticides than Vietnamese IR504. Third, Vietnam dominates low-value rice markets and requires huge amounts of low-value rice to meet this market demand.

Local rice millers have also pointed out that they have no capacity to absorb the excess paddy if Vietnamese rice traders stop buying Cambodian rice. The current capacity² of local rice millers in the three surveyed provinces covers about 5 percent of the total local rice production. Local rice millers need more capital and stable international markets to increase their capacities. All the local millers interviewed had borrowed money from financial institutions, with loans accounting for 20 percent to 70 percent of their working capital. The average interest rate is around 1 percent per month. Rice millers dry and mill paddy mainly for export; 70 percent to 80 percent of milled rice is sold to rice export companies; only 20 percent of milled rice is sold domestically. Local rice millers described their difficulties, including a shortage of working capital, high interest rates, unstable market orders, informal payments, high energy price, and a shortage of labor.

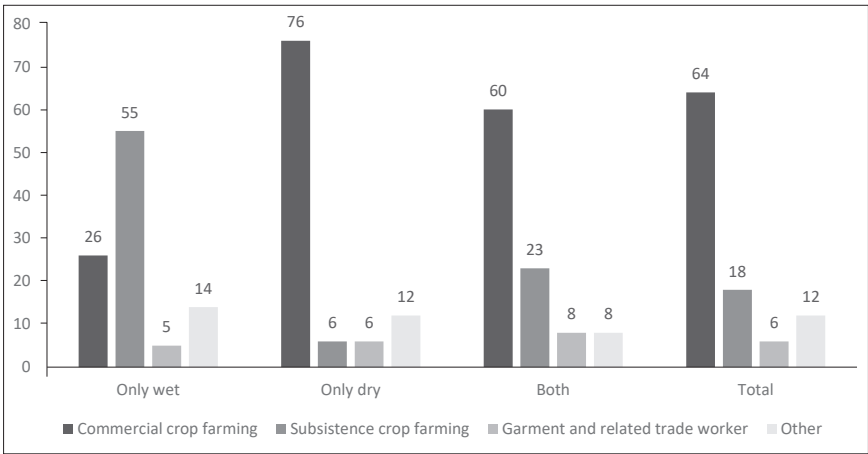
Key findings from quantitative approach

The objective of the household survey was to analyse the situation of farmers' livelihoods in the southeastern Cambodia. This study also compares the costs and benefits of growing different rice varieties. In order to compare livelihoods, we categorized households based on the rice varieties grown: *Only wet rice*, *Only dry rice*, or *Both*. The categories refer to rice varieties, regardless of seasons. "Wet rice varieties" and "Dry rice varieties" are commonly used by farmers in the region to differentiate between varieties. Wet rice varieties refer to those that are sensitive to photoperiod (the length of daylight) and other conditions. Most wet rice varieties are aromatic and premium varieties. Dry rice varieties are insensitive to photoperiod but need irrigation (CARDI 2011). It is possible to cultivate dry-season rice varieties during dry or wet seasons with the support of irrigation systems. This study also conducted a cost-benefit analysis among rice varieties, which were categorized based on their duration: short-term, medium-term and long-term. All the indicators such as yield, cost and revenues were generated for the comparison. Because the majority of farmers in the surveyed areas grew IR504 rice varieties (the main type exported to Vietnam) and the study intended to focus on this variety, we separated these varieties from the other short-term rice varieties and compared it with medium- and long-term varieties in order to calculate which were more profitable for farmers.

Occupation of household head

As figure 11.2 illustrates, the main occupation in the southeastern provinces is agriculture, especially food crops, for 82 percent of interviewed households. Up to 64 percent of these crops were commercial, while 18 percent was for family consumption. Only 6 percent of households claimed that their main occupation was working in the garment industry and local services. The majority (76 percent) of only dry-season rice growers did so for sale, while 55 percent of only wet-season rice growers did so for family consumption. 60 percent of households cultivated both dry and wet-season rice for commercial markets; only 20 percent of them grew rice for home consumption. This reflected that farmers grew dry rice mainly for commercial purposes while wet rice is mainly grown for family consumption.

Figure 11.2: Main Occupations (%)



Sources of household income

Figure 11.3 illustrates the percentage of various income sources in total household income. Waged work was the source of 35.4 percent of household income. Growing rice was the second highest contribution to household income, accounting for almost 20 percent of the total household income. Another 14.8 percent was from small business. Only 0.4 percent of income was obtained from vegetable farming, reflecting the small proportion of households that grew vegetables.

Figure 11.3 Sources of household income (%)

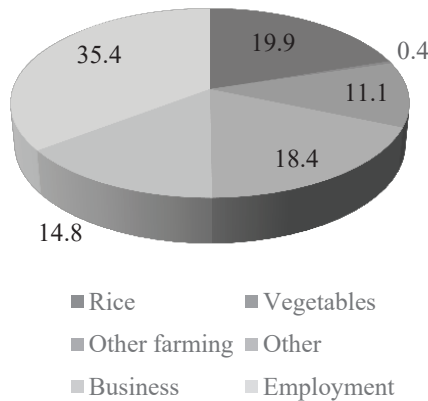
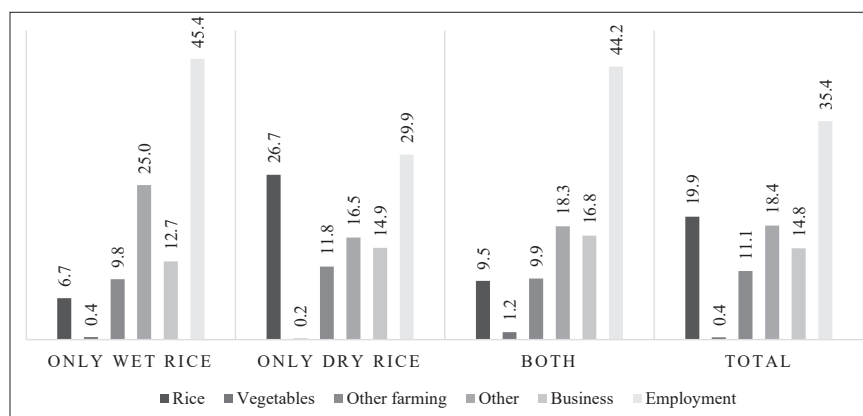


Figure 11.4 breaks down the sources of household income by types of household. Households that grow only wet rice varieties did not earn as much from rice farming as households that grow only dry rice varieties. The major source of income of wet rice households was paid employment, which accounted for 45.4 percent of the total income of these households. This situation was similar in households that grew both wet and dry rice varieties. On the other hand, households that grew only dry rice varieties earned only 30 percent of their income as employees and about 27 percent from rice farming. Lastly, households earned a very small income from vegetables, less than 2 percent of the total.

Figure 11.4: Percentage of income by household livelihood



Households in the southeastern provinces earned around US\$497 per year on average from rice farming (table 11.3). The highest income source was paid employment, around US\$883.2 per year on average. Households that grew both wet and dry rice varieties earned less than those that grew only dry-season varieties. Those growing only wet-season rice earned the least from rice farming. Surprisingly, households earned very little from growing vegetables, only around US\$10 per year.

Table 11.3: Sources of annual household income (US\$)

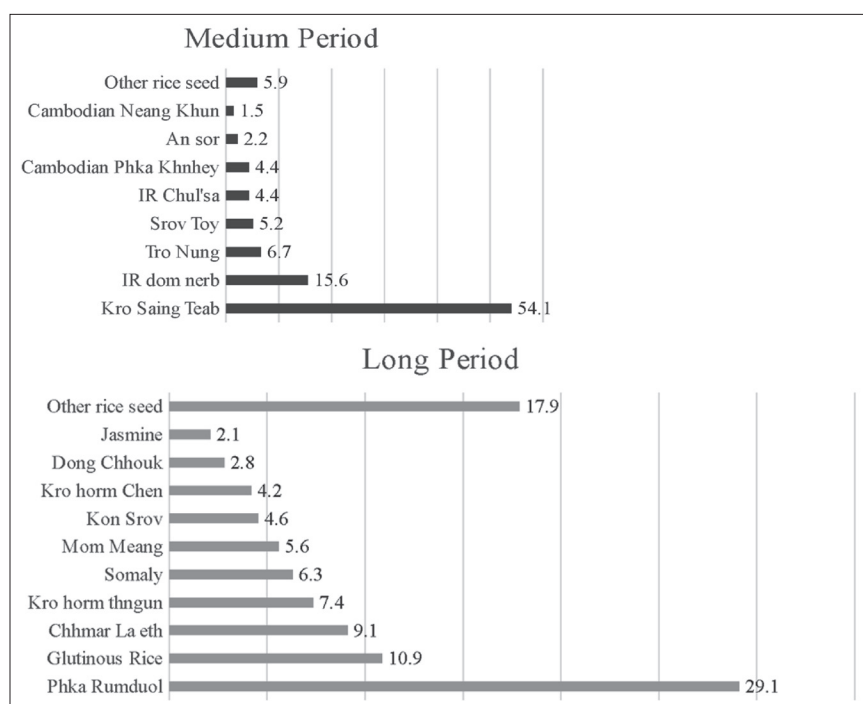
Source of Income	Only wet rice	Only dry rice	Both	Average
Rice	170.4	686.9	211.3	496.9
Vegetable	11	4.4	27.2	10.2
Other farming	248.4	305	219.9	277.7
Other	634.8	425.5	406.9	460.9
Business	321.2	383	373.2	369.5
Employment	1152.5	770.9	980	883.2

Costs and benefits of rice varieties

Rice Seeds

Figure 11.5 provides information about various rice seeds, categorized by duration. The name of rice seeds were recalled by farmers. Most (79.4 percent) of the short duration rice seed is IR504, followed by other IRs. More than half of the medium variety is Kro Saing Teab. The most common long-duration rice is Phka Rumduol.

Figure 11.5: Percentage of rice varieties, by duration



Rice yields

Generally, yield is a proxy to measure the productivity of rice farming. As reported in table 11.4, the total average rice yield of short duration rice seed is about 4.3 ton per ha, the highest among the three rice cultivars. There were no farmers growing long duration seeds in the dry season and the yield of short and medium varieties in dry season was higher than in the wet season.

Table 11.4: Rice yields (ton/ha)

Type	Short Duration	Medium Duration	Long Duration	Total
Wet season	4.1	2.3	2.4	3.2
Dry season	4.5	3.1	-	4.5
Total	4.3	2.4	2.4	3.7

Rice Inputs

The main inputs of rice production are seeds, fertilizers, pesticides, labor and sometimes others such as water or rented machines. Table 11.5 records the average volume of seeds used by the southeastern farmers, around 258 kg per ha. Short-duration rice varieties required the highest volume of seed and long-duration varieties the least. Households growing short-duration rice use more basal fertilizer than those growing medium and long-duration varieties. Usage of fertilizer is highest for growing short duration rice. Different kinds of pesticides were used, and the farmers couldn't estimate the exact amounts of each they applied. However, they could recall the expenditure for pesticides, which was highest for short-duration rice. Some households hire outside labor. Interestingly, the expense for hired labor was highest for medium-period crops, but the percentage of households hiring labor (table 11.6) was greatest for short-duration rice. Almost 100 percent in all categories rented machinery, at an average cost of around US\$108 per ha. Households growing short-duration rice spent the most on water and water pumps, and they relied on pumps much more than the other households.

Table 11.5: Inputs for rice production

Seed (kg/ha)	322.1	147.6	122.2	257.5
Basal fertilizer (kg/ha)	111	93.5	78.5	94.5
Top dressing (kg/ha)	349	216	198	301
Total fertilizer (kg/ha)	352	223	203	305
Cost of pesticides (US\$/ha)	116.7	39.7	21.3	94.5
Cost of hired labor (US\$ /ha)	27.4	62.5	32.5	30.9
Cost of rented machinery (US\$ /ha)	108.1	93.2	114.2	107.9
Cost of gasoline for machinery (US\$ /ha)	21.3	23.5	17.1	20.9
Cost of water (US\$ /ha)	71.4	33.4	17.9	67.3
Cost of using water pump (US\$ /ha)	45.5	30.3	17.9	43.5

Table 11.6: Usage of labor and machinery in rice farming (% of households using)

Labor & machinery	Short Duration	Medium Duration	Long Duration	Average
Hired labor	27.6	17	16.8	23.98
Machinery	100	98.5	99.6	99.76
Water pump	80.5	31.8	11.2	59.39

Table 11.7: Water demand in rice farming (% of farms using)

Water Sources	Short Duration	Medium Duration	Long Duration	Average
Natural sources (rivers, lakes)	28	16	4	21
Government irrigation system	11	4	1	8
Private irrigation system	28	0	0	19
Groundwater	18	4	1	12
Rainwater	15	76	94	40

There are various sources of water for farming in the study areas: rivers and lakes, government and private irrigation systems, groundwater, and rainwater. Rainwater is used by 40 percent of farms in the study areas, natural sources are the next most common, and the least used source is the government irrigation system. Water for short-duration rice came mainly from natural sources and private irrigation systems. Only 15 percent of short-cycle rice depended on rainwater.

Rice sales

Figure 11.6 shows the percentage of rice sold in the past 12 months. More than four-fifths of households sold their rice; the percentage was highest for households that grew short duration varieties. Households that grew medium varieties sold less than households growing long duration varieties. According to the figure, up to 86.7 percent of households sold their paddy wet. Very few sold milled rice.

Figure 11.6: Rice sales

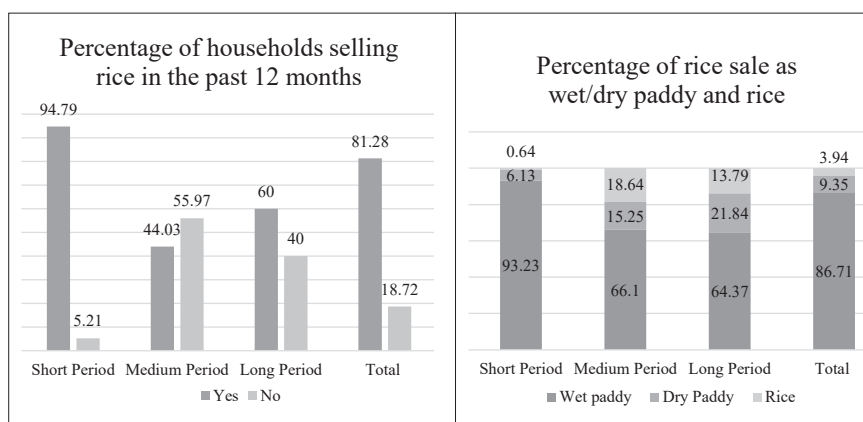


Table 11.8 compares the prices of varieties. There was a big difference between selling wet paddy and selling rice; the difference was greatest for long duration rice varieties.

Table 11.8: Crop price (riels/kg)

Type	Short Duration	Medium Duration	Long Duration	Total
Wet paddy	750	898	879	773
Dry paddy	843	1067	1015	933
Rice	1700	1873	2287	2100

Costs and benefits of growing IR504 vs other varieties

The study found that the majority of farmers in southeastern Cambodia grew dry rice for commercial purposes. IR504 is a short-term variety that is well known for its high yields. It is the most popular crop in the region.

In Vietnam, this variety can yield up to 10 tons per ha if farmers apply more chemical fertilizers and pesticides. However, intensive farming of this rice variety is harmful to the environment, degrading soil and water. Even so, this variety is still popular with farmers in Vietnam and Cambodia, because of its high yields and high market demand. Table 11.9 compares the costs and income of IR504 with the medium and long duration varieties in southeastern Cambodia. IR504 is more profitable than the medium and long-duration varieties. The price of IR504 is the lowest among the three varieties, but the output per hectare of IR504 was much higher.

Table 11.9: Comparison of IR504 and other rice varieties

Production Cost	IR504		Medium duration		Long duration		Average	
	US\$/ha	%	US\$/ha	%	US\$/ha	%	US\$/ha	%
Seed	88.1	15.6	46.1	15.3	38.6	14.0	69.7	15.3
Hired labor	7.7	1.4	10.7	3.6	5.5	2.0	7.5	1.7
Water	26.4	4.7	1.4	0.5	0	0.0	16.3	3.6
Pumps	39.4	7.0	9.2	3.1	2	0.7	25.7	5.7
Farming machinery	107.5	19.1	91.8	30.5	113.8	41.2	107.2	23.6
Fertilizer	173.5	30.8	116.3	38.6	102.5	37.2	147.5	32.5
Pesticides	120.7	21.4	25.9	8.6	13.6	4.9	80.5	17.7
Total input	563.3	100.0	301.4	100.0	275.9	100.0	454.4	100.0
Average price (wet paddy) (riels)	749.7	-	898.5	-	879.4	-	776.6	-
Output	827.2	-	508.9	-	487.4	-	697.4	-
Profit	263.9	-	207.5	-	211.5	-	243	-

To grow IR504, farmers spent slightly less on fertilizer than did growers of medium- and long-duration varieties. However, expenditure on pesticides for IR504 was much higher. Approximately 52 percent of the total cost of IR504 farming is spent on fertilizer and pesticides. The total amount spent on all inputs for IR504 was much higher than for the other varieties. Although IR504 can be more profitable than the other two varieties, spending large sums on fertilizer and pesticides lowers the rice value. According to the interview with Vietnamese agriculture

think-tank IPSARD, regularly applying chemical fertilizer and pesticides is harmful to human health and in the long term damages the quality of soil and water, negatively impacting the ecosystem as a whole. Based on the interviews, farmers should consider growing medium duration rice varieties instead of IR504, given their higher selling price and less damage to human health and the environment. Also, according to discussions with farmers, growing medium-rice varieties is not as labor-intensive as growing IR504. Farmers do not have to apply fertilizers or spray pesticides very often, leaving more time for off-farm jobs to earn extra income. Moreover, farmers said that they grew IR504 because of the demand from Vietnam for this variety. They can shift to growing fragrant rice, especially the medium-period variety, as long as there is a stable market for it; they are willing to grow this variety because it is less costly and less labor-intensive.

Conclusion

Vietnam is shifting away from producing and exporting low value rice due to a variety of environmental and economic challenges. Both public and private sector informants in this study stated that the policy is still new, however, and its implementation will take time. Farmers in southeastern Cambodia have been largely growing the lower-value IR504 variety for sale to Vietnamese rice traders and the new direction of Vietnamese rice policy, once fully implemented, is expected to have a serious impact on Cambodian farmers. However, given the slow pace of the shift to higher value varieties, Vietnamese rice traders may not soon stop their purchases of low-value rice from Cambodia.

FGDs with Cambodian rice farmers, and KIIs with Cambodian local rice traders and staff of provincial departments of agriculture and commerce confirmed that Vietnam is the major buyer of rice farmed in the three surveyed Cambodian provinces. The Vietnamese rice market is the main buyer and exerts some level of market power in price-setting. Cambodian rice farmers produced both wet rice (aromatic or high-value) and dry rice (low-value) varieties. Dry rice varieties were grown commercially, while wet rice varieties were mainly for family consumption, or traded when there was a surplus. Very few grew vegetables for sale.

Rice millers and traders in the studied areas have no capacity to absorb the excess paddy if Vietnam were to abruptly stop purchasing rice from Cambodia. Millers are in need of working capital and low interest rates in order to enlarge their capacity. There are a few big rice millers in Cambodia; however, given the inadequate transport infrastructure and logistics, they are not able to collect the paddy efficiently. As well, because farmers spend less time harvesting their paddy, traders and millers need to enlarge their purchases during the harvest, which requires large storage, drying and milling capacities. Cambodian policymakers realize the importance of finding new markets for agricultural produce such as China. The government has been encouraging farmers to grow fragrant rice varieties, which are of medium duration.

New stable markets are needed to replace the current low quality rice market. The interviews with rice farmers in An Giang province indicated that more than 50 percent of farmers in the Vietnamese Mekong Delta are still growing high-yield and low quality rice, including IR504. Yet they stated that they can shift to new crops as long as there is sufficient infrastructure, new technology and especially a stable market for their rice. A contract before planting can give farmers a better price. Moreover, exporters said that exporting high value rice could provide them higher margins; however, they did not suggest that the Vietnamese government completely abandon the existing low quality rice market. All in all, the intention to convert from producing low to high quality rice may not be possible in the short term. Therefore, this study suggests that the demand for paddy from Vietnam will not drop drastically in the short term.

The findings of this study strongly suggest that Cambodia farmers begin transitioning away from IR504 to higher-priced medium-duration rice varieties, which require less pesticides and chemical fertilizers. The price of medium rice varieties could almost triple if farmers sell it as milled rice. Therefore, medium duration varieties should be promoted, together with more stable market demand and prices.

Notes

¹ Sticky rice is also categorized as a high value rice in this study.

² This is an estimate by all the local millers in the three provinces.

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12

The Future of Natural Resource-Dependent Livelihoods in the Lower Mekong Basin

Malcolm McPherson and Le Thi Quynh Tram

This chapter analyzes the future of livelihoods in the Lower Mekong Basin (LMB) focusing on the livelihood strategies of natural resource-dependent rural households (hereafter, NRD households).¹ We examine the efforts being made by these households (and individuals) to sustainably raise their living standards and Basin-wide trends influencing that outcome.

Development specialists view livelihoods (or “means of living”) as the ability of households to gain access to and combine productive assets that yield sustainable levels of consumption, investment, and welfare (UNDP/UNISDR/IRP 2010: 7). The Sustainable Livelihoods Framework (SLF) is widely used to identify the capabilities, assets, and activities through which households generate their livelihoods as they cope with stresses and shocks while sustaining the natural resource base upon which they depend (Solesbury 2003). Our analysis is cast within that Framework.

We first describe key features of rural livelihoods in the LMB. This is followed by an examination of factors—poverty, food insecurity, limited access to livelihood assets, and social and economic isolation—which influence the livelihood prospects of NRD households. The next section describes policy initiatives that would enable households to raise their productivity, incomes and welfare. This chapter concludes with comments and suggestions for policy reform.

Natural resource-dependent livelihoods

An overwhelming feature of the large literature on this topic is that existing economic policies and institutional arrangements virtually guarantee that current standards of living, which are already low, cannot be sustained.² To respond effectively, policymakers need to understand the challenges confronting NRD households. With few exceptions, most

NRD households and communities are struggling. They are poor and food insecure. Because they lack assets, households are vulnerable to stresses and shocks (personal misfortune, market fluctuations, and the encroaching effects of climate change). To stabilize their incomes, they diversify their activities, but this strategy keeps their productivity low. Their engagement with mainstream economic activities gives them greater access to livelihood opportunities but, simultaneously, intensifies competition from outsiders.

National economic policies and institutional arrangements invariably exclude NRD households and communities from decisions about how the natural resources upon which they depend will be “developed.”³ Those decisions regularly displace or further marginalize NRD households often with little or no compensation. Most NRD households have limited access to social services such as education, health, water and sanitation.

Few members of the younger generation show any interest in pursuing NRD livelihoods. Ecotourism is a possibility, but competition is already stiff. Due to the wide-ranging occupations of NRD households—herding, fishing, handicrafts, slash-and-burn agriculture, recessional irrigation, and gleaning from forests and wetlands—no one-size-fits all policy response would be adequate.

The high and rising pressure on natural resources implies that all livelihood strategies of NRD households, at best, are transitional (Berdik 2014; *Economist* 2016: 44–45). If there were any prospect that those livelihoods could be sustained it will require far greater engagement and support from LMB governments than has been forthcoming so far. Some communities are being rewarded for land reclamation and are benefiting from “payment for ecosystem services” (PES) schemes.⁴

Determinants of livelihood trajectories across the LMB

Three factors dominate the livelihood trajectories of NRD households—poverty and food insecurity, institutional impediments, and resource degradation.

Poverty and food insecurity

World Bank data show that in Cambodia, Lao PDR, Thailand and Vietnam, 24 percent, 16.7 percent, 0 percent, and 3.1 percent of their respective populations were below the international poverty line of \$1.25

in 2005 purchasing power parity (PPP) prices.⁵ Low income, however, is only one dimension of poverty. More generally, it is “a denial of choices and opportunities, a violation of human dignity.”⁶ Deprivations in health, education and living standards, reflected in the Multidimensional Poverty Index (MPI), are relevant as well.⁷ By this measure, 33 percent of the population in Cambodia, 34.1 percent in Lao PDR, 0.9 percent in Thailand, and 7.1 percent in Vietnam were poor in 2016. These data mask stark differences between rural and urban poverty.⁸ The respective urban and rural MPIs are 7.1 percent and 38.1 percent in Cambodia, 7.4 percent and 43.3 percent in Lao PDR, 0.6 percent and 1.1 percent in Thailand, and 3.6 percent and 8.8 percent in Vietnam. When decomposed by poverty component, these data show that the most extreme poverty (defined as five or more deprivations)⁹ is found in the least accessible, least developed, and most highly NRD provinces.¹⁰ To illustrate, an estimated 28.4 percent of the population of Preah Vihear and Steung Treng in Cambodia is extremely poor; the corresponding figure is 41.6 percent in Saravane in Lao PDR.

Food insecurity, which refers to the inability of all households and individuals to gain access to adequate supplies of nutritious food to support and sustain a productive healthy life, is directly related to poverty.¹¹ Non-poor families can always purchase the food they need. By contrast, all food insecure families are poor and most lack the capacity to directly reverse that status.

None of the LMB countries has created the conditions in which all their citizens is food secure. Thailand is close to achieving this, but food insecurity and undernourishment persist.¹² In Vietnam in 2014–16, 11 percent of the population (equivalent to 10 million people) was undernourished. Corresponding data for Cambodia, Lao PDR and Thailand are 14.2 percent, 18.5 percent,¹³ and 7.4 percent, respectively (FAO/IFAD/WFP 2015, Table A1). As with poverty, MPI data show that the most severe undernourishment is in provinces with the highest share of NRD households.¹⁴

Persistent undernourishment across the LMB does *not* stem from the lack of food. Each country has rapidly expanded its food production and exports over the last two decades.¹⁵ Thailand and Vietnam are the world’s largest rice exporters. Food insecurity exists because the LMB economies, as currently organized, do not generate incomes adequate for

all households to have access to nutritious food on a continuous basis.¹⁶ In the case of NRD households, government policy is a major reason for this outcome.

Institutional impediments to rural development

Why are NRD households so poor and food insecure, despite major ongoing efforts by local and international agencies to reduce poverty throughout the LMB?¹⁷

Of the many explanations, two stand out. National development strategies emphasize the exploitation of natural resources rather than their sustainable management. LMB governments pay minimal attention to rural development in general and the challenges faced by NRD households in particular. There is ample evidence for these assertions.

Governments provide few resources to support agriculture and rural development. Minimal amounts are spent on agricultural and environmental R&D and technologies that would enable NRD households to raise their incomes and welfare.¹⁸ Rural residents, both farmers and others, have been regularly displaced to support development projects which primarily benefit urban residents. Examples include hydropower dams, the expansion of plantation agriculture, and watershed preservation. None of the displaced households is adequately compensated.¹⁹ State agencies add to the difficulties by mismanaging water releases which damage river-bank farms and degrade wetlands, and their inefficiency (including corruption) diverts income from farmers and other rural residents.

As a result, rural productivity and “amenity” are low, and rural–urban differences in income and living standards remain large (Carsten and Temphairojana 2013; McCaig and Pavcnik 2013: 36–37).²⁰

Resource degradation (the official choices not made)

The above are difficulties created by what LMB governments do. NRD livelihoods are also affected by what those governments fail to do. Three are noteworthy: the minimal enforcement of environmental regulations; the lack of transboundary cooperation; and the lack of integrated rural and urban development.

Each LMB country has environmental legislation which reflects state-of-the-art international practice, but implementation is weak, at best, because responsibility is distributed across multiple ministries and agencies (SRV 2014: XIV, XV, Articles 139 to 146).²¹ In addition to their inability to cooperate, many of these ministries lack authority to elicit compliance from other ministries or enforce it on public agencies. There are few resources (human and financial) to monitor the situation and remedy problems. Groups that are most seriously affected by pollution and environmental degradation have no capacity to be heard (Dasgupta et al. 2002). Fines for transgressions are low and rarely enforced. As a matter of course, major cities (Can Tho, Phnom Penh, Vientiane) use the Mekong to flush away untreated effluents. Regulations to prevent over-fishing, destructive logging practices, or pollution are ignored or, at best, weakly enforced (Berdik 2014; Schirmbeck 2017). LMB governments have done little to rationalize transboundary resource management. Such cooperation is a critical means of sustaining the productivity of the Mekong Basin as a whole. It is also fundamental for responding coherently to climate change. Indeed, without collaboration, no LMB country can effectively deal with the projected impacts of climate change—rising temperatures, the increased intensity of extreme weather, changes in the seasonal and total river flows, more frequent and intense pest infestations and diseases, deteriorating air and water quality, falling agricultural productivity, and environmental refugees.

Each LMB government has promoted its urban areas at the expense of its rural areas (World Bank 2008). In addition to not being part of the political agenda, the lack of integrated urban and rural development can be traced to each country's stove-piped administrative structure. Although effective in exercising top-to-bottom control, this structure provides no incentive for inter-ministerial and inter-agency cooperation.²² Unfortunately, such cooperation is essential for the key features that boost the livelihood prospects of NRD households, namely, integrated rural and urban development, enhanced national water governance, the efficient management of natural resources, and upgrading rural services and infrastructure.

None of these outcomes results from lack of government capacity. All LMB countries are "hard states" with each government forcefully demonstrating that it can achieve the objectives its leaders care about.

Thus far, the progress of NRD households has not been one of their priorities.

Alternative livelihood trajectories

What would have to change, how, and what official actions would be needed for the changes to sustainably raise the living standards of NRD households?

For a start, NRD households would have to be more productive, i.e., increase the output from the inputs they employ. That will not be easy given each household's limited assets, their low levels of technical skills, constraints on their access to productivity-enhancing information, and the poor quality and declining supply of natural resources (forests, wetlands, agricultural plots, rivers, and lakes) to which they have access.²³

NRD livelihoods would also improve if the institutional impediments which block their progress are removed or diminish. This could happen if each LMB government were to aggressively implement their commitments to achieve the United Nations' Sustainable Development Goals (SDGs). Two of the SDGs key principles are "leave no one behind" and "reach the furthest first,"²⁴ both of which directly involves engaging with and supporting NRD households.

LMB governments would further assist NRD households (albeit indirectly) if they were to value natural resources and ecosystem services at (or near) their full social cost. By incorporating this change into all their decisions, governments would significantly diminish the overuse, misuse, neglect, and degradation of natural resources. A useful start would be for LMB governments to adopt the System of Environmental-Economic Accounting (SEEA).²⁵

Developing the capacities and institutional mechanisms to implement these changes will take time. Some things, however, can be done immediately. For example, all LMB governments should raise the price of water to levels approaching its full (social) cost.²⁶ With a low (often zero) price of water, there is no incentive for anyone to conserve water. From standard microeconomic theory, a resource is used up to the point where its (risk-adjusted) marginal value product equals its price.²⁷ When a resource has no formal price or implicit fee (through quotas), it will be employed until marginal value product is zero. For individual users, this is rational; for all users collectively, it creates the "tragedy of the

commons.”²⁸ To introduce a fee, water use will have to be monitored. The poor can be protected through a “life-line” rate.²⁹

Appropriate pricing will not immediately end the destruction and neglect of natural resources. Yet, by shifting their prices through a system of fees, taxes, and quotas to levels that better reflected their social opportunity cost, LMB governments would create the incentive for their preservation and efficient use and in the process benefit NDR households.³⁰

Improving NRD livelihoods will also require national and transboundary cooperation. For this to happen, LMB governments will need to reduce bureaucratic overlap and ensure that agencies collaborate in ways that enhance NRD livelihood prospects rather than diminish them.

Finally, NRD households require explicit public assistance. The number of NRD households is well beyond the “carrying capacity” of the LMB’s natural resources. Many of them need alternative livelihoods.³¹ Public support will ease the disruption as they make the move.

Conclusion

Most NRD households in the LMB are poor and suffer from food insecurity; their economic status is fragile, and their livelihood prospects are dim. These circumstances will not change given current economic trends, government policies and institutional arrangements, and rising environmental pressures.

Reversing or moderating these trends will require that rural households gain access to additional resources—skills and knowledge, machinery and equipment, finance, and commercial and community networks—that compensate for the dwindling stock of natural resources. Gaining that access would pose few problems *if* there were less competition for all resources, *if* economic opportunities were available to these households to sustain rising productivity, *if* social support for training and relevant knowledge were being developed and disseminated to them, *if* the institutional framework (security of tenure, personal security, rule of law, and contract enforcement) existed to encourage rising rates of rural investment, and *if* local households were not deterred by extreme risk aversion (and regularly frustrated expectations) from productively responding.

Policymakers who appreciate this situation have a number of ways in which they can constructively respond. They include the following:

- One: Increase funding to support agriculture and rural development. Identify rural public works—roads, bridges, drainage schemes, reforestation programs—that will “crowd in” and encourage private rural investment.
- Two: Restructure the institutions responsible for rural development so that there are clear mandates and incentives for natural resource management, better water governance, and environmental protection.
- Three: Appropriately value natural resources so that the full social costs of their transformation are understood and not overwhelmingly borne by NRD households.
- Four: Promote integrated rural–urban development so that urban areas no longer progress at the expense of rural areas.
- Five: Devise mechanisms for transboundary cooperation to ensure the effective management and preservation of the LMB’s natural resources. Initial attention should be given to transboundary water governance, monitoring the effects of CC, infrastructure expansion, and regional economic development.
- Six: LMB governments should actively assist NRD households through cash programs and other support. Making Payment for (Forest) Ecosystems Services (PFES) schemes effective and equitable would help jump-start this process.

Finally, all LMB governments should aggressively implement the Sustainable Development Goals. By engaging with NRD households and communities they help “end poverty” (SDG 1), “end hunger” (SDG 2), “achieve gender equality” (SDG 5), “ensure ... water and sanitation for all” (SDG 6), “promote ... decent work for all” (SDG 8), “combat climate change and its impacts” (SDG 13), and “protect, restore and promote sustainable use of terrestrial ecosystems” (SDG 15). Accelerating the achievement of these goals would substantively increase the welfare of NRD households. By “leaving no one behind” and “reaching the furthest first,” each LMB government would ensure that NRD households escape poverty and food insecurity and have livelihood strategies that progressively reduce their isolation, marginalization and vulnerability.

Notes

- ¹ We recognize that “(U)nequal power relations, formal and informal, are the key drivers of women’s disproportionate vulnerability to environmental degradation, climate change and disasters” (Resurreccion et al. 2014). It would require a more detailed essay to discuss the intra-household and gender dynamics involved.
- ² See World Vision 2004; Johnston et al. 2010; ADB 2013; NAFRI/IPSARD 2013; IFAD 2014; World Bank 2014; Sok and Yu 2015; Le and McPherson 2015; Entzinger and Scholten 2016.
- ³ Thailand has sought greater “grassroots” development through the Community Work Accreditation Scheme. A review concluded “vulnerabilities ... remain ... particularly for the 10% of the rural population still in poverty and for informal workers in rural and urban areas” (Kelly et al. 2012: 36). The “nexus” approach (e.g., “water-energy-food”) emphasized by international donors seeks to foster “stakeholder engagement.” Typically, however, the poorest households who depend most heavily on natural resources have no representation (Leck et al. 2015).
- ⁴ In 2008, the Government of Vietnam began testing “payment for ecological services” schemes (ADB 2014). Cambodia is exploring the idea as well (Gies 2016). So far, these efforts have been too small to make a difference (Le and McPherson 2017).
- ⁵ World Development Indicators online. The cut-off is equivalent to \$1.9 per day in 2011 PPP prices. *National* poverty rates are 17.7% (Cambodia), 23.2% (Lao PDR), 10.5% (Thailand), and 13.5% (Vietnam), respectively. For Thailand, this share represents 7.2 million people, while for Vietnam, it is 12.2 million.
- ⁶ United Nations, “Statement of Commitment to Eradicate Poverty Adopted by Administrative Committee on Coordination”, press release ESOSOC/5759, New York, May 20, 1998.
- ⁷ This is a 10-dimension index covering education (years of schooling, school attendance), health (child mortality, nutrition), living standards (electricity, sanitation, drinking water, cooking fuel, housing, assets). MPI poverty is the share of the population which is “deprived of at least one third of the [10] dimensions.”
- ⁸ Such a gap is common to all developing countries (IFAD 2001, table 2.1). IFAD’s *Rural Poverty Report 2011* (2010: 3) noted that “at least 70 per cent of the world’s very poor people are rural.” More specifically, IFAD’s “rural poverty portal” noted in 2014 that “Cambodia’s poor people number almost 4.8 million, and 90 percent of them are in rural areas.”
- ⁹ Data come from the Oxford Poverty and Human Development Initiative, *Country Briefings June 2017*; 6-8; <https://ophi.org.uk/multidimensional-poverty-index/mpi-2015/mpi-country-briefings/>.
- ¹⁰ The causation runs from natural resource dependence to poverty. When other options are available, there is no evidence that the poor choose to depend on natural resources for their livelihoods. Studies which directly connect NRD and poverty, show that NRD households are more likely to be food insecure, poor,

marginalized, and deprived than other rural groups (IFAD 2001: 21–35; Sok and Yu 2015).

- ¹¹ Food insecurity exists “when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life” (FAO/IFAD/WFP 2015, annex 2, fig. A2.1).
- ¹² Undernourishment is a situation where “a person is not able to acquire enough food to meet the daily minimum dietary energy requirements, over a period of one year” (<http://www.fao.org/hunger/en/>).
- ¹³ The World Food Program’s Global Hunger Index rated the hunger situation in Cambodia as “serious”. For 2016, this index, which measures undernourishment, child stunting, child wasting and under-5 mortality, was 28.1 for Lao PDR, 21.7 for Cambodia, 14.5 for Vietnam and 11.8 for Thailand (IFPRI 2016, Table 2.1).
- ¹⁴ Provinces in Cambodia with the highest destitution rates are Rattanakiri (25.4%) and Preah Vihear and Steung Treng (24.5%). In Laos PDR, they are Phonsaly (28%) and Saravane (30.1%). Disaggregated, province-level data for Cambodia and Lao PDR and regional data for Vietnam provide detailed information on the contribution of under-nutrition to poverty. For instance, in the adjacent natural resource dependent provinces of Preah Vihear and Stung Treng in Cambodia, 62.2% of the population is in poverty with a further 18.6% in “near” poverty. These provinces have the highest rate of child stunting (USAID 2014).
- ¹⁵ Confirmed by FAOSTAT data on each country’s food balance.
- ¹⁶ A report on Cambodia noted: “Though Cambodia produces a surplus of rice for export, the population still exhibits significant levels of stunting, to various degrees and within all income levels” (USAID 2014: 1).
- ¹⁷ The “near-poor” often risk “slipping back into poverty” (Krishna 2004; World Bank 2013: 5, 21; fig. 1 and box 5).
- ¹⁸ GSO data show that only 6% of the Vietnam’s budget is spent on agriculture and rural development even though agriculture provides more than 40% of national employment and accounts for roughly 20% of GDP and 30% of national exports. In Thailand in 2012, only 6% of the national budget was spent in northeast Thailand which has 32% of the country’s population and generates 11% of national GDP. By contrast, 72% of the Thai budget was spent in the Greater Bangkok area which has 17% of the population and generates 25% of GDP. International aid flows to agriculture have followed similar patterns: “(T)he amount of aid going to low-income or least-developed countries, which contain over 85 percent of the poor stayed around 63 percent, and agricultural aid contracted by two thirds” (IFAD 2001: 37–41).
- ¹⁹ Adequate compensation means amounts that replace the permanent income and welfare lost due to displacement.
- ²⁰ Recent estimates show that the rural–urban income gap in Thailand is close to \$10,000 per worker while in Vietnam it is around \$3,500 (authors’ calculations using World Development Indicators and FAOSTAT employment data). The earnings gaps in Lao PDR and Cambodia are also large (Le and McPherson 2015).

- ²¹ The environmental laws of other LMB countries show similar overlap of responsibility.
- ²² A review of water governance systems in Vietnam, Lao PDR and Cambodia highlighted the massive degree of confusion and overlap in administrative and regulatory responsibilities among and within the key agencies (Pech and Ranamukhaarachchi 2013).
- ²³ Marschke et al. (2014) note that while local institutions can help villagers (in their case fisher folk) adapt to small-scale changes in their environment, they have minimal capacity to adapt to broader declines generated by pollution, climate change, and large-scale resource transformation.
- ²⁴ United Nations (2015, par. 4) “we pledge that no one will be left behind And we will endeavor to reach the furthest behind first.”
- ²⁵ See <https://unstats.un.org/unsd/envaccounting/seea.asp>, and <https://seea.un.org>. The Government of Vietnam has a program to roll out SEEA by 2020 (Duong 2015).
- ²⁶ A common mistake is to confuse price (i.e., what is paid for a good or service) with cost (i.e., the resources needed to provide the good or service).
- ²⁷ Marginal value product equals the marginal physical product of an input multiplied by the output price. Technically, risk effects should be included (McPherson 1986).
- ²⁸ The loss of mangroves has had a major impact on livelihoods (Orchard et al. 2016).
- ²⁹ “Lifeline rates” are common in energy pricing. All users are charged a low or nominal rate for the first few units (50 kWh or m³ per month) with use above that level attracting a higher charge (Van Nam 2015).
- ³⁰ Social opportunity cost is the “amount of other goods [and services] which have to be foregone because resources are used to make some particular good [or service]” (Black 1997: 435).
- ³¹ McCaig and Pavcnik (2013: 17–20). Berdik (2014) summarized the issue when he noted “The policy and development challenge is one of managing the transition ... there’s no way to stop it.”

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Impacts of the New Rural Development Program in the Vietnamese Mekong Delta, 2010–2015

Nguyen Van Giap and Ngo Quang Thanh

A major rural development program in Vietnam, the National Target Program on New Rural Development (henceforth, NRDP) was implemented in 2010 (GOV 2010). The Program's overall objectives are to improve rural infrastructure; foster linkages between the agricultural, industrial and service sectors, and between rural and urban economies; and to improve rural economic, social, and environmental living standards. In its first five years, the NRDP saw investments amounting to VND851,380 billion into rural areas across Vietnam. By early 2016, 1,761 communes or 19.7 percent out of a total 8,920 communes in Vietnam had achieved all its 19 criteria (Vietnam National Assembly 2016). The program was seen as a success by the government:

Rural scenery has changed dramatically, especially rural transportation, social infrastructure; large-scale agricultural production models have emerged; rural household income and living standards have improved physically and socially; rural dwellers' knowledge raised and ... local communities are empowered to participate and to make decisions in the New Rural Development program ... the program has become a nation-wide energetic movement. (Vietnam National Assembly 2016)

The NRDP's success remains debatable, however. A study jointly conducted by the International Fund for Agricultural Development (IFAD) and the World Bank concluded that while the NRDP had upgraded rural infrastructure and contributed to socioeconomic improvements in rural Vietnam between 2010 and 2015, there is little evidence for declaring it an unqualified success (Crockford et al. 2016). The IFAD-WB study also suggested that the 19 criteria for communes to qualify for "NRD status"

were inflexible and left little room for local priorities and, in many cases, led to non-essential infrastructure being built. In short, implementation was not needs-based. Villagers were not empowered as investment owners, and had to rely on provincial and district authorities to provide coordination and technical know-how (Crockford et al. 2016). External funding was given to hastily construct infrastructure simply in order to fulfill the 19 criteria. Some 14 percent of certified communes subsequently failed to maintain the standards of the criteria. Moreover, there has been little structural economic transformation in these communes (CAP 2016). Many communes have borrowed from commercial and development banks to finance NRDP projects, and are in debt: 3,637 out of 8,935 communes in the country have acquired debts of about VND4.2 billion per commune during the period 2011–2015.

This study assesses the NRDP's impact so far on household incomes and living standards in the Vietnamese Mekong Delta (VMD). The VMD encompasses the 13 provinces of Long An, Dong Thap, Tien Giang, An Giang, Ben Tre, Vinh Long, Tra Vinh, Hau Giang, Kien Giang, Soc Trang, Bac Lieu, Can Tho and Ca Mau. Specifically, this study aims to assess factors correlated to the success of the NRDP in terms of program criteria, structural transformation, connectivity and institutional improvements; evaluate its impacts on household income and expenditure; and finally, discuss potential risks and threats to the program. Secondary data and reports such as funding sources, program criteria achieved, commune socioeconomic and demographic data are used, in addition to data from the Vietnam Household Living Standard Surveys (VHLSS) 2010, when the program began, until 2014, after the first phase of implementation. VHLSS data from 2010 to 2014 for the same households were selected and new variables were added to each household with dummy variables indicating households in NRDP and non-NRDP certified communes; dummy variables were also added for each criteria achieved by the communes. An econometric model was then estimated using the difference-in-differences (DID) technique to measure the impacts of the NRDP on household income and expenditure.

New Rural Development in the VMD

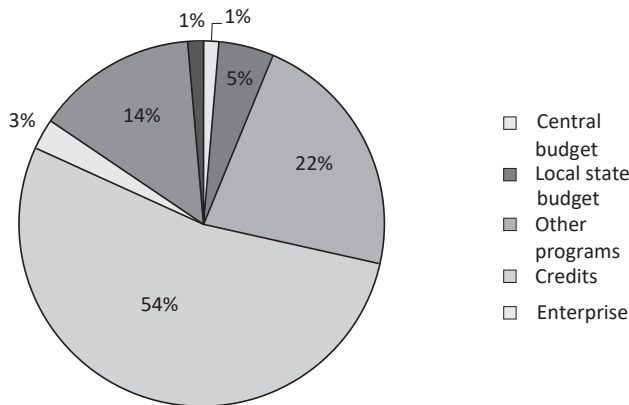
The VMD has a total land area of 40,604 km², with a population of 17.5 million people; it contributes 18 percent of the national GDP. It is a major

agricultural region for the domestic and export markets, producing some 90 percent of Vietnam's export rice, 60 percent of its seafood exports, and 70 percent of its fruit (GSO 2017). Yet this region is threatened by critical natural resource degradation and high poverty rates. Climate change is a great threat as sea levels rise, coastlines are eroded, and salinity intrudes into the Delta (GOV 2017). Economic activities are negatively impacting its natural resources and environment (Hashimoto 2001), including hydrological systems (Käkönen 2008).

Agriculture accounts for 32.3 percent of the Delta's GDP. In recent years, agricultural and economic growth have slowed down; agricultural output grew at 7.15 percent between 2001 and 2010 and dropped to 5 percent between 2011 and 2016. Living standards are improving at a slower rate than nationally: for example, the average per capita income is VND1.8 million per month, about VND200,000 lower than the national level (MARD 2017) and the poverty rate was 9.66 percent in 2016, much higher than in the Red River Delta (4.76 percent). There is a high rate of unemployment, with workers trapped in the agricultural sector due to a lack of job opportunities in the industrial and service sectors. Only 23.4 percent of rural laborers in the region have full-time jobs. The migration rate is high, 6.7 percent in 2014, and has been increasing in recent years (VHLSS 2014). In terms of the present study, only 22.7 percent of communes in the VMD attained NRDP status, lower than the national average of 30.5 percent and the Red River Delta's rate of 55.4 percent (MARD 2017).

The NRDP was designed to be an ongoing state-led development initiative to raise incomes and living standards and boost productivity in rural areas. In the Delta region, VND192,000 billion was invested in NRDP-related projects between 2011 and 2015. Funding for these projects has come from various sources, including the central government, local government, national programs (for improving rural roads, building schools, upgrading irrigation, etc.), private enterprise, and local contributions. Figure 13.1 shows that only 1 percent of the total funding comes from the central government, and 5 percent from local government. The bulk of funds comes from local government development credits or state-owned bank loans to private companies (54 percent) who were subcontracted to work on items/construction in the program. Finally, as indicated, funding also comes from existing national programs, which were being channeled to communes under the program by local government.

Figure 13.1: NRDP funding sources, 2010–15



Source: National Office of New Rural Development Program (2017).

The program revolves around 19 target areas: employment structure, income, culture, education, postal services, irrigation, health care, environment, modes of production (e.g. cooperatives, contract farming), cultural facilities, order and security, roads, master planning, electricity, housing, schools, rural markets, political organization, and poverty (table 13.1). The National Assembly’s Committee of Economic Affairs Supervisory report suggests that 12 of the 19 criteria have been met (or “passed”) *nationwide* and declared that Phase 1 of the NRDP was a success (Vietnam National Assembly 2016; table 13.2).

Table 13.1: The set of 19 NRD criteria

No.	Criteria	Contents	National level	Mekong Delta level
1	Planning	1.1. Land use planning for infrastructure, agriculture, rural manufacturing, and service activities	passed	passed
		1.2. Masterplan for infrastructure and socio-economic development, and the environment with new standards	passed	passed
		1.3. Residential plans following new standards, including the preservation cultural identities	passed	passed

No.	Criteria	Contents	National level	Mekong Delta level
2	Roads	2.1. Percentage of commune road that is concretized, meeting national standards issued by Transportation Ministry	100%	100%
		2.2. Percentage of village road that is concretized, meeting national standards issued by Transportation Ministry	70%	50%
		2.3. Percentage of hamlet road that is clean, and dry in rainy seasons	100%	100% (30% concretized)
		2.4. Percentage of agricultural/farming field road that is concretized	65%	50%
3	Irrigation	3.1. Irrigation system meets local water needs for agricultural and domestic uses	passed	passed
		3.2. Percentage of commune's irrigation canal that is concretized	65%	45%
4	Electricity	4.1. Electricity supply meets technical standards regulated by electricity authorities	Đạt	Đạt
		4.2. Percentage of households using electricity safely from different sources	98%	98%
5	Schools	Percentage of local schools (kindergarten, primary, middle schools) meets national standards	80%	70%
6	Cultural house	6.2. Cultural house and sport facilities meet standards issued by Ministry of Culture, Sport and Tourism	passed	passed
		6.3. Percentage of local villages that have cultural houses and sport facilities meeting national standards	100%	100%
7	Market	Market meets national standards issued by Ministry of Construction	passed	passed
8	Post office	8.1. Post Office in commune	passed	passed
		8.2. Internet is available at village level	passed	passed
9	Housing	9.1. Temporary, poor housing	None	None
		9.2. Percentage of houses meeting national standards as per Ministry of Construction	80%	70%
10	Income	Average commune income/provincial average income (per capita)	1.4 times	1.3 times
11	Poverty rate	Poverty rate	< 6%	7%

No.	Criteria	Contents	National level	Mekong Delta level
12	Agricultural laborer rate	Percentage of working as farm laborers in agricultural sectors	< 30%	35%
13	Production organization	Collaborative production groups and cooperatives exist	yes	yes
14	Education	14.1. Universalized education at high-school	passed	passed
		14.2. Percentage of middle-school graduates continue their education	85%	80%
		14.3. Percentage of laborers is trained	> 35%	> 20%
15	Health care	15.1. Percentage of population got health insurance	30%	20%
		15.2. Commune health station meets national standards issued by Ministry of Health	passed	passed
16	Culture	More than 70% of villages in the commune meet standards for cultural villages issued by Ministry of Culture, Sport and Tourism	passed	passed
17	Environment	17.1. Percentage of households with access to clean water	85%	75%
		17.2. Local production/businesses meet national environmental standards	passed	passed
		17.3. No polluting activities and/or having environment cleaning and protection activities	passed	passed
		17.4. Cemetery is planned and constructed	passed	passed
		17.5. Waste and sewage are collected and treated	passed	passed
18	Socioeconomic and political organizations	18.1. Commune staff meet national standards	passed	passed
		18.2. All socioeconomic and political organizations are in place at commune	passed	passed
		18.3. Commune Socialist Party branch and People's Committee are strong and clean (no corruption)	passed	passed
		18.4. All socioeconomic and political organizations are graded good	passed	passed
19	Security	Security and order are preserved	passed	passed

Source: National Office of New Rural Development Program (2017).

Table 13.2: Percentage of NRDP qualified Communes in VMD, 2010–15

Location	No. of communes	19 Criteria (%)	15–18 Criteria (%)	10–14 Criteria (%)	5–9 Criteria (%)	Less than 5 Criteria (%)
Nation-wide	8,978	0.20	0.14	0.37	0.25	0.04
Mekong Delta	1,293	0.17	0.13	0.54	0.15	0.00
Long An	166	0.27	0.19	0.48	0.07	0
Tien Giang	144	0.06	0.08	0.53	0.28	0.01
Ben Tre	147	0.03	0.07	0.41	0.47	0
Tra Vinh	85	0.20	0.08	0.72	0	0
Vinh Long	94	0.24	0.16	0.54	0	0
Đông Thap	119	0.22	0.09	0.66	0.03	0
An Giang	119	0.11	0.22	0.34	0.33	0
Kien Giang	118	0.16	0.13	0.60	0.11	0
Can Tho	36	0.33	0.39	0.28	0	0
Hau Giang	54	0.22	0.07	0.57	0.13	0
Soc Trang	80	0.15	0.08	0.74	0.04	0
Bac Lieu	49	0.16	0.18	0.55	0.12	0
Ca Mau	82	0.21	0.10	0.63	0.06	0

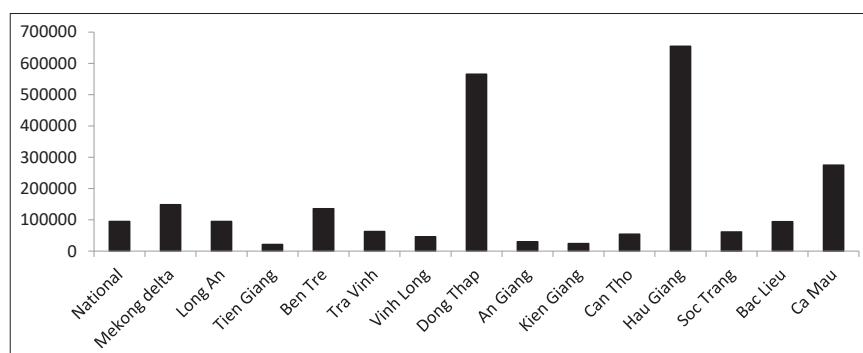
Source: National Office of New Rural Development Program (2017).

Notably, only 17 percent of communes have been recognized as “NRDP qualified” in the Delta region, compared to 20 percent at the national level. The percentage of certified communes varies from 3 percent in Ben Tre province to 33 percent in Can Tho province for the same period.

Resources, location, and leadership

Funding seemed to be an important factor determining the success of the program in each province. Provinces receiving higher levels of funding are likely to have higher rates of success. In fig. 13.2 we see that communes in Dong Thap, Hau Giang, and Ca Mau received higher amounts of funding than the average in the VMD, at VND565 billion, 654 billion, and 275 billion, respectively. These three provinces are among those with the highest rates of NRDP-qualified communes, at 22 percent, 22 percent, and 21 percent, respectively (though still lower than the national average).

Figure 13.2: NRDP funding per commune, 2010–15 (VND)



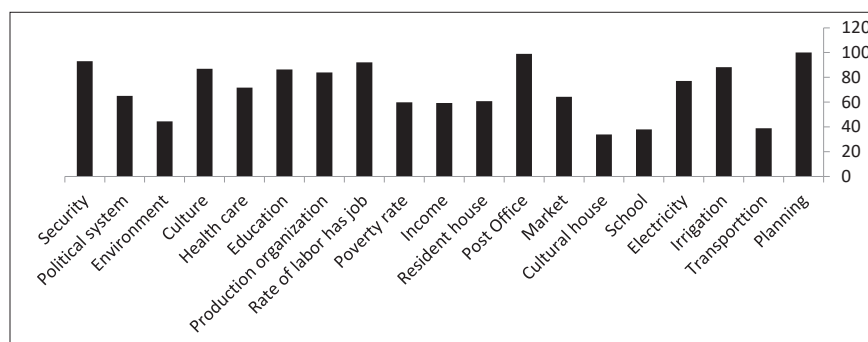
Source: National Office of New Rural Development Program (2017).

Funding, however, is not the only crucial factor correlated to the success of the program. For example, Ben Tre province received VND135 billion per commune for the period 2010 to 2015, the fourth highest in the VMD. Yet only 3 percent of communes in Ben Tre province have NRDP status. In contrast, Vinh Long and Long An provinces received VND95 billion and 46 billion per commune, respectively, but these provinces have higher rates of NRDP communes, 24 percent and 27 percent, respectively. Hence, there is no clear correlation between funding and the rate of NRDP-qualified communes. The correlation coefficient between NRDP funds per commune and the rate of qualified communes across provinces in the Delta is 0.2, positive as expected, but small in value.

Location and access to urban markets also play a role in attaining NRDP status. Long An, Vinh Long, and Can Tho have high percentages of NRDP-qualified communes, although these provinces have received relatively low funding. All three provinces are strategically located, however, and include major cities and hence have better access to markets, market information, and other resources. However, there are contrary cases as well. For example, Tien Giang, near Ho Chi Minh City on National Road No.1 and Trung Luong Highway has a low rate of NRDP-qualified communes, only 6 percent for the period 2010–2015. In contrast, Dong Thap province, which does not have a good location, has performed well in the program.

The success of the program, hence, must depend on factors other than just funding and location. For instance, provinces with leaders who believe in the importance of the program and work hard to implement it are more likely to be successful in getting certification for their communes. Both Hau Giang and Dong Thap provinces, among the most successful in gaining certification, have strong leadership that is committed to the program. These provinces have mobilized relatively large amounts of funds to meet the criteria—VND 654 billion and VND565 billion per commune between 2010 and 2015. Yet Ben Tre province, which traditionally has had a strong leadership and invested a high amount of NRDP funding per commune, VND135 billion, has a very low rate of NRDP-qualified communes as previously stated.

Figure 13.3: NRDP performance in the VMD, 2010–15 (%)



Source: National Office of New Rural Development Program (2017).

In fig. 13.3, we can see that among the 19 criteria, communes in the VMD likely passed those criteria that local leadership can influence, and in areas where the budget can be mobilized, for example: planning, irrigation, education, postal services, and security. Program criteria that require local participation, contributions and are affected by market forces and market linkages are less likely to be achieved, such as environmental improvement, production organization, cultural activities, market development, and a rise in incomes. In brief, this study identified three tentative factors that impact significantly on the success of the program. These are: available resources (funding), location (near urban, market

access, connectivity), and leadership. However, it is hard to judge which single factor determines the ultimate success of the program; a combination of these three factors would indicate a high probability that a province will qualify.

Rural transformation

The NRDP has undoubtedly brought significant improvements in terms of infrastructure and road access in the Mekong Delta. In this region, people traditionally use waterways, making use of densely-connected canal and river systems for transportation. The program invested public funds to build more roads and bridges so that cars and trucks can access commune centers. The program improved road access to villages and fields, which helped reduce time and costs of transporting farm and non-farm inputs and products, as well as brought new economic opportunities, such as the means to sell live shrimp directly to restaurants in Tra Vinh province, raise ducks to produce high-quality eggs for retail chains in Dong Thap province, and provide homestays and local cuisine to tourists in Can Tho.

The economy of Can Tho province has changed. The NRDP has brought new agricultural production models, such as VietGAP, GlobalGAP, large field model, contract farming, and agricultural value chains.¹ The average income of farmers in Can Tho province has increased by 15 percent because of cost saving and higher selling prices due to better road transport. Income from agriculture is decreasing; meanwhile, the shares of income from services, trading and non-farm sectors have been increasing. Job opportunities have been increasing since more enterprises have invested in food processing equipment and facilities. Numerous handicraft villages have also been developed. Rural household income in NRDP-qualified communes has been increasing rapidly. To take one example, farmers have increased their annual income from 28 million to more than 40 million per year in Trung An commune, Co Do district, Can Tho province.

Table 13.3: Income sources compared between non-NRDP and NRDP groups, 2010–14 (%)

Income share (%)	Non-NCCP			NCCP			Diff in Diff
	2010	2014	Diff	2010	2014	Diff	
Labor	38.14	39	0.86	53.95	35.56	-18.39	-19.25
Crops	5.07	0.36	-4.71***	5.81	0.67	-5.14***	-0.43
Livestock	0.77	1.89	1.12***	0.1	3.51	3.41***	2.29
Forestry	0.18	0.35	0.17	0	0.1	0.1	-0.07
Aquaculture	1.47	10.61	9.14	0	7.61	7.61	-1.53
Services	0	0.01	0.01	0	0.52	0.52	0.51
Enterprise/company	31.74	20.33	-11.41***	22.97	26.04	3.07***	14.48
Other incomes	22.62	27.45	4.83***	17.17	26	8.83**	4
Other farm activities	7.5	13.22	5.72***	5.91	12.41	6.5***	0.78

Note: *** significant at 1% level, ** at 5% level; Diff: difference

Source: Authors' estimates based on GSO, Housing Living Standard Survey (VHLSS), 2010–2014.

Structural economic transformation has occurred throughout the Mekong Delta. Traditional forms of agriculture, such as rice and vegetable cultivation, are shrinking; the income share from crops dropped 4–5 percent in the period 2010–2014. Higher-value commercial farming, such as rearing livestock, aquaculture, and fruit farming are playing bigger roles in household income. Table 13.3 shows that there have been significant increases in the proportion of income from livestock sales between 2010 and 2014 within both non-NRDP and NRDP groups, and a small increase in the proportion of household income from other farm activities and services.

Overall, however, the NRDP has not significantly transformed the rural economy of the Mekong Delta. But there are large differences between non-NRDP and NRDP groups in terms of income share from farm (harvesting, etc.) and private sector jobs (food processing, seafood processing, textile companies, etc.). Job opportunities in enterprises/companies were significantly higher in the NRDP group. Income from private enterprise in the NRDP group increased from 23 percent in 2010 to 26 percent in 2014; while this share for non-NRDP groups was dropping from 31.7 percent to 20.3 percent in the same period. Similarly, income from services (selling food, goods, machine repairs, etc.) increased more

quickly in the NRDP group compared to the non-NRDP group. The differences, however, are not statistically significant, hence we cannot associate these economic changes with the introduction of the program in the VMD.

Rural connectivity

Rural connectivity in the Mekong Delta improved during the first phase of the NRDP due to heavy investment in infrastructure. For both non-NRDP and NRDP groups, the percentage of communes with road access to commune centers, electricity supply, and postal services increased over the period 2010–2015. The program has created all-weather (concretized) rural roads, hence cars and trucks can access many more villages and commune centers. As a result, middlemen and enterprises have been able to travel to villages to buy produce and sell agricultural inputs such as feedstock, fertilizer, seeds, and pesticides. The newly built “Cultural houses” were used by local farmers to exchange market and technical information.² Some business service providers also use cultural houses as their points of transactions, such as credit and banking services, telecommunications, and extension services.

Table 13.4: Commune infrastructure between non-NRDP and NRDP groups, 2010–15 (%)

Indicators	Non-NRD (%)		NRD (%)	
	2010	2014	2010	2014
Road to commune	91	94	97	100
National electricity	85	86	94	95
Cultural House	36	43*	61	95***

There has been a significant improvement in road access during this period from 91 percent to 94 percent among non-NRDP communes, and from 97 percent to 100 percent among NRDP communes. Access to electricity has also improved among non-NRDP and NRDP communes. But improvements in road and electricity access are similar between non-NRDP and NRDP communes. This implies that we cannot conclude that the program itself has had a positive effect on infrastructure and electricity supply in this region. The program is only statistically significant in

respect to the construction of cultural houses: the percentage of communes with cultural houses increased from 36 percent to 43 percent in non-NRDP communes, but increased significantly from 61 percent to 95 percent among NRDP communes in the Mekong Delta.

Institutional changes

The NRDP program aimed to improve community-level participation in planning, implementation, and decision-making. While NRDP projects have been closely monitored by residents, local participation has been limited in many communities. Often, residents were just informed about the NRDP activities and infrastructure projects after they had been approved and designed. NRDP plans were just displayed at commune offices and local cultural houses to inform local residents, not to seek feedback. Local people were only involved when the NRDP infrastructure projects required their contributions in terms of labor, money, or land.

The program is supposed to help improve local administrative capacity. To some extent, local officials involved in the program have learned and practiced project preparation, planning, implementation and monitoring, etc. Local officials in certified communes are more proactive and professional compared to those in non-NRDP ones. Farmers in qualified communes have also experienced community development activities such as planning, participating, contributing, and monitoring project activities. The programs are helping some communes to become more dynamic in business and market activities. Residents in qualified communes are more likely to comply with regulations as the result of legal resources and legal discussion cafes established by the program in Can Tho City. They also have raised awareness on the environment and sanitation, and started collecting garbage to keep their neighborhoods clean. People living in qualified communes have also increased their sense of community and willingness to contribute to community work, such as cleaning up the environment, giving up land for road construction, and sharing electricity to light up village roads at night, as observed in Soc Trang and Dong Thap provinces. The sense of community is especially high among religious communities. When religious leaders understand and support the program, the program is implemented effectively with greater local contributions, as observed in Can Tho City.

Impact on household expenditure

The NRDP program was launched nationwide in early 2010 with an objective of 20 percent and 50 percent of national communes achieving certification by 2015 and 2020, respectively. VHLSS data from 2010 and 2014, collected by the General Statistics Office of Vietnam (GSO) is used to assess the impacts of the program on household income and expenditure. The data on households include demographic profiles, employment and labor force participation, education, health, income, expenditure, housing, fixed assets and durable goods, and the participation of households in poverty alleviation programs. Commune data include demography and general situation of communes, economic conditions, non-farm employment, agriculture, local infrastructure and transportation, education, health, and social affairs. The commune data contain information on natural disasters. For this study, the commune data has been merged with the household data.

Each of the VHLSS surveys covers more than 9,000 households. The data are representative for urban/rural and eight geographic regions. The entire data set of 2010, and 2014 household-level VHLSS covered 6,750 and 6,618 rural households, as well as 2,199 and 1,716 communes, respectively. In this study, we use the rural samples for the Mekong Delta. The selected sample of 2010 and 2014 household-level VHLSS covered 1,455 and 1,440 rural households, respectively. The selected sample of 2010 and 2014 commune-level VHLSS covered 470 and 278 communes, respectively. The two-stage household-level panel data in 2010–2014 with 628 households in each year, of which 51 households live in NRDP-qualified communes (see table 13.5).

A dummy variable is used to take the value of 1 if a commune is rewarded as a NRDP one, and 0 if otherwise. The unit of analysis is the household. Both consumption and income data have been deflated to January 2010 national prices through use of monthly and regional price indices calculated as part of the survey and using the General Statistics Office's CPI to adjust prices.

Table 13.6 presents a comparison of outcome variables between 2010 and 2014 and between non-NRDP and NRDP groups. There are significant increases between 2010 and 2014, in both non-NRDP and NRDP groups, in terms of total expenditure per capita, food expenditure per capita,

Table 13.5: Household and commune sample in the VMD, 2010–14

Year	Non-NRD		NRD		Total	
	Obs.	Row (%)	Obs.	Row (%)	Obs.	Row (%)
Household-level sample, 2010-2014						
2010	679	51.95	0	0.00	679	50.00
2014	628	48.05	51	100.00	679	50.00
Total	1,307	100.00	51	100.00	1,358	100.00
Commune-level sample, 2010-2014						
2010	268	51.94	0	0.00	268	50.00
2014	248	48.06	20	100.00	268	50.00
Total	516	100.00	20	100.00	536	100.00

Source: Authors' compilation from VHLSS 2010-2014.

income per capita, housing area, land area, and fixed capital assets. The increases also occur in both non-NRDP and NRDP groups. For example, there are significant improvements in both groups in terms of income and household fixed assets. Expenditure increased faster in NRDP households than for non-NRDP groups. In addition, the data showed that households in NRDP groups have to spend less on health care than those in non-NRDP groups.

Table 13.6: Expenditure by non-NRDP and NRDP groups groups, 2010–14

Outcome	Non-NRDP			NRDP			Diff in Diff
	2010	2014	Diff	2010	2014	Diff	
Expenditure	13,798	16,724	2,926	16,488	19,885	3,397	471
Food	6,470	7,596	1,126	6,987	8,287	1,300	174
Nonfood	7,328	3,716	-3,612	9,501	4,654	-4,847	-1,235
Durables	861	1,728	867	5,167	2,927	-2,240	-3,107
Income	16,093	52,352	36,259	17,694	63,865	46,171	9,912
Housing	70	81	11	68	83	15	4
Land	7,096	8,852	1,756	6,656	12,872	6,216	4,460
Fixed assets	17,167	30,774	13,607	30,395	47,472	17,077	3,470
Health	872	1,014	142	778	874	96	-46
Incidence	0.0211	0.0666	0	0.0262	0.067	0	0
Education	380	446	66	532	595	63	-3

Note: *** significant at 1% level, ** at 5% level

Source: Authors' estimation from VHLSS 2010-2014.

NRDP impacts model

We assume a household welfare indicator is a function of characteristics of households and communities as follows (Glewwe 1991):

$$\ln Y_{ijt} = \alpha_0 + X_{ijt}\beta_1 + C_{jt}\gamma_1 + NRD_{jt}\delta_1 + \tau_t + \varepsilon_{ijt} \quad (1)$$

Where the script ijt denotes for household i in commune j in the year t ; Y is a welfare indicator of households; X is a vector of characteristics of households such as demographic and socioeconomic variables; C is a vector of characteristics of communities such as general commune conditions, and initial infrastructure conditions; NRD is a dummy variable indicating whether a commune is qualified for NRDP status or not; τ is the dummy variable for years; ε represents unobserved variables. We use different indicators of household welfare including per capita income, and per capita expenditure. We use similar specifications as equation (1) for different dependent variables. The effect of the NRDP on households is measured by parameters δ_1 , δ_2 , and δ_3 . One problem in estimating the effect of the NRDP is the endogeneity of the NRDP dummy variable. The unobserved variables can be correlated with the NRDP. In equation (1), unobserved variables ε_{ijt} include both commune-level (v_j) and household-level variables (u_i). Since our NRDP are the commune-level variables, they are more likely to be correlated with unobserved commune-level variables. The unobserved commune-level variables can be decomposed into time-variant (v_{j1t}) and time-invariant commune-level variables (v_{j0}) in equation (2) below. We use the commune fixed-effect regression to eliminate unobserved time-invariant commune-level variables. It is expected that the endogeneity bias will be negligible after the elimination of these unobserved time-invariant variables and the control of observed variables.

$$\varepsilon_{ijt} = u_{it} + v_{jt} = u_{i0} + u_{i1t} + v_{j0} + v_{j1t} \quad (2)$$

We examine two sets of models: the small model (1) and the large model (2). The small model contains only demographic and commune-level variables such as general commune conditions and initial infrastructure. The large model includes additional socioeconomic variables such as education, occupation, as well as commune-level variables as in the small model. We use a small set of control variables that are more exogenous

or less likely to be affected by NRDP. The control variables should not be affected by the variable of interest, that is, the NRDP, in this study (Heckman et al. 1999). Consumption expenditure is used, instead of income, as the dependent variable, since consumption expenditure is widely used as an aggregate indicator for household welfare and expenditure data contain fewer measurement errors than income data.

The NRDP variable is suspected to be endogenous in the model (1), and thus the estimators can be inconsistent. Therefore, commune-fixed effect 2SLS regressions are employed to estimate the effect of the NRDP on household welfare. The Stata *xtivreg2* command is explored (Schaffer 2015). The NRDP variable is instrumented by a set of variables related to social support programs in the three years prior to 2010. Social support programs from the Vietnamese governments and other organizations (such as: job creation, hunger elimination and poverty reduction, investment in economic development and infrastructure, investment in culture and education, health and public health, environment/clean water) three years before 2010. Summary statistics are reported in table 13.7.

Table 13.7: Commune-level covariates: Government programs and/or support programs within three years of 2010

Covariates	Mean	Std. Dev.
Job creation (=1)	0.467	0.499
Hunger elimination and poverty reduction (=1)	0.717	0.451
Investment on economic development and infrastructure (=1)	0.592	0.492
Investment on culture and education (=1)	0.244	0.430
Health and public health (=1)	0.150	0.358
Environment/ clean water (=1)	0.236	0.425

Source: Authors' calculation from VHLSS 2010 (Commune survey).

Two models, which differ in the number of explanatory variables, are estimated to examine the sensitivity of the NRDP's impacts on the selection of explanatory variables. The small model contains only demographic variables (e.g. household size, proportion of adults above the age of 60 in households, proportion of children below the age of 15 in the household, proportion of female members in the household, and ethnicity) and commune-level variables such as general conditions (specific natural disasters in the last three years, number of enterprises per 1,000 people

in the previous five and ten years), and initial infrastructure conditions (infrastructure projects started within three years of 2010, i.e. roads to the district or province, roads within the commune, bridges, irrigation, canals, electricity, drinking water, a health center, school), and infrastructure completed within three years of 2010.

The large extended models include additional household-level variables related to socioeconomic characteristics (e.g. age of household head, gender of household head, proportion of household members currently employed, proportion of household members attending school), and commune-level variables such as general conditions, and initial infrastructure conditions as in the small model.

Empirical estimates

Table 13.8 indicates that households in NRDP-qualified communes have higher real expenditure per capita of around 1.1 times. We observed the negative effects of household size and the number of children on real expenditure per capita. In addition, households living in communes affected by floods during the survey year or by drought during the last three years have the probability of lower real expenditure per capita of 36.5 percent and 10.3 percent, respectively.

The results show that families with school-going children spend more. This implies that households in the Mekong Delta spend their money on education and on children as a priority. Households with greater chances of access to jobs with companies/factories also have higher expenditure. It means that non-farm jobs opportunities are important for helping households improve their living standards and welfare. Therefore, the NRDP's interventions to create more non-farm jobs and business opportunities assist rural household improve their standard of living.

In general, the program has had a positive effect on household welfare in the VMD. Results indicate that households in NRDP-qualified commune have higher real expenditure per capita of around 1.1 times. However, while efforts were made to identify the impact of NRDP, it is not possible to completely differentiate its impact from the spillover effects since NRDP is said to be a profound and comprehensive social mobilization (in economic, sociocultural development, productivity, living standards, lifestyle, customs and traditions). It is also not possible to completely disaggregate NRDP into its individual projects so as to evaluate its overall and specific impacts.

Table 13.8: Commune fixed-effects regressions of household expenditure

Variable	Small model: Real exp. pc	Extended model: Real exp. pc
NRD (Yes=1; No=0)	1.192*** (0.386)	1.022*** (0.348)
Household size	-0.0543*** (0.0152)	-0.0811*** (0.0129)
Proportion of child	-0.591*** (0.103)	-0.258*** (0.0914)
Occupation with "Leaders/ Managers" (%)		-0.0374 (0.103)
Occupation with "Professionals/ Technicians" (%)		0.0371 (0.196)
Occupation with "Clerks/Service Workers" (%)		0.0371 (0.0853)
Occupation with "Agriculture/ Forestry/ Fishery" (%)		0.217 (0.224)
Occupation with "Skilled Workers/ Machine Operators" (%)		0.838*** (0.235)
Occupation with "Unskilled Workers" (%)		0.249 (0.227)
Member with "No degree" (%)		-0.00151 (0.0993)
Member with "Primary school" (%)		0.282*** (0.104)
Member with "Lower Secondary School" (%)		0.511*** (0.113)
Member with "Upper Secondary School" (%)		1.064*** (0.152)
Member with "College and above" (%)		1.238*** (0.354)
Commune affected by flood during the survey year (=1)	-0.363* (0.211)	-0.305 (0.267)
Number of enterprises/firms/factories per 1000 commune members in 2001-2005	0.151** (0.0657)	0.155*** (0.0581)
Commune affected by drought during the last three years (=1)	-1.030*** (0.394)	
Observations	1,358	1,358
R-squared	0.010	0.200
Number of id_	679	679

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Policy discussion

This study shows that impacts of the NRDP are questionable for the Mekong Delta in particular and Vietnam in general. Obtaining certification is a one-time occurrence, and local officials and residents have been rushing to put in a great deal of effort and resources to meet the 19 criteria for certification due to political pressure and incentives. After getting the certification, however, local people face a shortage of necessary funding and resources to maintain the improved infrastructure and standards. Communes are given priority to receive investments from local and central government during the process of qualifying for the NRDP certifications. In addition, local officials are assessed based on the number of communes in their area that receive certification. Therefore, they have directed resources to those communes with better conditions in order to increase the number of NRDP qualified communes under their jurisdiction. As a result, remote and poorer communes were getting less support and investment for NRDP programs. Hence, the program has widened the gap between the better-off and the poorer communes in the Mekong Delta.

Undoubtedly, NRDP-linked investment has fostered local economic activities, market access, and connectivity. Schools and other educational facilities have improved since the beginning of the program. However, NRDP investment is likely to be poorly used as the program applies the same criteria and activities for each commune in an inflexible manner. For example, each commune is required to build a market of certain specifications for local people to exchange products, to buy agricultural inputs and consumer goods whether or not they need one. Many of the newly built commune markets are left unused after they are built. In rural areas, markets are naturally formed based on location, demand and supply of local products, among a cluster of communes, such that two or three communes may be better off sharing a market to minimize transaction costs. In some places, local markets also serve and accommodate local cultural activities. Therefore, requiring each commune to build its own market is a waste of resources and needs to be reconsidered.

Similarly, the program requires each commune to build a health-care center, and most communes invested a large amount of money to build one and hire a few health workers to serve local people. However, few residents use the commune health-care centers for reasons such as:

the centers are under-staffed or staffed by low-skilled healthworkers; health insurance cannot be used for reimbursement at commune health-care centers; commune health centers are poorly equipped and cannot even provide basic health-care services. The program should invest in health-care centers for a cluster of three to five communes, and provide them with good infrastructure, qualified staff, and proper equipment, and connected to the health insurance system. Finally, the building of cultural houses is wasteful in terms of money and resources that can be better channeled elsewhere. The program requires that each village and communes have a cultural house, but most are left unused, or used few times a year for local events. Cultural houses are often transformed into village offices.

Local participation in the program is crucial to its success. The program allows only small-scale investment such as village roads and cultural houses to be handed to local people to plan, construct and monitor. Local government selects contractors for larger projects, such as commune roads, schools, health center, cultural house, etc.: the end results are often poor quality but expensive constructions. Local authorities claim that local communities have little capacity so that they cannot handle large projects. In addition, they argue that government regulations are too complicated for local communities. The program should change such perceptions and simplify regulations so that local communities can undertake large projects. In NRDP communes, all social groups from the elderly, middle aged, youth, children, and women are involved in project activities at some level. However, children and women benefit the most from good schools, better roads, and market access. The elderly and the youth benefit less from the NRDP since most youth migrate for work, and the program pays less attention to providing services for the elderly. Local businesses perhaps benefit the most because they receive contracts for various projects due to their good connections with local government.

Central governments try their best to make the program visible for political purposes. Therefore, the NRDP is somehow driven by political will from above. Hence, infrastructure such as roads, houses, fences, buildings, etc., are politicians' favorites. In many cases, these investments do not necessarily benefit local residents. There is a high risk of resource waste and corruption in its implementation. The lack of local participation and residents' attitudes works against the program's objectives. In

addition, the projects are implemented at the commune level and lack regional coordination for wider, integrated and comprehensive rural development. Finally, there is no mechanism or funding in place for maintaining NRDP-initiated infrastructure and services.

Holistic rural development requires more than just thematic coherence. Specifically, the program seems intuitively to be raising the quality of life in Mekong Delta, and thus reducing the migration outflows. But the government has not yet established a clear and empirically-backed causal relationship between increases in infrastructure, political, social, and economic indicators under the program and the mitigation of the “push-pull” factors which could drive provinces out of poverty and underdevelopment. Therefore, there is a strong need for providing evidence-based causal relationships between NRDP interventions and quality of life improvements of rural residents. The value of such an exercise would be to narrow the scope of the NRDP which would directly contribute to the stabilization of the countryside, and thus freeing up much-needed resources for the expansion of the remaining program budgets and reducing communal and provincial debt burdens.

The principle of the NRDP that rural residents must serve as both participants and subjects has a mixed record in actual implementation. With respect to participation in the policy process, farmers have had little opportunity so far to provide planning input. Instead, planning and decision-making flows from the central government down to the provincial governments down to the district governments and ultimately down to commune-level authorities, with little in the way of intragovernmental feedback mechanisms or a channel of communication between citizens and government at any level. However, the public has had more opportunities for participation, especially in the construction of roads, the bidding process for which deliberately targets resident laborers and local contractors. Public participation in implementation also manifests in the form of voluntary contributions of land, labor, and money towards various projects and in many cases, at least with respect to monetary contributions, donations as a percentage of project budgets far exceed the 10 percent minimum threshold dictated by the government. Citizens are also included passively in monitoring and oversight process via the construction monitoring boards—nine-member committees which are nominated by local communities and have a mandate to ensure

contractor compliance with contract terms and conditions, verify bills for government-funded projects, sign off on acceptance notes, and prepare quarterly reports for the commune People's Committee.

The lack of public participation in the planning process of the NRDP needs to be addressed. The stipulation that all communes must have a cultural house that meets the standards of the Ministry of Sports, Culture, and Tourism makes this abundantly clear: when cultural houses are built without local input, they often end up being constructed in an inconvenient location and without reference to local architectural preferences. Cultural centers built this way see little in the way of public interest and usage, rendering these structures a waste of precious resources—an outcome which is avoidable if public input is solicited regarding siting, function and design. Ensuring effective local feedback on NRDP projects, and its criteria—which is politically important for policy implementers—would be an effective way to institutionalize public participation, in turn increasing public buy-in and increasing the efficiency of resource allocation.

NRDP funds are being preferentially channeled to rural areas which have a comparatively good baseline level of infrastructure and economic development, a profile which strongly resembles that of the provinces experiencing “delta-pattern” poverty and emigration; this suggests that the program is indeed aiming to stabilize the countryside. At the same time, however, the current metrics and criteria used to judge progress suggest a different ultimate goal, one that systemically treats rural development and commune development as an end in and of itself; rather than as a means to achieve some sort of human-centric outcome. To illustrate this point, consider two major infrastructural targets of the program: rural markets and schools. With respect to rural markets, the sub-criteria mandates that each commune must have a marketplace which meets the standards of the Ministry of Construction, but does not attach to these criteria any metrics about the human (societal or community) outcomes generated. This means that even if meeting a national standard, a rural market place may have no impact or even a negative impact on local livelihoods, yet the fact that such a market is built puts that commune one step closer to achieving NRDP recognition.

The same logic is present with schools, the criterion exists without being attached to any metric concerning the human outcomes generated,

hence even if they meet the national-standard, some of the newly built educational facilities had no impact or even a negative impact on local educational achievement (attendance rate, graduation rate, percentage of students who continue their studies in university, etc.), the fact that a new school was built would put a commune one step closer to achieving NRDP recognition. Thus, the findings in this study suggests that the Vietnamese government should consider revising the progress metrics and criteria which determine a “new rural commune.” The current approach systemically treats rural development as an end in itself. Instead, however, rural development should be treated as a means to an end. Given that the ultimate goal of the NRDP is stabilization of the countryside, interpreting commune-level outcomes in terms of the impact on individuals is a more appropriate way to determine progress.

Institutionalizing the importance of adherence to the appropriate legal and normative frameworks and the importance of good record-keeping practices would be beneficial because best practices would be easier to identify and replicate. Furthermore, Phase 1 of the NRDP has been plagued by corner-cutting behavior in infrastructure projects, particularly in the form of local authorities pressuring poorer households to adhere to the required land and labor contributions or extracting contributions that they cannot afford. Thus, making due process and accountable practices a prerequisite for recognition as a “new rural commune” would deter transgressive behavior and promote social justice.

Notes

- ¹ The large farm model is implemented by local governments. Local government encourages small farmers to produce the same crop varieties, using the same techniques and synchronizing seasons/growing periods. Farmers can collectively buy inputs and services including land preparation, irrigation, harvesting, etc., in order to reduce their production costs and take advantage of larger-scale farming. Contract farming is developed among small farmers and local traders to produce agricultural produce following particular procedures and product specifications in order to better meet market demand, which local traders will buy and distribute to markets. Agricultural value chains are encouraged by local governments to facilitate stakeholders such as farmers, input suppliers, traders, processors, retailers to work together to exchange market information, to set up market linkages, and coordinate production plans in order to achieve higher added-value for commodity chains and for each

stakeholder.

- ² Cultural houses were intended for cultural activities including performances. Many cultural houses are being used for other purposes.

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14

Impacts of the East-West Economic Corridor on Forest-Dependent Livelihoods in Vietnam, Laos and Thailand

Bui Duc Tinh and Dao Duy Minh

Proponents of regional economic integration around the world argue that it will raise household consumption, help create more seasonal and full-time employment, as well as more efficient resource allocation and technology transfer between the member countries. The impacts of economic integration vary among systems, countries, and regions, however (see for e.g. McCulloch et al. 2004). In some cases, economic integration has resulted in limited development, particularly for already disadvantaged communities, increased natural resource depletion, especially of forests, and income inequality. In the Greater Mekong Sub-region (GMS), there has been a lack of consensus about integration at various levels, despite great efforts made in this direction, such as the Association of Southeast Asian Nations (ASEAN) Free Trade Area (AFTA), Trans-Pacific Partnership (TPP), and ASEAN Economic Community (AEC) (ADB 2009).

The East-West Economic Corridor (EWEC) was one of the major cross-border highway projects initiated in the GMS to promote the development and integration of the five mainland ASEAN countries, Cambodia, Laos, Myanmar, Thailand, and Vietnam. Completed in 2006, the EWEC was the first highway running the entire width of mainland Southeast Asia, a total of 1,450 km. The project was promoted as a holistic approach to the spatial development of poorer areas of the GMS to stimulate economic growth, poverty reduction, and environmental protection, with a focus on transport, trade and investment; tourism, agriculture, and agribusiness; and human development (Bui et al. 2005; Isono 2010; ADB 2009, 2013). The completed EWEC runs through some 37 percent of Quang Tri province, Vietnam; 34 percent of Kyaikmaraw, Myanmar; and 45 percent of the total

area of Savannakhet province, Lao PDR (fig. 14.1). A significant proportion of the population in each of these areas remains below the poverty line. Most of them are forest-dependent communities whose livelihoods are dependent on subsistence or shifting agriculture (e.g. food crops, cattle raising), and non-timber forest product collection (NTFPs). Only a small percentage of these forest-dependent households have become involved in service provision or cash crop production since 2006 when the highway was completed.

A recent evaluation of the EWEC provides comprehensive statistics on improved logistics, cross-border vehicle and population movements, cross-border trade volumes, and increased tourism (Srivastava 2012). Yet an evaluation of the full impact of the EWEC remains challenging because of limited data available and a lack of transparency among stakeholders. In addition, there is a lack of information on changing conditions and livelihoods in the areas and communities opened up by the highway. Based on qualitative and quantitative studies of three areas affected directly by the highway in Laos, Vietnam and to a lesser extent, Thailand, this chapter aims to provide a better understanding of the actual impact of the EWEC on forest-dependent livelihoods in order to inform policymaking.

Analytical framework and research method

This study used the Sustainable Livelihood Approach (SLA) to evaluate the impact of the EWEC on forest-dependent communities. Developed by the United Kingdom's Department for International Development (DFID) in 1999, Faiz (2000), Davis (2000), D'Haese et al. (2007), and Cotton (2011), among others, have used the SLA to investigate the impacts of cross-border road construction on livelihoods. The SLA recognizes that households, particularly disadvantaged groups, derive their livelihoods from multiple activities based on their five core assets—human, social, natural, physical, and financial capital. Notably, this approach does not see material assets as determining household livelihood strategies. The SLA also recognizes that institutional factors such as governance, policy, laws, customs, and gender relations affect livelihoods.

Using the SLA for road construction impact analysis, Mu and van de Wall (2011) found that improved roads in Vietnam enhanced the development of local markets and non-farming employment, particularly

for rural communities, but not for disadvantaged communities and households with low literacy rates. Zhu (2006) highlighted the negative impact of the North-South Economic Corridor on natural resources and biodiversity due to the new ease of access. Zhu's study shows that illegal activities such as unlicensed logging and wildlife trafficking have increased in Xishuangbana. Forest resources have been decreasing, particularly in areas closer to the road, while areas under industrial crops such as palm oil and rubber have increased in the buffer zones. The same study also found that villagers who lost their livelihood assets (farm land or access to forest resources) in areas opened up by the new highway have become involved in illegal trading and labor migration, gold mining or commercial sex work. Another recent study has also indicated that disadvantaged local communities are more vulnerable to the socioeconomic changes along the economic corridor in Vietnam (Giang 2006).

A number of studies have also examined the relationship between improved infrastructure and trade, and its impact on local livelihoods. For instance, the United Nations Development Programme (UNDP 2006) examined the impact of cross-border trade on poverty, employment, gender, culture, and the environment. Other studies by the Asian Development Bank (ADB 2007), Fujimura and Edmond (2006), and Warr et al. (2009) focused on cross-border trade, migration patterns, and illegal logging. Warr et al. found that the enhanced cross-border trade generally has a positive effect on local livelihoods, but this impact varies greatly among groups and communities. It can benefit some communities and businesses while causing hardship in others, the outcome being partly dependent on pre-existing characteristics. A World Bank study on investment in infrastructure and economic growth in developing countries (Straub 2008) also showed that new roads had varying effects on different segments of the population, depending on the household characteristics and responses to the increased flow of goods and people. This study pointed to the correlation between infrastructure improvement and trade enhancement with improved local commerce, better access to health care, education, and other social services on the one hand, and negative social consequences such as increasing inequality, population displacement, and drug use on the other.

The ADB investigated the impact of road construction on poverty reduction and pointed out that improved roads allowed for better modes

of transportation, reduced travel time and costs, and benefited those who travel outside the community (Keoamphone 2007). The study highlighted that agricultural households with access to better roads have more livelihood alternatives compared with those with poor road access.

The above studies contain clear evidence that better roads, particularly cross-border ones, may have varying impacts on investment and trade as well as access to social goods and livelihood opportunities for affected populations. This study adds to this body of research by investigating the impact of the EWEC on the livelihoods of forest-dependent villagers in Laos, Vietnam and to a lesser extent, Thailand, by comparing changes in the five core assets in the SLA framework before and after the roads were in place.

Research methods

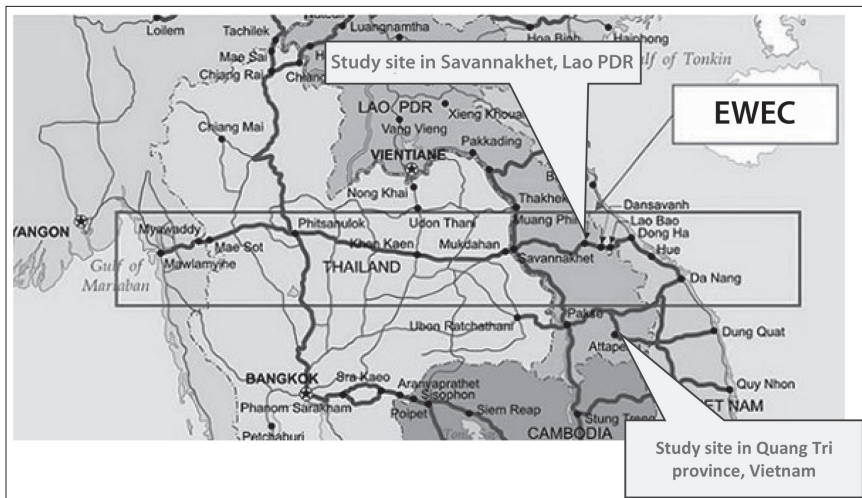
This study combined an analysis of GMS policy narratives as well as a literature review combined with some quantitative and qualitative research in 2017. Secondary data on socioeconomic indicators, environmental and forest resources, cross-border trade and investment, and commercial and industrial zones were collected to contextualize the study sites and analyse the impact of the EWEC and socioeconomic and forest resource changes in the area. Based on the literature reviews and secondary data, questionnaires were then designed for household surveys, key informant interviews, and focus group discussions. A total of 529 household surveys were completed, 249 in Quang Tri province, Vietnam, and 280 in Savannkhet province, Lao PDR. No surveys were conducted in Thailand, although some interviews were conducted there to assess changes in local livelihoods in the EWEC zone.

Qualitative information was gathered through key informant interviews and focus groups: 10 key informant interviews in Thailand; 16 key informant interviews in Vietnam; and 14 key informant interviews in Lao PDR; 22 focus group discussions were conducted in Vietnam and Lao PDR in which 13 focus group discussion conducted in Vietnam and 9 focus group discussion conducted in Lao PDR. The qualitative information was aimed at filling in gaps in knowledge and gaining a deeper understanding of the impact of the transboundary policy narratives and EWEC on local livelihoods and forest resources.

Forest-dependent livelihoods

The EWEC connects the port city of Mawlamyine (Myanmar) in the west, crosses the Thai provinces of Sukhothai, Phitsanulok, Phetchabun, Khon Kaen, and Mukdahan; the Lao province of Savannakhet; the Vietnamese provinces of Quang Tri and Thua Thien-Hua and terminates in Vietnam's Da Nang City in the East (fig. 14.1). The EWEC passes through many forest-dependent villages in all four countries.

Figure 14.1: Map of East-West Economic Corridor and study sites



Source: Adapted from <http://thedevelopmentadvisor.com/news/myanmar-thailand-laos-vietnam-east-west-economic-corridor/>.

Quang Tri province shares a border with Quang Binh province to the north, Thua Thien-Hue province to the south, Savannakhet province to the west. Quang Tri province is characterized by steep mountains in the west and narrow deltas in the east. Quang Tri is considered an important traffic hub, being the starting point of the EWEC connecting Vietnam with the ASEAN countries, particularly Lao PDR, Thailand, and Myanmar for commerce, tourism, agriculture, and transportation development.

In Quang Tri province, two forest-dependent villages were selected: Huong Hoa was selected as a district along the EWEC, and Dakrong as a village without access to the EWEC. Huong Hoa consists of two

communes with 14 villages, all largely dependent on forest resources, including Thuan commune (9 villages) and Huong Tan commune (5 communes). In Dakrong district, two communes were selected as villages outside the EWEC, namely Ba Nang and A Vao, located about 50 km to 70 km from the road respectively, with some villages situated about 100 km from the EWEC. The villagers' livelihoods are mainly dependent on forest resources.

Quang Tri province has a total area of 4,760 sq. km, comprising 301,993 ha of agricultural land, 41,421.31 ha of non-agricultural land, and 131,285 ha of non-used land. The province has abundant forests (about 220,797 ha) rich in flora and fauna. The quality of natural forests has decreased though the forested area has slightly increased, thanks to the rapid introduction of commercial plantations of acacia, rubber, and pine (Quang Tri Statistical Yearbook 2015). In 2015, the population of Quang Tri province consisted of 601,672 people living in 136,743 households with an average family size of 4.4 persons. There are 170,073 people out of 601,672 people living in urban areas (about 28.31 percent of the provincial total) and the rest of the population live in rural areas. About 346,287 people are classified as laborers (about 57.5 percent of the total population), 55 percent of whom work in agricultural sectors, including forest plantations, crop cultivation, and aquaculture (*ibid.*).

Located in central Lao PDR, the province borders on Khammouane province to the north, Quang Tri and Thua Thien-Hue provinces in Vietnam to the east, Salavan province to the south, and Nakhon Phanom and Mukdahan provinces in Thailand to the west. Savannakhet has a total land area of 21,774 km². It has about 1.1 million ha of forest, which accounted for about 52 percent of the total provincial area. The quality of forest and forest cover in this province has been reduced significantly to about 60 percent in 2005 and about 45 percent in 2014, due to the expansion of agricultural cash crops and illegal logging. This province has about 307,000 ha of agricultural land. Of which, about 285,000 ha of rice paddy cultivation. (Lao Statistical Bureau 2016).

Savannakhet is the most populous province of Lao PDR, with a total of 946,856 people (about 13 percent of the total population) living in its 15 districts. The majority of its population (62.1 percent) is Lao Lum. About 70 of the total labor force is working in agriculture, contributing nearly half of the province's Gross Output (GO). Meanwhile, about 30 percent

of the labor force works in industry and service sectors, generating about 51 percent of provincial GDP. Over 935 villages out of 1,001 villages in Savannakhet have been living off forest resources, with about 14,000 households classified as living below the poverty line (Savannakhet Statistical Yearbook 2014). Na Bo and Phon Muong were selected as the two villages connected by the EWEC. Na Bo has a total area of 7,991.74 ha, and over 6,053 villagers (about 80 percent of households) are dependent on forest resources. Phon Muong village has an area of 12,759 ha, and over 7,000 of its villagers (85 percent) have been making a living off the forest. Two other villages were selected as places where villagers lived either more than 50 km from the EWEC or outside the EWEC zone altogether. These include Xop Nam and Xepon. There is no updated statistical data available for these villages; however, key informants estimate that each has more than 5,000 inhabitants and over 90 percent of their inhabitants have been living off forest resources.

Transboundary policy narratives in the GMS

The dominant transboundary policy narrative around the EWEC since its inception has been based on how improving transport infrastructure, together with policies that facilitate the free flow of trade, investment, tourism, and labor across borders, will reduce poverty and bring about shared prosperity to the region. Economic corridors for this purpose are portrayed as the “backbone” or “arteries” for regional connectivity, economic integration, and development. Rivers marking sections of national borders are being perceived as sites for “friendship” bridges. During a meeting in 2001, senior officials from Thailand, Lao PDR and Myanmar explained that the EWEC’s purpose was to improve “the synergy and complementarities for the shared prosperity of the sub-region and its peoples” and reaffirmed their commitment to complete the eastern section of the GMS road network (ADB 2009).

A review of ADB’s plan for the construction of the EWEC from 2001 to 2008 shows that to establish and make the highway operational 79 policies were issued by the GMS countries, mainly related to infrastructure development, commerce, tourism, industry, and agricultural development. Construction was prioritized. “Shared prosperity” narratives speak more about solutions than problems. Such an approach may help explain their popularity. The focus on enhancing private investment and business—for

instance, by establishing special economic zones (SEZs)—has grown more prominent over time.

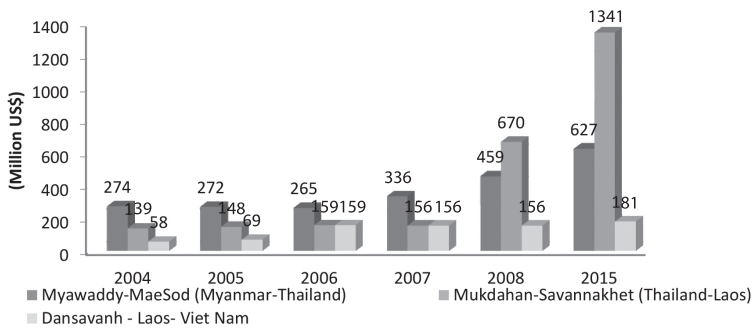
In order to strengthen the linkages with regional and international production networks as well as to boost cross-border trade along the EWEC, the ADB and Japan provided technical support to help establish SEZs located along the corridor. The SEZs were intended to facilitate private investment in the remote border zones. In the shared prosperity narrative, SEZs were seen as a “complementary initiative” to the economic corridors to generate more non-farming jobs for local communities. Many GMS countries emphasize using regional connectivity to develop their border provinces through increased trade and investment. This position is consistent with earlier national policies and plans to develop border towns as “trade points” and then “economic gateways” (Laine 2014).

A few SEZs were constructed along the EWEC, including the Savan-Xeno Special Economic Zone in Savannakhet, the Lao Bao Economic Zone in Quang Tri, and the Mae Sot-Myawaddy SEZ on the Thai-Myanmar border. Such zones were expected to attract more private investment as well as generate more local jobs. However, this has not been the case. Instead the SEZs have led to land acquisition, deforestation, an influx of labor migrants, generating more pressure on livelihoods of forest-dependent villagers. A Thai government spokesman, commenting on the Mae Sot SEZ, even suggested that “the government might need to revoke the protected forest status of some areas to allow development to go ahead” (*Bangkok Post*, Jan. 2013). NGOs have fiercely criticized such side-stepping of proper procedures because it “not only fast-tracks such projects, but also denies the people their right to manage natural resources.” In practice the SEZs together with the EWEC have been neither successful in attracting investment nor in job creation; indeed the SEZs have seen bankruptcy as many investors have withdrawn their capital and business. For many local residents, there has been less space for new non-farm livelihoods or to “share prosperity.”

On the other hand, there are signs that the EWEC has significantly contributed to the growth of cross-border trade in the GMS. The total export turnover of goods transported on the EWEC reached US\$1,285 million in 2008 and increased US\$2,149 million in 2015, which is over four times higher than that of 2006 (about 583 million) (fig. 14.2) (Nguyen 2016). Among the four countries traversed by the EWEC, cross-border

trading between Myanmar and Thailand increased from US\$265 million to US\$627 million; between Thailand and Lao PDR, trade has reached US\$1,341 million in 2015 comparison with US\$159 million in 2006. Cross-border trading revenue between Vietnam and Lao PDR through EWEC was US\$159 in 2006 and reached US\$181 million in 2015. Thus, an ADB official noted that “EWEC plays a key role in the booming economies of Myanmar, Lao PDR, and Vietnam” (ibid.).

Figure 14.2: Cross-border trade through border gates on the EWEC, 2004–15 (US\$ m)



Much of the cross-border trade along the EWEC consists of mining or forest products, such as timber, gypsum, and copper, mainly exported from Laos and Myanmar to Vietnam and to Thailand. For instance, the total export value of timber products increased from US\$61.96 million in 2010 to US\$319 million in 2014 (Nguyen 2016). About 92 percent of this timber was transported to Vietnam. As many as 150 enterprises have been established in Quang Tri province to import timber from Laos to Vietnam since 2006 (General Department of Vietnam Customs, annual reports). While the EWEC has improved access to and cheaper transportation of products, natural resources are still managed under inadequate pre-existing laws (key informant interviews, 2016). Most local and central governments in the GMS focus on promoting the EWEC for socioeconomic development but not for natural resource management. Many respondents involved in this study argued that natural—especially forest—resources have been massively reduced by up to 80 percent since the EWEC was introduced, with negative impacts on livelihoods.

Changing livelihoods

This study investigated the EWEC's impact on local livelihoods by comparing changes in their livelihoods between 2006 and 2016. It also compared changes in livelihoods of forest-dependent villagers living with or without access to the EWEC. The study reveals that the livelihoods of forest-dependent villagers changed dramatically in a decade. Respondents confirmed that the EWEC has generated better connectivity to market and social services, such as education and health care. Forest-dependent villagers in EWEC-related provinces in Vietnam, Lao PDR, and Thailand now have much better access to market, particularly for their agricultural products.

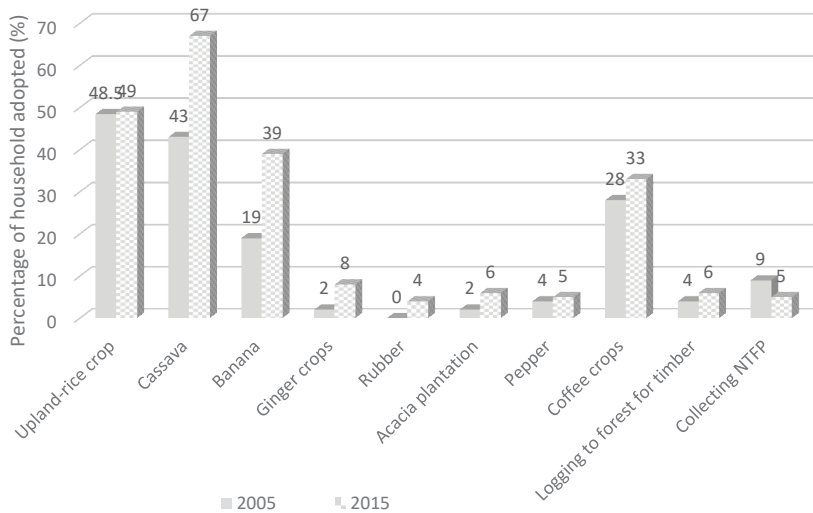
There has also been a shift from subsistence farming to market-oriented farming. Forest-dependent villagers have expanded their produce to include more market crops such as bananas, cassava, ginger, coffee and rubber by converting their upland farms and forest land. In 2005, the average cassava area was only 1,000 m² per household, which increased to 1,500 m² per household on average in 2015. Meanwhile, the average banana plot size per household increased from about 2,400 m² in 2005 to 4,100 m² in 2015 (80 percent more than 2005). The household survey revealed that households had converted significant portions of their upland rice fields for cash crops.

In Savannakhet province, urban areas and industrial zones have rapidly expanded along the EWEC. Before 2006, forest-dependent villagers mainly practiced swidden farming, cultivating upland rice, and collecting timber and NTFPs. Upland rice dominated the livelihoods of forest-dependent villagers in Savannakhet. By 2016 there had been a rapid increase in cash-crop farming, as a large proportion of households (47 percent) living in this province adopted banana, cassava, and rubber in swidden or fallow areas. Respondents confirmed that these cash crops were introduced from Vietnam and explained that the most important driver for these changes was the EWEC, including access to market, particularly middlemen from Vietnam, and the introduction of new crops from Vietnam.

As shown in fig. 14.3, the proportion of households involved in the production of cash crops such as cassava, bananas, and ginger, had significantly increased in 2015 compared to 2005. About 19 percent of households in the survey cultivated bananas in 2005 compared with about

39 percent of households in the study site. The proportion of households growing cassava increased from 43 percent in 2005 to 67 percent in 2016. Meanwhile, the percentage of households cultivating forest land or collecting NTFPs has significantly reduced due to the depletion of forests. The ratio of households cultivating upland rice has not changed, but the area used for upland rice has been reduced significantly.

Figure 14.3: Household adoption of cash-crop cultivation in Vietnam and Laos, 2005 and 2015



Since the EWEC, a number of agribusinesses have been set up in rural Northeast Thailand, including a cassava starch factory, dairy and sugar factories and rice mills. Some Thai farmers have also established small-scale family-run factories in this area. This has resulted in some changes in local livelihoods with some farmers getting involved in non-farming activities in smaller family-run factories. These Thai villagers still live off agriculture, but are less dependent on actual farming than they were before the EWEC. They spend only 35–40 percent of their time on agriculture compared with about 60 percent of their time on non-farming practices, such as working in agribusiness factories or migrating to Bangkok. Villagers living along the corridors tend to decrease their own production and change their traditional crops, such as rice and vegetables, to tree crops.

Figure 14.4: Products sold in the market 2005–15

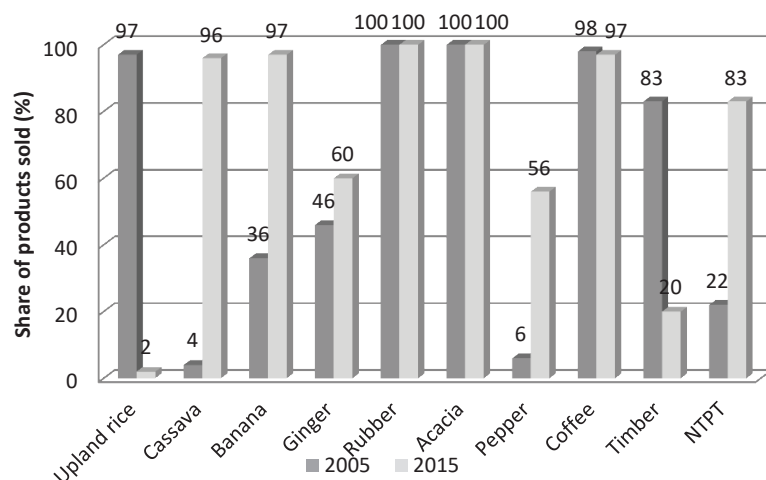


Figure 14.4 shows the changes in household level agricultural production between 2005 and 2015. There is a significant difference in the ratio of agricultural products sold in the market of forest-dependent villagers in 2005 and 2015. Before the EWEC (in 2005), crops such as cassava, bananas and black pepper were grown mainly for family consumption or animal feed in garden plots. Upland rice, and some rubber, and coffee were the main cash crops, while cassava, bananas, pepper, and NTFPs were supplementary ones. However, there has been a significant increase in the number of households that have switched to growing rubber, acacia, and coffee or who have expanded their original production of these crops since 2005.

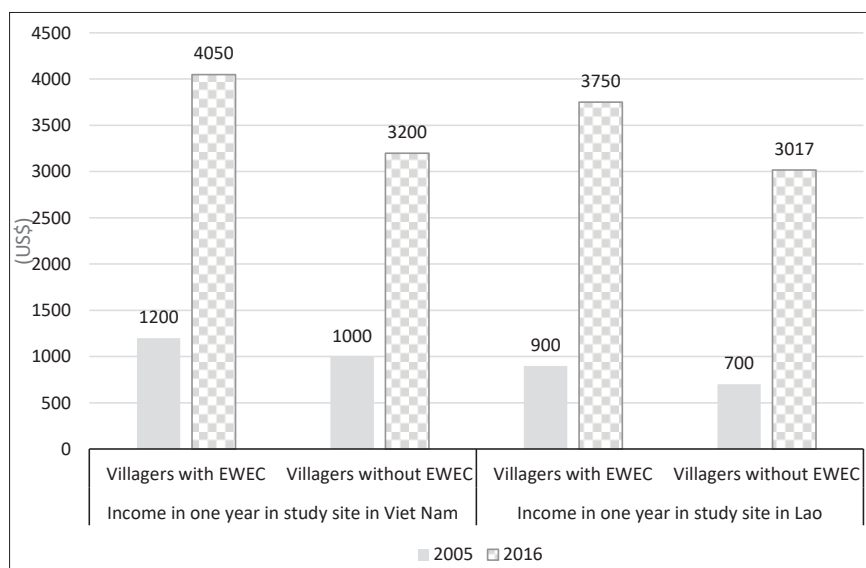
The study shows clear evidence of waves of incoming migrants into villages located along the EWEC supported by government resettlement programs and the free migration of households seeking business opportunities directly related to the EWEC or for non-farming jobs, such as timber processing, timber and agricultural produce collectors, thus causing more pressure on forest resources and local employment. Large areas of forest land have been allocated to migrant households for residential and production purposes, particularly in Savannakhet province, Laos. Among the surveyed households, 26.3 percent confirmed their migration to villages along the corridor in the Vietnam sites and about 29.5 percent of households had migrated to villages in Savannakhet, Laos. Meanwhile, less than 5 percent of forest-dependent villagers of

working age who participated in this survey migrated to seek jobs. Very few young locals found employment in non-farming sectors along the EWEC. Fewer original households established services along this corridor; most of the services located along the EWEC were established by migrant households.

Household income is an important indicator of the impact of the EWEC on forest-dependent villagers. The study provides clear evidence that there is a significant difference in income between the two groups of households “before and after” for the Vietnam study sites. The income of households living along the EWEC has significantly increased from VND26.95 million to VND97.42 million per household over the first ten years of the EWEC (equivalent to US\$1,200 in 2005 to US\$4,050 per household in 2016) in Vietnam. In Vietnam, the sources of income were diverse with agriculture, including annual and perennial cash crops, the main source (57 percent of the annual income). The second most important source of income was pig and poultry farming. However, participants in the focus group discussions reported that the profits from pig and poultry farming were much lower than in 2005 due to price fluctuations. Households living along the EWEC have had more opportunity to improve their income by adopting non-farming activities such as timber collection. It should be noted that the income of surveyed forest-dependent villagers living outside the EWEC is much lower than that of forest-dependent villagers along the highway. The annual income of EWEC households was about VND21.95 million (equivalent to US\$1,000/household in 2005) and increased to about VND66.9 million per household (equivalent to about US\$3,200 per household). The main source of their income is from agricultural production and forest plantations.

There is similar evidence regarding the significant differences in income of forest-dependent villagers in Savannakhet province, Lao PDR. The income of forest-dependent villagers living along the EWEC in Savannakhet province has increased from under US\$900 in 2005 to about US\$3,750 per household compared with about US\$700 in 2005 to about US\$3,017 in 2016 of forest-dependent villagers who have no access to the EWEC (fig. 14.5).

Figure 14.5: Difference in income of forest-dependent villagers with and without the EWEC



The cost of living is an important indicator of the impact of the EWEC on forest-dependent villagers. The study highlighted that villagers living with the EWEC have a better standard of living than those living without the EWEC. The average monthly expenditure of households living with the EWEC is VND2,444,2000 per household (US\$120) compared with VND1,732,140 (US\$80) per household living without the EWEC in Vietnam. In Savannakhet province, the monthly living expenditure increased from KIP590,000 in 2005 to about KIP 1 million in 2016 (about US\$70 to US\$110). The findings also indicate that households living along the EWEC spent on more nutritious food, such as fish, meat, eggs and milk as well as on education and health care than households living outside the EWEC area. Furthermore, there were also considerable differences between the two groups of households in terms of spending on information and communication technology and services such as mobile phones, fixed line phones, and internet services.

Social services vs social capital

This study shows that forest-dependent villages have experienced a significant improvement in both education and health care since the

EWEC. About 83.6 percent of respondents living in forest-dependent villages with access to the EWEC reported an improvement in education for their children, while only 10.2 percent of surveyed households reported that there was no change. This finding ties in with the focus group discussions and key informant interviews where participants reported that, thanks to the new highway, their children had better access to high school and tertiary training. The survey in Savannakhet also confirmed better access to amenities, such as markets, schools, and health care: only 77 percent of respondents in villages outside the EWEC confirmed better access to education for their children compared with 95 percent of respondents living in forest villages along the new roads.

The new roads have created convenience and mobility, increasing access to educational and health-care services. Many forest-dependent villagers also claim that this has brought more opportunities for the younger generation, and is an important factor in enhancing human capital for long-term sustainable development. Similarly, improved access to health care was highly rated by respondents; 79.1 percent of households in the study agreed that health services have improved significantly. Nearly 95 percent of respondents often choose to go to larger clinics and hospitals in communes, districts, and even provincial capitals when family members need treatment. In Savannakhet, there is a significant difference in access to health-care services between the two groups from about 29 percent in 2005 to 36 percent in 2016 for forest villagers without access to the EWEC compared with about 39 percent in 2005 to 48 percent in 2016 of villagers living along the EWEC. Survey participants in Thailand also confirmed the important contribution of the highway to better access to social services, including education, health care, job opportunities, and markets.

Forest-dependent villagers living along the EWEC mainly come from low-income households who are often classified as poor or semi-poor. The lack of capital is one of the most common difficulties constraining them from adopting new livelihoods. Some 65 percent of total surveyed households living with the EWEC had access to different sources of loans to meet their demands compared with about 48 percent of surveyed households living further away. The former often have access to formal banking systems, including Farmers' Associations, Vietnam Women's Union, Bank for Agriculture and Rural Development, and Bank for Social

Policies, with lower interest rates, while many villagers living outside the EWEC have to rely on informal banking (i.e. credit) systems where they are charged higher interest.

Another significant difference is in the quality of housing. Over 51 percent of villagers living along the EWEC reside in permanent and semi-permanent houses, while about 49 percent of surveyed houses have been living in weak or temporary houses. Meanwhile, up to 84.5 percent of total surveyed households from forest-dependent villages outside the EWEC zone lived in poorly built or temporary houses, with only 14.5 percent of surveyed households living in permanent or semi-permanent households. The results mean that forest dependent villagers living along the EWEC have better and safer housing than those living away from the highway. There has been some but not statistically significant difference in housing conditions of forest-dependent villages as a large proportion of surveyed households living along EWEC and villagers living away from the EWEC confirmed similarities in their housing conditions between 2005 and 2016.

The study also investigated the EWEC's impact on community cohesion and unlawful activities. The results revealed a significant change in both between the two groups of villagers. Villagers living along the EWEC tend to adopt to modern life by replacing unpaid communal labor associated with house building, crop harvesting, and participation in various ceremonies, including weddings and funerals, with daily paid labor or services. Young laborers living in villagers near the EWEC tend to have more free time; hence, they have also adopted some bad habits such as speeding, drinking excessive alcohol, and gambling. These trends are potential risks to their communities and livelihoods. Meanwhile, forest-dependent villagers living outside the EWEC still maintain community cohesion, helping each other out for house construction, weddings, harvesting, and traditional village festivals.

There has been a significant increase in social violence and crime in villages along the EWEC. About 38 percent of total surveyed households confirmed the rapid increase in violence since the highway was completed, including drug trafficking, gambling, and theft (particularly of cash crops such as bananas, coffee, and latex rubber). The discussions and interviews conducted in Vietnam and Laos revealed that since the EWEC, the burgeoning vehicle traffic and cross-border trade has also enabled drug trafficking, prostitution, and smuggling in the border areas.

Risks and challenges

The biggest risk to forest-dependent villagers' livelihoods is the impact of the GMS 'prosperity narrative'. Thailand, Vietnam, and Lao PDR have used the prosperity narrative to promote the EWEC, arguing that it would attract more private investment, improve infrastructure, increase cross-border trading, develop agricultural markets, tourism, jobs and reduce poverty. There were no plans or policies specifically for sustainable forest development and protection. While most narratives focused on the EWEC's successes, such as raising cross-border trade turnover, improving transportation infrastructure, and attracting private investment, some also expressed concern about its potential pitfalls, including challenges to sustainable livelihoods.

First, vast areas of forest and agricultural land were allocated for infrastructure construction and SEZs, and not many local villagers were able to get jobs in the EWEC's construction. As mentioned, many private investors have withdrawn from SEZs or commercial zones along the corridor, hence the EWEC has not necessarily attracted more private investment or generated new non-farming jobs.

Second, while the EWEC has boosted cross-border trade among GMS countries, particularly between Vietnam and Lao PDR, this trade largely consists of products obtained from the exploitation of non-renewable natural resources (timber, copper, gypsum), and some consumer goods. Thus, once natural resources are exhausted or export restrictions are applied, the cross-border trade turnover will significantly decrease.

Third, in-migration has increased along the EWEC. Migrant households have better resources to establish farms and provide non-farm services, such as running grocery shops, liquor stores, timber processing, and agricultural collecting agents than the local forest-dependent villagers. Many migrant households now own a farm and acquired land from local villagers to expand their farm. This often means that the locals face land loss, deforestation and competition over livelihood resources.

Fourth, while the EWEC has led to the rapid development of cash-crop production in this region of the GMS, it has left forest-dependent villagers vulnerable to fluctuating markets and prices. This study also revealed that local governments could not control land use at the village level. For instance, in the mountainous Huong Hoa district, the government allocated 600 ha for banana plantations, but villagers were

cultivating 6,700 ha of bananas in 2015. The overall position of forest-dependent villagers in the agricultural supply chain is very weak. Forest-dependent villagers earned about 35–40 percent of the total net profits in the agricultural supply chain, but paid about 80 percent of the total cost of agricultural products. Meanwhile, about 90 percent of crops such as bananas, ginger, and coffee, as well as rubber, are exported to regional markets, mainly to China. Export prices fluctuate dramatically and are dependent on the Chinese market, which is driven by collaboration between key middlemen and Chinese importers (see Bui and Pham 2018). This explains why forest-dependent villagers often change their crop patterns and have to deal with “good harvest, bad price.” Consequently, many forest-dependent households are now in debt.

Finally, since the adoption of market-oriented agriculture with fewer resources, forest-dependent villagers expanded their farms and adopted mono-crop production. Thus, they face more risks to their livelihoods, including unstable markets, climate change-related risks, and policy changes. Many of them are poorer households with fewer resources. This study indicates that the livelihoods of forest-dependent villagers have become close to being unsustainable since the introduction of the EWEC.

Conclusion

The vision of a more interconnected and prosperous Mekong Region criss-crossed by economic corridors was created by Japanese aid experts, scripted by the ADB, and enacted by governments and big business. The narrative of roads bringing investment, trade, and wealth to forest-dependent villages is of course an older concept and a cornerstone of the lexicon of the World Bank (Lima and Venables 2001). In the GMS, economic corridors were the initial priority, and created opportunities from the start for Japanese banks, construction firms, and later for industry at large. The power of the promise of shared prosperity brought about by road construction lies in the way that governments have simplified its complex realities, denying possible victims, burdens or risks (Robertson and Colic-Peisker 2015). This study shows that policy narratives may influence the decisions which lead to the financing and construction of roads, bridges, and border posts (Bui 2018).

The EWEC’s contribution to the socioeconomic development of forest-dependent villages in its path as well as economic regionalization

in the GMS is widely recognized. This is consistent with the conclusion of previous studies by Guina (2008), Isono (2010), Lord and Tangtrongjita (2010), and Phuc and Kalkins (2012). The EWEC is an important factor contributing to the success of many cross-border agreements among the GMS countries, such as between Vietnam and Lao PDR, Lao PDR and Thailand, Thailand and Myanmar, and among all four countries. There has been also a significant increase in cross-border trading of mainly natural resource and consumer goods as well as non-farming activities in villages along the corridors (Bui et al. 2005; Phuc and Kalkins 2012). However, the SEZs and commercial zones along the corridor, particularly in Vietnam and Lao PDR, have been largely unsuccessful.

It is true that the EWEC has given forest-dependent villagers better access to regional markets and some jobs. The corridor has generated jobs in the non-farming sector, but not for local villagers. Instead migrant labor and households with better resources and suitable job experience have taken these opportunities to develop services and farming/non-farming employment, thus putting more pressure on natural forest resources. With fewer skills and less know-how required for work in these new industries, locals cannot make use of potential opportunities, and their livelihoods remain largely embedded in subsistence agriculture and natural resource extraction (Gachassin et al. 2010; Henning and Saggau 2012). Some forest-dependent villagers have adopted market-oriented crops, such as bananas, cassava, ginger, and coffee, with up to 90 percent of product volume being exported to regional, mainly Chinese, markets; however, they lack market information and their position in the agricultural supply chain is weak in comparison with other actors. The indigenous villagers are vulnerable to collectors cum traders and price fluctuations. Their livelihoods are now more exposed to market risk, deforestation, and climate change.

It is also important to acknowledge that the EWEC has improved access to social services and assets, such as better education for the young, health care, housing, and access to credit. However, the EWEC areas show a decline in social capital among forest-dependent villagers and an increase in illegal activities and violence.

While this study has focused on transportation infrastructure, we believe our key findings related to economic cooperation and resource governance are relevant to examining other large-scale water, energy, and telecommunication projects in the Lower Mekong Basin and other areas

where economic integration is being promoted or pursued. In market-led regional development, nation-states give up some of their power to the private sector and international banks. National security is downplayed as international cooperation turns “battlefields into marketplaces,” and borders grow more porous. Transboundary agreements are reached by representatives of states and not by local residents or farmers who have to live with the consequences of such agreements. As private actors take on larger and larger roles, it is less clear where accountability lies. Shared prosperity, poverty reduction, and socioeconomic development are fine objectives of large-scale infrastructure crossing multiple borders; however, the reality of fair distribution of benefits is filled with burdens and risks which threaten the livelihoods of vulnerable forest-dependent villagers. Policymakers and implementers in the GMS countries must take into consideration forest resources and the actual needs of local villagers for sustainable regional development and poverty reduction.

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15

Gender Roles in Farming Systems in the Mekong Delta Floodplains, Vietnam

Tran Thi Phung Ha

Women in the Vietnamese Mekong Delta, in particular the poorest, have fewer livelihood and job opportunities and resources than men in the face of natural resource scarcity, environmental degradation, and extreme weather events (Hue 2009). These constraints add to the difficulties of women who seek to improve their family incomes and participation in the new market economy alongside maintaining their roles both in terms of production and reproduction (Werner 2002). In these agricultural households, women contribute more working hours than men to cultivation, livestock breeding, agricultural processing, and marketing. Despite their essential contribution to family income, livelihoods and well-being, women continue to face cultural and institutional barriers to accessing key resources, including land, loans or financial services, extension services, and skills training, all of which in turn limit their involvement in rural development decision-making (MARD 2003).

Throughout Vietnam women account for 60.5 percent of the rural workforce and this proportion has increased due to the outmigration of men to the cities in search of jobs (UN Vietnam and Oxfam 2012). Men from rural areas migrate to the urban centers, leaving behind women, the elderly and children. The absence of their husbands heavily burdens wives who are left to maintain the family's agricultural and other forms of household production.

Attitudes toward women's roles, values, and behavior in Vietnam have been shaped by Confucianism, Marxism, and other influences. For example, Confucianism states that a woman's virtue is in following, not leading; thus, the "ideal" woman always follows the man (her father/brother before marriage, or husband/son). Nevertheless, since the twentieth century researchers have attempted to assess women's issues

while emphasizing their roles in agriculture using rights-based gender analysis (Duong 2001). A range of gender mainstreaming policies have been developed to empower women, improve their access to education and credit, and promote gender equality (Wells 2005). These policies aim to provide safer and fairer working conditions and economic benefits for women, enhance their socioeconomic status, legal rights and promote gender equality. For instance, the Land Law and Family and Marriage Law in Vietnam require the names of both husband and wife on land and property certificates. And some micro-credit loans are available for women to expand their own businesses or diversify their livelihoods.

The most prominent organization working to support gender equality is the Vietnam Women's Union (VWU), a mass organization with about 12 million members, which supports poor, rural and remote-area women and women in disadvantageous situations or who are suffering from the negative effects of economic change (Wells 2005). However, it is still difficult for many women in rural areas to sign up for such programs due to the lack of information and accessibility (UN Women 2005). Although working environments, health-care services and access to infrastructure are slowly improving for most Vietnamese women (Scott and Chuyen 2007), in the rural areas in particular, there is still a need to greatly boost their capacity to access useful social networks and training, in order to build their confidence, motivation and resilience.

This study aims to understand rural women's participation and opportunities in the agricultural sector, their challenges in terms of household income generation, accessing natural resources, and improving their social lives and well-being. The findings suggest policy interventions that should help to improve gender equity in the floodplains of the Vietnamese Mekong Delta (VMD), all of which will also contribute to improving livelihoods and income in these communities.

Methods

Study sites and samples

This research was conducted among women involved in seven agricultural systems (i.e. double rice, triple rice, rice-upland crop, rice-aquaculture, floating rice-upland crop, inland fisheries, and services) in four districts of An Giang and Dong Thap provinces in the VMD.

Key informant interviews (KIIs), focus group discussions (FGDs) and a household survey were carried out between May and October 2015. Qualitative and quantitative data were collected on historical changes in gender roles, women's participation and difficulties in agricultural production, their needs and expectations, legal rights and social barriers, living conditions and capacity to access infrastructure in order to improve the design and implementation of gender development programs.

We began with several KIIs at the district level, with participants from VWU and the local Division of Agriculture and Rural Development (DARD). At the same time, secondary data on agricultural management and production and socioeconomic development plans were collated from district and provincial censuses and reports. Four FGDs were conducted at the commune and district levels with official leaders, experienced female farmers, VWU and agricultural officers. The FGDs included discussions of how to enhance women's participation in various farming systems. A sample of 120 households (HHs) was selected through a balanced sampling of women in the various farming systems (see table 15.1), 88 percent (105) of whom were wives.

Table 15.1: Distribution of sampled HHs by farming systems in four districts (no. of HHs)

Farming systems	An Giang		Dong Thap		Total
	Tri Ton	Chau Phu	Thanh Binh	Hong Ngu	
Double rice cropping	6	7	7	10	30
Triple rice cropping	7	6	4	4	21
Rice-upland crop	0	5	3	0	8
Rice-aquaculture	0	0	0	5	5
Floating rice-upland crop	7	0	13	0	20
Inland fishery	3	7	4	8	22
Services	5	4	4	1	14
Total	28	29	35	28	120

Analytical framework

The research used the frameworks of Niehof and Price (2001) and Hahn et al. (2009) to identify socioeconomic and environmental factors that may affect vulnerabilities, i.e. the difficulties affecting women's lives and livelihoods. These factors were grouped according to three levels:

personal, household, and environmental; these three were further categorized into “material” and “non-material” factors. At the household level, all of these factors were seen to interact with wider structural phenomena (see table 15.2).

Table 15.2 Material and non-material factors that may affect women’s livelihoods

	Personal level	Household level	External environmental level	
			Natural	Man-made
Material	Health	Income, land, labor, amenities and farm implements	Natural resources, land, water, climate, biodiversity	Physical, infrastructure
Non-material	Skills, knowledge, experiences, understanding, perceptions of well-being, risk taking	Household management, culture		Institutions, policies, services, markets

Sources: Adapted from Niehof and Price (2001) and from Hahn et al. (2009).

The twelve difficulties that the women face were divided into four groups:

- Group 1: *Socioeconomic* difficulties at the household level: i) poverty, low income; ii) overwork/exhaustion; iii) less chance to access know-how and education; and iv) few job opportunities.
- Group 2: *Environmental* difficulties: i) pollution; ii) harsh weather; and iii) natural resource degradation.
- Group 3: *Infrastructure*: i) the lack of or badly maintained roads; ii) inadequate electricity; and ii) water supply. In particular, the study highlighted health problems caused by a poor quality and polluted water supply.
- Group 4: *Non-material* difficulties: i) no relatives/extended family or other community networks for support and help; ii) isolation in the remote rural areas; iii) stress; and iv) absence of land ownership.

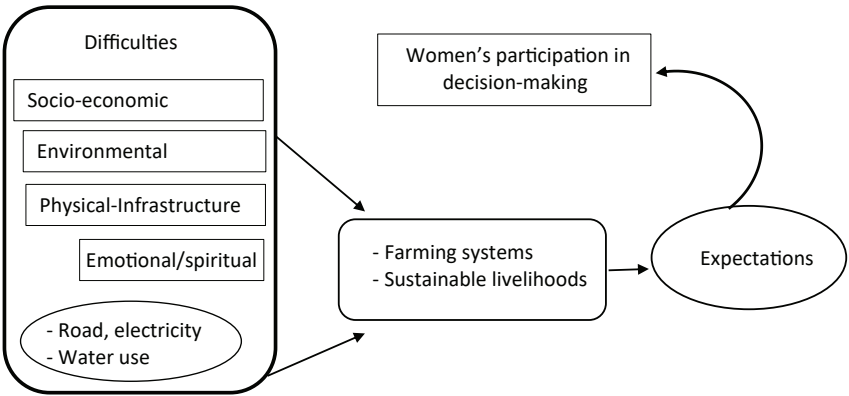
The factors related to water availability are the riverine topography, river system, floristic composition, soil composition, rainfall, water pollution and sanitary conditions, water quantity and quality, and sociocultural norms relating to water usages. We assumed that difficulties

in accessing water directly affects human health and acts as a barrier to agricultural production. Time- and energy-consuming water collection may be preventing women from doing more productive jobs, child-rearing, learning new skills and improving their knowledge.

Respondents were asked to state a few of their life aspirations or expectations ranked in order of importance. These expectations were grouped in relation to the women themselves, their families, and the community. We selected the three most important and frequently cited expectations among respondents and analyzed the trends and values this revealed about the women’s perceptions. We combined this information with open-ended questions to better understand the role of women as the main actors in household agricultural production and livelihood strategies.

Within the framework of this study (fig. 15.1), the four groups of difficulties were always present and affected everyone engaged in all the local farming systems, even if in different ways. Individual women perceived their level of difficulty differently according to their capacity to participate and contribute to decision-making processes. We assumed that the more women were able to access necessary resources or participate in decision-making, the fewer difficulties they faced. Notably, women used various means to overcome their difficulties and improve their livelihoods, hence all items in the framework were interlinked, multifaceted, and influenced each other (Tran and Binh 2014).

Figure 15.1: Framework for studying gender issues in agriculture-based livelihoods



Surveyed respondents were asked to rank the above 12 difficulties into five levels, ranging from not difficult to extremely difficult. To identify the relationship between qualitative and quantitative parameters we used SPSS to calculate the frequencies of women's participation in farming; ANOVA to test bivariate-correlations of the level of difficulties; and Crosstab to figure out the ratio of water use for domestic use and agriculture in different farming systems. Pearson's chi-squared correlations were run to examine the relationships between independent variables of women's roles, participation, difficulties and expectations in different farming systems.

Results and discussion

Farming systems

The FGDs in the triple rice farming area show that the largest rice harvest is in the autumn, following a spring and summer crop (table 15.3). The triple rice farming area has well-constructed dike systems that allow farmers to cultivate rice or upland crops during the flood season. In the floating rice system, people cultivated cassava or chili in the dry season and floating "long-duration" rice in the flood season. In general, the triple-rice system yielded VND50 million per ha per year while the upland crop yields varied according to market prices; however, upland crop yields were always higher than that of rice alone, and required more labor at harvest time. The quality of infrastructure and social conditions, e.g. transportation, electricity, water supply, healthcare, schools and markets, differed among the systems. Triple rice farmers had better infrastructure and used higher levels of mechanization; nevertheless, this system provided fewer job opportunities and created a wealth gap. In all agricultural systems, many people migrated seasonally for short periods every year to find substitute incomes after the harvest, or for longer periods when faced with very poor harvests, environmental degradation or severe weather events.

Gender division in farming systems

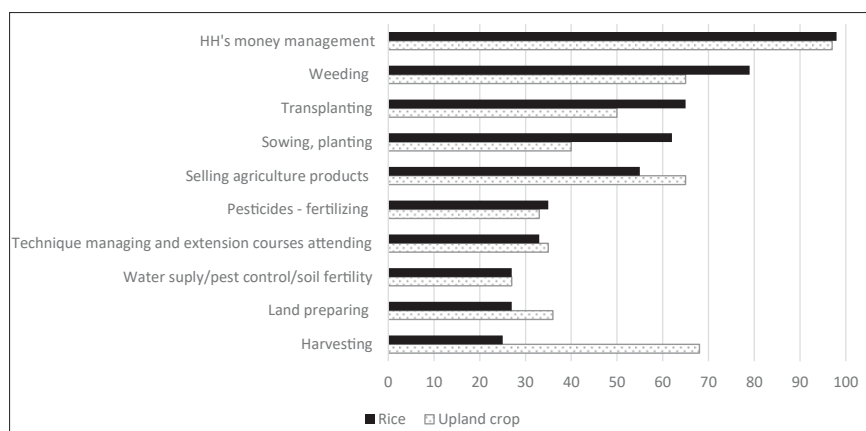
In *rice cultivation*-based systems (i.e. double rice, triple rice, rice-upland, floating rice-upland), the distinctions between male and female tasks were

Table 15.3: Focus groups and farming systems in the research sites

Places	General information	Farming characteristics
Village: My Thuan Commune: My Phu District: Chau Phu Province: An Giang	<ul style="list-style-type: none">- Good infrastructure- Revenue ~ VND50million ha/year/triple rice- Mechanization	Three rice crops Monthly → 4 11-12-1 3 7 11 Winter-Spring Spring – autumn 3 rd rice
DARD at district level District: Chau Phu Province: An Giang	<ul style="list-style-type: none">- Good infrastructure- Wealth differences- High migration rate- Price of crop fluctuation	Double rice + vegetables (onions, cucumbers, bitter melons, chilis, pumpkins) Monthly → 4 11-12 3 7 11 Winter-Spring Spring – autumn 3 rd crop
Village: Cay Gon Commune: Luong An Tra District: Tri Ton Province: An Giang	<ul style="list-style-type: none">- Rural area- Poor infrastructure- No flood in 2015- floating rice 2 ton/ha (VND12,000 /kg)- Crop: Cassava (net income VND45 million/ha/year	Floating rice + crop (cassava, spring onions, watermelons, chilis) 2 Monthly → 6 12 <- Crop -> <- Floating rice ->
Village: Tan Thanh Commune: Tan Long District: Thanh Binh Province: Dong Thap	<ul style="list-style-type: none">- Good infrastructure- no flood in 2015- price fluctuation- high migration rate- Floating rice and chili- Revenue from chilis: VND60 million /ha/year	Floating rice + crop (chilis, corn, spinach, okra) 12 Monthly → 6 12 <- Crop -> <- Floating rice ->

blurred and their labor was frequently interchangeable. However, more women than men performed so-called “light” tasks in the fields such as pulling up and transplanting seedlings, hand-weeding and looking after fields (55–80 percent). Women also assisted the men in “heavy and technical tasks” such as preparing or clearing the fields, applying fertilizers and pesticides, mechanical harvesting, hauling and transporting products (25–35 percent) (fig. 15.2). Men were more motivated to attend training workshops to learn and improve mechanical and technical know-how and skills (>70 percent); thus, nearly all men played an active role in cultivating their own fields, and many who owned their own small farms also undertook paid work on neighboring fields. For instance, while spraying pesticides or fertilizers was considered a heavy, hazardous and technical job suitable for only men, it could earn them about VND200,000 per day.

Figure 15.2: Women’s participation in rice and upland crop farming (%)



In *upland crop cultivation* (rice-upland and floating rice-upland crops), as in lowland rice farming, women were active in marketing and selling the harvested rice, and were mainly responsible for safekeeping the earnings (65–97 percent) (fig. 15.2). Here too, they were responsible for supposedly “light” tasks such as sowing, weeding and protecting plants (40–65 percent) but also assisted the men in more technical tasks such as applying pesticides and fertilizers and joining them in extension training (30 percent). Women earned extra income from growing secondary crops

for sale (pumpkins, chillies, and other vegetables) and they also performed the major proportion of the post-harvest packaging, storage, preparing, and marketing (up to 90 percent).

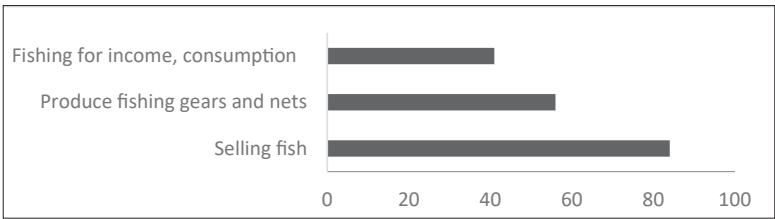
The extent of women's participation in this system was also a function of farm size. In small-scale farms, women participated in most activities and assisted the men with the heavy tasks; on larger farms that relied heavily on mechanization, women worked on domestic tasks while female laborers from landless families were hired for heavier tasks to complement the mechanized work carried out by men. For instance, using a machine one man can harvest a crop of cassava, beans or onions, but he needs four women to prepare, package, store, and market the products. There were plenty of part-time jobs for women in non-rice farming. However, even when men and women shared precisely the same type of work on the field, the women laborers were paid less since they are perceived as physically weaker. They received VND100,000 per day (6 a.m. to 2 p.m.) for work in the fields; domestic work earned even lower wages.

The analysis also showed that women showed more skill in performing "light" and "routine" tasks; unlike men, the more often women performed so-called routine tasks, the more motivated they felt. Women preferred working in-house and could multi-task while the men preferred to concentrate on one task at one time. Men tended to take on "big jobs" and make higher investments, tended to work for cash, and believed themselves the "backbone" of household finance. They attend more agricultural extension training, dominated access and control over resources, including local meetings, the means to migrate, technical and mechanical agricultural knowledge, education and communication. More women than men in households were responsible for saving the family earnings because women were believed to be "domestic banks" and better financial managers. Most women worked very hard, spent less on themselves than on the rest of their families, and budgeted carefully for household expenditure, food, healthcare, children's education and other needs.

Customarily, women in this region rarely engaged in offshore or long-distance fishing due to the labor required and social taboos (i.e the belief that women bring bad luck on boats). Hence, women more commonly undertake subsistence and small commercial inland (or near-shore) fishing using small boats. Therefore, in the research sites, the role of women in *fisheries* was not recognized or under-valued (fig. 15.3). During the severe

drought in An Giang and Dong Thap provinces in 2015, fish stocks declined so much that many men and women had to migrate in order to find employment. If the men migrated alone, 40 percent of wives left behind had to take over men’s tasks, including catching fish for family consumption and sale. Overall, 56 percent of women also played a major role in important fishing-related activities: preparing the equipment, making fish traps (from bamboo) for sale, mending nets, preparing provisions for the fishing trips, and sorting, drying or fermenting and marketing the catch.

Figure 15.3: Participation of women in inland fisheries (%)



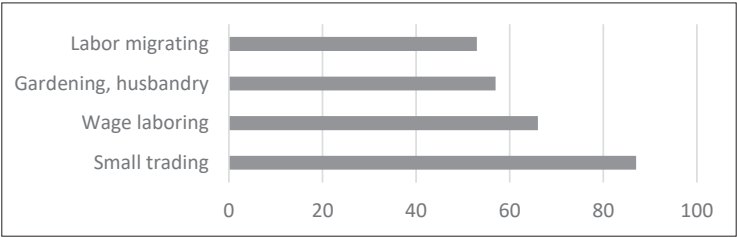
Case 1: Livelihood of an inland fishery-based family

We were relocated to this resettlement area over ten years ago. In the first years life was so easy that we fished in the flood season and made bamboo fish-traps to earn cash in the other (season). Recently there has been neither fish nor water; thus, nobody wants to buy the traps anymore. My children have to go to Binh Duong province [industrial zone near Ho Chi Minh City] to earn an income and left their children with us. Life is so expensive that their salary is not enough for whole family. We struggle to survive. (Mr. Hung, age 65, Binh Thanh commune, Hong Ngu, Dong Thap)

Besides their multiple roles and responsibilities as mothers, women in the research sites had productive roles as earners of income from non-farm activities. Many women ran small businesses like grocery shops or were street food vendors (87 percent). Others worked as paid laborers on farms nearby (66 percent) or migrated temporarily to the cities (53 percent); raised livestock or grew vegetables on garden plots (57 percent). In other words, most women in the research sites often managed complex household tasks while pursuing multiple livelihood strategies. Their

activities typically included trading and marketing, cultivating food crops for home consumption because they were concerned about family nutrition, securing potable water, and looking after their children’s health and education. Although all these are essential to the well-being of rural households, and allows the men time to farm or fish, women’s domestic responsibilities and small-scale trading is not defined as “employment” and usually not valued by the community due to being seen as supplementary and lower sources of income.

Figure 15.4. Role of women in diversifying livelihoods (%)



Gender and decision-making

For the smooth running of a family, it is important for men and women to have equal status in making decisions on household issues or goals. Women in the research sites dominated in consulting with their husbands on almost all issues such as “whether or not to join community activities or participate in communal organizations” to have a chance to access networks for help (82 percent). Many women were also willing to participate in local “religious or charity groups”. Many discussed with their families “whether or not they should shift to other agricultural systems, or to diversify their livelihoods to generate income” (77 percent). Given their knowledge of market prices and negotiating with customers, women usually advised their husbands “where to buy the inputs and which cost is feasible, when and where to sell the harvested crop,” etc.

In general, because women were seen as being better at “household-related” tasks, they made decisions on most “inside” (domestic) activities; they were less consulted on “technical” issues, such as “what kind of fertilizers and pesticides would be used and when” or “who would be hired for which activities and when” (51 percent). Table 15.3 shows that

there were significant correlations among the seven farming systems in terms of women's advisory role. While women in rice-aquaculture dominated consultation on every issue (88 percent), women in the rice-upland crop system (50 percent) were least consulted about matters affecting their households on every item, showing that while the latter perceived their roles in production positively they were passive in household/family decision-making.

Table 15.4: Women's participation in providing help, comments and advice (%)

Women's consultancy	Double rice	Triple rice	Rice – crop	Rice-aquaculture	Floating rice – crop	Inland fishery	Services	Average
Participation in the communal networks for farming	87	90	62	80	75	77	86	82
Shift to another farming system ^a	90	62	62	100	90	64	71	77
Diversifying in agriculture	83	71	62	80	80	77	71	77
Investment cost or price of agricultural products ^a	87	62	25	100	75	86	50	72
Change the farming technique ^a	60	48	38	80	50	54	29	51
	81	67	50	88	74	72	61	72

Note: ^a Denotes significant differences between means within rows ($p < 0.05$)

It was found that women were consulted on different household issues, but their right to make decisions was suppressed by the dominant man or men of the household (fig. 15.5). Women contributed very little to decisions about joining self-help networks, marketing inputs and outputs, or diversifying incomes (5–19 percent); and on the issue of changing farming techniques, they left the decision to the men entirely.

The overall findings suggest women's participation in decision-making remained very low (<20 percent) both in high and low income households (figs. 15.5, 15.6). However, notably, women in low income households were more likely to participate in making investment decisions than those in high income households (20 percent and 5 percent respectively); only 8 to 16 percent of women in high income households made decisions to

Figure 15.5: Participation in decision-making (% of women, men and both)

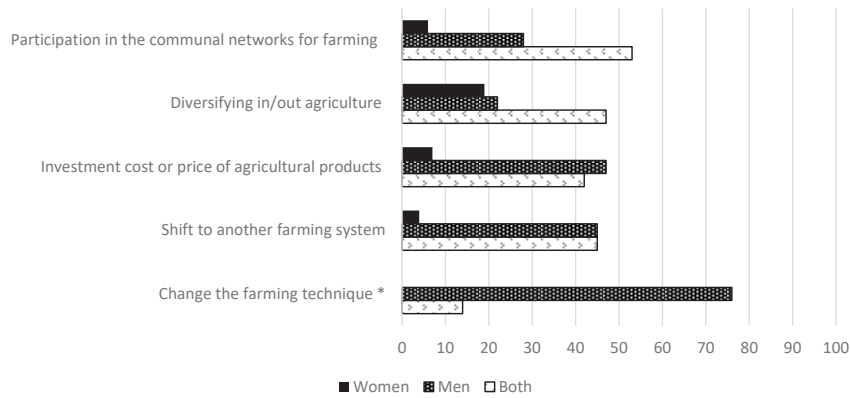
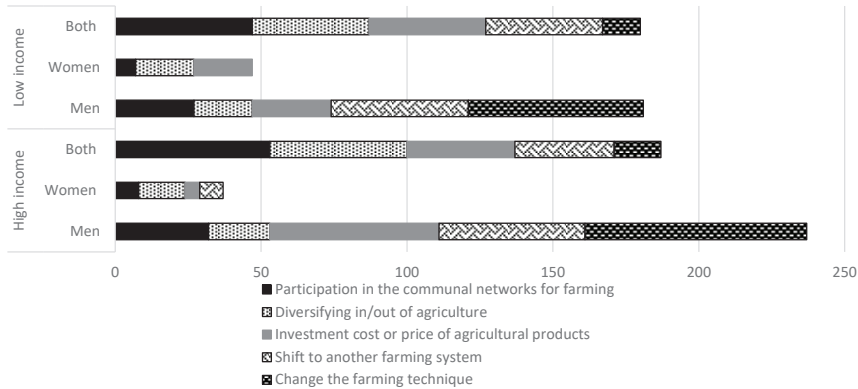


Figure 15.6: Participation of men, women or both in farming in decision-making in lower and higher income households



shift to another farming systems or diversify their livelihoods. The overall participation rate of women in decision-making was very low compared to that of men's, particularly, in the high income households, where up to 75 percent of men made solo decisions to apply new techniques in their farms. The big gap between women's and men's decision-making shows that women customarily followed men's decisions, especially on issues related to the main source of household earnings. Women's domestic roles were seen as a priority; so that they might make more decisions on childcare, marriage and the education.

Gender difficulties

Income generation

Most respondents were living in nuclear families of which 69 percent were male-headed and 12 percent female-headed; however, this didn't correspond to the general poverty rate of 12 percent for all samples. There was significant correlation, however, between household wealth and farming systems, with higher income groups more dominant in the rice-crop system (75 percent); whereas fewer households practicing inland fishery (46 percent) had higher income (table 15.4). Income variation among groups was directly proportional to the number of samples. In this study, low, middle and high income is defined as households earning an annual net revenue of VND42.4; 82.1 and 112.1 million respectively.

Table 15.5: Income distribution and gender in farming systems (% HHs)

Women's consultancy	Double rice	Triple rice	Rice – crop	Rice-aquaculture	Floating rice – crop	Inland fishery	Services	Average
High income	37	43	75	20	20	9	36	32
Middle income	60	57	25	80	75	46	43	56
Low income	3	0	0	0	5	46	21	12

Socioeconomic difficulties were ranked most important to respondents, who were afraid of hardship and poverty; all aspired for their families to be better off. Table 15.5 shows that women whose livelihoods were based on floating rice-crops, inland fishing and providing services (labor) found that a decline in economic, infrastructural and natural resources affected them negatively (3.5–3.6). In contrast, women in the rice-crop systems felt the least affected by these vulnerabilities (2.6) (see table 15.6) and ranked all these difficulties lower (2.8). Job opportunities were mostly guaranteed and they faced little financial stress. These women could harvest secondary non-rice crops to sell for income as needed. This financial stability in the rice-crop system enables women to have better access to other assets, know-how and education (2.4), as shown in table 15.6.

Table 15.6: Factors affecting women in different agricultural systems, according to: household economics; natural resources; infrastructure affecting health, and social perception

Factors affecting women's livelihood opportunities, health and well-being		Double rice	Triple rice	Rice – crop	Rice-aquaculture	Floating rice – crop	Inland fishery	Services	Average
1	Poverty, low income ^a	3.5	3.8	2.8	3.4	4.3	4.7	4.5	4.0
	Overworking ^a	3.7	3.5	2.9	3.6	4.4	4.6	4.1	3.8
	Less access to skills and education ^a	3.8	3.3	2.4	3.2	4.5	4.4	3.9	3.6
	Fewer job opportunities ^a	2.9	2.2	2.4	2.2	3.9	3.6	3.6	3.0
2	Harsh nature, climate	3.4	3.5	4.1	4.2	3.8	3.9	3.9	3.8
	Reduced natural resources	3.6	3.7	3.8	3.6	3.9	4.5	3.7	3.7
	Soil degradation or pollution	3.0	3.5	3.4	2.6	3.6	3.4	4.0	3.4
3	Poor infrastructure ^a	3.0	3.4	2	2.6	3.6	3.2	3.7	3.1
4	No extended family for support ^a	2.8	2.4	2.8	1.8	4.1	3.1	3.1	2.9
	Remote location/ loneliness ^a	2.5	2.5	1.2	2.4	2.5	2.9	3	2.4
	Stress	2.3	2.3	1.9	2.4	2.9	2.3	2.6	2.4
	Having no land tenure	1.5	2.0	1.2	2.4	2.0	2.0	2.1	1.9
Average		3.0	3.0	2.6	2.9	3.6	3.6	3.5	3.2

Note: ^adenotes the significant differences between means within rows ($p < 0.05$).

In general, “poverty” was scored the greatest difficulty (4.7); particularly for women depending on inland fishing and services (4.5), and the floating rice-crop (4.3). “Too much hard work” or “less chance to study” or “no job opportunities” scored slightly higher, showing women holding or maintaining families as providers rather than heads or leaders. The results show that women were active and willing to contribute to family income and felt more responsible for managing the family budget and expenditure; loss of livelihoods or poverty likely affected these women more deeply. Landless farmers or those with small farms also found it difficult to secure their livelihoods, regardless of gender. People in these groups were strongly dependent on good weather and access to natural resources for sustaining their livelihoods; they were more

vulnerable to climate change, natural resources scarcity, a decline in fish stocks, unseasonal droughts and floods, and reduced agricultural prices.

Cases 2 and 3: Workload variation during harvest and flood seasons

Many young people migrated to the cities for paid labor, for salaries of VND5 million per month on average, depending on the employment. Therefore during the chili harvest season, the village is short of labor and we need to recruit farmhands from outside; most of them are women who travel tens of kilometers to come here daily. (Mrs. Xuyen, 57, Tan Long Commune, Thanh Binh, Dong Thap).

We are terribly busy in the cassava cropping season but have nothing to do in the flood months because there're no fish in the irrigation canals anymore. So, I return to my old hometown at that time to do non-farm labor, such as, selling in the market or working in a cafeteria, to earn a little. (Mrs. Duyen, 46, Luong An Tra commune, Tri Ton, An Giang).

Transportation and electricity

Women in the floating-rice and triple-rice systems, and service provision had less access to infrastructural support for their livelihoods and well-being in comparison with those in the other farming systems (3.6; 3.4 and 3.7 respectively) (see table 15.6), and qualified the access as inconvenient (see case study). Their locations limited access to essential services and infrastructure such as a water supply, electricity, healthcare, food markets, and children's schooling.

In floating-rice areas, the two main means of transportation were motorbikes and boats, but the paths were slippery for the bikes during the rains, and the water in the canals was too shallow at low tide for boats; both increased inconvenience and transport costs, e.g. to go to school or the market. Each village had two or three primary and secondary schools, but there was only one high school per district. Thus older children had to travel further to their schools; this meant greater costs and time spent delivering and picking children up from school.

Case 4 and 5: Poor transportation in a floating rice area

- It is expensive to go to school here, so I send my children to relatives in my old hometown to study. The older one is taking care of the younger; I visit them yearly during the flooding season. I would like them to stay with me but I have no other choice. (Mrs Duyen, 46, Luong An Tra village, Tri Ton district, An Giang province).

- The school is too far from here, and I, myself, can't ride the motorbike to take our son. In the dry season, we need to pay VND50,000 per day to take him to school by motorbike. In the rainy season, when he needs to go by boat, the cost may be double. So my husband takes him there in the morning and waits until the class ends. All house chores are left for me, while I need to work for cash as well. It's a heavy load, but we have no other option. (Mrs. Kim Em, 56, Luong An Tra commune, Tri Ton district, An Giang province).

Besides inadequate transportation, most of the other infrastructure which could improve living standards such as electricity, water services, and sanitary conditions and health services were poor. Villagers in Luong An Tra commune, Tri Ton district, could afford to buy solar kits from a private NGO project (VND3 to 12 million per kit). These generated electricity to pump up groundwater and to light up homes, allowing children to study at home and parents to watch extension training programs, and charge up their mobile phones, improving connectivity. Good infrastructure is necessary for socioeconomic development. As detailed below, access to safe drinking water is a basic human right and enables women and girls to devote more time to pursue their education or earn an income.

Domestic water supply and health

Both river and tap water were commonly used for domestic use in the research sites (56 percent and 49 percent respectively) (table 15.6). Compared to tap water, river water is less expensive but more polluted due to sediments and organic matter, and contamination by agricultural pesticides and other chemicals; thus, it was mainly used for domestic uses other than drinking (24 percent). People rarely used groundwater due to its alum content, and the high cost of installing a water station (comprising of a pump and well) (VND10 million per set). However, households engaged in floating rice agriculture had to use groundwater for domestic

use (30 percent) and for cooking and drinking (15 percent) due to the inaccessibility of tap water. Tap water stations were generally located in the center of the village and supplied around 1,000 to 2,500 households. Rainwater was a good water source in the wet season, but households had no equipment to store it for use during the dry season. For drinking, people could use bottled water, or wells and rainwater, but the last two sources were not common (5 to 30 percent).

Case 6 and 7: Water quality and supply in the floating rice area

About 30 percent of the households have wells (about 30 m deep); the others use river and rainwater for drinking. River water is muddy and polluted with alum, and needs to be treated by charcoal or by simple sediment-deposition. Nobody tests the water before use. Some houses have no water tanks or bathrooms; to save water, women bathe in the canals before having a wash at home, which causes gynecological or skin diseases. (Women in Luong An Tra Commune, Tri Ton district and Tam My Commune, Thanh Binh district, Dong Thap)

The tap water supply system was set up last year but I use this water for cooking only. We feel that it is free of charge to pump water from the canal to our water tank for washing and flushing the toilet (Women in Tan Long Commune, Thanh Binh district, Dong Thap)

River or canal water is unsafe. Water pollution can cause many diseases and affect the digestive system. Indeed, the five most common diseases in the research sites were all water-related skin infections, gynecological problems, intestinal (diarrhea), parasitic infestations (worms), and poisoning. The first three diseases were the most frequently mentioned and prevalent, particularly in the rice-aquaculture areas where 20 percent of the population used river water for domestic use and the ratio of tap water use was very high (60–80 percent) (table 15.7). The high incidence of water-borne diseases was not only caused by the polluted domestic water supply but also by toxic chemicals from pesticides and fertilizers used in agriculture and aquaculture.

Table 15.7: Distribution of different water sources according to farming systems (% of HH use)

Water sources	Double rice	Triple rice	Rice – crop	Rice-aquaculture	Floating rice – crop	Inland fishery	Services	Average
For domestic use								
River water	50	57	50	20	65	64	57	56
Tap water	63	48	50	60	20	55	50	49
Groundwater*	3	10	0	0	30	0	0	8
Rainwater	7	5	0	0	5	0	7	4
For cooking, drinking								
Tap water	63	57	75	80	55	68	43	61
River water	27	33	25	20	20	18	21	24
Bottle water	30	14	12	0	15	23	29	21
Rainwater	10	19	0	0	35	14	21	17
Groundwater*	0	0	0	0	15	0	0	2

Notes: Water treatment for domestic use is a combination of different processes according to sources of supply. Tap water and bottled water (sold without qualified testing) were considered the highest quality, thus people don't use any treatment methods. In contrast, rainwater, groundwater and water from rivers contain bacteria, chlorine, pesticides, alum or inappropriate pH levels, various contaminants harmful for human health.

Table 15.8: Common diseases in research sites (% of responses)

Water sources	Double rice	Triple rice	Rice – crop	Rice-aquaculture	Floating rice – crop	Inland fishery	Services	Average
Skin diseases	37	29	25	60	40	41	29	36
Gynecological problems	10	19	0	40	10	23	14	15
Diarrhea	17	5	13	20	25	0	0	11
Total	64	53	38	120	75	64	43	62

Emotional and psychological well-being

Traditionally, married women are expected to leave their families to live with their in-laws. They are expected to respect their husbands and older sons and in turn expect male family members to protect them. One consequence is that married women become “strangers” in their in-laws’ neighborhood and may experience great difficulty in settling down or assimilating; however, our informants did not indicate such troubles or stresses nor did they report feeling lonely or isolated (1.9–2.9) (table 15.6). However, women who farmed floating rice mentioned that they were stressed due to the lack of an extended family whom they could call upon for help (4.1) (table 15.6). Although VWU actively promotes policies to benefit women, its practical influence is limited due to the isolation of many communities (Wells 2005). The women here preferred to join “informal” voluntary or charity or religious groups. They cooperated with their neighbors or in-laws, learned with and from each other, shared experiences and knowledge, all of which created opportunities for autonomous improvements in their livelihoods. Joining these networks and organizations helped women living in isolated Delta areas to access larger networks for know-how and credit, support and services. Therefore, informal social networks were seen as more important than the VWU in the research sites.

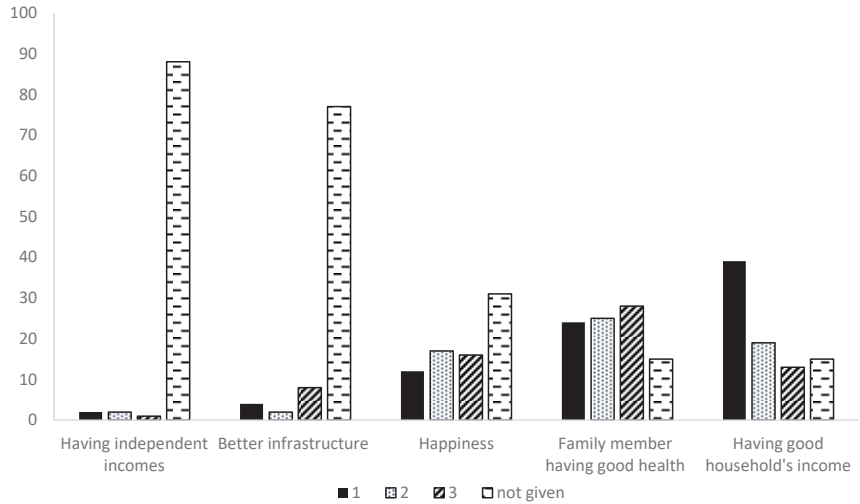
“Loneliness” was not rated high on the scale of difficulties (2.4) (table 15.6), but its incidence increased with male out-migration. Although the migration of husbands and sons played an important role in supplementing household income, especially during the flood season, interviews showed that the women left behind were stressed and lonely during the migration-season. Many women dreamed of having agricultural-processing factories in the villages to provide jobs for all the family members or to sell their products to at a higher price.

The research found that women underestimated the importance of not being legal co-owners of their land, giving it the lowest score (1.9) in table 15.6. Women trusted in their husbands and the traditional system of *của chồng công vợ* (husband’s property, wife’s effort); they preferred to have a “de facto” share of the land rather than securing it legally. Rather than insisting on having their names on land-use certificates, they wished to avoid conflict and insecurity in their families.

Women's expectations

The women were asked to list their hopes or expectations in order of importance. Women always raised family issues, hoping for: improved household financial status (34 percent), good health for all family members (24 percent) and happiness (12 percent). These three expectations were frequently repeated among respondents; whereas, expectations for themselves e.g. having an independent income, being respected in the village, having chances to attend agricultural extension training, better chances for education, time to relax and travel, etc., were rarely expressed (88 percent not given). Despite its importance, better infrastructure was listed as less important. In general, the emphasis on hopes for the family indicated that the women's domestic perceptions and "backward" attitudes endured; this perhaps was the result of a thousand years of Confucianism.

Figure 15.7: Women's expectations ranked by level of importance (I: most important; II: important; III: less important, not given: no answers)



Conclusion

Overall, the findings of this study confirm the significant role of women in agriculture and livelihood strategies in this part of the Mekong Delta of Vietnam. Women participate in all farming activities, are responsible

for handling household finances and saving money, child-rearing and maintaining family well-being; however, they seem to prefer leaving important decisions to their husbands. Working conditions, sanitary and social infrastructure services for women are still relatively poor, varying according to different farming systems, eco-agricultural conditions, accessibilities and household financial status.

Long-standing cultural beliefs and various environmental and other factors may be acting against women becoming more involved in agricultural decision-making in the Delta region. VWU and other organizations should actively promote women's participation by improving their capacity to earn a fair income and be recognized for their productivity. Hence, we recommend that more research is needed on capacity building for women; gender adaptation in the context of agricultural and domestic water shortages; the linkages between gender, climate change and migration; the barriers to personal, family and community decision-making and how to involve them in the broader development of their local economies and communities.

Acknowledgments

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16

Implications of Rubber Land Concessions on Local Resource Governance in Cambodia

Oulavanh Keovilignavong and Diana Suhardiman

The economic land concession (ELC) policy to promote agricultural industries in Cambodia has been criticized for its ineffectiveness and adverse socio-environmental impacts. This chapter contributes to the debate by highlighting how a rubber land concession has changed one community's access to livelihood resources and transformed gender roles in farming. This case study of the Sopheak-Nika Company ELC in Sesan district, Stung Treng province, employs concepts of access, resource governance and gender to examine the impacts of the rubber ELC on the local Brao community. This chapter reveals how the Brao community in Sesan has had to adopt off-farm strategies to sustain their livelihoods, following their reduced access to communal forests. From a policy perspective this study urges a greater role for local government in natural resource governance, beyond their current role as the central government's extension agents, towards more accountable decision-making.

Dating back to the French colonial period, land concessions in Cambodia have been presented as a tool “to allow for large scale management and exploitation of forest and fisheries resources and the development of agricultural land under plantation” (Diepart and Schoenberger 2016). Land concession rules were incorporated into the 2001 Land Law (RGC 2001; Scheidel et al. 2013). A land concession is defined as “a legal right given [by the state] to any person or legal entity or group of persons to occupy a land and to exercise the rights set forth by this law” (RGC 2001: Article 48). Moreover, the Law states that “land concessions responding to an economic purpose allow the beneficiaries to clear the land for industrial agricultural exploitation in the territory of the Kingdom of Cambodia” (ibid.: Article 49).

The 2001 Land Law defines two systems for the granting of land concessions: Economic Land Concessions (ELCs) grant state land to private companies for agriculture and industrial plantations; and Social Land Concessions (SLCs) allocate state land for the landless and poor households (RGC 2001, 2005; Bickel and Löhr 2011; Dararath et al. 2011; Neef et al. 2013; Scurrah and Hirsch 2015; Diepart and Schoenberger 2016). To ensure the performance of all ELC contracts and compliance with the 2001 Land Law, the Royal Government of Cambodia (RGC) (2005) issued a sub-decree on ELCs to determine the criteria, procedures, mechanisms and institutional arrangements for initiating and granting new concessions. As the granting of ELCs to private companies has often resulted in further marginalization of the poor (Rudi et al. 2014) and encroached on farmers' rice fields and orchards, and increased the number of landless and near-landless farmers (Un and So 2011), the RGC have used SLCs as a supplementary mechanism to ELCs for redistributing land to land-poor and landless farmers. Neth et al. (2013), however, have agreed that SLCs are strategically deployed by the Cambodian ruling elite to smoothen the adverse social impacts of their very own land policies and minimize resistance by dispossessed rural people.

The 2001 Land Law was followed by a sharp increase in the granting of land concessions in Cambodia. The Ministry of Agriculture, Forestry and Fisheries (MAFF) reported a total increase in the ELC area to reach 1,204,750 hectares (ha) in 2012 (Open Development Cambodia 2015) while others have reported that more than 2 million ha have been leased (Oldenburg and Neef 2014; Davis et al. 2015). Neef et al. (2013) highlight the important role played by the political elites in driving this increase, as evidenced from large land concessions granted to Cambodian tycoons and foreign investors with close connections with the ruling parties. In other words, ELCs have become an instrument for the Cambodian elite to allocate state land to gain economic benefits (Un and So 2009, 2011; Neth et al. 2013; Scurrah and Hirsch 2015). Oldenburg and Neef (2014) claim that resource capture by these elites is rooted in their control of the judiciary, which in turn has created a climate of impunity, and hindered the overall implementation of the legal land use framework, wherever the latter does not serve their interests.

Driven by these political and economic interests, in practice the ELCs have focused on promoting rubber investors in particular. This is most

evident from the way the RGC has made rubber a development priority, regardless of its demonstrated negative impact on local livelihoods and the environment (Dararath et al. 2011; Paul and Leandri 2011; Slocomb 2011). This includes granting controversial ELCs inside protected areas to rubber plantation companies (Paul and Leandri 2011).

As reported in the *Cambodia Daily* (2013), Prime Minister Hun Sen granted 1.2 million ha of land to rubber companies, and forecasted that one in ten Cambodians would work in the rubber sector. Nonetheless, little attention has been given to how individual rubber ELCs have changed resource access for local communities, how the local inhabitants have responded to the changes, and how this response in turn has transformed gender roles and relationships within farming households in Cambodia. This chapter attempts to address these issues.

Impacts on rural livelihoods

In the Mekong region, large-scale rubber concessions are associated with land-use and livelihood conflicts with local communities who lose their access to both individual farmland and communal forest land (Barney 2007). In Cambodia, while the policy objectives of the ELCs are to raise socioeconomic standards, increase agricultural yields, create employment and protect natural resources (RGC 2005), scholars have widely criticized their adverse impacts (Neef et al. 2013; Jiao et al. 2015). Jiao et al. (2015) found no evidence of the positive income effects of ELCs on rural households in their vicinity. Scheidel et al. (2013) also highlight the ELCs' limitations in generating direct employment—instead, the concessions have been contributing to massive rural–urban migration, with a large number of now displaced or landless farmers migrating to urban areas to seek work.

While arable land is essential for rural livelihoods, 69 percent of farming households in Cambodia have less than one ha of farmland, with 14.7 percent of farming households being landless (Bickel and Löhr 2011). This situation has worsened due to ELCs' encroachment of farmland, community forests and indigenous territories—amounting to more than 50 percent of the country's arable land, contributing to the rising rural landlessness (Neef et al. 2013).

Oldenburg and Neef (2014) revealed a large gap between the legal framework and the implementation of the land concession policies and

a complete disregard of customary land rights, driven by widespread corruption, resource misallocation, and unresponsive government institutions. For example, they found that many ELCs were approved without prior social and environmental impact assessments, with villagers and local authorities hardly consulted in the overall process, and some ELCs were even granted within protected forest areas (*ibid.*: 58). Local villagers displaced from their farm land by land concessions cannot rely on the legal or court system because they cannot afford the fees; in addition, the court is likely controlled by rich and powerful businesspersons and investors (*ibid.*: 59).

As weak land governance, land speculation and corruption have exacerbated the negative impacts of large-scale land deals on the poor (Scheidel et al. 2013), there is a need for an effective monitoring system towards more sustainable development in Cambodia (Rudi et al. 2014). For example, Jian et al. (2015) suggested that enhancing policy compliance was critical to ensure transparency in ELC management, local consultation, equitable compensation mechanisms, and securing the rights and interests of local communities. Scurrah and Hirsch (2015) have also raised the importance of more investigations of how rubber ELCs in particular are affecting local resource governance and livelihoods in Cambodia.

Building on these earlier studies, this chapter contributes to the debates on the local impacts of ELCs, focusing on how rubber land concessions have changed farm households' resource access, gender roles in farming, and the very notion of local governance. In particular, it describes and analyses how a local community has adapted its livelihood strategies to sustain and maintain well-being; how local gender roles have changed due to the presence of the rubber ELC; and, how the local government has attempted to cope with rubber concessions in its territory. To assess how an ELC (re)shapes local livelihood options, we examine how the local community's livelihood strategies are linked to their access to a wide range of resources. This study extends the definition of "access" by Ribot and Peluso (2003: 153, 154), i.e. "the ability to benefit from things—including material objects, persons, institutions, and symbols," to better understand who actually benefits from ELCs and what processes enable them to do so.

Research methods

To gain a better understanding of how farming households view ELCs in relation to their resource access, gendered activities, and the overall notion of local governance, the first author conducted in-depth research in one rubber investment site in Sesan district, Stung Treng province, from 23 November to 5 December 2015. This rubber investment site was awarded by MAFF to a Cambodian rubber company, the Sopheak-Nika Investment Agro-Industrial Plant Co. Ltd (Sopheak-Nika, hereafter) with a total concession area of 10,000 ha for a period of 70 years, located about 22 km from Stung Treng town, which has a Brao majority.

Referring to the gender, assets and agriculture (GAAP) framework (Meinzen-Dick et al. 2011), the research focuses on how the ELC is affecting gender relationships in farming households, through examining the changes in the joint and separate activities of men and women, and how these changes shape their livelihood strategies, and vice versa.

We conducted five focus group discussions in Katot village, disaggregated by gender (male and female groups) and ethnicity (Khmer and Brao) and a village development committee, to gain an overview of their resource use, gender activities, and livelihood changes since the arrival of Sopheak-Nika. For this, we asked each group to sketch resource locations, how these support their livelihoods, and how it has changed over time, specifically before and after the arrival of Sopheak-Nika. Informed by our focus group discussions, we interviewed six different farming households, namely the Brao community chief, families with female and male household heads, a family living near the concession land, the family of a teacher, and a family compensated by the company. Unlike the Khmer, the Brao community's livelihood strategies are more closely linked to natural resources.

To gain a better understanding of how local authorities viewed and perceived the impacts of the ELC in relation to their roles and responsibilities in natural resource governance, the first author conducted a series of in-depth, semi-structured interviews with six provincial and five district authorities (hereafter, the local authorities). This includes staff from the local offices of Agriculture, Forestry and Fishery; Environment; Industry; Water Resource and Meteorology; Rural Development; Land Management, Urban Planning and Construction; and Women's Affairs.

Brao perceptions

While searching for arable land for farming, the Brao established Katot village in 1964. Katot remained a Brao village until 1979, when Khmer families began settling in the village by buying or renting the land from the Brao. Currently, comprising of 59 Brao and 54 Khmer households (see table 16.1), Katot is one of the poorest villages in Sesan district. Since Sopheak-Nika ELC was set up in 2005, more Khmer have moved to the village, working mainly as laborers for the rubber company with some also engaging in commercial farming (Baird and Fox 2015).

Table 16.1: Demographic profile of Katot Village, 2015

Categories	Brao	Khmer	Total
Households	59	54	113
Rubber households	0	27	27
Families	78	51	129
Female	163	88	251
Population	323	214	537

Source: Interview with Katot village chief, December 2015.

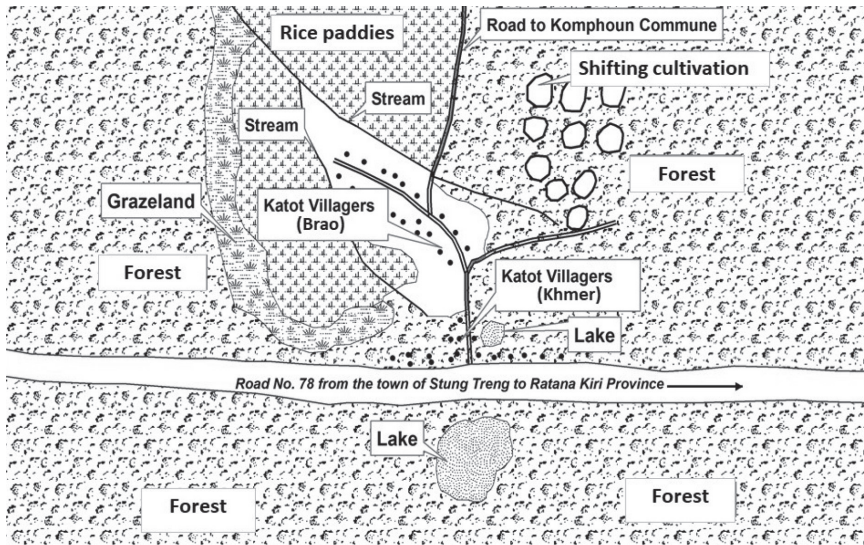
Brao perceptions on local resource uses and conflicts

Prior to Sopheak-Nika's arrival, the Brao viewed their local forest, land and water resources as abundant. After Sopheak-Nika set up its rubber plantation, the government allocated 500 ha of community forest and 60 ha of paddy fields in the form of an SLC for the villagers as an indirect means of compensating their loss of a large forest area to the company (see fig. 16.1b).

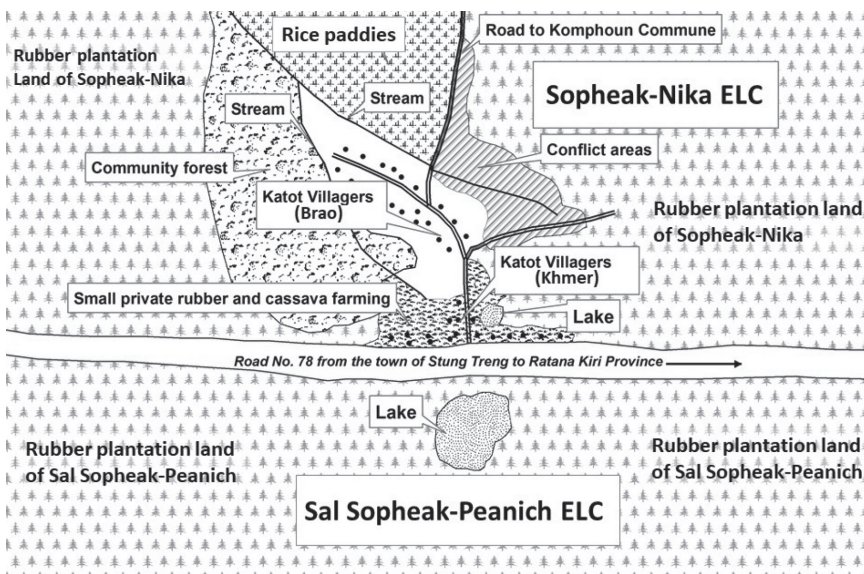
Following the new rubber plantation, many Brao had conflicts with the company over low compensation and unclear land boundaries, as some of their farmland (especially those used for shifting cultivation) fell within the concession area. When marking its land concession boundary, Sopheak-Nika did not discuss it or inform the local people: the company only compensated for plots with rice growing on them, while uncultivated (fallow) rice fields were taken over without any compensation. During our interviews, many Brao expressed anger because nobody had informed them about the land concession prior to Sopheak-Nika workers marking its boundary. As one of the Brao men said: "The company did not consult

Figure 16.1: Land use and natural resources used by local community at Katot village, Stung Treng province

A: Before the arrival of Sopheak-Nika



B: After the arrival of Sopheak-Nika Company



Source: Katot villagers, community resource mapping following focus group discussions, Dec. 2015.

us. They took our forest and farmland. It hurts our feeling and we cannot do anything.”

Moreover, the Brao claimed that there was now a shortage of water for their agriculture and domestic consumption, and blamed the Sopheak-Nika rubber plantation for that. They described how “following forest clearance and rubber tree cultivation, water flow declined in terms of quantity and quality, as it becomes dirty, mixed with sand and polluted with chemical fertilizer, particularly in the rainy season.” To address this problem they had requested Sopheak-Nika to preserve a buffer zone in the forest of 200 to 300 meters adjacent to streams. However, the company refused to comply with this request. To address water issues for the Brao, the Development and Partnership in Action (DPA), a local nongovernmental organization, provided two hand-pump wells for the village in 2013. These pumps are now broken. Lacking the money to repair the pumps, the villagers have asked the commune and district authorities for technical support. But as many of the Brao said: “until now, nothing has happened.” In addition, the Brao also reported the problem of poor and degraded soil quality due to a lack of water and having to recultivate the same land over and over, resulting in a reduced harvest. As one of the Brao farmers explained: “We got more than 30 bags per ha from rice when practicing shifting cultivation, but now we get less than 25 bag per ha of paddy fields, due to poor soil and water.”

Since the rubber ELC, the Brao have lost productive farmland and suffer from poor soil and water quality in their existing farms. After cultivating the same land for decades, the Brao had regarded the area as belonging to them and viewed land titling as unnecessary. However, their experience with Sopheak-Nika has made them realize the importance of having land title to secure their land rights and landownership. Apart from land titling, they also expressed the need to develop their own rules to protect their lands from external interference. As the village chief argued:

To protect our land from the rubber company, it is important that we develop our own local rules and regulations, which clearly demarcate our village and forest community boundaries, and can be recognized by commune, district, provincial and national authorities.

Brao livelihood strategies

The Khmer and the Brao in Katot have different livelihood strategies. The Khmer villagers were less dependent on local resources and often worked as laborers for the larger rubber companies, local cassava farmers, rubber smallholdings, and traders or businesspersons. The Khmer have located their dwellings along the main road with convenient access to the rubber ELC. The Brao, on the other hand, remain strongly dependent on access to natural resources. Prior to the Sopheak-Nika ELC, the Brao used the land for various types of farming, mainly shifting cultivation of lowland rice. They also relied on the forest for food and income through collecting non-timber forest products (NTFPs), raising livestock, logging and hunting wild animals, while using the river for fishing, and for agricultural and domestic use.

After Sopheak-Nika, the Brao lost their farmland and access to clean water and forestland. Brao households have tried various strategies to maintain their livelihoods and well-being. The wealthier Brao have applied both farming and non-farming strategies to improve their livelihoods. For example, those having land turned to cassava farming as an additional source of income. One of them said that “we harvest the raw cassava once year, about 5–6 tons per ha. After drying, the price per ton ranges from 450,000 to 600,000 Riel (US\$110–150).” However, some of the cassava farmers faced difficulties due to the high cost of planting materials, sandy and poor quality soil and erratic rainfall. Eventually, they leased their lands to Khmer families and collected the rental for income. While many of the Brao still grow paddy rice by relying on rainwater in their SLCs (see fig.16.1b), some of them practiced illegal logging. One Brao villager revealed that “we still have to rely on logging as our main income source.”

Unlike the wealthier Brao, the Brao poor and landless had made little effort to adapt to the new conditions and secure their livelihoods. As one of the landless household heads explained: “After we lost our forest, we have just stayed home doing nothing since we don’t have any skills and resources.” A few of them had worked briefly for Sopheak-Nika but left the company because:

we don’t want to work for the company because we hate them. They did not respect us and consult us beforehand about the ELC. They give us a

low wage with monthly salary but we need a daily wage for our daily expenditure ... we also have to work on our farms as well.

Unlike the Brao, the Khmer farmers in Katot village had better access to financial sources and lands to invest in their own rubber smallholdings. Nonetheless, from our interviews and discussions, it is unclear as to whether they really benefit from cultivating rubber. As one of the Khmer rubber smallholders revealed:

We planted 5 ha of rubber trees 12 years ago, using our children's savings from working in Thailand. We took risks in this business. Before, the demand and price of latex rubber was high, so we saw its potential as our long-term investment. But after planting, we faced many challenges. Our land quality became poor and sandy. We faced water shortages as well as soil erosion problems. We spent a lot of money on [chemical] fertilizers to keep the rubber trees growing properly. Later, we learnt that the rubber price became unstable and declined but hope that we still can make profit.

Struggling to make a living, most of the Brao view that the local authorities have not done anything to help them tackle their problems related to the impact of the ELC. As one of the Brao farmers said:

We informed our village and community chief about problems and challenges we face after the land concession. We conveyed the message to district and provincial authorities via commune authorities ... but nothing has happened and we don't know why.

On the other hand, Sopheak-Nika has provided the Brao with some agricultural machines and also improved the village infrastructure (e.g. road, schools). However, the Brao insisted that the company's presence did not benefit them:

Yes, the company widened the road to our village, gave us two-hand tractors, and built one primary school in our village, but we don't recognize these as benefits from the land concession, especially after we lost our forest and farmland.

Brao perceptions of gender roles

Prior to Sopheak-Nika's arrival, Brao men played an important role in securing household income, centered on activities such as fishing, logging, hunting, and collecting high value NTFPs in the forest. Women's role in

income generating, on the other hand, were viewed as quite insignificant and their responsibilities mainly domestic, such as collecting firewood, planting vegetables and crops, housework, and collecting wild fruits and vegetables in the nearby forests. Both men and women worked together on labor-intensive land preparation for shifting cultivation, lowland rice cultivation and NTFP collection.

Since the setting up of the rubber ELC, both joint and separate activities of Brao men and women have changed as their access to natural resources has significantly reduced. After losing their forestland, men's involvement in NTFP collection, hunting, and logging almost stopped. Currently, the Brao view their joint activities, including paddy rice cultivation, cassava and cash crop plantations and selling their labor to private farmers, as the main source of household income. This change in livelihoods has also expanded women's activities from the domestic to commercial sphere, where they work as laborers, traders and businesswomen and earned additional income for their families. These women have been trained and involved with some development activities, organized by NGOs and local authorities. The programs were conducted in Katot as it was ranked as a poor village, and because the indigenous Brao women suffered as their livelihoods were affected by the ELC.

Interestingly, the study found that the Brao perceive that gender relationships have become more equal after Sopheak-Nika's arrival. First, since the rubber ELC created resource pressure, both men and women in their community needed to discuss and agree with each other before taking any actions and decisions regarding their livelihood. Both men and women were involved in household decision-making. Second, government gender policy has prioritized and encouraged local and indigenous women to participate in training and higher education to gain knowledge. Accordingly, both Brao men and women have participated in various types of training, organized by NGOs and local authorities. Many of the young women have also migrated to Phnom Penh and/or Thailand to work as laborers, sending remittances home.

While the land concession has to a certain extent improved gender equity, this does not mean that it automatically benefits Brao women in general, especially in relation to post-ELC household strategies. Like men, women also suffer from the socioeconomic and environmental impacts of the ELC. For example, one female household head, who lives with a

20-year-old son and a 13-year-old daughter, described the ELC's negative impacts on women's well-being:

In the past, we were not so poor. We had 25 buffalos, practiced both shifting cultivation and grew lowland rice, and collected our food in forest sometimes. Since my husband passed away in 2003, our livelihood started suffering. In 2005, the situation only worsened after we lost our forestland and have to stop shifting cultivation and cattle raising. At present, we work as laborers for other farmers, earned a low wage [US\$5 per day] and cultivated paddy rice in our 3 ha with insufficient water.

Local authorities' perceptions

Prior to Sopheak-Nika's arrival, the local authorities found the lands in Stung Treng covered with forest, and the local community used this forestland for livestock raising, NTFP collection, paddy rice and shifting cultivation, and vegetable and cassava growing. The dense forest also acted as a watershed and abundant natural resource, providing sufficient water along with fertile soils for agriculture. Since Sopheak-Nika set up its monoculture plantation, local authorities have observed a decline in the availability and quality of natural resources. They criticised the national government for looking at economic benefits without considering the social and environment impacts at the ELC site, and claimed that the economic benefits did not really accrue at the local level.

The local authorities also highlighted their lack of involvement in these matters, against the absolute power of the central government over ELC approval. This power asymmetry is most apparent in the Provincial Department of Agriculture, Forest and Fishery's (PAFF) statement that "as the land belongs to the state, the RGC can use it for their development purpose [giving land to companies]. [Here], the decision to approve ELCs to the rubber companies is made by [only] the national governments without involvement from local authorities."

The local authorities were not involved in the process of discussion, approval and granting of the ELC to the rubber companies. Formally, the cabinet makes the decision along with technical recommendations from relevant ministries. For example, MAFF would recommend monitoring impacts on agricultural land and plantation, the Ministry of Environment (MoE) would recommend pollution monitoring, the Ministry of Land

Management on land boundaries, and the Ministry of Water Resources and Meteorology on water pollution aspects. The national government is required to consult with local authorities prior to approving the ELC. In practice, however, the decisions were often made without any input from the local authorities. As revealed by one of the agricultural and forest authorities: "The company visited the land site, discussed with some relevant provincial authorities, then proposed to the relevant Ministries, and after that requested the Prime Minister to award them the land, ... without our inputs."

When local authorities were asked how they deal with various problems in the ELC areas, all of them replied that they follow a so-called "reporting-line system," which even they think is ineffective. This system was developed for local authorities to report problems in the field to provincial government agencies representing relevant ministries, and later to sectoral ministries as well. In practice, however, as provincial government agencies and sectoral ministries can only tackle issues directly related to their area of responsibility, the reporting line became excessively long and ineffective. For example, the Department of Water Resources addresses only water pollution but not agricultural water, water supply deterioration or related land-based conflicts: local authorities had to report such issues to different departments, creating additional administrative work and further delays in addressing local problems. Furthermore, the local authorities highlighted the importance of following the instructions of their directors, senior and national authorities in addressing any governance issues regarding the ELCs. Nevertheless, while they know that this approach somehow protected them from making any mistakes, many also realized that it prevents them from dealing effectively with the negative local impacts of ELCs.

A few local officials highlighted some livelihood challenges at the Sopheak-Nika site in terms of land conflicts, unclear land boundaries and low compensation paid to affected households. They have reported these issues to their respective provincial authorities and ministries. They have also contacted Sopheak-Nika company to address emerging issues related to the ELC. Nonetheless, as the current reporting line obliges local authorities to first report everything to higher authorities, this does not give them the needed space to respond to local communities' development needs and aspirations. As a member of the environmental authority

stated: “local authorities can only set up a task force to address small, insignificant issues.”

Lacking the power to counter decisions made by national agencies, local authorities struggle to fulfill their role and mandate in natural resource governance. Political pressures from the national government, the reporting-line system, and power asymmetry have hindered local authorities from taking an active role in the overall discussion of ELCs and creating space for political engagement at the local level.

Discussion and conclusion

Supported by Cambodian political elites, ELCs have become a legal means for private developers to impose their business agenda and interests on local communities living in concession areas, often forcing them to change their agricultural practices and depriving them of their livelihoods and access to natural resources. Centralized, top-down decision-making processes in granting ELCs hinder local authorities from playing an active role in facilitating discussions between local farmers and the companies. When local authorities play hardly any role in natural resource governance, this highlights not only the existing power asymmetry between national and local government bodies, but also the latter’s limited capacity and leverage to be accountable to local community’s needs.

The Sopheak-Nika rubber plantation has also changed the patterns of the joint and separate activities among Brao men and women. As men lose access to traditional hunting areas and upland crop fields in the forests, women have to work more to make up income shortfalls and are engaged in diverse non-farm activities to support their families. Brao villagers in Katot highlighted that there has been an improvement in gender equality and women’s roles, but they stress that this does not mean that women’s welfare has improved. Indeed, women might face various health and mental issues due to increasing pressure on them to earn additional income for their households where men have lost their traditional means of livelihood.

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